Grain Legumes Strategies and Seed Roadmaps for Select Countries in Sub-Saharan Africa and South Asia

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Abstract

Tropical Legumes II (TL-II) is a Bill and Melinda Gates Foundation (BMGF) sponsored project implemented by three International Agricultural Research Centers – ICRISAT, CIAT and IITA. TL-II aims to improve the livelihoods of smallholder farmers in the drought-prone areas of Sub-Saharan Africa (SSA) and South Asia through improved productivity and production of six major grain legumes – chickpea, common bean, cowpea, groundnut, pigeonpea and soybean. The project activities are in Burkina Faso, Ghana, Mali, Niger, Nigeria, Senegal, Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Uganda and Zimbabwe in SSA and India and Bangladesh in South Asia. The project has formed a wide range of partnerships with the host national agricultural research systems, advanced research institutions, NGOs, and several other projects funded by the BMGF and other organizations to ensure the sustainability and scalability of the project outcomes. In the six years since inception in 2007/08, a total of 113 new legume varieties have been released in collaboration with NARS in the partner countries. The newly released groundnut, cowpea, common bean, chickpea, pigeonpea and soybean varieties are fast replacing old varieties in these areas of Africa and Asia resulting in significant increases in productivity and production at national level. Participatory variety selection trials have been expanded to new villages to up-scale dissemination of new varieties in all project countries. The project was able to undertake trials with more than 281,000 farmers directly during the past six years (2007/08–2012/13). Workable and efficient models for the production of different categories of seed have been identified. The seed production systems are country-specific. Women and women's groups have been empowered to produce and market legume seed in many countries. A total of 222,531 tons of improved legume seed of all six crops have been produced and distributed since inception. The project strategy is to reach smallholder farmers with improved varieties through small seed packs (1, 2 and 5 kg) for wider technology dissemination. At the current smallholder land allocation to legumes of approximately 0.2 ha per household, the 5kg pack will guarantee farmers their seed legume requirement within one season. The seed so far produced is enough to serve 44.5 million smallholder farmers, providing the legume protein and nutrition requirement of 222.5 million individuals (5 persons per household). Cumulatively, as a result of improved seed availability and accessibility, farmers have adopted improved legume varieties in about 27% of the area under legumes in Mali, 38% in Niger, 57% in Malawi, 35% in Tanzania, 59% in selected districts of Uganda and 22% in Nigeria. The reduction in per unit cost of cultivation of improved varieties ranges from 21% in Malawi to 44% in Uganda, compared to local varieties.

Cover Photo Captions *(clockwise)*

1. Ms Shabila Musa, her husband and daughter – one of many smallholder farmers from Southern Tanzania – are now making a living from seed production of improved groundnut varieties; they are members of the Muungano Farmer Group in Mnanje village Masasi.

2. A chickpea farmer in Andhra Pradesh, India admiring his lucrative crop.

3. A woman farmer from the Lake Zone region of Tanzania shelling her groundnut. Women are empowered to make decisions on marketing their produce.

Grain Legumes Strategies and Seed Roadmaps for Select Countries in Sub-Saharan Africa and South Asia

Tropical Legumes II Project Report

Editors

Emmanuel S Monyo and CL Laxmipathi Gowda

This work has been undertaken as part of the CGIAR RESEARCH PROGRAM ON Grain Legumes

ICRISAT Science with a human face

International Crops Research Institute for the Semi-Arid Tropics

Patancheru 502 324, Andhra Pradesh, India

2014

Contents

Foreword

Legumes – Country Strategies and Seed Roadmaps

Comprehensive in-country information on grain legumes in developing countries is currently available only through searches of a multitude of hard-to-access documents. To begin to address this problem, a group of dedicated scientists from Sub-Saharan Africa and South Asia worked hard to organize future opportunities in 13 Sub-Saharan African and 2 South Asian countries for six key legume crops. It will serve as an important benchmark and reference document for several different types of stakeholders, including donors and project implementers to help them target legumes and broader cropping systems investments. The crops include common bean (*Phaseolus vulgaris*), cowpea (*Vigna unguiculata*), chickpea (*Cicer arietinum*), soybean (*Glycine max*), pigeonpea (*Cajanus cajan*) and groundnut (*Arachis hypogaea*). Taken together, these crops are grown on some 60 million hectares in low income geographies, an area greater than that devoted to maize cultivation.

This publication represents an important output of the Tropical Legumes II project supported by the Bill & Melinda Gates Foundation, containing information that is not available elsewhere in such a one-stop way. The Tropical Legumes II project is being executed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in collaboration with a broad range of partners including two CGIAR centers, the International Center for Tropical Agriculture (CIAT) and the International Institute for Tropical Agriculture (IITA) as well as the National Research Institute of each partner country. The project has made remarkable successes – release of 113 new legume varieties during the past 6 years; the adoption of new chickpea cultivars and agronomic practices that have doubled yields in Ethiopia; and the re-invigoration of the groundnut export trade in Malawi through efforts by the project to extend crop management practices for the control of aflatoxin and to get seed of improved varieties to farmers.

The legume crops featured in this publication are critically important to smallholder farmers for a number of reasons. They help intensify staple cereal, roots and tuber cropping systems as catch, relay and intercrop options and provide nitrogen and other soil health benefits associated with crop rotation. Legume grains contain 2–3 times higher protein content than the starchy staples that form the bulk of the diets of smallholder and urban poor families thus providing critical nutritional and health benefits. As the legume crops are largely grown by women, improvements in legume productivity bring additional income to them. Legumes help diversify smallholder food production and income streams and hence mitigate risks associated with price fluctuations, and reduce disease and pest infestations and climate-related production disruptions. Thus grain legumes contribute significantly towards the Foundation's core goals of reducing poverty, improving food security, improving nutrition and health, enhance women's empowerment and sustain the natural resource base.

We congratulate the volume editors Emmanuel Monyo and CL Laxmipathi Gowda for their outstanding effort to bring the various country level perspectives together in a highly readable document. We are proud to have supported the people and institutions across Sub-Saharan Africa and South Asia who contributed to this work.

Jeff Ehlers and David Bergvinson
Bill & Melinda Gates Foundation

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Grain Legumes Strategies for Eastern and Southern Africa

Ethiopia

Common bean

Kidane Tumsa, Robin Buruchara and Steve Beebe

Introduction

Beans (*Phaseolus vulgaris*) are increasingly becoming an important crop in Ethiopia. The crop largely contributes to the national economy (commodity and employment) and is a source of food and cash income to the resource-poor farmers. Of 1,357,523 ha (11.8% of crop land) covered by pulse crops in Ethiopia in 2010/11, 237,366 ha (2.01%) were covered by common bean and 340,279 tons of production was obtained (Source: CSA 2011).

The country stands seventh in area and sixth in production among the 29 countries that produce common bean in Sub-Saharan Africa (SSA). During 2003 to 2010, the area under beans increased by 34.3%, from 181,600 ha in 2003 to 244,012 ha in 2010, while production increased threefold, from 117,750 tons in 2003 to 362,890 tons in 2010 (Fig. 1) and the average yield more than doubled, from 0.615 t ha^{-1} to 1.487 t ha^{-1}. By 2012, bean area expanded to about 350,000 ha. Ethiopia is the largest exporter of common bean in Africa, earning about US$ 66 million in 2010 compared to US$ 17 million in 2006. The export quantity rose to about 77,000 tons in 2010 compared to 49,000 tons in 2006. Since 2005, the quantity of formal bean export (particularly white-seeded bean) has increased from 62,000 tons to 75,000 tons (Fig. 2).

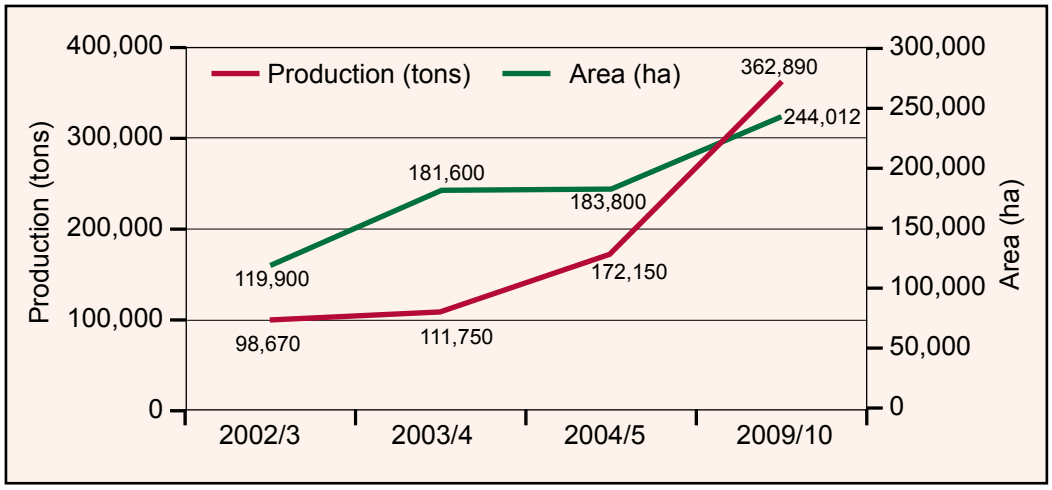

Figure 1. Trends in bean production and area during 2002/03 to 2010.

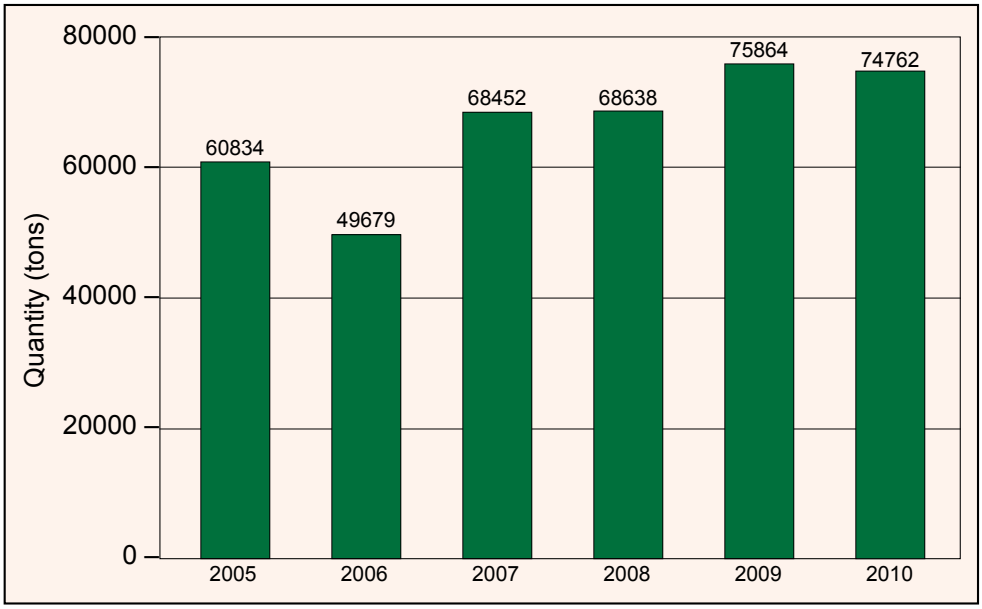

Figure 2. Quantity (tons) of exported bean products during 2005 to 2010.

Research and development

The National Bean Research Program focuses on strengthening national bean crossing program, acquiring and evaluation of germplasm (advanced lines, elite materials) from international sources in different locations, and conducting different performance trials and releasing varieties. Breeding and variety selection is guided by adaptability needs, market demand and food security of the Ethiopian consumers. More research is conducted on integrated crop management options and market access challenges.

Variety development

The Ethiopian National Bean Research Program in partnership with CIAT has made extensive efforts to develop common bean suitable for different agroecologies in the country. More than 40 varieties from the different market classes of beans have been developed and few of them have been popularized (Table 1). Despite the release of several bean varieties, the majority of farmers still grow old varieties with traditional crop management practices.

Major bean production constraints

Genetic factors

- Limited varietal option for small white market class seed which are highly demanded by the canning industry internationally.
- Narrow genetic diversity in global germplasm collection for small-seeded bean varieties contributes to these constraints. But it is possible to create variability through breeding.

Prevalence of diseases and insect pests

- Diseases such as common bacterial blight, anthracnose, rust, angular leaf spot, halo blight and common mosaic virus are also the major factors which contribute to the heavy loss of yield.
- Major insect pests like bean stem maggot and storage pests such as bruchids and beetles also contribute to reduced yield and production.

Table 1. Common bean varieties released by NARS in Ethiopia.

Variety	Pedigree	Year of release	Suitable areas
Lehode	DA-NAZCR-02-12	2010	Northeastern
Loko	AFR-716	2009	Western
Batu	A197xOM NAZCr-02-11	2008	In areas with short season
Deme	SUG-131	2008	In all bean growing areas
Kufanzik	MX-8754-9M	2008	Eastern (Hararghe Highland)
Dursitu	DOR-811	2008	Eastern (Hararghe Highland)
Hawassa Dume	SNNPR-120	2008	Southern region (Wolaita, Sidama, Gamu Gofa)
CRANSCOPE	-	2007	Central Rift Valley (CRV)
ACOS RED	-	2007	CRV and Southern region
GABISA	VAX-2	2007	Western bean growing regions
Chercher	STTT-165-96	2006	Eastern (Hararghe Highland)
Haramaya	G-843	2006	Eastern (Hararghe Highland)
Chore	STTT-165-92	2006	CRV and Eastern Ethiopia
Dinkinesh	XAN-310	2006	All bean growing regions
Melkadima	RAB-484	2006	Southern and Southwest
Batagonia	RWV-482	2005	Southern
Anger	EMP-376	2005	Western
Tibe	812-BRC-28	2004	Western
Wedo	MAM-41	2003	Northwest
Ibado	AFR-722	2003	Southern
Omo-95	RWR-719	2003	Southern
Nasir	Dicta-105	2003	Across all bean growing regions
Dimtu	DOR-554	2003	Across all bean growing regions
Tabor	A-788	1998/99	CRV and Southern
Zebra	GX-1175-3	1998/99	Across all bean growing regions
Gobe Rasha-1	ICS-15541	1998/99	Southern and Southwest
Beshbesh	Originally 'Cross 5'	1998/99	Local cross and for bean stem maggot problem areas
Melke	Originally 'Cross 14'	1997/98	Local cross and for bean stem maggot problem areas
Ayenew		1997	Eastern
Gofta	G-2816	1997	Across all bean growing regions
Atndaba	A-262	1997	Across all bean growing regions
Red Wolaita		1974	Southern
ARO4GY		2005	CRV
Nazareth-2	TAO4JI	2005	CRV
Awash Melka	PAN-182	1998/99	All bean growing regions
Roba		1990	All bean growing regions
Awash 1		1990	All bean growing regions
Mexican 142		1973	All bean growing regions

Lack of suitable varieties for mid to higher altitudes and for irrigated and short growing seasons

- Due to the recurrent occurrence of moisture stress in mid altitude areas of the country, common bean is now replacing the already potential legume crops (faba bean and field pea).
- Due to improvement of price and market opportunities, bean production by using irrigation is profitable and production during the short growing season (*belg*) is crucial especially to support food and nutritional security of resource-poor farmers.
- But no varieties have been developed for all the three scenarios.

Environmental stresses (climatic and edaphic factors)

- Erratic rainfall and heat stress
- Allocation of marginal land with poor soil fertility
- Low soil pH conditions (including Al toxicity) in western and southwestern growing regions

Socioeconomic, technology transfer and utilization factors

- Access to quality seed by all resource-poor farmers
- Marketing services
- Poor grain quality (varietal mixture and foreign matter)
- Low domestic production (especially of niche market varieties)
- Limited research and extension interventions in utilization technology and nutrition of beans

Research for development emphasis in TL-II Project Phase 2

- Support national crossing program
- Support introduction and exchange of germplasm lines which are tolerant/resistant to different production constraints
- Support variety evaluation trials including participatory variety selection (PVS)
- Support demonstration and popularization of newly released varieties
- Intensify seed production and strengthen community-based seed systems
- Introduce affordable machinery for plowing, planting, weeding or intercultivation, harvesting, cleaning and packaging
- Develop and introduce effective integrated pest management (IPM) strategies against bean stem maggots
- Strengthen research on biofortified food type varieties and promotion of the developed varieties (such as Gofta, Roba and others)
- Encourage the introduction of policies on grades and quality standards especially for colored beans

Expected outcomes from National Bean Research Program

- Increased access by farmers to improved common bean varieties resistant to multiple environmental stresses
- Increased access to cost-effective and environment-friendly integrated stress management options
- Increased capacities of men and women to participate in technology development, delivery and decision-making
- Increased access to new and existing markets and its opportunities
- Increased access particularly for information and knowledge that shapes bean technology development and delivery and influences policy

Agroecological zones

Common bean is widely grown across the country. The highest concentrations are located in Oromia region where more than 50% of common bean grain products are produced for export market. Central Rift Valley (CRV) that consists of parts of East Shewa, Arsi and West Arsi zones and west and east Hararghe highlands belong to Oromia region. The CRV areas are considered the major "common bean belt" and specialize in white-seeded beans that are mainly produced for the export market (Fig. 3). West and East Hararghe highlands produce beans intercropped with sorghum, maize and *chat.*

The Southern (SNNP) region, which includes Sidama, Wolayta and Gemu Gofa zones, is the second production area (Table 2). Most of the production from SNNP is used for household consumption. Various administrative zones in north and north-central, southwestern, western and northwest parts of Ethiopia also produce bean (Fig. 3). Regions other than CRV produce mostly colored beans of various sizes that are used as food and for local markets, although these are also exported to neighboring countries like Kenya and Somalia, mostly through informal channels.

Table 2. Area and production of common bean across regions in 2010/11 cropping season in Ethiopia.

Region	Area (ha)	Production (t)
Oromya	108,658	142,522
SNNP	76,398	104,904
Amhara	16,442	20,110
Tigray	84	119
Gambela	25	12
Dire Dawa	273	505
B/Gumiz	5614	8541
Total	207,494	276,713

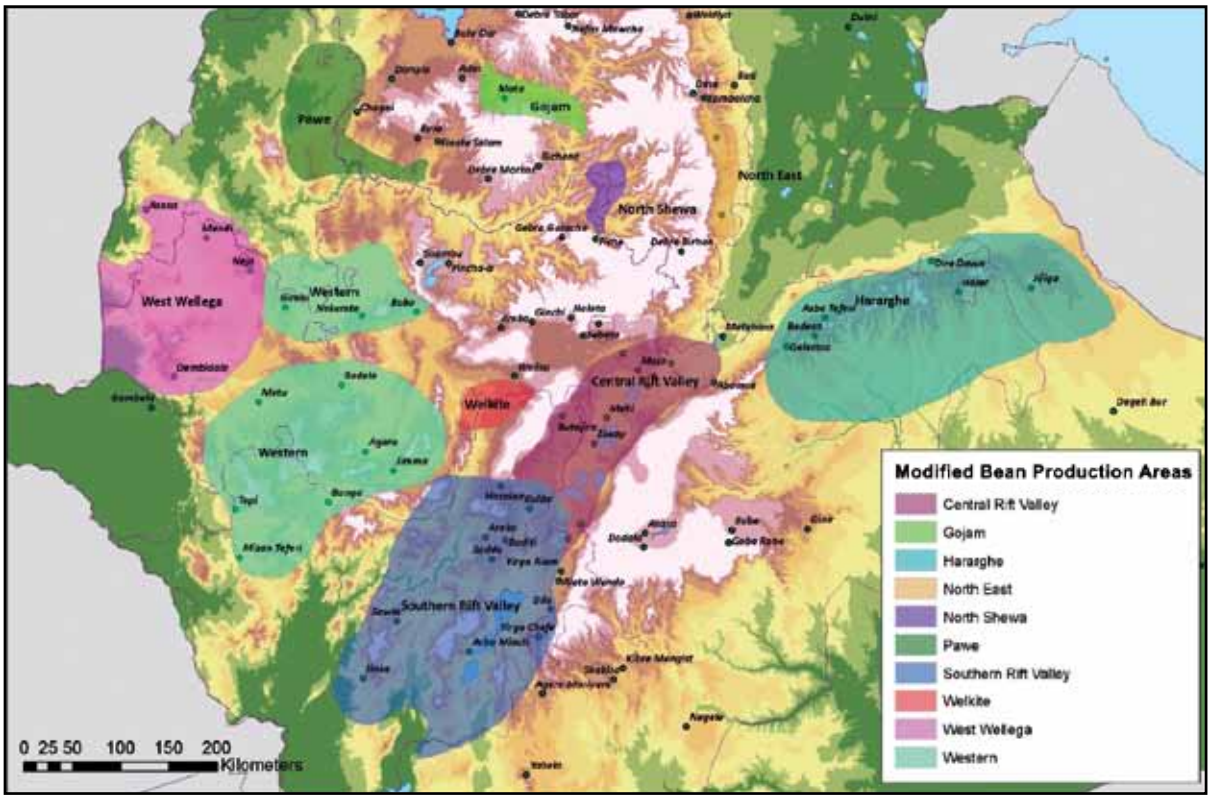

Figure 3. Bean production areas in Ethiopia.

Achievements in the seed systems

Foundation seed production and distribution

Foundation seed production is primarily done by the National Bean Research Program and distributed through different partners. Since 2004, about 771 tons of foundation seed of more than 15 improved varieties have been produced and distributed (Table 3).

Table 3. Foundation seed supplied during 2004 to 2011.

Year	No. of varieties	Quantity (t)
2004	9	137
2005	8	66
2006	8	83
2007	7	56
2008	15	122.4
2009	7	112.2
2010	8	98.9
2011	7	95.5
Total		771

The increased availability of foundation seed served to augment the subsequent production of certified and quality declared seed which was availed to farmers. This increased access to good quality seeds (certified, farmer accepted quality) of improved and adapted varieties supported by the use of a range of improved agronomic practices [appropriate seed rate and plowing, timely weeding and judicious use of fertilizers (about 100 kg ha^{-1} DAP)] led to increased productivity. At national level, the grain yield more than doubled from 0.615 t ha^{-1} to 1.487 t ha^{-1} during 2004 to 2010 (Fig. 4) (Source: CSA 2010). Farmers' cooperative unions played a major role in improving the fertilizer accessibility as loan to their members.

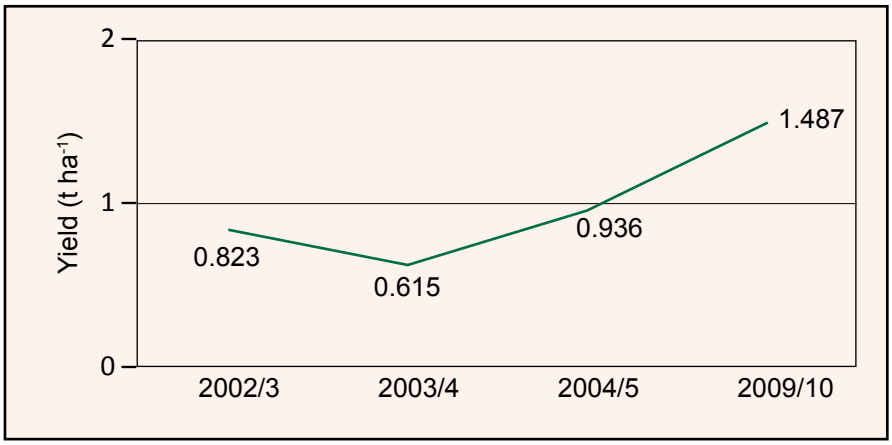

Figure 4. Trend in bean productivity during 2003 to 2010.

Improvement in market access and bean price

One of the major concerns of farmers in sustaining the use of improved varieties particularly in CRV region was the lower price of grain paid to farmers. Therefore the wider use of improved technologies depended on bean price. During 2004 to 2010, the bean price per ton increased fivefold. In 2004, the price was US$ 120 per ton; and this increased to US$ 650 per ton in 2010 after the establishment of Ethiopian Commodity Exchange. At the same time the quality of grain supplied to ACOS (seed company) increased (impurity decreased from 25–30% in 2006 to 3% in 2009).

Seed requirement for three years

Current bean area has expanded to about 350,000 ha of land. With mean seeding rate of 100 t ha^{-1}, 35,000 tons of seed will be required nationally to obtain 100% adoption. If 30% adoption is targeted under TL-II by the end of three years, 10,500 tons of seed will be needed to achieve the target. Our productivity goal is 2.5 t ha^{-1} at intervention sites and 1.8 t ha^{-1} nationally, to reach a total national production of 630,000 tons.

Source of seed

Research centers

Research centers together with different partners will contribute towards production and distribution of the target amounts of seed. It is expected that the bean research centers under federal and regional research institutes together will produce 300 tons of seed. About 100 tons of this seed will be distributed using small packs and 200 tons will be distributed using commercial packs (large packages).

Partners

The remaining 10,200 tons of the seed is expected to be produced by partners in the private sector (Table 4). About 75% of the seed will be distributed to moisture stress environment and 25% to the other potential bean growing agroecologies of the country.

Table 4. Estimated amount of seed to be produced by partners.

Partners	Amount (t)	Seed class
Farmer cooperative unions (FCU)	6200	C1-C3
Private farm	1200	C1-C3
Farmer groups and individual farmers	1300	C1-C3
Parastatals (Seed enterprises)	1500	Basic, C1-C3

Constraints

- Informal system dominates and has technical and infrastructural gaps
- Certification system for the informal system is not clear
- Total lack of mechanization at all steps
- Unpredictability of market price
- Lack of quality seed at any point in time in adequate quantities by variety

Potential partners

- CIAT, PABRA, ECABREN
- Ministry of Agriculture, Regional/Zonal/Woreda ADOs
- Seed enterprises (ESE, OSE, SSE, ASE)
- Research institutes (SARI, OARI, ARARI, TARI)
- Higher learning institutes (Alage CoA, Haramaya and Hawasa)
- NGOs (CRS: MCS and WCS, NDPlc)
- Farmers' cooperative unions (MB, LA, COB, Liban, UW, Admas, Melik)
- Private farms (Alemayehu, Robani, Aser, ELFORA)
- Farmer groups and individual farmers
- Agricultural Transformation Agency (ATA): newly emerging and potential one

Table 5. Common been seed production plan for Ethiopia for 2012 to 2014.

		Variety characteristics				Seed production (t)			Seed production goal (t)		
Ecology	Demand (ha)	Productivity (t ha^{-1})	Type	Promising varieties	Available breeder + foundation seeds (t)	Breeder seed	Foundation + certified seeds	Seed to reach 30% adoption (t)	Year 1 2012	Year 2 2013	Year 3 2014
Moisture stress (75%)	42,000	2	Export	Awash-1	299.5	63.0	1197.0	1260.0	252	378	630
	26,250	2.5	Export	Awash Melka	154.7	39.4	748.1	787.5	158	236	394
	34,125	2.5	Both (export and food)	Nasir	192.1	51.2	972.6	1023.8	205	307	512
	7,875	2	Both	Hawasa Dume	37.4	11.8	224.4	236.3	47	71	118
	7,875	2	Both	IBADO	37.4	11.8	224.4	236.3	47	71	118
	7,875	2	Both	Dimtu	37.4	11.8	224.4	236.3	47	71	118
	10,500	2	Both	Dinknesh	49.9	15.8	299.3	315.0	63	95	158
	13,125	1.9	Food	Gofta	22.3	19.7	374.1	393.8	79	118	197
	13,125	1.8	Food	Roba	1.8	19.7	374.1	393.8	79	118	197
	13,125	2	Both	Batu	9.8	19.7	374.1	393.8	79	118	197
	13,125	2.2	Both	GLP 2	6.8	19.7	374.1	393.8	79	118	197
	13,125	2.2	Both	ECAB 0056	5.8	19.7	374.1	393.8	79	118	197
	13,125	1.7	Both	DRK	4.8	19.7	374.1	393.8	79	118	197
	15,750	2	Both	Deme	4.8	23.6	448.9	472.5	95	142	236
	10,500	2.2	Both	Dursitu	5.6	15.8	299.3	315.0	63	95	158
	10,500	2	Both	SARI-1	6.6	15.8	299.3	315.0	63	95	158
	10,500	2.4	Both	Gobe Rasha	5.6	15.8	299.3	315.0	63	95	158
Potential areas (25%)	14,000	2	Export	Awash-1	66.5	21.0	399.0	420.0	84.0	126.0	210.0
	8,750	2.5	Export	Awash Melka	41.6	13.1	249.4	262.5	52.5	78.8	131.3
	11,375	2.5	Both	Nasir	54.0	17.1	324.2	341.3	68.3	102.4	170.6
	2,625	2	Both	Hawasa Dume	15.5	3.9	74.8	78.8	15.8	23.6	39.4
	2,625	2	Both	IBADO	13.5	3.9	74.8	78.8	15.8	23.6	39.4
	2,625	2	Both	Dimtu	12.5	3.9	74.8	78.8	15.8	23.6	39.4
	3,500	2	Both	Dinknesh	9.6	5.3	99.8	105.0	21.0	31.5	52.5
	4,375	1.9	Food	Gofta	10.8	6.6	124.7	131.3	26.3	39.4	65.6
	4,375	1.8	Food	Roba	0.5	6.6	124.7	131.3	26.3	39.4	65.6
	4,375	2	Both	Batu	0.5	6.6	124.7	131.3	26.3	39.4	65.6
	4,375	2.2	Both	GLP 2	0.2	6.6	124.7	131.3	26.3	39.4	65.6
	4,375	2.2	Both	ECAB 0056	0.2	6.6	124.7	131.3	26.3	39.4	65.6
	4,375	1.7	Both	DRK	0.3	6.6	124.7	131.3	26.3	39.4	65.6
	5,250	2	Both	Deme	0.1	7.9	149.6	157.5	31.5	47.3	78.8
	3,500	2.2	Both	Dursitu	0.1	5.3	99.8	105.0	21.0	31.5	52.5
	3,500	2	Both	SARI-1	0.1	5.3	99.8	105.0	21.0	31.5	52.5
	3,500	2.4	Both	Gobe Rasha	0.1	5.3	99.8	105.0	21.0	31.5	52.5
Total	350,000				1,107	525	9,975	10,500	2,100	3,150	5,250

Opportunities

- Building on lessons and experiences to expand decentralized seed system
- Expanding well established partnerships
- Availability of market for seed and grain
- Improved policy environment (ATA, GTP)
- Establishment of Ethiopian Commodity Exchange (ECX)
- Availability of improved varieties
- Improved awareness in using common bean as food and nutritional security crop

Seed production and distribution plans

These are given in Tables 5 and 6.

Table 6. Common bean seed distribution plan for Ethiopia.

Region	Zones	Woredas (districts)
Oromiya	East Shoa	Adama, Lume, Boset, Bora, Adamitulu and Ziway Dugda
	West Arsi	Shashamane, Siraro, Shala
	Arsi	Sire, Dodota, Merti jeju, Aseko, Seru, Shirka
	West Showa	Goro
	East Wollega	Sibu sire, Diga, Gutin, Bako Tibe, Gobu sayo, Bila, Fincawa, Illu galan
	West Wollega	
	East Hararghe	Kersa, Goro Gutu, Meta, Deder
	West Hararghe	Guba Koricha, Anchar, Chiro, Doba, Tulo, Oda bultum, Daro lebu
	Guji	Guji
	Borena	Borena
	Bale	Del-mena, Giro, Ginder, Berbere, Sawena, Rayitu
SNNP	Sidama	Dale, Loka Abaya, Boricha, Hawasa Zuria, Bursa, Bensa, Aroresa
	Wolaita	Humbo, Sodo Zuria, Kindo koysha, Boloso sore, Kindo didaye, Damot pulasa, Ofla
	Gamo gofa	Kucha, Goffa, Bonke, West abaya
	Dawro	Tercha, Loma
	Kambata Tembaro	Angacha, Tembaro
	Hadiya	E/Badawacho, W/Badawacho, Shashogo
	Silte	Silti, Sankura, Dalocha, Hulbareg
	Guraghe	Abeshege, Cheha and Enemorna Ener, Mareko
Amahara	North Wolo	Sirinka, Kobo
	South Wolo	Borena, Sayint, Meqdela, Kalu, Tehuledere, Werebabo
	North Showa	Kewet, Merhabete, Berehet, Efratana gidim, Antsokiya gemiza, Ankober, Asagrit
	South Gonder	Lay gayint, Tach gayint, Simada, Libokemkem, Ebnat, Dera
	East Gojam	Shebelberenta, Goncha sisoenese, Enebse sarmidir, Hulet eju enese, Baso liben, Awobel
	West Gojam	Bure, Jabitehinan, Gonj kolela, Yilmanadensa, Wonberma
Tigray	South Tigray	Alamata, Mohoni
	Central Tigray	
Benishangul	Metekel	Dibate, Pawe, Mankush, Mandura, Mambuk, Bulen
	Kemashi	
Somali	Jigiga	Jijga, Gursum, Babile

Chickpea

Asnake Fikre, Million Eshete, Ganga Rao and Said Silim

Introduction

Chickpea is one of the important legumes accounting for about 15% of Ethiopian legumes (1.5 million ha) with about one million households engaged in its production (Source: www.csa.gov.et). Its cultivation area (220,000 ha) is about 1.7% of total field crops cultivation in the country. It is less labor intensive compared to many field crops (Kassie et al. 2010) as its production is towards the end of the cropping season, so there is less weed pressure and less soil management cost (drainage). The crop is known for soil nitrogen enrichment, rotational advantages and less cost of production. It is also an important source of diet and consumed in Ethiopia in different preparations like snacks, curry, blend, green pea, salads to mention a few. Ethiopia is the leading producer (3.1 million tons), consumer and seller of chickpea in Africa, and is the sixth most important producer in the world (Kassie et al. 2010). With the emerging situation, Ethiopian chickpea production is shifting from traditional cultivars to improved varieties and from desi types to the kabuli types. Other progressive shifts include the use of market oriented cultivars and enhanced adoption of production packages recommended by research. Production of chickpea has shown steady improvement over the last decade. The major contributor of this production is the dramatic productivity improvement of the crop than area expansion (Fig. 1).

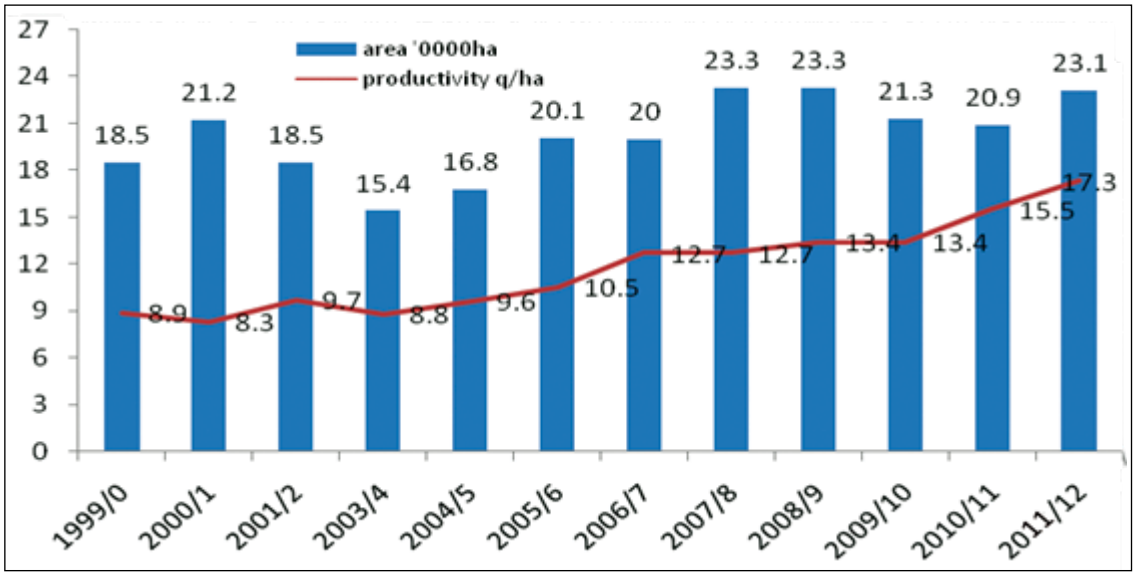

Figure 1. Area and productivity of chickpea in Ethiopia (Source: Central Statistical Agency, Ethiopia).

Contribution to national GDP, farmer income and food and nutrition security

Chickpea is an important market crop in Ethiopia. Most farmers sell more than 75% of the produce. The contribution of chickpea to the national economy is significant. Ethiopia shares about 4.5% of global chickpea market and on average received US$ 16 million during 2000 to 2008.

Both the local and export markets of chickpea are getting more attractive. Farmers currently receive a total income of 30000 to 40000 birr (US$ 1760–2300) per ha for improved chickpeas. The net income is high since the production cost for chickpea is among the lowest. Chickpea is among the economically viable commodities in Ethiopia. Its role in soil fertilization is significant. An average of 4 kg per person

per annum is the current production consumption ratio in Ethiopian chickpea. In any case chickpea is an important food source (curry, snack, green pea, splits) in the food habit of Ethiopians that complement the need for protein sources.

Research and development

Conventional breeding has been practiced in Ethiopia since four decades. Full-fledged research undertakings started in the 1970s using local diversity collection, characterization and evaluation. The germplasm pool in the early breeding program was desi type. Hence old varieties have been developed as desi types, until recently getting overridden by the kabulis which have increasing demand and preference. Variety development is a well established scheme in research, where on average it has taken 6 to 8 years for development of each variety (Table 1).

Table 1. Characteristic features of chickpea varieties released in Ethiopia.

Variety[1]	Year of release	Pedigree	Area of potential coverage (ha)	Area of actual adoption estimate (ha)	Average yield potential on-farm (kg ha^{-1})	Selected varietal traits
Minjar	2010	ICCV 03107			1700	
Acos Dubie (K)	2009	Acos Dubie	10000	10	1800	Extra large seed size, best niche market
Natoli (D)	2007	ICCX 910112-6	25000	50	3000	Good yield and seed quality, root rot tolerance
Mastewal (D)[2]	2006	ICCV 92006	5000	100	2000	Good yield and seed quality
Yelibe (K)[2]	2006	ICCV 14808	3000	50	1750	Good yield and seed quality
Ejere (K)	2005	FLIP-97-263c	3000	1000	2250	Good yield, aschochyta blight tolerance, earliness
Habru (K)	2004	FLIP-88-42c	50000	15425	2700	Earliness, good yield, aschochyta blight and root rot tolerance
Chefe (K)	2004	ICCV 92318	7000	964	2450	Root rot and aschochyta blight tolerance, good yield and adaptation
Shasho K)	1999	ICCV 93512	50000	19536	2300	Root rot tolerance, good yield and adaptation
Arerti (K)	1999	FLIP-89-84c	100000	41436	3350	Aschochyta blight resistance, good yield and adaptation
FLIP (K)	2005		1500	420	1850	Good adaptation, not registered, introduced by MoA
Akaki (D)		ICCL-820016	10000	5000	2000	Good yield and seed size, fusarium wilt and root rot tolerance
Worku (D)		ICCL-820104	10000	6000	2000	Good yield and seed size, fusarium wilt and root rot tolerance
Marye (D)	1985	K-850-3/27 × F378	12000	10000	1850	Good yield and seed size, fusarium wilt and root rot tolerance
Dubie (D)	1978		2000	1000	1500	Good yield, seed size and adaptation

1. D = Desi; K = Kabuli.
2. Released by Amhara regional research system.

The major constraints to chickpea production are:

- Pests and diseases and their dynamism (bruchids, pod borers, aschochyta blight, fusarium wilt, stunt virus)
- Waterlogging, drought, heat, cold/frost
- Seed supply inadequacy, green-pea picking, poor cultural practices
- Lack of harvester, thresher, grading and planting machines at affordable level

Agroecologies for chickpea cultivation

Chickpea is a cool season crop and fits well in the central highlands of Ethiopia. It is commonly produced on black vertisols where both waterlogging and soil cracking due to moisture stress are significantly recognized. Hence its production has to be cautiously undertaken through optimization of the two extremes. Recently we have developed district-based agroecological discrimination of chickpea in Ethiopia (Fig. 2). These maps can be used with the zonal distribution map developed earlier by Shiferaw

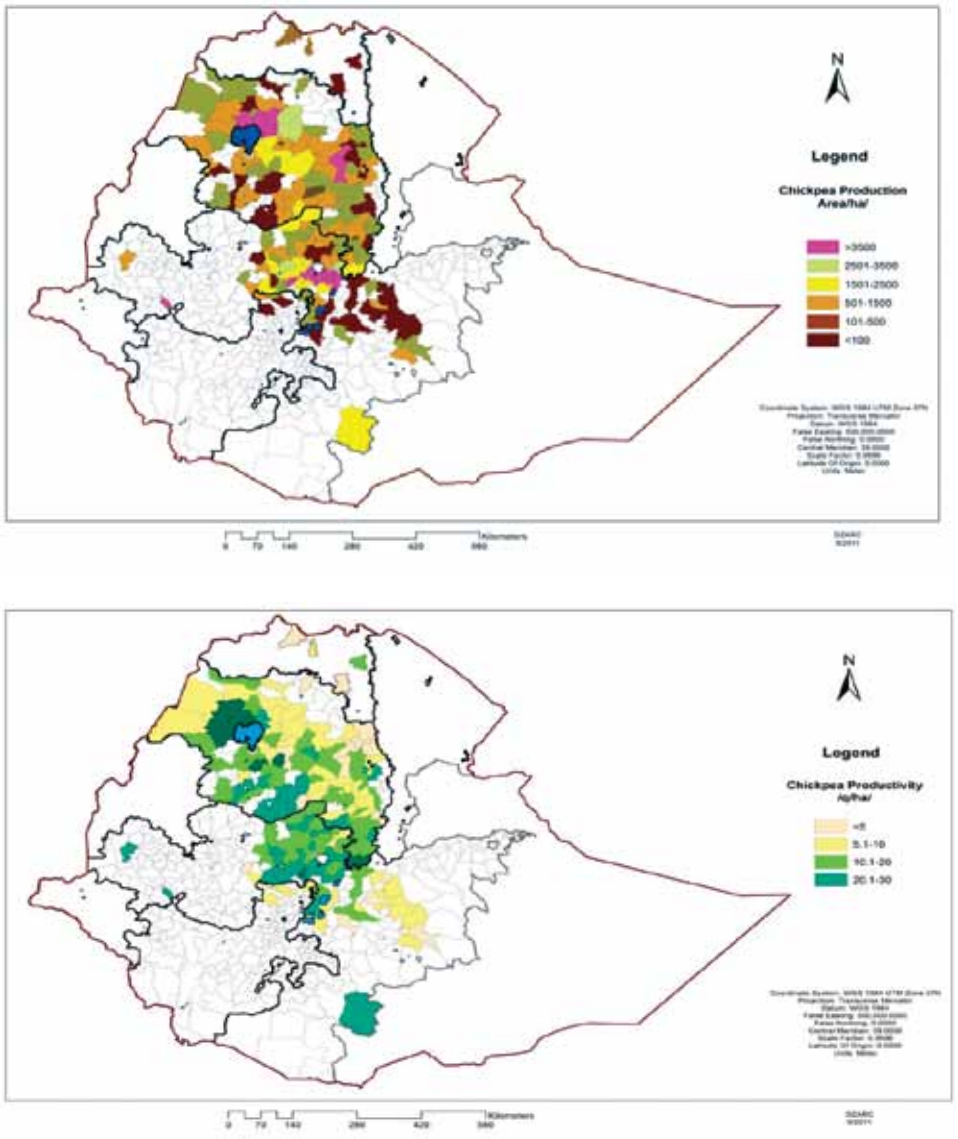

Figure 1. Area and productivity of chickpea in Ethiopia.

et al. (2007) for better decision-making on interventions and research priorities. The maps include the area and potential (productivity) of chickpea in the districts based on existing level from 2009 and 2010 data average. Accordingly there are districts with more than 3500 ha under chickpea and there are districts with average productivity level up to 3 t ha^{-1}. Therefore appropriate technologies can be followed according to the potential of the agroecology in question.

Seed systems

Seed system is a well established entity in Ethiopia since the last three decades. Ethiopian Seed Enterprise is the foremost institute serving the seed production in the cereal-based cropping system. As a business institution the enterprise works in more than 90% of the cases with cereals (hybrid maize, wheat, sorghum). Hence legumes in general and chickpea in particular are served in less than 7% of its seed demand. Therefore the major actor in the seed system of chickpea is the informal seed sector (seed grower associations, unions, individual farmers, etc).

The private sector, as is common with self-pollinated crops, is poorly involved in chickpea seed production. Hence the alternative chickpea seed system pathway appears to be the informal seed system.

Seed systems strategy (2012–14)

With all functional key stakeholders in place, the seed production (informal seed system dominated) strategy of Ethiopian chickpea is given below:

Total area: 220,000 ha

Mean seed rate: 120–140 kg ha^{-1} based on seed size

National seed demand: 30,800 t (2012–14) to cover 220,000 ha

Capacity to deliver 35% total area: 77,000 ha

Total seed required to cover targeted area of 77,000 ha $\simeq$ 9293 t

Target of productivity enhancement: 3 t ha^{-1} at intervention sites and 1.8 t ha^{-1} at the national level

Total production target: >400,000 t

Opportunities, constraints, partnerships and seed strategy

The target is to cover 35% area in each agroecology.

Opportunities

- Well developed informal seed system experience and existence of certified associations
- Good market setup for chickpea in general and chickpea seed in particular
- Policy environment that enhances innovative seed system
- Availability of suitable varieties at federal and regional levels (>20)
- Sufficient land mass suitable for chickpea (millions of ha)
- High consumption level/culture in the country

Constraints

- Dominated by informal system that has technical and infrastructural gaps
- Certification process is not clear for informal seed system
- Total non-existence of mechanization at all steps
- Unpredictability of market price
- Lack of adequate quality seed of any variety on demand

Partners and seed production plans

The key partners are listed in Table 2. Seed production plans are given in Tables 3 and 4. Seed delivery will be handled mainly in a seed revolving or seed loan approach until the bigger impact and demand is established. The higher demand will then be satisfied by seed growers that eventually grow along with the technology promotion. By 2014 at least 50% of chickpea farmers at national level will get seed access through the informal seed system arranged already at accessible point in a decentralized way. Effective monitoring and support to validate seed quality in a decentralized manner will be served by the seed department of the Bureau of Agriculture, mandated research centers and the seed enterprises affiliated to that seed scheme in a contractual agreement.

Table 2. Key partners and their roles in the chickpea seed roadmap implementation.

Partner	Role
Research institutions – Debre Zeit ARC, Gondar ARC, Debre Birhan ARC, Sirinka ARC, Axum, Mechara, Areka	Germplasm development, variety release, production of nucleus, breeder and pre-basic seeds, dissemination
Agricultural universities – Haramaya, Hawassa, Bahir Dar, Gonder, Ambo	Training agriculturists
Seed enterprises – ESE, OSE, SSE, ASE	Certified seed production, marketing
Agricultural Transformation Agency	Facilitation of research and extension
ICRISAT-TL-II	Funding, provide improved germplasm, capacity building, facilitate seed production and distribution, up-scaling
MoA and regional BoA extension services	Inputs, seed departments for supporting seed producers, farmers' mobilization and dissemination
Local government authorities or policy makers	Farmers' mobilization, supportive policy, funding, dissemination/up-scaling
NGOs, CBOs, farmers' associations	Mobilization of farmers, group formation, facilitate access to loans, inputs and markets, advisory services, facilitate seed production
Agro-dealers	Advisory services, inputs/seed availability, loans to farmers
Seed companies – ACOS, Gadisa Plc, Buta Plc, etc	Certified seed production, marketing and distribution
Agro-processing – Hilina Plc	Value addition or agro-processing
Contract farmers	Produce quality seed
Individual farmers	Seed buyers and users, grain producers and buyers, dissemination/up-scaling

Table 3. Chickpea seed roadmap for Ethiopia.

Ecology (Zone)	Demand (ha)	Promising varieties	Yield potential on-farm (t ha^{-1})	Seed rate (kg ha^{-1})	Total area to be covered (ha)		Seed production						Total seed required to reach 35% adoption (t)
							Breeder seed in 2012		Foundation seed in 2013		Certified seed in 2014		
					Zone wise	Variety wise	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)	
Potential	150,000	4			52,500		16.2	25.63	205	378	3088	6354	6354
	90,000	Arerti	2.5	120		31,500	3.48	8.7	72.6	181.5	1512	3780	3780
	37,500	Shasho	2.0	120		13,125	2.84	5.68	47.3	94.6	788	1576	1576
	7,500	Acos Dubie	1.0	140		2,625	7.21	7.21	51.5	51.5	368	368	368
	15,000	Ejere	1.5	120		5,250	2.69	4.04	33.6	50.4	420	630	630
Moisture	70,000	3			24,500		8.31	14.21	118.5	203.9	1699	2940.6	2940.6
deficient	56,000	Habru	1.8	120		19,600	5.81	10.46	87.1	156.8	1307	2352.6	2352.6
	7,000	Minjar	1.5	120		2,450	1.25	1.88	15.7	23.5	196	294	294
	7,000	Yelibe	1.5	120		2,450	1.25	1.88	15.7	23.5	196	294	294
Total	220,000				77,000		24.51	39.84	323.5	581.9	4787	9294.6	9294.6

Table 4. Certified chickpea seed production (t) plan for three years.

Variety	2012	2013	2014
Arerti	567	945	2268
Shasho	236	394	945
Acos Dubie	55	92	221
Ejere	95	158	378
Habru	353	588	1411
Minjar	44	74	176
Yelibe	44	74	176
Total	1394	2323	5576

Vision of success

The vision of chickpea in Ethiopia is to attain highest productivity (≥3 t ha^{-1}) at national and global levels thus contributing to the wealth of producer farmers with significant contribution to domestic food consumption. The overall production will satisfy the national demand and significantly contribute to the gross domestic product (GDP) with significant amount of exports and/or agro-processing.

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Kenya

Common bean

Davis Karanja, Robin Buruchara, Jean-Claude Rubyogo and Steve Beebe

Introduction

Kenya is the seventh highest producer of dry beans (Fig. 1). Dry beans contribute KES. 13.18 billion annually to the national economy and are a source of dietary protein, especially for the rural and urban poor. Common bean is the basic food of daily diet for many Kenyans. Nutritionists characterize the common bean as a nearly perfect food because of its high protein content and generous amounts of fiber, complex carbohydrates and other dietary constituents. They serve as a cheap source of cholesterol-free proteins. On average 401,880 tons of beans are consumed annually (MoA 2010).

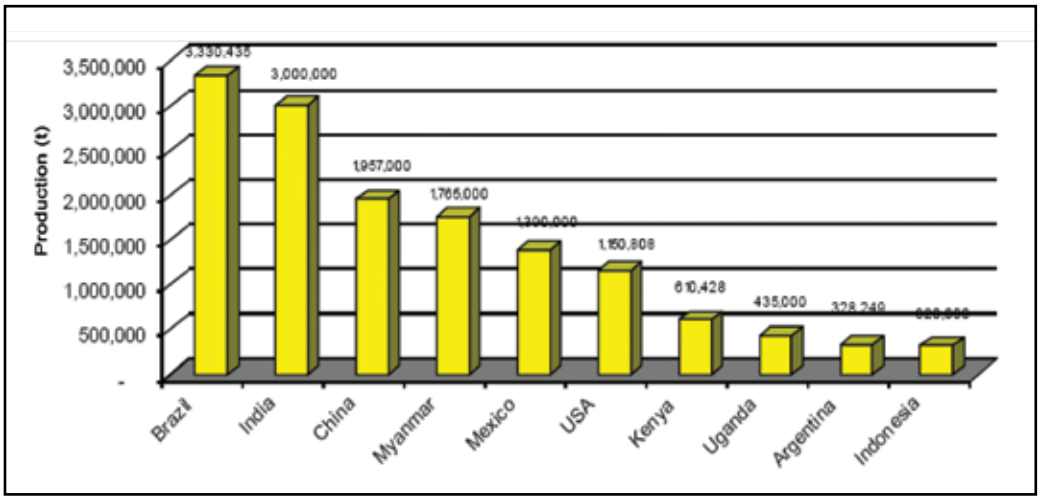

Figure 1. Dry bean production in the world (Source: USAID COMPETE 2010).

In Kenya beans are widely grown and consumed particularly by medium and low income households which are the majority in the region. Beans have high potential for export and ready open-air market but there is no organization to plan for contract production for marketing. Dry beans have consistently good prices. The average monthly prices are Ksh. 3,291 per bag of Canadian Wonder, Ksh. 3,307 per bag of Rosecoco and Ksh. 3,180 per bag of Mwitemania (Source: KIPPRA-MoA Report 200**7**).

Trends in production

The area under bean production in Kenya has been variable over the years with the highest being in 2005 and lowest in 2008 (Fig. 2). The area was 610,428 ha in 2008 representing 28% decrease compared to 2007 (Table 1). Consequently, production also declined by about 20% to register 2.9 million bags compared to 3.5 million bags produced in 2007. This decline can be attributed to unfavorable weather conditions in the producing areas which resulted in yield decline from 6 bags per ha in 2007 to 2 bags per ha in 2008. In 2008 production was also probably limited by post-election violence; peace in rural areas is crucial for agricultural development.

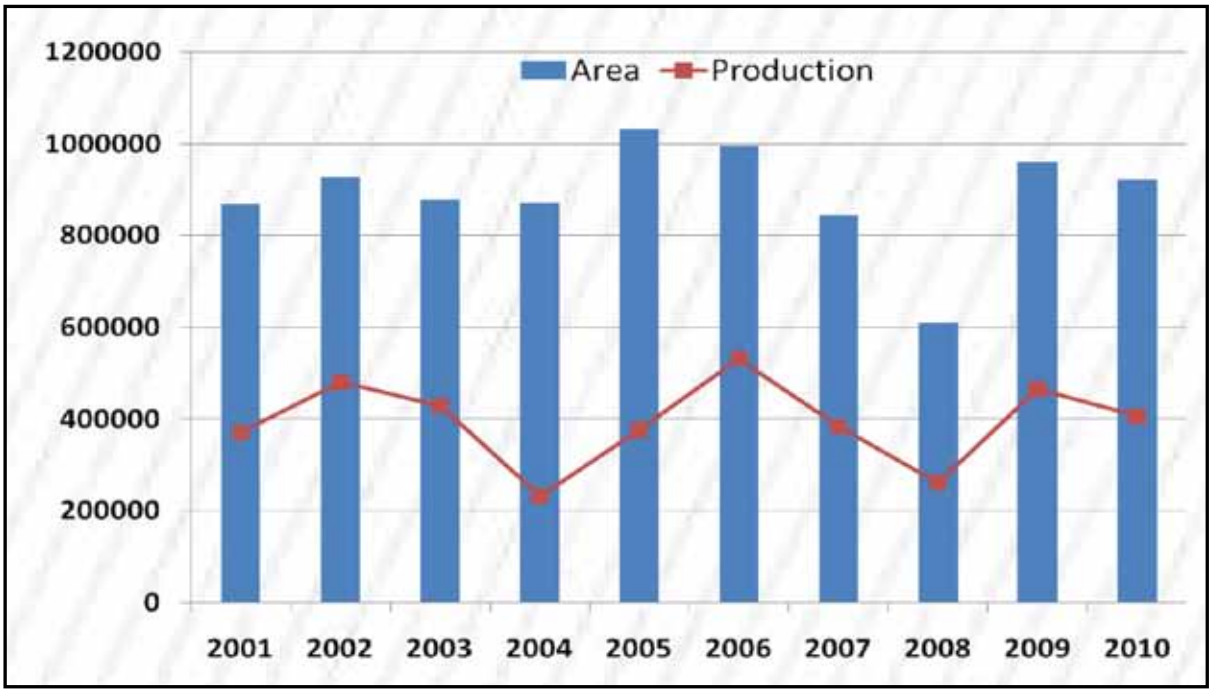

Figure 2. Trends in area (ha) and production (t) of dry beans in Kenya (Source: MoA, Kenya).

Table 1. Economics of bean production in Kenya during 2005 to 2009.

Particulars	2005	2006	2007	2008	2009
Area (ha)	1,034,477	995,391	846,327	610,428	960,705
Production (90 kg bags)	4,175,772	5,908,887	3,455,512	2,901,237	5,170,696
Production (t)	375,820	531,800	383,900	261,137	465,363
Unit price per bag (Ksh)	2,500	2,540	4,400	4,500	5,134
Average yield (bags per ha)	4	6	4.8	2	5.4
Consumption (t)	400,450	460,000	524,400	260,000	390,000
Total value (billion Ksh)	10.44	18.02	16.29	13.10	26.54

In general bean yield was low during 2005 to 2009 with an average of <1 t ha^{-1}. The production of beans is projected to grow at 3%, 6% and 7% in 2013, 2014 and 2015 respectively. This will be subject to availability of seed of new varieties and favorable climate. The consumption is also expected to increase by 7% per year subject to bean prices remaining constant or low.

Research and development

Varieties available and under production

Recommended varieties of bush habit are presented in Table 2 and climbing beans in Table 3. The older varieties have a seed system in that they are still under production by Kenya Seed Company and East African Seed Company. The drought tolerant KAT beans have been promoted by Kenya Agricultural Research Institute (KARI) and the Ministry of Agriculture. Three seed merchants have undertaken commercial production of these varieties. Some of the new varieties released by Kenya Plant Health and Inspectorate Services (KEPHIS) are slowly finding their way into the local market.

The old bean varieties (sometimes called ruling varieties) are Mwitemania, Rosecoco, Mwezi Moja, Canandian Wonder and Red Haricot, which have good seed systems from the formal seed sector that fits well with the informal seed sector. Other varieties are for Western Kenya mainly for root rot prone areas. These are KK 22, KK 8 and KK 15.

The drought tolerant beans KAT B1, KAT B9, KATX56 and KATX69 have been promoted widely in Kenya especially after the TL-II project was started. They are being produced by three seed merchants and the Ministry of Agriculture and NGOs have strong programs promoting these beans. KATX56 is becoming widely adapted while KAT B1 is the most marketed and consumed variety of the drought tolerant beans.

The other varieties in the National Variety Lists have been released in the last few years and some of them are in the stage of breeder seed production while some have no seed system yet. Some have been taken up by seed companies for production. More promotion is required to interest the seed companies.

Constraints: pair-wise ranking

Major constraints in Kenya can be summarized as low contribution of dry beans to food security and income generation. Table 4 shows eight major groups of constraints and their causes. From the analysis, one major constraint was identified from each value chain segment and subjected to pair-wise ranking to obtain the core problem. The pair-wise ranking was done by the stakeholders to rank the problems. The stakeholders ranked low adoption of improved technologies as the core problem, followed by disease/pest susceptibility and low-yielding varieties (Karanja et al. 2012).

Table 2. KEPHIS national common bean bush variety list[1].

Variety name/code	Year of release	Owner(s)	Maintainer and seed source	Optimal production altitude range (m amsl)	Time to maturity (months)	Grain yield (t ha^{-1})	Special attributes
Mwitemania – Pinto (GLP 92)	1982	KARI/KSC	KARI/KSC	900–1600	2–3	1.2–1.5	Drought tolerant
Rosecoco (GLP 2)	1982	KARI/KSC	KARI/KSC	1500–2000	2–3	1.8–2	High yield, wide adaptation, attractive seed color, good taste
Mwezi Moja (GLP 1004)	1982	KARI/KSC	KARI/KSC	1200–1600	2–3	1.2–1.5	Good performance in dry areas, early maturity, tolerant to drought and bean fly
Canadian Wonder (GLP 24)	1982	KARI/KSC	KARI/KSC	1200–1800	3–3.5	1.3–1.8	Moderately resistant to angular leaf spot
Red Haricot (GLP 585)	1982	KARI	KARI	1500–2000	2.5–3	1–1.5	Suitable for high rainfall areas, resistant to bean common mosaic virus
GLP-X 1127 (New Mwezi Moja)	1982	KARI/KSC	KARI/KSC	1000–1500	2.5 –3	1–1.5	Wide adaptation, resistant to bean common mosaic virus, tolerant to rust
Kat/Bean 2	1987	KARI	KARI-Katumani	1200–1800	2–3	1–1.2	Tolerant to shade
KATX 16	1994	KARI	KARI-Katumani	900–1600	2–3	1.5–1.8	High yielding
KATX56	1995	KARI	KARI-Katumani	900–1800	2.5–3	1.5–1.8	High yielding, drought tolerant, early maturing, cooks fast
KATX69	1995	KARI	KARI-Katumani	1200–1800	2–3	1.5–1.8	High yielding, drought tolerant, early maturing, cooks fast
KK 22 (RWR 719)	1996	KARI	KARI-Kakamega	1500–1800	2.5–3	1.8–2	Tolerant to root rot
KAT B1 (Katheka)	1987	KARI	KARI-Katumani	1000–1800	2.5	1.2–1.5	Early maturity, heat and drought tolerant, no flatulence, cooks fast and is sweet
KK 8 (SCAM-80/15)	1997	KARI	KARI-Kakamega	1500–1800	2.5–3	1.8–2	Tolerant to root rot
KK 15 (MLB 89-49A)	1997	KARI	KARI-Kakamega	1500–1800	2.5–3	1.8–2	Tolerant to root rot
KAT B9	1998	KARI	KARI-Katumani	900–1600	2.5–3	1–1.8	Tolerant to heat, high yielding, drought tolerant, early maturing, cooks fast
Wairimu Dwarf	2008	Kenya Seed Co	Simlaw Seeds	500–1700	2.5–2.8	1.5–1.75	Early, heat tolerant, good for maize intercropping, excellent cooking qualities

Continued

Table 2. *Continued.*

Variety name/code	Year of release	Owner(s)	Maintainer and seed source	Optimal production altitude range (m amsl)	Time to maturity (months)	Grain yield (t ha^{-1})	Special attributes
New Rose Coco	2008	University of Nairobi	University of Nairobi	1100–2000	2.5–3	1.3–2.3	Upright growth habit, early, moderate resistance to rust, common bacterial blight, angular leaf spot, anthracnose, bean common mosaic virus and necrotic virus, large grains
Miezi Mbili	2008	University of Nairobi	University of Nairobi	1000–2000	2.5–3	1.2–2.26	Large grains, early, resistant to floury leaf spot, halo blight, angular leaf spot, anthracnose, bean common mosaic virus and common bacterial blight
Kenya Early	2008	University of Nairobi	University of Nairobi	1100–1900	2.5–3	1.07–2.15	Large grains, early, moderately resistant to halo blight, angular leaf spot, anthracnose, bean common mosaic virus and common bacterial blight
Kenya Red Kidney	2008	University of Nairobi	University of Nairobi	1000–2100	2.5–3	1.09–2.8	Large grains, moderately resistant to halo blight, angular leaf spot, anthracnose, bean common mosaic virus and common bacterial blight
Super Rose Coco	2008	University of Nairobi	University of Nairobi	1000–2100	2.5–3	1.14–2.8	Medium maturity, moderately resistant to halo blight, angular leaf spot, anthracnose, bean common mosaic virus and common bacterial blight
Kenya Wonder	2008	University of Nairobi	University of Nairobi	1030–2000	3–3.5	1.13–2.09	Large grains, moderately resistant to halo blight, angular leaf spot, anthracnose, bean common mosaic virus and common bacterial blight
Kenya Sugar Bean	2008	University of Nairobi	University of Nairobi	1000–1900	2.5–3	1.08–1.81	Early, large grains, moderately resistant to halo blight, bean common mosaic virus and common bacterial blight
Kabete Super	2008	University of Nairobi	University of Nairobi	1300–2000	3–3.5	1.05–2.47	Large grains, resistant to floury leaf spot, halo blight, angular leaf spot, anthracnose, bean common mosaic virus and common bacterial blight
Chelalang (AFR 708)	2008	Egerton University	Egerton University	1800–2200	2–3.5	1.2–2.2	
Tasha (Lyamungu 85)	2008	Egerton University	Egerton University	1500–2000	2.5–3.5	1.1–2.1	Resistant to leaf spots, anthracnose and root rot
Cianku (ECAB 0081)	2008	Egerton University	Egerton University	1500–2150	2.5–3.5	1.0–1.9	Resistant to leaf spots, anthracnose and root rot

1. Source: KEPHIS National Variety List updated 2012.

Table 3. National climbing bean variety list[1].

Variety name/code	Official variety release name	Year of release	Owner(s)/ Licensee	Maintainer and seed source	Optimal production altitude range (m asl)	Time to maturity (months)	Grain yield (t ha^{-1})	Special attributes
Flora		1996	KARI	KARI-Kakamega	1500–2200	4–5	2–2.5	Light pink pods
Vunikingi		1996	KARI	KARI-Kakamega	1500–2200	4–5	2–2.5	Red pods
Umubano		1996	KARI	KARI-Kakamega	1500–2200	4– 5	2–2.5	Dark red pods
MAC 13	MAC 13 (Kenya Safi)	2012	KARI and University of Nairobi	KARI and University of Nairobi	1400–2000	3–4	1.2–1.5	Sugar grain type (cream white background with red flecks), large seeds, resistant to anthracnose
MAC 34	MAC 34 (Kenya Tamu)	2012	KARI and University of Nairobi	KARI and University of Nairobi	1400–2000	3–4.5	2–2.5	Red mottled, large wedge-shaped seeds, resistant to angular leaf spot and common bacterial blight
MAC 64	MAC 64 (Kenya Mavuno)	2012	KARI and University of Nairobi	KARI and University of Nairobi	1400–2000	3–5	2–3	Dark red mottled, medium seeds, resistant to anthracnose and common bacterial blight
MN 14	Kenya Madini	2010	University of Nairobi	University of Nairobi	1500–1900	3–4	2.15–2.5	High grain iron and zinc concentration, medium sized, yellow grain
MN 17	Kenya Majano	2010	University of Nairobi	University of Nairobi	1500–1900	3–4	2.2–3	High grain iron and zinc concentration, medium and yellow seeds
MN 19	Kenya Afya	2010	University of Nairobi	University of Nairobi	1500–1900	3–4	2.23–3.2	High grain iron and zinc concentration, medium and brownish yellow seeds

1. Source: KEPHIS National Variety List updated 2012.

Planned Phase 2 activities

The activities planned for TL-II Phase 2 will focus on breeding, screening and selecting for high-yielding and drought tolerant bean varieties. This will be combined with developing a sustainable seed production and delivery system for smallholder farmers in Kenya. This will involve the drought tolerant bean varieties that are being marketed by seed companies and KSU. There is a need to improve their access to a wider range of farmers through the formal seed marketing. The new bean varieties developed by the breeding programs will also need to be given attention. The promotion of these drought tolerant bean varieties will be essential in addressing nutritional, food security and income problems of small-scale farmers thereby contributing to the gross domestic product (GDP) of the country.

Objective 4. Breeding for drought tolerance

One red mottled variety passed in the National Performance Trial (NPT) and DUS testing and was released in early 2013. Breeder seed production commenced in March 2013. Drought screening of at least 20 lines (black, small red, red mottled) has been done. The lines have resistance to several bean diseases. Participatory multilocational evaluation will be done to generate about six lines that will be put in advanced yield trials and national variety trials later in 2013 or in 2014. Populations to enhance drought tolerance will be done with acutifoliars.

Objective 8.3.1. Improving the availability of foundation (base) seed for further multiplication through diversification of production sources in each country

1. NARS produce 10 tons per year foundation (base) seed per country (total >80 tons). The Seed Unit and seed companies will be encouraged to produce drought tolerant varieties (no financial support required from TL-II).

   Milestone: 3 tons of drought tolerant bean seed.

2. Diversified partners produce 10 tons per year foundation (base) seed per country (total >80 tons).

   a. Partners produce foundation and certified seed and will be assisted in promotion (KSU and seed companies, eg, Dryland Seed Company, Kenya Seed Company, Frescho Seed Unit).

   Milestone: The companies will produce about 300 tons of bean seed.

   b. NGOs (CARD, Catholic Diocese of Homabay) assisted to produce and market farmers' seed.

   Milestone: 10 tons of drought tolerant bean seed.
   Milestone: Four promotion activities held.

3. Seed production in particular of the new line selected from the TL-II Fast Track nursery, and also two bush beans from the Embu station. Produce breeder seed and promotion materials for the new varieties.

   Milestone: Breeder seed KAT RM-1 100 kg.
   Milestone: Embu varieties – each variety 100 kg.

4. Training and promotion of the new line from TL-II and the bush beans from Embu station.
   Milestone: 500 pamphlets developed and printed.

Table 4. Pair-wise ranking of constraints to production of dry beans in Kenya[1].

Constraints	1 Low-yielding varieties	2 Disease/pest susceptibility stresses	3 Unavailability of certified seeds	4 High input costs	5 Low adoption of improved technologies	6 Poor market linkages	7 Lack of appropriate postharvest technologies	8 Unfavorable policy environment	9 Limited diversity of bean products	10 Poor product packaging	Total	Rank
1 Low-yielding varieties											7	2 (3)
2 Disease/pest susceptibility stresses	1										7	2 (2)
3 Unavailability of certified seeds	1	2									4	5 (6)
4 High input costs	4	2	4								6	3 (4)
5 Low adoption of improved technologies	5	5	5	5							9	1 (1)
6 Poor market linkages	1	2	3	4	5						3	6 (7)
7 Lack of appropriate postharvest and utilization technologies	1	2	7	4	5	7					5	4 (5)
8 Unfavorable policy environment	1	2	3	4	5	6	7				1	8 (9)
9 Limited diversity of bean products	1	2	3	4	5	6	7	9			2	7 (8)
10 Poor product packaging	1	2	3	4	5	6	7	8	9		0	9 (10)

1. Source: Karanja et al. (2012).

Objective 8.3.2. Design and testing of alternative certified and high quality seed production models

1. Two entrepreneurs per country legally produce and sell commercial seed.
2. Two NGOs/farmer groups/farmer unions in each country facilitate the scaling-up of seed production (with at least 20 decentralized seed producers).

Objective 8.3.3. Designing and testing diffusion and marketing models

1. Action research determines strengths and weaknesses of different outlets for selling seed (open markets, country stores, agro-dealers, field days).
   Milestone: Three marketing pathways evaluated.
2. 20,000 small packets sold per country per season (160,000 per season, across countries).
3. Agro-dealers networks and 2–3 local seed traders in each country engaged in small pack selling.
   Milestone: 10 tons seed marketed.
4. Impact studies in selected sites: Nyanza (CARD) for seed fairs, small packets and seed loans while in Central Kenya, Eastern province and Central Rift Valley, small packets, seed loans and stockists sales.
   Milestone: One study conducted.

Objective 8.3.4. Enhancing local capacity to produce, deliver, store and market seed

1. Agro-dealers networks in each country exposed to specific demands of small pack trade.
2. Two 'bigger' seed/grain traders in each country exposed to specific demands of small pack trade.
   Milestone: SMART Logistics, Leslio Grain Handlers and East African Grain Council exposed seed marketing while Kenya Seed Company and Dryland Seed Company pack bean seed in smaller packs.
3. National workshop with partners on beans.
   Milestone: One workshop held with partners, NGOs, researchers, extension, seed companies, agro-dealers, banks and grain traders.

Objective 8.3.5. Creating demand and awareness through smart use of mass media

1. Radio programs appear in each country related to variety quality and seed availability.
2. Policy briefs development on small packs and seed quality.
3. Developing SMS based platform for bean seed dissemination.
4. Mapping of partners and gender issues.

Expected outcomes

The expected outcomes of TL-II Phase 2 are:

- Increased access to high-yielding and better adapted bean varieties, information and crop management practices by diverse farmers (women and men, rich and poor) in the various agroecologies
- Increased utilization of high-yielding bean varieties and information
- Improved food and nutrition security and increased income for farmers
- Increased quantity of beans consumed and traded thereby improving the GDP of the country

Agroecology

In Kenya, beans are grown in a wide range of agroecological zones ranging from medium (800 m) to high altitude areas (2000 m) of central, rift valley, coast, western, Nyanza and eastern provinces (Wortmann and Allen 1994) (Fig. 3). They are mainly grown by smallholder farmers in the high and medium rainfall areas. However, in semi-arid areas it is grown with additional rainwater harvesting. Beans are marginally grown in agroecological Zone 5 due to prevailing high temperatures.

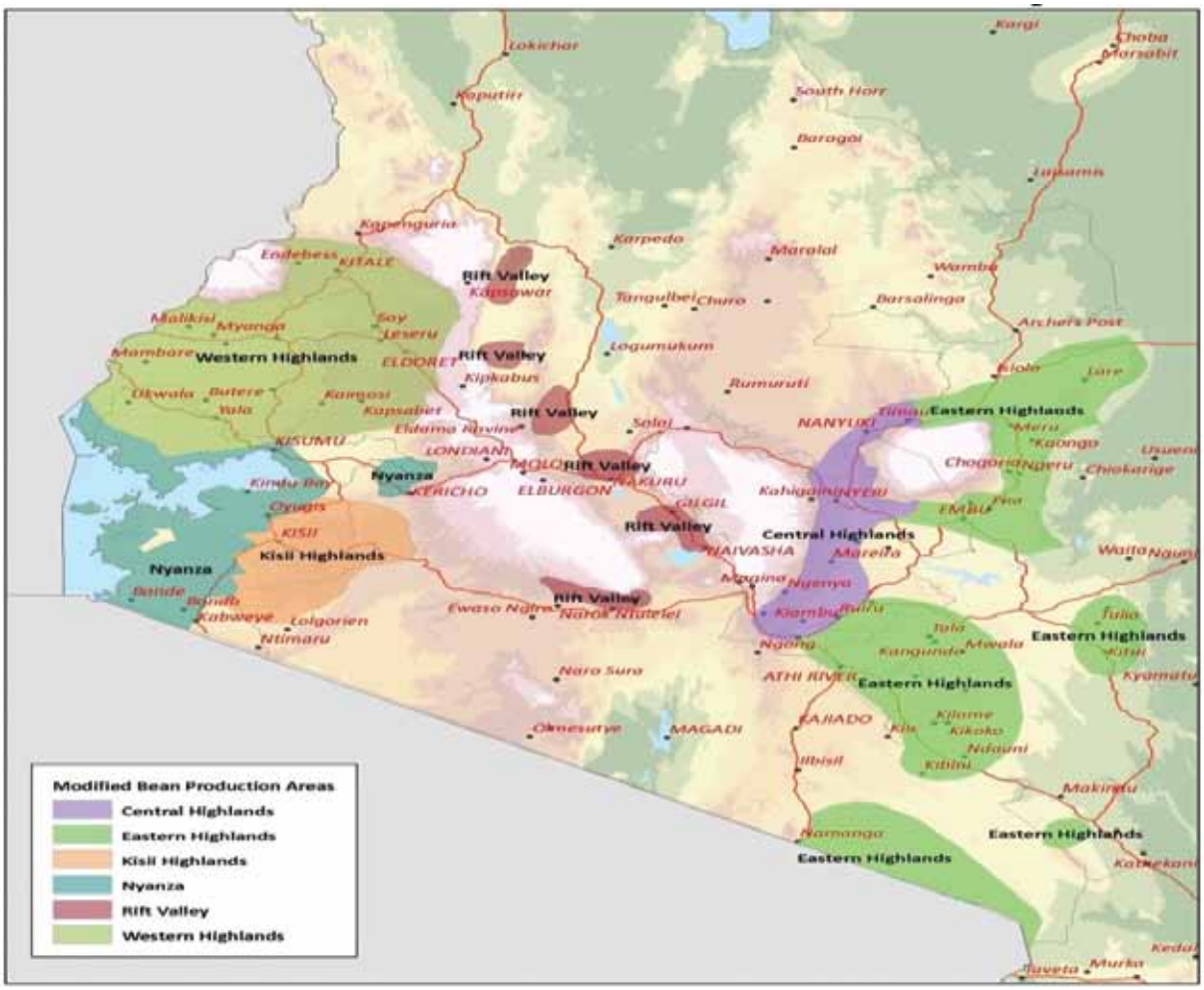

Figure 3. Bean production areas in Kenya (Source: Wortmann 1998).

Seed systems

Opportunities

1. There is a good pool of new improved market preferred bean varieties.
2. There are improved technologies for bean production.
3. Farmers in some areas have support of several agencies for dissemination of new bean technologies and marketing.
4. Some seed companies are willing to produce and market new improved bean varieties once they are assured of increased seed demand for these varieties.
5. There are structures for formal and informal seed production.
6. Systems are in place for certified seed marketing.
7. Bean is preferred and consumed in large quantities in Kenya.
8. Opportunities for improving on existing policy issues.
9. Potential of increasing bean production by paying attention to zones with larger land sizes for crop production.
10. Interest from marketers and processors for bean seed which indirectly leads to increased seed demand.

Constraints

1. In the dry lowlands there are frequent changes in weather patterns with frequent drought thus reducing bean production.
2. Changing rainfall patterns affect bean harvesting and reduce grain quality due to rain during crop harvesting period.
3. Pest and disease issues that lower production.
4. Inadequate use of improved technologies by farmers.
5. Inadequate access to improved market preferred varieties due to inadequate seed production and marketing.
6. Lack of adequate information by farmers and stockists limiting access to improved bean varieties and technologies.
7. Lack of effective use of dissemination pathways by partners to promote bean technologies.
8. Lack of structured marketing systems for bean seed.
9. Lack of effective farmer production and marketing groups/associations.
10. Increase in population leading to land subdivision and reduced land for bean production.

Key partners

Seed production: EU, KARI, Universities (University of Nairobi and Egerton), Kenya Seed Company, Dryland Seed Company, Frescho Seed Co, Leldet, East African Seed Company, NGOs, CBOs

Distribution: Seed companies, distributors and stockists, research, extension, CBOs, NGOs

Markets: Farmer groups, farmers, seed companies, exporters, financial institutions

Table 5. Dry bean seed production plan for Kenya.

Ecology	Demand (ha)	Productivity (t ha^{-1})	Variety (Area)	Area to be covered (ha)	Certified seed (t)	Breeder seed in 2013		Foundation seed in 2014		Certified seed for use in 2015 – Area (ha)	Seed to reach 35% adoption (t)
						Area (ha)	Production (t)	Area (ha)	Production (t)		
Drought-prone regions	210,000	1	KAT B1 (20%)	42,000	2,100	5.25	5.25	105	105	2,100	2,100
		1	KAT B9 (5%)	10,500	525	1.31	1.31	26.25	26.25	525	525
		1.5	KAT × 56 (65%)	136,500	6,825	17.06	17.06	341.25	341.25	6,825	6,825
		1.5	KAT × 69 (2%)	4,200	210	0.53	0.53	10.5	10.5	210	210
		1.3–1.8	KAT RM-1 (3%)	6,300	315	0.79	0.79	15.75	15.75	315	315
Mid altitude regions		2.5	Embean 14 (3%)	6,300	315	0.79	0.79	15.75	15.75	315	315
		2–2.3	Embean 118 (2%)	4,200	210	0.53	0.53	10.5	10.5	210	210
Total				210,000	10,500	26	26	525	525	10,500	10,500

Table 6. Potential quantities of bean seed produced by stakeholders in Kenya.

Stakeholder	Breeder seed (kg)	Foundation seed (kg)	Certified seed (t)	Farmers' seed (t)
Kenya Seed Company	1,000	5,000	10,000	
Dryland Seed Company	200	2,000	300	
Frescho Seed Company	50	500	100	
KARI Seed Unit	200	5,000	300	
NGOs/CBOs				25,000
Total	1,450	12,500	10,700	25,000

Seed production plans

Seed production plans are presented in Tables 5 and 6. The farmers' seed is not recognized by the seed laws of Kenya. It is also not easy to track the quantity of seed being used by farmers.

Integration of gender issues and strategies

The Government of Kenya developed a *National Gender and Development Policy* in 2000, which forms the framework for guiding different sectors and agencies. The policy guidelines address the following critical areas: (i) the economy; (ii) poverty and sustainable livelihoods; (iii) law; (iv) political participation and decision-making; (v) education and training; (vi) health and population; (vii) the media; and (viii) policy implementation and resource mobilization. This policy framework needs to be applied for dry bean production and marketing. Dry bean in Kenya is a woman's crop. It is grown and marketed by women in open-air markets and supermarkets. When the dry bean gets more commercialized, there is a tendency of it shifting from a woman's crop to a man's crop thereby affecting the social and economic status. There is promotion of bean technologies by a range of partners including research institutions (national and universities), Government extension service, NGOs and financial institutions and they need to integrate gender issues in their activities.

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Chickpea

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Introduction

Chickpea is a relatively new crop grown by smallholder farmers in dry areas of Eastern Kenya and dry highlands of Rift Valley provinces. Improved chickpea germplasm lines were introduced in Eastern and Rift Valley provinces in the late 1980s. However, a recent survey indicates that local accessions have been in existence under cultivation in coastal and eastern parts of Kenya for the last 40 years (Kaloki 2009). The crop has since spread in Kenya and is currently adapted to varied agroecological zones such as dry highlands, medium altitudes and also in dry lowlands with annual rainfall of 250–550 mm (Jaetzold and Schmidt 1983, Kibe and Onyari 2007, Onyari et al. 2010).

Currently Kenya produces approximately 40,000–55,000 tons of chickpea from an area of 18,000–20,000 ha (Kibe and Kamithi 2007, MoA 2010). The national average yield is estimated at 540–1200 kg ha^{-1}. Production and area of chickpea has been declining over the last 10 years, but recent efforts in districts where TL-I/II interventions occurred over the last four years (Njoro, Bomet and Koibatek, Naivasha in Rift valley) report average yields of about 1500–3000 kg ha^{-1} (Kimurto et al. 2009, ICRISAT 2010). Data on national demand are not available, but it is estimated that approximately 70,000–100,000 tons of chickpea is consumed in Kenya annually and unknown quantity exported.

The crop is currently gaining more popularity and importance as a cereal–legume relay crop in the dry highlands (Bomet Uasin Gishu, Nakuru and Timau) during the short rains after wheat, maize and finger millet harvest. Growing chickpea in relay with wheat has the potential to contain current threat of ug99 strain of wheat stem rust since it could break the lifecycle of the pathogen. It has the potential of improving soil health through nitrogen fixation and also contributes to food and nutritional security in dryland areas where food insecurity is >60%, occupying approximately 80% of total land area. Currently chickpea is imported from Tanzania and processed in Kenya for export to Asia or for local consumption due to large demand in big cities from Indian/Asian population consuming chickpeas locally. This indicates that Kenya has a great potential for chickpea production to meet local and export market demand in deficit countries in Southeast Asia.

During 2004 to 2010 area of chickpea increased by 11% while a mean of 10% increase in production and 41.8% increase in productivity were recorded. The increased productivity and production are expected to have resulted in increased nutritional food security and income for farmers in growing areas. Currently there are no data available on processing and chickpea export in Kenya, although there are several milling companies like Presco Millers Ltd who process and package chickpea for local consumption in major supermarkets and for export.

Due to current popularity and importance in relay cropping in dry highlands and its choice in dry lowlands as an alternative drought tolerant legume to dry beans, projections suggest that the rate of growth in area, production, demand and yield would be 38.7%, 22.9%, 7.7% and 6.5% respectively by 2017 as compared to 20%, 6.6%, 4.6% and 6.0% respectively by 2014. It is expected that the rate of growth in area and production will rise steadily due to promotion of chickpea in medium- and large-scale farms in Rift Valley. Demand will remain fairly constant through 2017 and beyond (Table 1). This would provide opportunities for further increase in chickpea export.

Research and development

During TL-II Phase 1, concerted research and development efforts through on-farm, farmer participatory varietal selection (FPVS) and demonstrations on varieties and utilization resulted in landmark fast track

release of first set of varieties (Table 2). In Kenya, four improved chickpea varieties namely ICCV 97105, ICCV 00108, ICCV 95423 and ICCV 00305 were released during 2009 to 2011. Three new varieties are under evaluation by KEPHIS (ICCV 92944, ICCV 97126 and ICCV 95011).

Table 1. Current and projected status of chickpea in Kenya.

Parameters[1]	2004–09	2010	2014	2017
Average area ('000 ha)	18	20	42	112
Average production ('000 t)	50	55	71	162.4
National demand ('000 t)	100	112	134.4	168
Yield (kg ha^{-1})	670	950	1200	1450
Proportion sold (%)	60	60	60	60
ROG for area (%)	11[2]	11	20	38.7
ROG for production (%)	9.6[2]	10	6.6	22.9
ROG for demand (%)	12[2]	12	4.6	7.7
ROG for yield (%)	3.42[2]	41.8	6	6.5

1. ROG = Rate of growth (annual).
2. Calculated for the period from 2001 to 2010.

Table 2. Characteristic features of varieties released in Kenya.

Variety	Year of release	Pedigree	Potential area (ha)	Average on-farm yield potential (kg ha^{-1})	Varietal traits
Chaina Desi 1	2012	ICCV 97105	26,325	1500	All these varieties have medium seed size, medium maturity (earliness), resistance to fusarium wilt, market opportunities
ICCV 00108 (Desi)	2011	ICCV 00108	7,300	1500	
Saina K 1	2012	ICCV 95423	17,665	1200	
ICCV 00305 (Kabuli)	2011	ICCV 00305	3,830	1200	
ICCV 92944 (Desi)	-	ICCV 92944	25,300	1500	
ICCV 97126 (Desi)	-	ICCV 97126	1200	1200	

Agroecology for chickpea cultivation

Chickpea is a new grain legume for Kenya that is targeted for source of protein and nutritional security. It is mainly grown by smallholder farmers with overall farm size of 1.5–2 ha per household. Large- and medium-scale cereal farmers may have >5 ha per household. The crop is mainly grown in Rift Valley and Eastern provinces. Since its introduction, the crop has spread in Kenya and is currently adapted to varied agroecological zones such as dry highlands of Rift Valley provinces (Nakuru, Koibatek and Uasin Gishu, Timau and Naivasha districts) (altitude range of 1600–2500 m amsl), with mean annual rainfall of 550–1800 mm medium altitudes (Bomet, Kabete, Mbeere) and also in dry lowlands (Baringo, Kerio valley, Machakos, Mwea) with mean annual rainfall of 250–550 mm (Jaetzold and Schmidt 1983, Kibe and Onyari 2007, Onyari et al. 2010).

Seed systems

Generally farmers in Kenya still use Ngara Local and very limited awareness exists on improved chickpea varieties, due to consistent failure of public sector to supply good quality source seed and the lack of interest by the private sector to engage in legume seed production. In addition, often seed is produced in high potential areas or areas with infrastructure for storage and processing far away from the area of utilization, leading to high transaction costs. Requirements for high seeding rates further limit the spread of new varieties.

Seed production target

Total area: 81,620 ha

Seed rate (mean): 90–105 kg ha^{-1} based on seed size

National seed demand: 7670 tons (2012–14) to cover 81,620 ha

Capacity to deliver 30% total area: 32,648 ha

Total seed required to cover targeted area of 24,486 ha ≃ 2300 tons

Opportunities, constraints and partnerships to cover 30% of area

Opportunities

- Farmers in the target areas have recognized that chickpea is a drought tolerant crop when compared to beans and hence can be used to mitigate the effects of climate change. Furthermore, most of the improved materials have tolerance to fusarium wilt coupled with early maturity to catch up with the huge Indian market. This creates a big demand for seed of the improved materials.
- There is available market and demand for the seed and grain within and outside the country.
- Leldet Seed Company has released two varieties and has taken up production of seed in small quantities.
- Four new varieties were released and their seed availability is planned through sustainable seed systems under TL-II; CRP grain legumes and national level support will contribute significantly to seed availability.

Major constraints

The major constraints to chickpea production are the foliar disease ascochyta blight, pod borer (*Helicoverpa armigera*), fusarium wilt and drought. Low utilization and socioeconomic and organizational constraints include limited coverage of current interventions and limited access of farmers to quality seed.

Partners

The key partners involved in chickpea production are listed in Table 3.

Table 3. Key partners and their roles in the chickpea seed roadmap implementation.

Partners	Role
Research institutions (Egerton University, KARI)	Germplasm development, variety release, breeder seed production, dissemination
KEPHIS – Kenya Plant Health Inspectorate Services	Seed certification and quality control
KARI-Seed Unit	Production of breeder, foundation and certified seeds, marketing
ICRISAT – TL-II	Funding, provide improved germplasm, capacity building, facilitate seed production and distribution, up-scaling
Extension services	Advisory services, farmers' mobilization and dissemination
Local government authorities/policy makers	Farmers' mobilization, supportive policy, funding, dissemination/up-scaling
NGOs (KENPAP), CBOs, farmers' associations	Mobilization of farmers, group formation, facilitate access to loans, inputs and markets, advisory services
Agro-dealers	Advisory services, inputs/seed availability, loans to farmers
Seed companies (Leldet, Faida seeds)	Seed production, marketing and distribution
Contract farmers	Quality seed production
Individual farmers	Seed buyers and users, grain producers and buyers, dissemination/ up-scaling

Vision of success

Seed production will be enhanced during 2012 to 2014 starting with production of breeder seed and foundation seed of six major varieties to meet 40% adoption of total area in key agroecozones (Tables 4 and 5). This will be achieved by involving seed companies, NGOs, CBOs and farmers.

Since gender equality is a key factor for achieving the objectives of improving food security and nutrition in this project, all activities will be implemented with gender considerations. All stakeholders (farmers, entrepreneurs, extension, NGOs, CBOs) including women farmers, women's groups and their cooperative societies will be involved in seed production.

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Table 4. Chickpea seed roadmap for Kenya.

Ecology (Zone)	Demand (ha)	Promising varieties	Yield potential on-farm (t ha^{-1})	Seed rate (kg ha^{-1})	Total area to be covered (ha)		Breeder seed in 2012		Foundation seed in 2013		Certified seed in 2014		Total seed required to reach 30% adoption (t)
					Zone wise	Variety wise	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)	
Rift Valley	80,250	6			24,075		8.15	10.91	113	154.5	1623	2161	2261
	25,300	ICCV 97105	1.5	90		7590	1.64	2.46	27.3	41	455	683	683
	25,300	ICCV 92944	1.5	90		7590	1.64	2.46	27.3	41	455	683	683
	17,665	ICCV 95423	1.2	105		5300	3.55	4.26	40.5	48.6	463	556	556
	7,300	ICCV 00108	1.5	90		2190	0.47	0.71	7.9	11.9	131	197	197
	3,485	ICCV 00305	1.2	105		1045	0.7	0.84	8.0	9.6	92	110	110
	1,200	ICCV 97126	1.2	90		360	0.15	0.18	2.0	2.4	27	32	32
Eastern Kenya	1,370	2			411		0.14	0.181	1.9	2.7	28	39	39
	1,025	ICCV 97105	1.5	90		308	0.07	0.11	1.1	1.7	19	29	28
	345	ICCV 00305	1.2	105		103	0.07	0.08	0.8	1.0	9	11	11
Total	81,620				24486		8.29	11.091	114.9	157.2	1651	2200	2300

Table 5. Certified seed production (t) plan for three years.

Variety	2012	2013	2014
ICCV 97105	107	178	427
ICCV 92944	102	171	410
ICCV 95423	83	139	334
ICCV 00108	30	49	118
ICCV 00305	18	30	73
ICCV 97126	5	8	19
Total	345	575	1380

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Soybean

Jandeka Mahasi and Frederick Baijukya

Importance of soybean in Kenya

Soybean production in Kenya remains low at an average of 2,000–5,000 tons a year. Surprisingly the industrial demand for soybean products continued to grow from 50,000 tons in 2008 to roughly 120,000 tons in 2011 of soybean meal and about 150 tons of soy protein concentrates and textured soy protein (Source: FAOSTAT 2011). In Kenya, human consumption accounts for 10–15% (or 10,000–15,000 tons) per annum indicating that a part of the domestic human demand for soybean is currently being fulfilled through soybean import (Chianu et al. 2008). Soybean is produced in Western, Nyanza, Rift Valley as well as Central and Eastern provinces (Fig. 1), on an area of about 2,500 ha with an average yield of 0.8 t ha^{-1} as against the potential yield of 1.5–3.0 t ha^{-1}, depending on the location (Mahasi et al. 2011). In 1999, the Ministry of Agriculture estimated that to attain self-sufficiency, 135,000 ha is required to produce over 108,000 tons, suggesting that deliberate measures need to be taken to promote domestic soybean production to meet this demand. Increased awareness on the health benefits and nutritional value by the international agricultural organizations (including CIAT and IITA) in partnership with the government has seen improvements in development of soybean sub-sector, notably in Western Kenya where soybean production has increased from 46 tons in 2010 to over 1315 tons in 2011 (Kadenge et al. 2012).

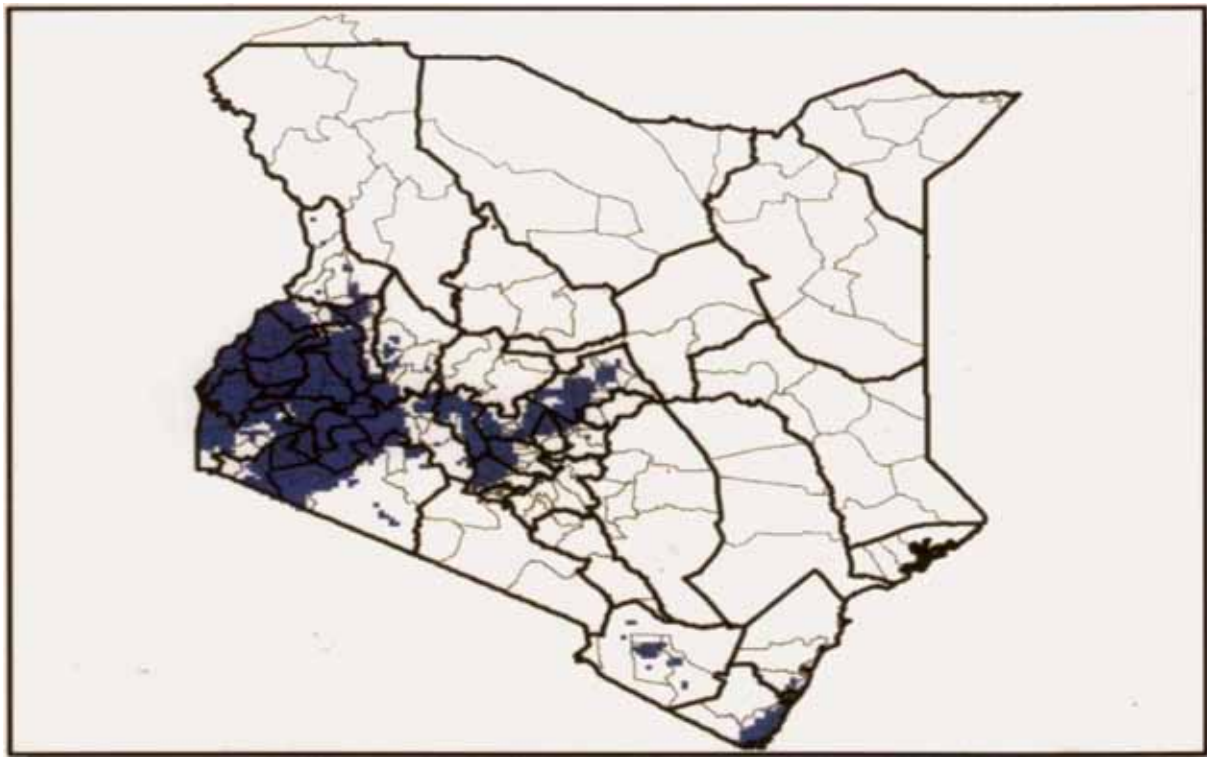

Figure 1. Major soybean production areas in Kenya.

Soybean contribution to farmer income and food and nutrition security

Soybean has increasingly become a cash crop among smallholder farmers notably in Western Kenya. This is after a collaborative agreement was reached between CIAT and a group of companies including Equity Bank (providing loans for inputs), Promasidor (soybean buyer), Smart Logistics (linking

smallholders to markets) and Kilimo Salama (providing crop insurance) and joined N2Africa and TL-II to support soybean production. N2Africa and TL-II have now developed knowledge of input requirements for soybean, costs, resultant yields and prices allowing for estimation of benefits to farmers. Total production costs of soybean are estimated at US$ 266 per ha. Fertilizer is the largest single cost (US$ 119) and inoculants one of the least (<5% of total). A household earns US$ 947 per year from one ha, enjoying a benefit-cost ratio of 3.5 to 1 (Source: N2Africa 2012). Following the long rains in 2011, Smart Logistics purchased over 45 tons of soybean from 691 farmers belonging to 16 partner organizations that are participating in TL-II and N2Africa projects. In early 2012, Smart Logistics purchased 217 tons of soybean worth about US$ 111,000 from 19 partner organizations. Little information is available for soybean trade on local markets probably because it lacks a formal market. However, the current price on local markets and the one offered by Promasidor is US$ 0.6–0.7 per kg, which is slightly higher than the world market price. Considering a huge deficit between production and demand and small farm holdings among farmers, it is likely that soybean produced in Western Kenya may not be competitive in the international market unless farmers attain high productivity of above 1.5 t ha^{-1}. Farmers in Western Kenya are also engaging in home-based value addition through their association by making soybean flour, soy nuts, fortified flours for porridge like soybean finger millet flour and soybean sorghum flour, soya beverage, soya milk and soya crunches. By June 2012, more than 8,000 households were reported to process and to consume various soybean by-products (Kadenge et al. 2012), suggesting that soybean is contributing to the nutritional and food security of communities in Western Kenya.

Research and development

Variety development

Initial research work on soybean in Kenya focused upon identifying suitable varieties for different agroecolocial conditions (Chianu et al. 2008). Consequently, five soybean varieties namely Nyala, Hill, Black Hawk, Gazelle and EAI 3600 that have been used in the country for a long time were officially released and registered in April 2009 by Kenya Plant Health and Inspectorate Services (KEPHIS), targeting specific growing areas with yield potential of up to 2 t ha^{-1}. In June 2010, two dual-purpose promiscuous varieties TGx1740-2F and TGx1895-33F and one grain variety SC-1 were released. The varieties TGx1740-2F and TGx1895-33F are high yielding (6.5% over the mean yield of checks) and have other characteristics preferred by farmers and large-scale processors (Table 1).

The rapid spread of soybean rust and the need to have varieties with high biological nitrogen fixation (BNF) potential has necessitated further evaluation of new varieties from various breeding programs. In this attempt, six promiscuous varieties TGx1904-6E, TGx1987-10F, TGx1987-62F, TGx1987-18F, Namsoy 1N and Maksoy 4M and five grain varieties 835/5/30, SBH3/7/4, Sc Squire, Sc Sequel and Sc S823-6-16 were evaluated through PVS process. Three varieties namely SC Saga, Namsoy 4M and TGx1987-62F (Table 1) were selected by farmers and have been submitted to KEPHIS for inclusion in National Performance Trials (NPT), in preparation for official release.

Disease management and fertilizer input requirements

In 2011, management of soybean rust was examined in Western Kenya relying upon foliar spraying with Artea and Amistar fungicides (products from Syngenta) (Table 2). Results were promising although the adoption of fungicide technologies is uncertain suggesting that integrated pest management strategies, including disease resistant varieties, may be better avenues for research. Trials to assess the response of soybean to *Rhizobium* inoculation and/or phosphate fertilizer were conducted for three seasons at 10 sites across Western Kenya. *Rhizobium* inoculation and phosphate fertilizer application led to tremendous increase in soybean yield in some of the sites while in others there was either

Table 1. Characteristic features of common soybean varieties selected by Kenyan research system.

Variety name by breeder	Release name	Year of release	Source of materials	Average on-farm yield (kg ha^{-1})	Varietal traits
Nyala	Nyala	2009	Seed Co, Zimbabwe	700	Early maturity, large grain size, can be intercropped with other crops
Hill	Hill	2009	KARI, Njoro	850	High yielding, medium maturity, tolerant to aphids
Black Hawak	Black Hawak	2009	KARI, Njoro	850	High yielding, medium maturity
EAI 3600	EAI 3600	2009	KARI, Njoro	800	High yielding, early maturity, resistant to major insects
Gazelle	Gazelle	2009	KARI, Njoro	1100	High yielding, large grain size, attractive color
TGx1740-2F	DPSB 19	2010	IITA	900	Free nodulation, high grain and biomass yield, good for monocropping, high pod clearance, good pod load, medium maturity, good for making milk
TGx1895-33F	DPSSB 8	2010	IITA	950	Free nodulation, good for intercropping, high grain and biomass yield, high pod clearance, good pod load, good for making milk, attractive color
Namsoy 4M	Namsoy	In NPTs	Makerere, Uganda	1200	High grain and biomass yield, high protein content, good for monocropping, tolerance to soybean rust
TGx1987-62F	DPSB 96	In NPTs	IITA	1,400	High grain and biomass yield, high protein content, good for monocropping, free nodulation, tolerance to soybean rust
SC Saga	Saga	In NPTs	Seed Co, Zimbabwe	1,600	High yielding, high oil content, high pod clearance, large seed size, tolerance to soybean rust, good for intercropping

Table 2. Effect of foliar spraying with fungicide on six soybean varieties to rust.

	Mean grain yield ± SD (kg ha^{-1})	
Treatment	Suseptible varieties (3)	Resistant varieties (3)
Not sprayed	1283 ± 151	1591 ± 190
Sprayed	1522 ± 138	1674 ± 89

moderate increase or no response at all (Fig. 2). The lack of response to *Rhizobium* inoculation and phosphate fertilizer suggests that other factors are limiting and call for in-depth analysis to identify those limiting factors.

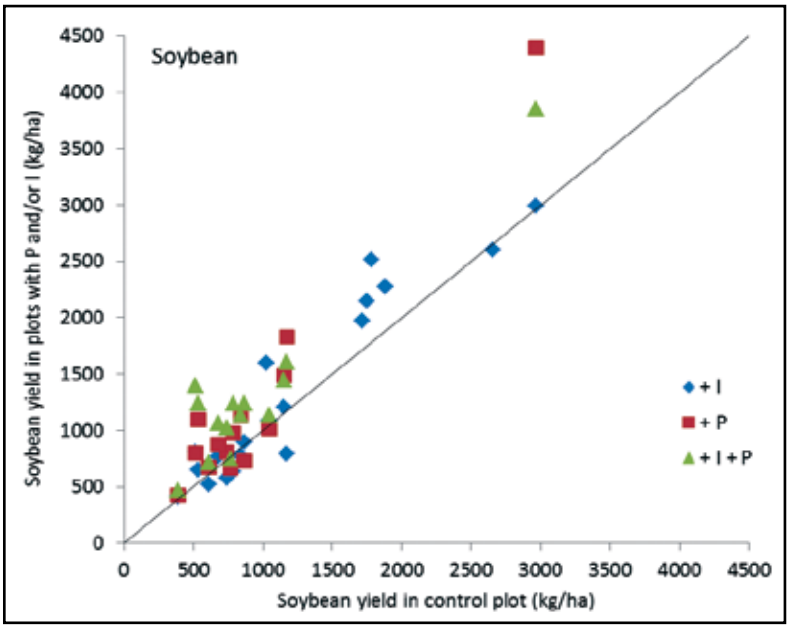

Figure 2. Response of soybean to* Rhizobium *inoculation (I) and phosphate fertilizer (P) application across 10 sites of Western Kenya over 3 seasons (short rains of 2010 through the long rains and short rains of 2011).

Major constraints to soybean production

Major constraints to large-scale soybean adoption in Kenya have been identified.

1. Lack of quality seed of appropriate varieties for various agroecological conditions, forcing farmers to buy seeds from open-air markets. Besides there is little information on dual-purpose varieties (eg, TGx and Seed Co. materials), which offer multiple benefits such as high yield and soil fertility improvement.
2. Poor agronomic practices among smallholder farmers.
3. Outbreak of pests and diseases including soybean rust, bacterial blight, bacterial pustule, frogeye, etc.
4. Declining soil fertility and increased frequency of mid season drought.
5. Lack of (or low) awareness of the crop in most parts of Kenya as a nutritional supplement, a source of cash crop or a crop capable of improving soil fertility.
6. Limited information on utilization, particularly on various forms in which soybean can be processed and incorporated in local recipes.
7. Lack of commercially viable, adaptable and affordable technologies especially for small and medium-sized business operations.
8. Lack of coordination among institutions promoting soybean.
9. Lack of supportive policy to the sub-sector leading to failure of attempt to promote the crop, so it receives little attention in terms of overall agricultural sector development.

Planned Phase 2 activities and their contributions to national efforts

In Phase 2 of TL-II project, we will work to increase soybean production through development and dissemination of appropriate technologies for management, processing and utilization of soybean at household and cottage levels and ensure access for smallholder farmers to seed of improved varieties.

At the end of this project (2014) it is expected that productivity of soybean will increase to an average of 1.5 t ha^{-1}, and at least 25% of households in West Kenya will have acquired knowledge on soybean processing and consuming various by-products of soybean, thereby improving their nutritional status.

Expected outcomes from Phase 2 soybean improvement for production and productivity

The outcomes of Phase 2 will be increased income and nutritional status of soybean farmers and farm practitioners, increased national soybean production of more than 2,500 tons and productivity of 1.5 t ha^{-1}. This will lead to reduction in the soybean deficit resulting from higher demand than supply, which should save the country some foreign exchange.

Areas for soybean cultivation

The potential areas for soybean production in Kenya are summarized in Table 3. Western province stands out as the leading soybean producing province in Kenya, accounting for nearly 50% of total national smallholder planted area and production in 2011. The main soybean producing districts in Western province are Butere/Mumias, Busia, Bungoma, Teso, Kakamega, Mount Elgon, Lugari and Vihiga. Butere/Mumias, Busia and Bungoma districts accounted for approximately 80% of the total soybean production in the Western province of Kenya in 2003. Other major soybean producing provinces in Kenya are Nyanza and Central, which accounted for 11–12% of total smallholder soybean production in 2011.

Table 3. Main soybean production districts in Kenya.

Province	District
Western	Busia, Bungoma, Teso, Butere/Mumias, Kakamega, Mount Elgon, Lugari, Vihiga
Rift Valley	Nakuru, Nandi, Trans Nzoia, Koibatek, Narok, Trans, Mara, Laikipia, Bomet
Eastern	Meru, Embu, Mbeere, Machakos
Nyanza	Rachuonyo, Homabay, Gucha, Kisii, Nyamira, Siaya
Central	Kirinyaga, Murang'a, Maragwa, Nyeri

Estimates of area potentially suitable for soybean production range from 157,000 ha (Source: MoA 1995) to 224,000 ha (by the Lake Victoria Basin Development Authority). While Nyanza province accounts for 11–15% of Kenyan land area potentially suitable to soybean cultivation, the Western province accounts for 9–13%. At district level, Uasin Gishu, Trans Nzoia, Siaya and Bungoma districts account for the largest proportion of land potentially good for soybean production in Kenya. The current project however, will focus on developing soybean production in Western, Nyanza and Rift Valley provinces.

Soybean seed system

Although Kenya is considered self-sufficient in seed production, there is insufficient seed for most legume crops such as soybean. Eight varieties (6 grain and 2 promiscuous) have been released by KEPHIS targeting specific growing areas with yield potential of up to 2.5 t ha^{-1}. Despite progress made in the development of improved soybean varieties, their adoption by farmers remains low largely because of poor seed supply. Seed companies are reluctant to invest in production of legume seeds because of difficulties to recover production costs since most farmers recycle the seed for several years. Consequently, most of the seeds being planted are obtained from open-air grain market or derived

from previous year's harvest. A few players like Western Seed Company have risked their investments into soybean seed production, but the price is usually beyond the reach of many smallholder farmers. The situation is complicated with the rampant poverty and lack of well-organized marketing structures.

Kenya soybean seed system strategy (2012–14)

This seed system strategy aims to increase the productivity and production of soybean through improved access for smallholder farmers to seed of improved soybean varieties (tolerant/resistant to biotic and abiotic stresses). A new approach known as integrated seed system where community-based seed production (now recognized by the seed act of Kenya) will be a cornerstone. CIAT, in collaboration with the seed unit of KARI, Kakamega and KEPHIS have initiated community-based seed production groups under the umbrella of Western Seed Growers Association. Through these groups, several tons of seeds of new soybean varieties have been produced and distributed to farmers in local communities. Selected seed producers have been trained in seed multiplication and will be provided with foundation seed to multiply under supervision of the extension workers, and KEPHIS is responsible for inspecting the fields and the final product as required by Kenya Seeds and Plant Varieties Act. CIAT-TSBF will provide technical support in seed production and marketing, including farmer training and linkages to the markets. The Community Seed Producers are in charge of seed production aspects and also run the seed marketing enterprises. They will jointly set up Community Soybean Seed Banks (CSSB) where other members of the society can access and purchase those improved seeds. These community seed banks are harmonized to operate together with other established Soybean Resource Centers. The long-term goal of these activities will be to link these community seed producers to major seed companies on contract farming basis and let the process be self propelling.

Seed requirement based on targets

Area: 6224 ha

Seed rate (mean): 60 kg ha^{-1}

National demand: 373.4 tons (2012–14)

Capacity to deliver 20% area: 89.7 tons

Target of productivity: 1.8 t ha^{-1} at intervention sites and 0.8 t ha^{-1} at national level

Total production target: 2688 tons

Opportunities, constraints, partnership and seed production to cover 20% area

Opportunities

- Availability of suitable soybean varieties for major soybean growing areas
- Presence of community seed growers with experience in seed production
- Strong domestic demand of improved seeds and grain
- Availability of research capacity in the country
- Availability of agro-delaers in the country
- Policy environment that enhances innovative seed system

- Presence of production partnership between soybean buyers, processors and farmers
- Potential for increasing government support

Constraints

- Increasing trend of soybean import
- Fluctuation of soybean prices by season
- Insect pests and diseases in the field
- Small and fragmented soybean producers
- Low direct access to sources of credit
- Undeveloped soybean seeds within the seed industry
- Lack of seed storage facilities

Strategic partners

Partners and their role in the seed system are given in Table 4.

Table 4. Strategic partners for soybean sub-sector in Kenya.

Partner	Role
CGIAR centers (CIAT-Kenya, IITA)	Provision of improved germplasm, guidance on appropriate farming technologies (agronomic practices)
Kenya Agricultural Research Institute (KARI)	Breeding, bulking, screening and maintenance of germplasm
Kenya Plant Health Inspectorate Services (KEPHIS)	Seed legislation, regulation and quality control
Seed companies (KARI-Kakamega Seed Unit, Seed Co, Western Seed Co, Leldet)	Provision of guidance in crop production technologies through field days, demonstrations and agriculture shows; assist in marketing of farmers' seeds
Western Seed Growers Association	Recruit and organize farmers for seed production; spearhead recognition of community seed producers through the legal framework; create awareness about soybean work through public media
Agro-dealers, Soybean Resource Centers (SRC) and farmer associations	Farmer knowledge dissemination, linkage between the farmer and consumers, enhance accessibility of farm inputs to farmers
Smart Logistics and Farm Concern	Organize farmers into commercial groups, linkage to financial institution, ie, credit facilities, linkage to market
Equity Bank	Provision of credit facilities to farmers
Promasidor, BIDCO	Provision of market services and processing soybean into various products and by-products (value addition)
Sygneta East Africa	Provision of farm inputs specifically chemicals for control of pests and diseases
MEA Limited	Provision of inputs specifically inoculants and mineral fertilizers
Higher institutions of learning: University of Nairobi (UoN), Egerton University, Moi University, Maseno University, others	Test improved germplasm for various technologies in terms of adaptability, performance and agronomic potential; UoN explores, screens, authenticates various *Rhizobium* strains and does quality control; Offer formal training to postgraduate and PhD students in seed systems and crop protection management; Provision of capacity building through training and technology dissemination

Seed production plan

Seed production plan of seed required to cover 20% soybean area in Kenya is presented in Tables 5 and 6. The seed will be produced mainly by community seed producers under the supervision of KARI Seed Unit and KEPHIS.

Table 5. Soybean seed production plan for Kenya.

Ecology	Promising varieties	Productivity (t ha^{-1})	Seed production (t)		20% additional seed requirement (t) (*1.2%)	Seed production (t) goal		
			Breeder seed	Foundation seed		Year 1 2012	Year 2 2013	Year 3 2014
Western region	TGx1740-2F	1.8	0.026	0.789	7.89	7.89	7.89	7.89
	Namsoy 4M	2.0	0.017	0.552	6.14	6.14	6.14	6.14
	TGx1835-10E	1.5	0.008	0.210	1.75	1.75	1.75	1.75
	TGx1895-33F	1.7	0.007	0.186	1.75	1.75	1.75	1.75
Nyanza region	TGx1740-2F	1.5	0.018	0.448	3.74	3.74	3.74	3.74
	Namsoy 4M	1.8	0.004	0.124	1.24	1.24	1.24	1.24
	TGx1835-10E	1.8	0.002	0.062	0.62	0.62	0.62	0.62
	TGx1895-33F	1.6	0.002	0.046	0.41	0.41	0.41	0.41
Rift Valley region	TGx1740-2F	1.5	0.01	0.019	0.44	0.44	0.44	0.44
	TGx1895-33F	2	0.01	0.01	0.22	0.22	0.22	0.22
	TGx1835-10E	1.5	0.06	0.093	0.44	0.44	0.44	0.44
	Gazelle	1.8	0.02	0.032	1.55	1.55	1.55	1.55
	EAI 3600	1.5	0.03	0.046	0.88	0.88	0.88	0.88
	SCS-1	1.5	0.1	0.105	0.88	0.88	0.88	0.88
Central region	EAI 3600	1.2	0.08	0.102	0.29	0.29	0.29	0.29
	Gazelle	1.4	0.06	0.085	0.29	0.29	0.29	0.29
	SCS-1	1.5	0.03	0.046	0.14	0.14	0.14	0.14
Eastern region	TGx1740-2F	1.5	0.07	0.102	0.36	0.36	0.36	0.36
	TGx1835-10E	1.2	0.04	0.044	0.12	0.12	0.12	0.12
	Gazelle	1.8	0.05	0.084	0.36	0.36	0.36	0.36
	Namsoy 4M	1.8	0.01	0.026	0.12	0.12	0.12	0.12
	SCS-1	1.5	0.04	0.065	0.24	0.24	0.24	0.24
Total			0.694	3.278		29.87	29.87	29.87

Table 6. The certified seed production (t) plan for three years.

Variety	2012	2013	2014
TGx1740-2F (DPSB 19)	12.4	12.4	12.4
Namsoy 4M	7.5	7.5	7.5
TGx1835-10E (DPSB 8)	2.9	2.9	2.9
TGx1895-33F	2.4	2.4	2.4
Gazelle	2.2	2.2	2.2
EAI 3600	1.3	1.3	1.3
Total	28.7	28.7	28.7

Vision of success for soybean in Kenya

The productivity level of soybean will be raised to 1.5 t ha^{-1}, thereby increasing the household income from sale of soybean to US$ 360 per year benefiting more than 6,000 smallholder farmers and reducing soybean import by 20%.

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Malawi

Groundnut

Albert Chamango, Geoffrey Kananji, Francis Maideni, Patrick Okori and Emmanuel Monyo

Introduction

Production

Groundnut (*Arachis hypogaea*) is among the major valuable and versatile grain legume crops with tremendous contributions to improving household food security, nutrition, soil health and fertility in Malawi. Additionally, groundnut thrives under low rainfall and poor soils, and can be grown with minimum capital investment. The average annual cultivated area for groundnut for the period 1991–2006 (17000 ha) accounted for 27% of the total legume area. Groundnut production per year during the same period accounted for 28% of Malawi's total legume production. The area planted to groundnut was about 14% of the area planted to maize (Simtowe et al. 2009).

Importance of the crop to Malawi's economy

Within Malawi, groundnut is the most important legume and oilseed crop both in terms of the total area cultivated as well as production. Groundnut has huge untapped potential for contributing to the socioeconomic development in the country (Edriss and Simtowe 2002). It serves as a good source of both protein (generally 12–36%) and vegetable oil (generally 35–54%), and provides a good source of minerals (calcium, phosphorus, iron, zinc and boron as well as vitamin E and small quantities of vitamin B complex) to the rural households that usually find it difficult to access other forms of nutritious foods. Over 25% of agricultural cash income among smallholder farmers is realized from groundnut (Chirwa 2005). However, due to numerous constraints groundnut productivity remains low as evidenced (Table 1).

Table 1. Current and projected status of groundnut in Malawi[1].

Parameter	2002–11	2014	2017
Average area (ha)	254,578	267,561	310,621
Average production (tons)	227,089	244,121	303,271
National demand (tons)	168,294	176,372	203,008
Average yield (kg ha^{-1})	863	1,211	1,573
Proportion sold commercially (%)	40	45	50
Average ROG in area (%)	5.1	NA	NA
Average ROG in production (%)	7.5	10	15
Expected annual ROG in demand (%)	4.8	4.8	46
Expected average ROG in yield (%)	1.5	2.0	2.5

1. ROG = Rate of growth; NA = Not available.

Research and development

Focus

The major goal of the Groundnut Improvement Program of the Department of Agricultural Research Services in the Ministry of Agriculture and Food Security, Malawi is to develop groundnut production technologies that meet requirements of the farmers and other producers, processors, consumers, exporters and other end-users. The program partners with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) to source improved germplasm because the crop is an introduced albeit important crop (Chamango et al. 2013). The program partners with several national farmer and other associated partners to ensure that products reach the farmers. The focal areas of research for the program are improving productivity in two botanical types of groundnut – Virginia and Spanish. Virginia types are generally spreading and semi-spreading (semi bunch) in growth and tend to be medium to large seeded with a relatively long maturity period of more than 120 days. Spanish types on the other hand comprise groundnut varieties that display an erect (bunch) growth habit, and tend to be relatively small seeded maturing in 90–110 days. Currently, all varieties released for production by farmers in Malawi were conventionally bred through one or a combination of any of the three approaches, namely introduction, hybridization and selection.

Variety development

Decades of research and variety development by NARS and CGIAR partners in Malawi have resulted in the development of numerous technologies for enhancing groundnut productivity (Chiyembekeza et al. 1998). The technologies developed fall into two broad categories, namely improved varieties with resistance/tolerance to major biotic and abiotic stresses, and a package of improved agronomic management practices. So far, 14 groundnut varieties have been released in two botanical or market groups since 1968 when Chalimbana and Malimba were first released (Saka et al. 2006). Current activities have concentrated on promotion of recent releases of three Virginia type and three Spanish type varieties with each group comprising varieties that combine high yield, disease resistance and other market preferred traits (Table 2). The available package of agronomic practices highlights recommendations on time of planting, plant population, weed management, and harvesting and postharvest practices for increasing yield, and reducing both quantity and quality losses. Despite variation across years, the groundnut production trend in Malawi has generally been increasing while yield has remained low averaging less than 1 t ha^{-1}.

Table 2. Groundnut varieties released in Malawi and their adoption.

Variety	Market type[1]	Year released	Adoption (%)	Attributes and use
CG7	VB	1990	30.0	High yield, wide adaption, confectionery, oil
Nsinjiro	VB	2000	20.0	High yield, rosette resistant, confectionery
Chalimbana 2005	VB	2005	0.1	High yield, rosette resistant, confectionery
Kakoma	SB	2000	7.0	High yield, confectionery
Baka	SB	2001	0.5	High yield, rosette resistant, confectionery
Chitala	SB	2005	0.2	High yield, rosette resistant, confectionery
Chalimbana	VB	1968	39.0	High yield, rosette resistant, confectionery
Chitembana	VR	1982		High yield, rosette resistant, confectionery
Mawanga	VR	1982		Oil
Mani Pintar	VR	1969	3.2 (trace)	Oil
RG1	VR	1975		Confectionery

1. VB = Virginia bunch; SB = Spanish bunch; and VR = Virginia runner.

Malawi promotes Virginia type varieties in the mid altitude agroecology and Spanish types in the lowland agroecology. However, overlap of varieties occurs across agroecologies as farmers become more knowledgeable about varietal characteristics, market preferred traits, management recommendations and market demand. Dominant varieties include Chalimbana, CG7, Nsinjiro and Kakoma in mid altitude, and CG7 and Malimba in lowlands.

Key constraints to groundnut production

The current national groundnut yield trend reveals a yield gap of 53% between the national average and realizable productivity at research stations. The yield gap is attributed to several biotic and abiotic factors (Naidu et al. 1999), including institutional, policy and other value chain related constraints (Tchale 1997). Major biotic factors comprise the groundnut rosette virus disease and other fungal foliar diseases (early and late leaf spots, and groundnut rust), *Aspergillus* infection and aflatoxin contamination, and insect pests such as aphids, the leaf hopper (*Hilda patruelis*), termites, cutworms and leaf-eaters. The abiotic factors include drought, low soil fertility (low Ca and P) and poor agronomic practices (low plant density, late planting and late weeding). Tangible evidence exists to suggest low adoption of improved varieties and certified seed by farmers. The majority of poor smallholder farmers use poor quality own-saved seed of unimproved varieties owing to limited availability of adapted improved varieties and good quality certified seed, and because seed is either overpriced or inaccessible. Other socioeconomic factors include lack of labor-saving technologies, lack of technologies for processing and utilization, lack of clear policies on marketing and associated regulatory frameworks, and limited domestic and international marketing opportunities.

Planned Phase 2 activities and their contribution to national efforts

Phase 2 activities will aim to harness gains made in the previous phase and hasten outcomes from continued farmer participatory varietal selection (FPVS) to identify traits preferred by farmers and markets. Efforts will concentrate on implementing seed roadmaps to avail adequate and easily accessible high quality seed of preferred varieties to as many farmers as possible, expand and intensify use of improved varieties and certified seeds through targeted development of options (productivity, quality and demand guided by preferences), explore and validate technology options (varieties and agronomic management), integrate formal and informal seed systems components, build capacity of partners through training and infrastructure support and carryout rigorous monitoring, evaluation and assessment of impact.

Target yield and beneficiaries by 2015

Phase 2 efforts target raising the national groundnut yield to 1205 kg ha^{-1}. The attained level of productivity increase will translate into a 15% increase in the number of beneficiaries of improved groundnut varieties and use of good quality seed.

Possible interventions to increase production and productivity

The interaction between the NARS and their CGIAR counterparts will be strengthened through joint evaluation of breeding materials in hotspot screening sites for specific stresses. The NARS will continue selection of segregating materials and evaluating international breeding nurseries to identify suitable lines for local needs, and initiate crossing programs. Rigorous FPVS will be implemented to identify farmer and market preferred varieties and traits. Concerted efforts will focus on seed production training of partners in improved production technologies and availing of market information.

Institutional and technical innovations that will be enhanced in Phase 2

The existing network of institutions with an agricultural orientation will be explored to enhance linkages and exploit synergies among NGOs, community-based organizations (CBOs) and the private sector to avail improved seed and better marketing opportunities to farmers. The existing farmer associations (NASFAM, ASSMAG and GALA), the Legume Platform and the Legume Development and Marketing Association will serve to spearhead technical innovations and dialogue with farmers.

Processing and storage requirements in aid of market opportunities

Aflatoxin contamination is a major constraint reducing international trade benefits from groundnut. Areas with late rains suffer postharvest contamination. Therefore, proper drying procedures and technologies for handling produce are necessary to minimize risk of postharvest contamination. The minimum standards set for traded groundnut have greatly restricted access to international markets by many African countries including Malawi.

Key innovations for enhancing smallholder farmer competitiveness in the groundnut value chain

Raising groundnut yield by accurate targeting of varieties to appropriate agroecologies remains a key strategy for increasing production and reducing losses due to various risk factors. For the mid altitude and plateaus there is a need to focus on high-yielding, rosette and early leaf spot resistant varieties, while drought resistant, early-maturing, early leaf spot resistant varieties will be the focus in lowlands and lakeshore areas. Concerted effort is required to enhance productivity of confectionery groundnut varieties in both agroecologies guided by current trends in market demand. The development of improved farmer and market preferred varieties and agronomic packages that reduce aflatoxin risk will be emphasized for farmers to access high value markets. Support for farmer–research–extension–market linkages will facilitate market information flow and value chain coordination and enable farmers respond to market signals. Transformation of production system components will be advocated through enhanced private sector involvement in processing and marketing of groundnut, and mechanization of production activities to reduce drudgery and labor costs.

Expected outcomes from Phase 2 improvement for production and productivity

Phase 2 activities will contribute high-yielding varieties with resistance to major diseases and tolerance to drought, and other farmer and market preferred traits, enhanced availability of good quality seed and improved agronomic management. The efforts will result in increased productivity and production of groundnut, translating into nutritional security, increased volume of agro-processing, increased exports and more income to poor smallholder farmers.

Agroecologies for groundnut cultivation

Malawi has a total land area of 119140 km^2 (11.78 million ha), 20% of which is covered by surface water resources dominated by Lake Malawi while 34% is arable and the remainder is forest land. Three main agroecologies are recognized based on climatic conditions and differences in altitude: the mid altitude or plateau areas (900–1200 m amsl), the lakeshore and the Shire Valley. The lakeshore and the Shire Valley are often regarded as one lowland agroecology (up to 899 m amsl). Agriculturally, the country is further divided into eight agricultural development divisions based on physiography and weather

conditions. Legumes cover about 27% of cultivated area while groundnut covers 31% of the total legume area (2010/11 crop statistics). Groundnut is primarily a rainfed crop almost exclusively grown by 20% of the rural poor smallholder population, particularly women. However off-season production is also possible in some parts of Nkhatabay and Karonga districts. The crop is either grown as sole or intercropped with other crops (maize, sorghum, millets, soybean and pigeonpea). Groundnut is grown from near sea level to >1500 m amsl, but over 70% is produced in the mid altitude and plateau areas, covering Lilongwe and Kasungu in central Malawi, and Mzimba district in northern Malawi (Table 3). The lowland agroecology (Fig. 1) also contributes substantially to the groundnut economy.

Table 3. Groundnut share of the total production by agricultural development division[1].

Ecology/ District	Production (t)	Yield (kg ha^{-1})	Area (%)	Production (%)	Dominant varieties
Karonga	4346	639.96	2.5	1.6	Chalimbana
Mzuzu	26128	896.42	10.9	9.8	Chalimbana, CG7
Kasungu	76547	1122.7	25.6	28.7	Chalimbana, Chalimbana 2005, CG7, Nsinjiro, Kakoma
Lilongwe	96828	1118	32.5	36.2	Chalimbana, Chalimbana 2005, CG7, Nsinjiro
Salima	8789	878.55	3.8	3.3	Kakoma, Malimba, CG7
Machinga	26775	751.58	13.4	10.0	Kakoma, Malimba
Blantyre	25363	945.46	10.1	9.5	Chalimbana, CG7
Shire Valley	2302	692.81	1.2	0.9	Malimba, Kakoma, Baka

1. About 75% of groundnut produced is sold in local markets.

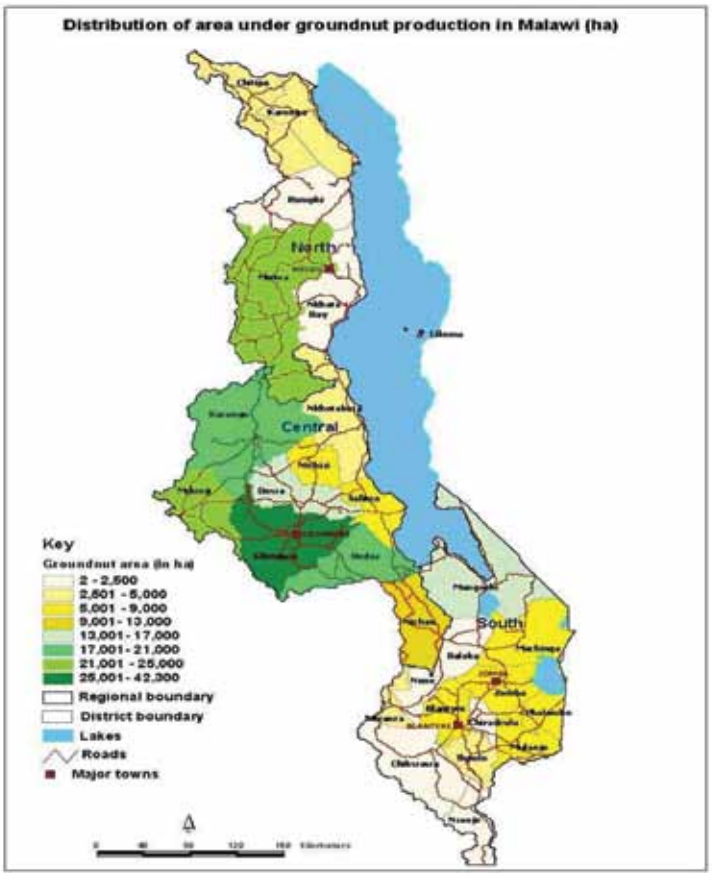

Figure 1. Groundnut production potential by district in Malawi (Adapted from Simtowe et al. 2009).

Seed systems for groundnut green revolution in Malawi

The groundnut sub-sector in Malawi is driven by both the formal and informal seed delivery systems. Besides breeder seed production, the formal system regulates basic and certified seed production while informal seed delivery systems operate through CBOs. This is critical for self-pollinated crops such as most grain legumes as for a long time the private sector has had no interest in these crops because of low profit margins. Malawi under TL-II Project continues to carefully integrate the formal and informal seed production and delivery systems through operational modifications to ensure seed quality by facilitating certification of various categories of seed producers (STAM members, individual growers, CBOs, community-based seed banks, farmer research groups and associations).

Strategic partners and their roles

In order to consolidate gains from previous investment in groundnut research, new innovative approaches to ensure aggressive promotion of technologies is a fundamental requirement. Partnerships among NARS, NGOs, private sector and farmers' organizations (Table 4) will help to popularize preferred improved varieties and improved crop production practices.

Table 4. Key partners in the groundnut value chain and their roles.

Partner	Role
Department of Agricultural Research Services; Ministry of Agriculture and Food Security	Undertake variety development, evaluation and release; produce breeder and foundation seeds; develop integrated crop management technologies; and provide aflatoxin testing services
Seed Services, Malawi	Seed systems support to help collaborating NGOs and CBOs in monitoring quality seed production
Department of Crop Production; Ministry of Agriculture and Food Security	Provide guidance in integrated groundnut production technologies and associated packages; facilitate groundnut value chain coordination
Department of Agricultural Extension Services; Ministry of Agriculture and Food Security	Undertake farmer education and technology dissemination
Ministry of Industry and Trade	Identify opportunities in regional and international groundnut trade
Farmers	Use products and services
Farmers Union and Associations (FUM, NASFAM, GALA, ASSMAG, MLDA)	Capacitate farmers formation of associations for collective production and marketing; facilitate linkages to other agro-industries
NGOs (CISANET, CARE-Malawi, Plan Malawi)	Support farming communities by imparting knowledge and skills for increased production; facilitate farmer friendly agricultural policies
ICRISAT, CGIAR	Provide improved germplasm; build capacity through training; conduct research on effective methods for technology dissemination
Private sector (market intermediaries, seed enterprises, processors and agro-input dealers)	Facilitate processing and commercialization

Major initiatives and key policies (recently implemented/needed) to promote legumes

Several initiatives and policy interventions have been initiated in support of the agricultural sector in Malawi. Interventions with a direct influence on the performance of the groundnut sub-sector are discussed.

The Farm Input Subsidy Program (FISP)

Malawi has embarked on an ambitious agricultural input (maize seed and fertilizer) subsidy program. The initiative has significantly revolutionized agricultural productivity turning the country from being food insecure in the past five years to recording surplus maize production for three consecutive years (2007–09). The program has been extended to legume seed (groundnut, beans, soybean), stimulating private sector participation into legume enterprise development because of ready market.

The Greenbelt Initiative

To benefit from underutilized water resources in Malawi, the government conceptualized the "Greenbelt Initiative" with the aim of increasing production and productivity of various agricultural crops, livestock and fish farming both inland and along the shores of Lake Malawi, and banks of major rivers including Shire River. The initiative will benefit the legume sector through development of irrigation schemes.

The Presidential Initiative to end Hunger and Poverty

The government has currently introduced the initiative in order to increase production and productivity of six legume crops including groundnut, and small stock livestock to enhance export opportunities, diversify forex generation and household nutritional security.

The Agriculture Sector Wide Approach Support Project (ASWAp-SP)

As a priority investment framework to achieve the Malawi Growth and Development Strategy (MGDS) targets and the Millennium Development Goals (MDGs), Malawi is implementing the ASWAp-SP to improve food security and nutrition, increase agricultural incomes and ensure sustainable use of natural resources. The recent incorporation of legumes in the mainstream of activities to receive support from the project will help to promote groundnut.

Agricultural Policy Advocacy through Farmers Union of Malawi (FUM) and Civil Society Agricultural Network (CISANET)

The contribution of FUM and CISANET backed by legume-based associations (Legume Development and Marketing Association) and platforms (Legume Platform) in advocating for farmers equitable rights in agriculture, particularly in policy spheres of input-output pricing, market access, land rights and farm levies will facilitate agricultural policy reforms and attract farmers and potential investors in legume enterprise development.

Regional projects on harmonization of seed policies and seed trade

Malawi is a partner in implementing projects aiming at promoting harmonization of policies to facilitate variety registration and movement of seed in the SADC region. Notable projects include: the Harmonized Seed Security Project (HASSP), the Seed Policy Enhancement in the Africa Region (SPEAR) Project and the Malawi Seed Industry Development Project (MSID) by ICRISAT in Malawi, but with potential spill-overs to other countries in the region. These efforts will contribute to increased productivity of groundnut.

Capacity needs of key stakeholders (NARS, NGOs, farmer organizations, traders and processors) in value chain coordination

The legume sub-sector currently faces a great deal of inefficiency due to inadequate staffing (only 126 research scientists and support staff currently) and limited infrastructure, translating into significant losses to farmers through increased transaction costs. There is need to increase the number of

trained grain legume scientists through on job training in various aspects including modern breeding methodologies (molecular marker technology) to enhance breeding efficiency. Through skills transfer, the farmers' capacity to organize and access improved agricultural technologies, and technical aspects of collective marketing will be enhanced. Capacity building in enterprise development for traders and processors will ensure success of the private sector in input-output marketing, value-addition and processing.

Special cross-cutting issues (cultural, gender and HIV/AIDS considerations)

Groundnut is generally considered not only as a woman's crop but also labor-intensive. Enhancing the crop's potential to generate income through increased yield and reduced labor requirement entails raising the status of women in society. The high rate of HIV/AIDS prevalence among rural communities entails reduced labor available for farming activities. Promotion of labor-saving devices will help to ease labor shortage, and promotion of household level value-addition will enhance rural nutrition. Poorer households and women farmers attempting to participate in market value chains face multiple restrictions to access factors of production as well as agricultural inputs, credit and information.

Environmental/sustainability issues

Legumes can fix substantial amounts of nitrogen through biological nitrogen fixation (BNF) activities. Groundnut fixes atmospheric nitrogen and contributes an equivalent of 325 kg ha^{-1} of urea fertilizer (150 kg N ha^{-1}) to nourish subsequent cropping. This would translate into sustainable cropping systems, increased productivity, raised GDP through surplus produce sales, and enhanced forex from exports and import substitution. Use of rosette, early leaf spot and rust resistant varieties will ensure environmental safety minimizing the need for chemical sprays.

Seed production plan

The seed production and delivery plan is presented in Table 5.

Table 5. Seed delivery plan to cover the required area (20% of national area under groundnut).

Ecology (Zone)	Demand area (ha)	Promoting varieties	Seed required to reach 20% adoption (t)	Breeder seed 2012		Foundation seed 2013		Certified seed 2014		Certified seed 2015	
				Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
Mid altitude	129,600	CG7	2,131.2	16	13	338	270	1,620	2,430	1,680	2,520
	64,800	Nsinjiro	1,094.4	6	5	113	90	540	810	540	810
	10,800	Chalimbana 2005	230.4	14	11	110	88	528	792	540	810
	10,800	ICGV-SM 01711	0.0	6	5	13	10	60	90	90	135
Lowland	27,000	Kakoma	432.0	1	0	45	36	216	324	270	405
	27,000	Chitala	432.0	1	1	56	45	270	405	330	495
Total	270,000		4,320	44	35	674	539	3,234	4,851	3,450	5,175

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Common bean

Virginia Chisale, Geoffrey Kananji, Francis Maideni, Rowland Chirwa and Steve Beebe

Introduction

Importance of the crop in Malawi

Common bean *(Phaseolus vulgaris)* is an important legume crop for the resource-poor small-scale farmers in Malawi. It is an important source of protein for many people both in rural and urban areas, especially those who cannot afford animal protein. Beans are high in calcium, magnesium, vitamin B, iron and zinc which are essential for immune function in human beings. Common bean is also a source of income to many small-scale farmers who are major producers. Beans improve soil fertility when grown in rotation with other crops such as maize or tobacco. Another important role that beans play is the gap filling when food shortages reach a climax and people depend on beans alone for their survival.

Production and demand

In 2012, common bean area in Malawi was estimated at 243,700 ha and production at 127,464 tons (Table 1). In the major bean growing areas, 74% to 90% of farmers grow beans as their main cash crop; also beans are second only to maize as a food crop (Source: Scott and Maideni 1998). About 35% of the production is marketed contributing about 25% of total household income for over 68% of the households who sell their surplus (Source: Kalyebara et al. 2005). Both production and demand for beans in Malawi are trending upwards, with an annual growth rate of 4% in production during 2002 to 2011. Area under common bean increased tremendously in 2009 by about 51,844 ha in response to the government mobilization of farmers to include legume in their cropping system, when some NGOs intervened with provision of seeds as inputs to farmers and additional area under irrigation system.

Projections for 2014–20 suggest continued growth in both national demand and production of beans. Common bean experiences high fluctuations in production associated with high variability in rainfall conditions, often resulting in excess demand. There is an indication of demand for improved high-yielding common bean varieties to stabilize yields.

Table 1. Production of beans during 2002 to 2012 in Malawi.

Year	Area (ha)	Production (t)	Yield (kg ha^{-1})
2002	227917	99828	438
2003	239476	109832	459
2004	204515	76964	376
2005	233845	85759	367
2006	242568	117808	486
2007	268688	132689	494
2008	268995	129948	483
2009	220770	120084	544
2010	228880	106219	464
2011	232638	124184	534
2012	243700	127464	523
Average	237454	111889	470

Research and development

Variety development

The bean improvement program in the Department of Agricultural Research Services, Malawi started developing bean varieties in 1996. This research is conducted in collaboration with the International Center for Tropical Agriculture (CIAT) and through PABRA, and other NARS partners, such as the University of Malawi-Bunda College of Agriculture. So far, a total of 30 bean varieties have been released in Malawi, of which 18 of them were released by the Department of Agricultural Research Services and 12 by the University of Malawi-Bunda College of Agriculture (Table 2).

Production constraints

The current bean yields are very low estimated at about 500 kg ha^{-1} (Table 1). There are many factors that are responsible for low yield. These include:

- Lack of availability and accessibility of good quality seed of improved varieties;
- Poor market access for inputs and grain associated with poor marketing structures; and
- Diseases, insect pests, drought and low soil fertility.

The problem of poor accessibility to bean seed is further exacerbated by the low investment by the private seed companies in the production and marketing of bean seed. Therefore, strategies are needed to address this gap.

Planned Phase 2 activities

The project objectives will be achieved through strategic planning involving partners, indulging in available opportunities and capacity building while mainstreaming culture and gender into project work plans.

Access to sufficient quantities of bean seed of preferred improved varieties will be enhanced, as well as other eco-efficient non-variety bean production technologies will be employed.

Knowledge empowerment for farmers on bean production technologies will play a big role in production and productivity increase. This will be achieved through training of extension personnel and lead farmers. Farmer participatory variety selection (FPVS) will be implemented to identify farmer and consumer preferred varieties and traits. Field days and demonstrations will be conducted to create awareness and demand for the newly released improved varieties and associated bean production technologies.

Expected outcomes

Phase 2 of the project aims at ensuring national self-sufficiency in bean and surplus for sale. This is expected to translate into improved household food and nutrition security and more income from bean sales at local as well as regional markets.

Agroecological zones

The bean crop is grown across the country in the agroecologies categorized according to altitude as high, medium and low (Table 3). Figure 1 presents the major bean growing areas in Malawi by

Table 2. List of released varieties in Malawi.

Variety	Year of release	Institution	Optimal production altitude range (m amsl)	Time to maturity (days)	Grain yield (t ha^{-1})	Special attributes
Namajengo	1980	University of Malawi-Bunda College	1000–1200	90	2.5	High yielding
Saperekedwa	1980	University of Malawi-Bunda College	1000–1200	90	2	Good taste, attractive seed color
Kanzama	1980	University of Malawi-Bunda College	1000–1650	95	2.5	High yielding, wide adaptation
Kalimtsiro	1980	University of Malawi-Bunda College	1000–1200	90	2.5	High yielding
Nasaka	1980	University of Malawi-Bunda College	1000–1200	80	1.5	Early maturity, cooks fast
Bwenzilaana	1980	University of Malawi-Bunda College	1000–1200		2.5	High yielding
Kalima	1993	University of Malawi-Bunda College	1000–1400	90	2	Large seed
Bunda 93	1993	University of Malawi-Bunda College	1000–1400	90	2	Wide adaptation
Chimbamba	1993	University of Malawi-Bunda College	1000–1400		2	Large seed
Bunda 1	2005	University of Malawi-Bunda College	1000–1200	85	2	Resistant to bean common mosaic virus
Bunda 2	2005	University of Malawi-Bunda College	1000–1200	85	2	Resistant to bean common mosaic virus
Bunda 3	2005	University of Malawi-Bunda college	1000–1200	85	2	Resistant to bean common mosaic virus
Kambidzi	1996	Department of Agricultural Research Services	1400–1650	85	2.5	High yielding, tolerant to angular leaf spot
Maluwa	1996	Department of Agricultural Research Services	1000–1300	90	2	Tolerant to common bacterial blight
Mkhalira	1996	Department of Agricultural Research Services	1400–1650	85	2.5	High yielding, tolerant to low soil fertility
Napilira	1996	Department of Agricultural Research Services	1400–1650	90	2	Resistant to angular leaf spot, halo blight, powdery mildew
Sapatsika	1996	Department of Agricultural Research Services	1000–1300	90	2	Dark red kidney (attractive seed color), wide adaptation
Nagaga	1996	Department of Agricultural Research Services	1000–1300	90	2	Tolerant to low soil fertility, resistant to bean common mosaic virus
Kabalabala	2002	Department of Agricultural Research Services	1000 –1650	90	2.5	Tolerant to angular leaf spot and common bacterial wilt, wide adaptation

Continued

Table 2. *Continued.*

Variety	Year of release	Institution	Optimal production altitude range (m amsl)	Time to maturity (days)	Grain yield (t ha^{-1})	Special attributes
Kholophethe	2002	Department of Agricultural Research Services	1000–1650	90	2	Resistant to bean common mosaic virus and angular leaf spot, tolerant to low soil fertility
NUA 45	2009	Department of Agricultural Research Services	1000–1200	69	1.5	Early maturity, high iron and zinc
NUA 59	2009	Department of Agricultural Research Services	1000–1200	70	1.7	Early maturity, high iron and zinc
VTTT 924/4-4	2009	Department of Agricultural Research Services	1000–1650	90	2	Large seed, good color, good taste
KK03/KK25/68	2011	Department of Agricultural Research Services	1000–1650	90	2	High yielding, large seed
KK03/KK25/68	2011	Department of Agricultural Research Services	1000–1650	90	2	High yielding, large seed
MAL/KK25/112	2011	Department of Agricultural Research Services	1000–1650	90	2	High yielding, large seed
MAL/KK25/9	2011	Department of Agricultural Research Services	1000–1650	90	2	High yielding, large seed
MAL/KK35/443	2011	Department of Agricultural Research Services	1000–1650	90	2	High yielding, large seed
KK25/NAG/184	2011	Department of Agricultural Research Services	1000–1650	90	2	High yielding, large seed
KK25/MAL/19	2011	Department of Agricultural Research Services	1000–1650	90	2	High yielding, large seed

Table 3. Bean production zones in Malawi[1].

Bean production zone	Agroecological conditions	Bean area (ha)	Dominant varieties
High altitude (districts: Chitipa, Livingstonia, Viphya, Dedza)	Subhumid, >1500 m amsl, >400 mm of unimodal rainfall and acid soils	124,971	Kholophethe, Kalima
Mid altitude (districts: Mzimba, Lilongwe, Dowa, Nmawera, Shire)	Subhumid 1000–1500 m amsl, >400 mm, unimodal rainfall	114,198	Muluwa, Napilira
Low altitude (Lake Basin, Phalombe)	<1000 m amsl, unimodal rainfall	26,158	Kabulengeti, Kayela

1. Source: Adapted from Wortmann et al. (1998) and updated for bean area and dominant varieties.

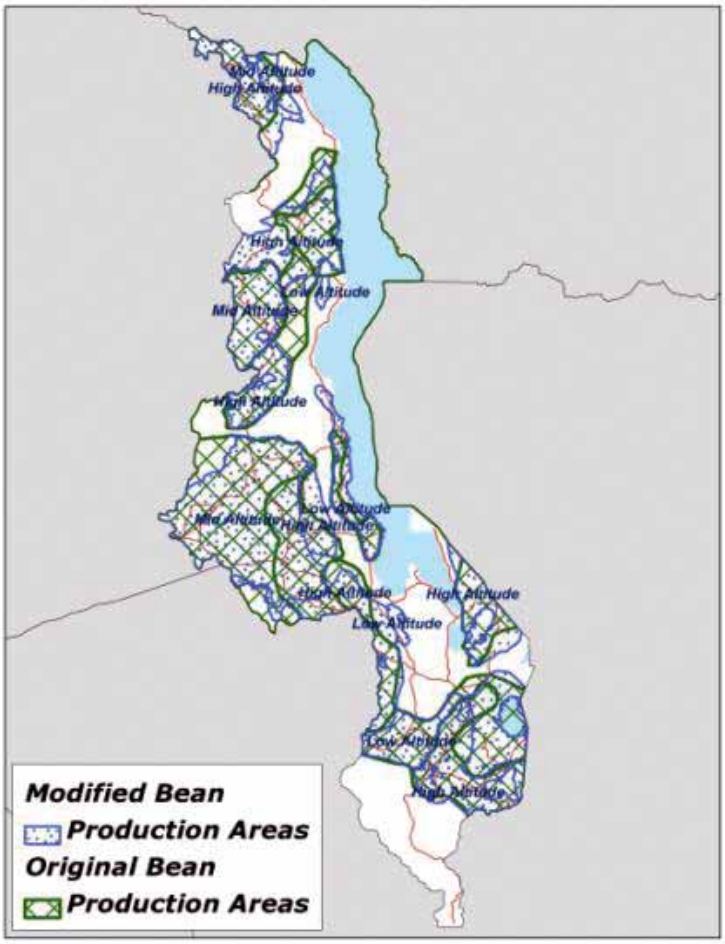

Figure 1. A map of the bean production zones of Malawi showing "original" (estimated in 1998) and current ("modified") areas.

production zones. Along the lakeshores and in the Shire Valley, beans are less cultivated because the crop is not adapted to these areas.

Farmers and consumers prefer bean varieties based on seed size, color, taste and cooking time. The commonly preferred varieties are the large-seeded, red or red speckled in color and the sugar (cream striped) types. Common varieties include Phalombe (local variety), Kholophethe (Sugar 131), Maluwa (CAL 113) and Napilira (CAL 143). The importance of these varieties across the agroecological zones is indicated in Table 3.

Seed systems

Opportunities

- Extension of small pack strategy
- Engaging diverse partners for production of foundation and certified seeds
- Strengthening of breeder seed production

Constraints

- Unavailability of improved varieties
- High input costs

Strategic partnerships and roles

Partners will be involved to enhance organization of proper target groups in the targeted areas and to popularize improved high-yielding bean varieties with acceptable end-user traits and associated improved bean production technologies. Partners and their roles are presented in Table 4.

Table 4. Key partners in the bean value chain and their roles.

Partner	Role
Department of Agricultural Research Services	Variety development, evaluation and release; production of breeder and foundation seeds; develop integrated crop management technologies
Seed companies – Seed Co, Pannar	Facilitate processing and commercialization of bean seed and products
Farmers organization/associations (ASSMAG, GALA)	Capacitate farmers formation of associations for collective production and marketing seed systems support, help collaborating NGOs and CBOs with quality seed production and monitoring
NGOs – CRS, CARE World Vision	Provision of guidance in crop production technologies and associated packages
CGIAR center – CIAT	Provide improved bean germplasm/breeding populations; capacity building through training; research on effective methods for technology dissemination
Seed trade association of Malawi – Demeter, Peacock	Support to farming communities to impart knowledge and skills for increased on-farm production; facilitate farmer friendly agricultural policy advocacy
Farmers	End-users of technologies in terms of high-yielding varieties and management practices
Department of Crop Development Planning and Extension	Support to farmer field schools to impart knowledge and skills for increased production on-farm

Seed production plan

Total bean area in Malawi is estimated at 225,000 ha, of which 40% or 90,000 ha is targeted. At a seed rate of 80 kg ha^{-1}, this will require 7,200 tons. The goal yield is 1 t ha^{-1}, for a national production of 225,000 tons, and these estimates have been used to develop the bean seed roadmap (Table 5).

Table 5. Seed production system plan to reach 40% adoption by 2015.

Agroecology	Area (%)	Variety	Seed rate (kg ha^{-1})	Productivity (t ha^{-1})	Area (ha)	Target area (40%)	Breeder seed (2013)		Foundation seed (2014)		Certified seed (2015)	
							Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
High altitude	10	Napilira	80	1.5	22500	9000	5	5	58	58	720	720
	30	Kholophethe	80	1.5	67500	27000	14	14	173	173	2160	2160
	15	VTTT 924/4-4	80	1.5	33750	13500	7	7	86	86	1080	1080
	5	Kabalabala	80	1.5	11250	4500	2	2	29	29	360	360
	5	KK 112	80	1.5	11250	4500	2	2	29	29	360	360
	5	KK 68	80	1.5	11250	4500	2	2	29	29	360	360
	5	KK 168	80	1.5	11250	4500	2	2	29	29	360	360
	5	Maluwa	80	1.5	11250	4500	2	2	29	29	360	360
Medium altitude	5	NUA 45	80	1.5	11250	4500	2	2	29	29	360	360
	5	NUA 59	80	1.5	11250	4500	2	2	29	29	360	360
	5	Ser 45	65	2	11250	4500	2	2	29	29	360	360
	5	Ser 85	65	2	11250	4500	2	2	29	29	360	360
Total					225000	90000	46	46	576	576	7200	7200

Pigeonpea

Geoffrey Kananji, Ganga Rao and Said Silim

Introduction

Pigeonpea is the most versatile grain legume grown by smallholder farmers in Malawi for both local consumption and export. It ranks as the third most important legume crop after groundnut and beans. The crop is now planted on 196,516 ha producing about 216,716 tons per year during 2010 to 2012 (Ministry of Agriculture, crop estimates data, 2012) having increased from 78,000 tons per year during 1991 to 2006. These statistics clearly show that there is a great potential to increase production and expand area of pigeonpea in Malawi. Although the crop is now grown in all the agricultural development divisions (ADDs), Blantyre and Machinga ADDs remain major growing areas accounting for more than 90% of the total area planted to pigeonpea (Fig. 1). Farmers prefer growing pigeonpea either as an intercrop or pure stand because it provides food at the time when all the other legumes have been harvested from the field. It provides cash to the farmers and it is one of those legumes that can be produced with fewer inputs. Available estimates indicate that 65% of the pigeonpea produced is consumed on-farm, 25% is exported, while 10% is traded on the domestic markets. Pigeonpea also provides fodder/feed for livestock and has the potential to improve soil fertility. The plant is deep rooted and is adapted to withstand the intermittent or terminal droughts depending on the type of varieties grown.

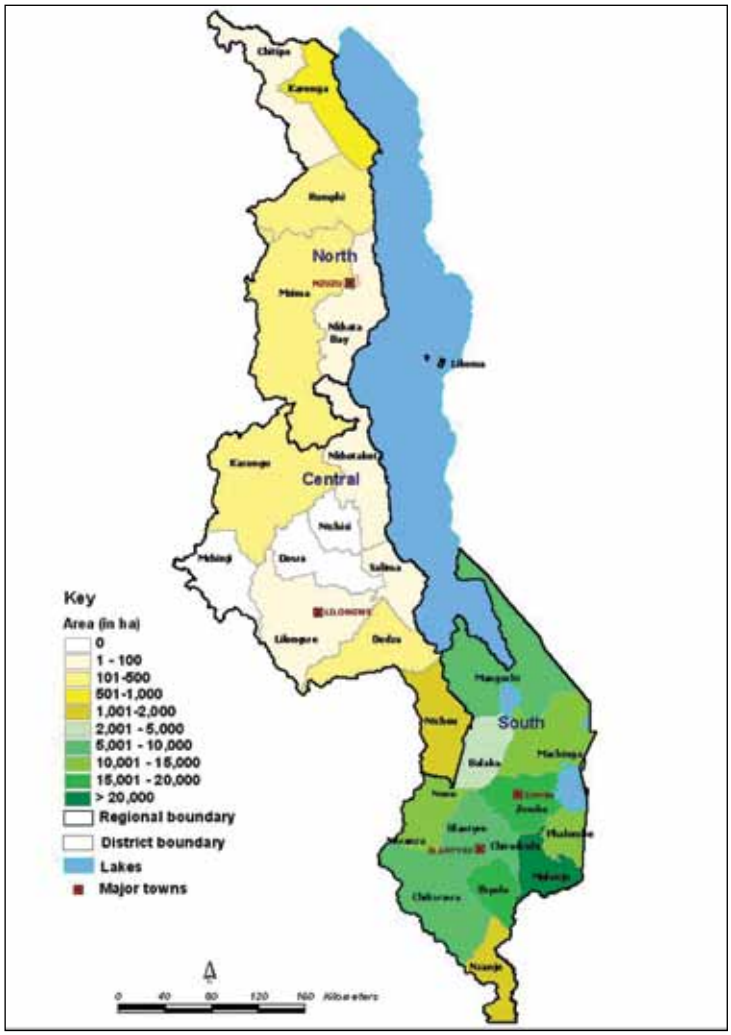

Figure 1. Area under pigeonpea production in Malawi.

Research and development

The pigeonpea improvement program has been working in partnership with ICRISAT to develop superior pigeonpea lines and evaluate them at national and regional multilocational sites for adaptability and acceptance of the new improved pigeonpea varieties. Historically, desirable traits in pigeonpea have been selected by farmers from landraces to suit their production systems and uses. ICRISAT along with the national programs in Malawi, has focused on developing short-, medium- and long-maturing pigeonpea varieties. Two short-, two medium- and two long-duration pigeonpea varieties have been released during 1987 to 2011 (Table 1). Although varieties released from these breeding programs have served the immediate need of farmers, major deficiencies still exist. There is an urgent call for national programs in partnership with ICRISAT to focus on breeding for insect pest resistance and resilience to effects of climate change.

Table 1. Pigeonpea varieties released and their characteristics.

Variety	Pedigree	Year of release	Special varietal attributes	Recommended agroecologies	Yield potential (kg ha^{-1})
Sauma	ICP 9145	1987	Long duration, fusarium wilt resistant	High altitude areas	1500
Kachangu	ICEAP 00040	2000	Long duration, large seeded, fusarium wilt resistant, easy to dehull	High altitude areas	2000
ICPL 87105	ICPL 87105	2003	Short duration, multiple cropping	Low to medium altitude areas	2000
ICPL 93027	ICPL 93027	2003	Short duration, multiple cropping	Low to medium altitude areas	2000
Mwaiwathualimi	ICEAP 00557	2010	Medium duration	Low to medium altitude areas	2500
ICEAP 01514/15	ICEAP 01514/15	2011	Medium duration, high yielding	Low to medium altitude areas	2500

Each of the released cultivars has economically important traits that make it attractive to smallholder farmers. Sauma and Kachangu are resistant to fusarium wilt and have high yield potential. The short-duration varieties are less tolerant to fusarium wilt but have an added advantage in that they can be consumed as grain as well as a vegetable. Their capacity to mature early also makes them more suited for the semi-arid regions and provides an opportunity for double cropping in regions with long or bimodal rainfall season.

Agroecologies of pigeonpea cultivation

Southern region of Malawi with Blantyre and Machinga ADDs is traditionally the major pigeonpea growing area accounting for 92% of the total pigeonpea area (Table 2), and contributing up to about 20% of farmers' income. Pigeonpea is widely grown as an intercrop with maize in southern Malawi, but it is mainly grown as a boundary marker in northern Malawi although lately pigeonpea has developed great potential in Karonga and Chitipa districts. In the central region, Salima, Kasungu, Lilongwe and Mchinji districts have seriously taken up cultivation of the medium-maturing varieties.

Dominant varieties

Over the years, six improved pigeonpea varieties (2 short, 2 medium and 2 long duration) were released in Malawi. They are: short-duration varieties ICPL 87105 and ICPL 93027; long-duration varieties ICP 9145 (Sauma) and ICEAP 00040 (Kachangu); and medium-duration varieties ICEAP 00557 (Mwaiwathualimi) and ICEAP 01514/15. Presently the popular varieties with farmers are ICP 9145, ICEAP 00040 and local landrace Mthawajuni. The medium-duration varieties ICEAP 00557 and

Table 2. Trends in pigeonpea area in major growing divisions in Malawi.

ADD	2008/09	2010/11	% change over 2 seasons
Southern region	164,502	192,457	14.5
Blantyre	108,245	127,263	14.9
Machinga	46,829	53,390	12.3
Shire Valley	9,428	11,804	20.1
Central region	2,583	3,165	18.4
Lilongwe	2,343	2,768	15.4
Kasungu	148	142	–4.2
Salima	92	255	63.9
Northern region	702	894	21.5
Karonga	483	628	23.1
Mzuzu	219	266	17.7
Grand total	167,787	196,516	14.6

ICEAP 01514/15 which were released through TL-II Phase 1 are spreading very fast in all pigeonpea agroecologies (the three regions of the country).

Seed systems

In Malawi, lack of awareness and limited or no access to quality seed is attributed to consistent failure of public sector in supplying good quality breeder/foundation seed in desired quantities. The private sector has shown little interest in investing in pigeonpea seed production and marketing. Most often seed production areas are far away from its area of utilization because of isolation requirements and availability of infrastructure for storage and processing leading to high transaction seed costs. Through this project selective investments have been made to overcome these constraints in breeder and foundation seed production, and seed sale proceeds used to create seed revolving funds especially in Malawi (ICRISAT model) for future use.

Private seed companies and NGOs took the lead in acquiring foundation seed for further seed increase and dissemination. Most of the farmers rely on own-saved seed and access to seed of improved varieties through informal networks. The baseline survey also points out existence of two seed supply systems, namely informal, which are usually non-market based and the quasi-formal, mainly market-based seed supply systems. The informal seed supply sources included own-saved seed, gifts from family and friends, farmer-to-farmer seed exchanges and others. The importance of quasi-formal system seems to increase with formal release of new farmer- and market-preferred varieties, which helps in augmentation of seed demand and seed markets for superior varieties.

Seed production target

Total area: 196,516 ha

Seed rate (mean): 10 kg ha^{-1}

National seed demand: 1965 tons (2012–14) to cover 196,516 ha

Capacity to deliver 25% of total area: 49,200 ha

Total seed required to cover targeted area of 49,200 ha: 580 tons

Opportunities, constraints and partnerships

The target is to produce seed required to cover 25% of area.

Opportunities

- Pigeonpea is one of the crops included in Malawi government's input subsidy scheme and is also in the Presidential Initiative for poverty and hunger reduction. It is considered a strategic crop that can contribute towards the economic recovery program plan for the Malawi government. These programs require substantial amount of good quality pigeonpea seed.
- Expansion into new areas in central and northern regions after release of two medium-duration varieties
- Policy environment that enhances innovative seed system
- Availability of suitable varieties for different agroecologies and high demand for quality seed

Challenges/constraints

- Insect pests and poor crop management practices
- Fusarium wilt and cercospora leaf spot
- Lack of knowledge on pigeonpea use in non-traditional potential areas
- Lack of organized markets
- Seed accessibility issues
- Limited technical know-how by frontline extension staff
- Terminal droughts where farmers use local varieties

Partners

The strategic partners and their roles are given in Table 3.

Seed production plan

The seed production plan for Malawi is given in Tables 4 and 5.

Vision of success

Pigeonpea area is increasing and with the release of medium-duration varieties the crop is spreading into parts of central and northern regions of Malawi. Low seed rate and high multiplication ratio are the major advantages of pigeonpea. The revolving seed scheme has been successfully implemented in Malawi by ICRISAT in close collaboration with various stakeholders including NASFAM. Farmers have seen the production potential of the new set of varieties and they are already reaping yields of more than 1 t ha^{-1}. With the development of vibrant seed production strategy and ever growing demand for pigeonpea from Asian markets, there will definitely be good growth of pigeonpea sub-sector in Malawi.

Table 3. Strategic partners and their roles.

Partner	Role
Department of Agricultural Research Services, Ministry of Agriculture and Food Security	Variety development, evaluation and release; production of breeder and foundation seed
ICRISAT	Provide improved pigeonpea germplasm/breeding populations; capacity building through training; research on effective methods for technology dissemination
Seed Services-Malawi	Seed systems support, help collaborating NGOs and CBOs with quality seed production and monitoring
Department of Crop Production, Ministry of Agriculture and Food Security	Provision of guidance in crop production technologies and associated packages
National Smallholder Farmers' Association of Malawi (NASFAM)	Capacitate farmers formation of associations for collective production and marketing
CARE-Malawi or Plan-Malawi	Support to farmer field schools to impart knowledge and skills for increased production on-farm
Farmers	End-users of technologies in terms of high-yielding varieties and management practices
Agro-processors (Export Trading, Grain Traders & Processors Association)	Marketing and value-addition
Seed Traders Association of Malawi	Coordination of pigeonpea seed trade to ensure quality delivery
Legume Platform (Legumes Development Trust)	Promote production and marketing of pigeonpea

Table 4. Pigeonpea seed roadmap for Malawi.

Ecology (Zone)	Total demand (ha)	Promising varieties	On-farm yield potential (t ha^{-1})	Seed rate (kg ha^{-1})	Area (ha) to be covered for 25% adoption		Breeder seed in 2012		Foundation seed in 2013		Certified seed in 2014		Seed required to reach 25% adoption (t)
					Total	Per variety	Area (m^2)	Production (kg)	Area (ha)	Production (t)	Area (ha)	Production (t)	
Southern	192,457	4			48,100		630	63	6	6	566	566	566
	67,340	Mwaiwathualimi	1	10		16,835	220	22	2.1	2.1	198	198	198
	67,340	ICEAP 01514/15	1	10		16,835	220	22	2.1	2.1	198	198	198
	38,480	Kachangu	1	10		9,620	130	13	1.2	1.2	113	113	113
	19,240	Sauma	1	10		4,810	60	6	0.6	0.6	57	57	57
Central	3,165	2			800		10	1	0.1	0.1	10	10	10
	1600	Mwaiwathualimi	1	10		400	5	0.5	0.05	0.05	5	5	5
	1600	ICEAP 01514/15	1	10		400	5	0.5	0.05	0.05	5	5	5
Northern	894	2			300		4	0.4	0.04	0.04	4	4	4
	450	Mwaiwathualimi	1	10		150	2	0.2	0.02	0.02	2	2	2
	450	ICEAP 01514/15	1	10		150	2	0.2	0.02	0.02	2	2	2
Total	196,516				49,200	49,200	644	64.4	6.14	6.14	580	580	580

Table 5. Certified seed production (t) plan over three years.

Variety	2012	2013	2014
Mwaiwathualimi	31.25	50.75	123
ICEAP 01514/15	31.25	50.75	123
Kachangu	17	28	68
Sauma	9	14	34
Total	88.5	143.5	348

Soybean

Geoffrey Kananji, Francis Maideni and Hesham Agrama

Importance of soybean in Malawi

Soybean (*Glycine max*) is an important legume crop in Malawi as a source of high quality protein for both human and animal nutrition. The typical smallholder farming system in Malawi is based on maize production. Intercropped with maize, soybean provides a strategy for crop diversification, food security and soil fertility replenishment. Increased maize productivity from most of the depleted cultivated soils managed by the smallholder farmer, demands the use of inorganic fertilizers which are costly, surpassing an average farmer's purchasing power. Soybean constitutes an important component of the smallholder cropping systems and holds considerable potential for arresting soil fertility decline, enhancing household nutrition security as a cheap source of essential protein and minerals, raising rural incomes as an important cash crop, and reducing poverty. Use of soybeans in the smallholder farming systems, provides a potential technological option to improve soil fertility for Malawian farmers.

Nutritionally, soybean is very rich in protein and can therefore be utilized to combat severe nutrition deficiency and enhance household food security. In malnourished children, especially under the age of five, provision of highly nutritious baby foods made from soybean can be a better option to combat such nutritional deficiency problems. Soybean is the only grain legume that contains 40% protein and 20% unsaturated fat very much desirable for human nutrition. In addition to nutritious weaning foods, whole soybeans can form important ingredients in recipes for preparing adult meals. This provides an important benefit to the relatively carbohydrate maize-based Malawian diets. Soybean also serves as an alternative source of cash in those areas where groundnut pops is a problem. The crop is well adapted to a range of agroecologies and unlike beans and pigeonpea very few insect pests attack soybean to significantly affect their potential yield. Soybean therefore has an important role to play in establishing household food security in Malawi.

Soybean can help to halt the precipitous decline in soil fertility. In Malawi, the declining agricultural productivity especially of crops like maize is largely due to soil fertility depletion. The benefits of including grain legumes such as soybeans, in rotation with maize, have been verified. Promiscuous soybean varieties remain green for an extended period of time enabling the crop to fix more nitrogen in the soil. Self-nodulating soybean varieties reportedly add approximately 20 kg nitrogen per hectare per season. This is added benefit to the farmer considering that inorganic fertilizers are untimely available and if available are very expensive. Increased soybean production can therefore help to overcome serious problems of malnutrition, address loss of soil fertility and reduce rural and urban poverty.

Soybean can help mitigate worsening rural poverty. Besides improving soil fertility, soybean intercropped with maize or grown in pure stand also provides a supplementary source of income to smallholder farmers especially rural women. Domestic demand for soybean by the processing agro-industries is high. A number of factors have now generated fresh and growing demands for soybean – for export to the regional markets and for domestic processing to meet the rising domestic demand for soybean meal and soybean oil.

History of soybean research and development in Malawi

Soybean is not a new crop in Malawi. Reports by the Ministry of Agriculture and Food Security indicate that this crop has been grown in Malawi since 1909. It was being grown as a minor crop in association with *tung*. When varietal and agronomic research work was conducted on the crop, some useful

information was generated that made soybean to be a more important crop. Research work conducted on soybean has shown that the crop is well adapted for production in all agroecological zones in Malawi. Key studies on agronomic practices have been done. Full-fledged and focused research program on soybean was done in the 1980s leading to release of improved varieties such as Impala, Kudu, Geduld, Bossier, Hernon 147, Hardee, etc. However, these varieties had short shelf life, high rate of shattering and were not attractive to the processors. Efforts were therefore required to develop new soybean varieties that were high yielding with acceptable characteristics by the processors such as cream/white hilum and large seed size.

In partnership with several local and international institutions such as INSOY, AVRDC, IITA and Seed Co the above soybean varieties as well as those currently in the market were developed. New improved varieties under commercial production include Makwacha, Nasoko, Ocepara-4, Soprano, Solitaire, Squire and Tikolore. Specific varietal attributes for each of the varieties including their recommended agroecologies are presented in Table 1.

Table 1. Characteristics of soybean varieties currently grown in Malawi.

Variety	Source of material	Year of release	Special varietal attributes	Recommended agroecologies	Yield potential (kg ha^{-1})
Makwacha	Zimbabwe	2003	Cream/white hilum, large seed size	Medium to high altitude areas	3000
Nasoko	Zimbabwe	2002	Cream/white hilum, large seed size	Medium to high altitude areas	3000
Ocepara-4	USA	1993	Nematode resistant	Medium altitude areas	2500
Tikolore	IITA	2011	Early maturing	Low, medium and high altitude areas	2500
Solitaire	Seed Co-Malawi	2003	High yielding, tolerant to frogeye	Widely adapted to most agroecologies	3000
Soprano	Seed Co-Malawi	2003	High yielding, tolerant to frogeye	Medium to high altitude areas	3000

Soybean production trends in Malawi

Research results show that soybeans are well adapted for production in all agroecological zones in Malawi. Soybean yields are still low as farmers obtain 40% less (800 kg ha^{-1}) on average than the potential yield of 2000–2500 kg ha^{-1}. This however, is an increase in yield from 600 kg ha^{-1} which is attributed to efforts made to develop and promote use of new high-yielding soybean varieties currently grown by farmers in Malawi over the last six years.

Increased production through area expansion may not be possible in most parts of the country because of population pressure on the land; development of improved varieties with preferred market traits therefore remains a viable pathway to achieve increased soybean production and productivity. Soybean production in Malawi has fluctuated over the years (Table 2) largely due to poor farm-gate prices offered to farmers and other production challenges/constraints.

Table 2. Soybean production in Malawi during 2002–12.

Year	Area (ha)	Production (t)	Yield (kg ha^{-1})
2002	45428	29568	651
2003	53579	40889	763
2004	47128	33758	716
2005	68524	40396	590
2006	71652	55248	771
2007	79465	71295	897
2008	73942	64489	872
2009	82217	79615	968
2010	70654	67873	961
2011	70955	69596	982
2012 (R2)[1]	96950	99980	970
Average	76050	65271	914

1. R2 means second round crop estimates made at vegetative stage of plant growth; R3 estimates are more accurate.

Seed production target

Average production: 65,271 tons (2012 national data)

National demand: 111,000 tons

Expected growth in demand: 4.6% per year

National projected demand in 2015: 139,000 tons

Proportion of production sold commercially: >85%

Dominant varieties: Makwacha, Solitaire, Nasoko, Soprano and Ocepara-4

Malawi is agroecologically divided into eight agricultural development divisions (ADDs). Five main landforms are evident in most of these agroecologies: Highlands, Escarpments, Plateau, Lakeshore, Upper Shire Valley and the Lower Shire Valley. The Plateau represents three quarters of Malawi at elevations of 750–1300 m amsl. Although the major soybean production districts are concentrated in the Plateau, soybean virtually grows well in all ADDs. However, taking into account production and hectarage of the eight ADDs, Kasungu, Lilongwe and Mzuzu produce more soybeans and together represent approximately 91% of the total area (Table 3).

Table 3. Main soybean production sites in Malawi[1].

ADD	Area (ha)	Production (t)	Yield (kg ha^{-1})
Kasungu	29,414	33,729	872
Lilongwe	26,780	24,805	1080
Mzuzu	8,410	7,044	1194

1. Based on 2011 national data, Ministry of Agriculture, Food Security and Water Development.

Seed system

Key constraints to soybean production

- Soybean rust and other diseases
- Drought (terminal and low moisture stress)
- Poor soil fertility (low phosphorus)
- Leaf-eating caterpillars and leaf rollers
- Limited access to seed of improved varieties and other inputs such as fungicides
- Poor market access (infrastructure), price volatility and lack of organized markets
- Weak extension services
- Poor crop management practices
- Lack of knowledge on soybean processing and utilization
- Low farm-gate prices and unpredictable demand

Opportunities for increased soybean production

- High demand for soybean due to expansion of the poultry and fish industry in Malawi
- Private sector interest, especially processors to support and enhance soybean production to meet local demand
- Availability of suitable varieties adaptable to almost all agroecological zones
- Formation of the Soybean Association of Malawi that is equipped to drive the soybean industry

Key partners

The key partners and their roles are given in Table 4.

Capacity building needs (staff, infrastructure)

- Postgraduate training in the areas of breeding and pathology is needed (only one PhD level staff available to work on many legumes)
- Short-term training for research technicians in specialized areas
- Inoculant production lab requires equipment to improve its quality
- A legume entomologist is also required to look at entomological aspects of all legumes
- Research technicians in various research centers also need on the job short-term training. There is need for infrastructure upgrading such as improving irrigation facilities, upgrading the inoculant production facility and infrastructure for seed increase and long-term seed storage; also vehicles for field work are necessary for Malawi NARS.

Table 4. Key partners along the soybean value chain and their roles.

Partner	Role
IITA-Malawi	Soybean breeding, variety development, technical backstopping and training
Ministry of Agriculture and Food Security	Agricultural policies
Department of Agricultural Research Services (DARS)	Research on varietal development
Bunda College of Agriculture	Research and training
National Smallholder Farmer's Association of Malawi (NASFAM)	Production of quality declared seeds and linking farmers to markets
Association of Smallholder Seed Multiplication Action Group (ASSMAG)	Farmer owned and controlled rural seed production and marketing organization
Department of Agricultural Extension Services (DAES)	Extension of technologies
Seed Co-Malawi (private seed company)	Production and marketing of seeds
Central Poultry Feeds (CP Feeds) and Rab Processors	Buy soybean grain from farmers, process soybeans into human food and animal feed
Soybean Association of Malawi (SOYAMA)	Address soybean trading and marketing issues as well as lobby financing institutions to support the soybean industry
Grain Legumes Development and Marketing	Enhance production and marketing of legumes
Department of Crop Development	Provide guidance in crop production

Special cultural/gender considerations

Women's role in soybean production, processing and utilization is high.

Processing and storage requirements and market opportunities

- Unlike other legumes, soybean can be stored without insect damage.
- Depending on storage conditions, soybean loses viability very fast and with respect to seed, this can be costly as replanting becomes inevitable.
- Farmers need to be trained in processing of this crop for household consumption as well as small-scale processing to generate income.
- There are large-scale processors like Export Trading Company, Central Poultry Feeds (CP Feeds) and Rab Processors who buy grains from farmers to produce human food (such as maize–soy blend, weaning baby food), feed for livestock and cooking vegetable oil.
- Although there is market farmers need to be linked with processors for mutual benefits with trust. Farmers need to be organized into groups to collect their produce and have bargaining power in marketing soybean grains.

Key policies (recently implemented/needed)

- The Government of Malawi has included soybean seed subsidy program to promote its production since 2007/08 season.

- The Presidential initiative on promotion of grain legumes (soybean, groundnut, pigeonpea and beans) production and marketing is aimed at doubling legume production in the country thereby generating income for farmers and also forex for the country.
- Malawi has developed the "Greenbelt Initiative" concept with the aim of increasing production and productivity of agricultural crops, livestock and fish farming both inland and along the shores of Lake Malawi and the banks of the Shire River through the development of small-scale and large-scale irrigation schemes.
- Protectionist trade policy measures intended for protecting the poultry industry – import quota for poultry meat – have resulted in a substantial increase in demand for soybeans primarily to supply the feed industry, with positive prospects for edible oil. This change in trade policy encouraged the rapid growth of the local feed industry, with increased derived demand for soybean and soybean cake.
- The private sector has established the Soybean Association of Malawi which is likely to drive production and use of soybean locally.
- The stakeholders in the entire legume value chain in partnership with the government of Malawi have also formed "Grain Legumes Development and Marketing Association" aimed at massively increased production and marketing of legumes in Malawi.

Key issues for competitiveness (reducing production costs, increase market value)

- Raising yields (high yield potential, improved crop management, etc) to reduce per unit production cost. Indeed, increasing the productivity of the crop per unit area is key to reducing cost of production and enhancing competitiveness. Seeds of improved varieties with good agronomic management practices and other inputs like P fertilizer and inoculants are key to enhancing productivity.
- Producer capacity strengthening as well as producer organization for meeting quality standards and reducing transaction costs through group marketing activities.

Mechanization as it relates to timely planting/harvesting and processing

- Since all agricultural operations of small-scale farmers are by hand hoe, it will definitely improve efficiency and productivity if there is some level of mechanization.
- Availability of rented tractors for plowing and small combiners for threshing could be desirable.
- Availability of soybean processing equipment such as Vitagoat and oil pressers would be desirable to start small-scale businesses by household, particularly women.

Environmental/sustainability issues

- Promoting soybean production has beneficial effect on the environment.
- Soybean cultivation has a paramount effect in reversing land and soil degradation due to cereal monoculture.
- Yield of cereal crops like maize increases when grown after soybean in rotation due to residual N availability either from the roots, fallen plant parts of soybean or nitrate-sparing effect.
- Increased soybean production will help to improve soils in Malawi in a more sustainable and natural way where up to 90% of the farmland is allocated for maize culture.

- Using soybean in the farming systems would help reduce dependence on mineral N fertilizer for maize, which reduces cost of production for farmers.
- Soybean is also known to reduce *Striga* seed bank from the soil, which helps to increase yield of subsequent cereals.

Monitoring and evaluation component

- Annual sub-regional review and planning meetings
- Half-yearly and annual reports
- Monitoring visits during the cropping season
- Farmers–scientist–extension staff interaction meetings to assess impact
- Annual Department Review and Monitoring Programs

Seed production plan

Seed production plan for soybean in Malawi is given in Table 5.

Table 5. Seed production plan and total demand for soybean by 2014.

					Breeder seed		Foundation seed		Certified seed	
Agroecology	Area (%)	Variety	Area (ha)	Production (t) for 40% target area	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
Potential: Mid	100		83000	33200	5	8	94	142	1771	2656
	40	Makwacha	33200	13280	2	3	38	57	708	1062
	40	Tikolore	33200	13280	2	3	38	57	708	1062
	15	Ocepara-1	12450	4980	1	1	14	21	266	398
	5	Nasoko	4150	1660	0.3	0.4	4.7	7.1	88.5	133

Target average yield by 2015

Targeting an adoption rate of 20% and employing strategies to promote use of new improved soybean varieties through demonstrations, field days and the media, it is envisaged that average production of 1,500 kg ha^{-1} can be achieved.

Mozambique

Groundnut

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Importance of the crop to Mozambique's economy

Production

Groundnut occupies the largest area among the grain legumes; it is ranked the fourth most important crop after cassava, maize and sweet potato. About 99% of the area under groundnut is cultivated by small-scale peasant farmers on traditional farms and the crop is important both as a subsistence food crop as well as a source of cash (Diop et al. 2003). The oilseeds sector in Mozambique has been expanding, especially through the interventions of various NGOs, principally in Manica, Zambezia and Nampula (Diagnostic Integration Trade 2004). In Mozambique, markets for diverse crops such as legumes especially groundnut are limited to local or provincial outlets (Bias and Donovan 2003). Indeed groundnut has an important marketing channel from the northern to the southern provinces of Mozambique.

Economic importance

Mozambique has a total area of 789800 km^2, with approximately 45% of the country considered suitable for agriculture. The population of Mozambique is expanding rapidly from 21 million people in 2007 to an estimated 28 million in 2020; hence agricultural productivity must accelerate in order to improve rural incomes and satisfy the growing demand for food in both rural and urban areas. Among the most important legumes cultivated in Mozambique, groundnut occupies 42% of the total area (Table 1). Agriculture accounts for 22% of the gross domestic product (GDP) and provides employment for 81% of labor force. Mozambique's agricultural sector has steadily grown over the last decade with recent data showing that during 2000 to 2011 the sector grew at an average rate of 8.4% per year (World Bank 2012). Groundnut makes a significant contribution to GDP and has in the postwar period been targeted as one of the growth poles for improving livelihoods of the vast majority of Mozambique's populations (USAID 2002). Due to its pivotal place in food security groundnut has been prioritized for investments in the country.

Table 1. Relative importance of the different grain legumes grown in Mozambique.

Crop	Area (ha)	% of total area of the main legumes
Groundnut	315,000	42
Pigeonpea	190,000	25
Cowpea	126,000	17
Common bean	106,000	14
Soybean	15,000	2
Total	752,000	100

Research and development

During the civil war in Mozambique, research and development (R&D) was similarly affected. Before 1975, research on legumes was neglected in Mozambique. However, prior to the war during colonial times R&D was conducted on legumes. The main focus of R&D at that time was variety selection and postharvest control.

After 1975, research on groundnut was carried out at the Instituto Nacional de Investigacao Agronomica (INIA). Research efforts at INIA resulted in development of some improved groundnut production technologies in the country (Ramanaiah et al. 1988). During the prolonged civil war, much of the country's infrastructure and expertise in research was debilitated to a great extent. As a result, valuable genetic resources were lost forever. The strategy used to overcome this constraint was emphasis on capacity building, collection of local landraces and introduction of improved groundnut varieties generated by ICRISAT. The current average yield of groundnut is very low, with a nation-wide mean of about 450 kg ha^{-1}, which is one of the lowest in the world. The dominant varieties are Bebiano Branco, Mamane and Nametil. The target is to move from 450 to 850 kg ha^{-1} in 2015. Most recently new groundnut varieties were released, with good traits for farmers' use. The new varieties are: ICGV-SM 99541, ICGV-SM 99568, ICGV-SM 01513, ICGV-SM 01514, JL 24 and CG 7 (Table 2).

Table 2. Major characteristics of the new groundnut varieties.

Variety (kg ha^{-1})	Type	Yield (kg ha^{-1})	100-seed weight (g)	Seed color	Disease resistance[1]	Annual rainfall (mm)
ICGV-SM 99541	Spanish	3,000	25	Tan	Rosette	600–800
ICGV-SM 99568	Spanish	2,000	25	Tan	Rosette	600–800
ICGV-SM 01513	Spanish	3,000	25	Tan	ELS, LLS	600–800
ICGV-SM 01514	Spanish	3,000	25	Tan	ELS, LLS	600–800
CG 7	Virginia	2,800	52	Red		>800
JL 24	Spanish	2,500	25	Tan		600–800

1. ELS = Early leaf spot; LLS = Late leaf spot.

There is distinct difference between groundnut production in the northern and the southern regions of Mozambique. In the South, small-seeded groundnut (Spanish type) is popular while in the North a large proportion of the area is allocated to the planting of the large-seeded groundnut (Virginia, runner type) (Table 3).

Table 3. Differences between the two most important groundnut growing regions in Mozambique.

Description	South	North
Objective of production	Food (Family)	Market
Characteristics of the varieties	Short duration (90–120 days)	Medium–long duration (120–180 days)
	Small grain	Large grain
	Erect plants	Semi-erect to prostrate plants
	Non-dormant seeds	Dormant seeds
	Low yield (200–300 kg ha^{-1})	High yield (500–700 kg ha^{-1})
	Spanish type	Virginia type
	Pure or intercropped with maize	Pure or intercropped with cassava

Major constraints to groundnut production

Groundnut is grown by smallholder farmers, especially women farmers, under very low input conditions, without any fertilizers and pesticides, largely as mixed crop with bambara groundnut, cowpea, cassava, maize and sorghum. Groundnut yield in Mozambique is relatively low and can easily be doubled through adoption of varieties resistant to the most common diseases in most of tropical Africa, ie, rosette, rust and leaf spots (Ndunguru et al. 1994, Naidu et al. 1999) and by following basic cropping practices. Production constraints differ between the contrasting agroecologies. Other challenges include non-availability of improved varieties adapted to various production systems, lack of organized seed production and delivery systems, drought, poor soil fertility and cultural practices. Aflatoxin contamination is a serious quality problem of groundnut in Mozambique. Loss of international/ regional export markets is attributed to low quality of nuts due to aflatoxin contamination.

Planned Phase 2 activities and their contribution to national efforts

TL-II project aims to increase the productivity and production of six major grain legumes: chickpea, common bean, cowpea, groundnut, pigeonpea and soybean. For this particular strategy the focus is on groundnut particularly Objective 2. The aim is to improve availability and access of improved seed by Mozambique farmers and the particular activities are outlined below:

1. Continue introduction of farmer- and market-preferred varieties with resistance/tolerance to major biotic and abiotic stresses.
2. Develop a sustainable seed systems model (both community-based and medium-scale private producers) for the newly released varieties.
3. Popularize new and high-yielding varieties.
4. Introduce good agronomic practices in groundnut producing areas.

Project results: The expected outcomes and outputs

Vision of success for groundnut in Mozambique

Promotion and wide adoption of improved groundnut varieties will increase production and productivity which will ultimately lead to improved household food, nutrition and income security. Identification of key stakeholders and willingness of all the partners involved in the project coupled with the conducive environment for R&D will make this vision a reality.

Expected outcomes

The expected outcomes from the project will include but are not limited to: (i) increased farmers' groundnut productivity in various agroecological areas contributing to their improved overall food and nutrition security and household incomes; (ii) increased quantity and quality of groundnut produced, consumed and sold by farmer/communities and others (increase in household incomes); enhanced knowledge and skills of seed producers, NARS and other participating partners in decentralized,

farmer-led seed production and delivery system; (iii) increased access to and utilization of high-yielding groundnut varieties and information by a wide range of farmers/farming communities in the various agroecologies; (iv) stronger partnership and linkages forged among the key stakeholders for better sharing of available resources for wider coverage and dissemination of high-yielding groundnut varieties; and (v) increased social benefits resulting from change of attitude towards production of groundnut seeds and grain as profit making enterprise.

Expected outputs

The project is expected to generate a number of outputs including the establishment of a practical, functional and sustainable community-based, farmer-led seed enterprise; increased access by the farming communities and other stakeholders to high-yielding, improved varieties; increased knowledge and skills of stakeholders and intended beneficiaries in seed production (management and utilization), institutional and organizational development, and entrepreneurship and business skills; enhanced knowledge in establishing and supporting decentralized seed production and supply schemes; multiplication of adequate foundation/breeder seed of the improved high-yielding varieties that are accessible by the farmer groups for production of quality seeds and the establishment of pilot site platform for interactions among stakeholders to create strong and sustainable partnerships and linkages among stakeholders and allow for sharing of experiences on decentralized seed production and supply with other interested organizations.

Agroecologies for groundnut cultivation

The agroclimatic conditions in Mozambique allow growing a broad range of diverse crops (cereals, legumes, root and tubers, oilseeds, horticulture, fruit and others). Most of the groundnut are produced in the northern provinces of Nampula, Zambezia and Cabo Delgado and in the southern provinces of Inhambane, Gaza and Maputo. Shorter duration early-maturing cultivars are more popular in the south where it is relatively drier with erratic rainfall (≤600 mm per year). In the central and northern regions that receive more rainfall (800–1200 mm), medium to late-maturing varieties are grown. Groundnut is grown mostly as an intercrop or in rotation with maize, cassava, sorghum, millet and plantation crops. The rainfall patterns and agroecologies for groundnut production in Mozambique are presented in Figure 1. As indicated in the map, the crop is grown in almost throughout the country, but more than 70% is grown in north and central provinces of Nampula, Zambezia, Cabo Delgado and Niassa.

Seed systems for a groundnut green revolution in Mozambique

An effective seed production and delivery system is necessary to make good quality seed available to farmers at the right time and at low cost. In Mozambique, there is no formal groundnut seed production and supply system. Approximately 90% or more of the planting material used is from farmers' own-saved seed. Usually, the few seed companies operating in Mozambique prefer to produce and sell hybrid seed. Seed companies do not show interest in production of self-pollinated crops. Some constraints with farmers'-saved seed of groundnut are listed.

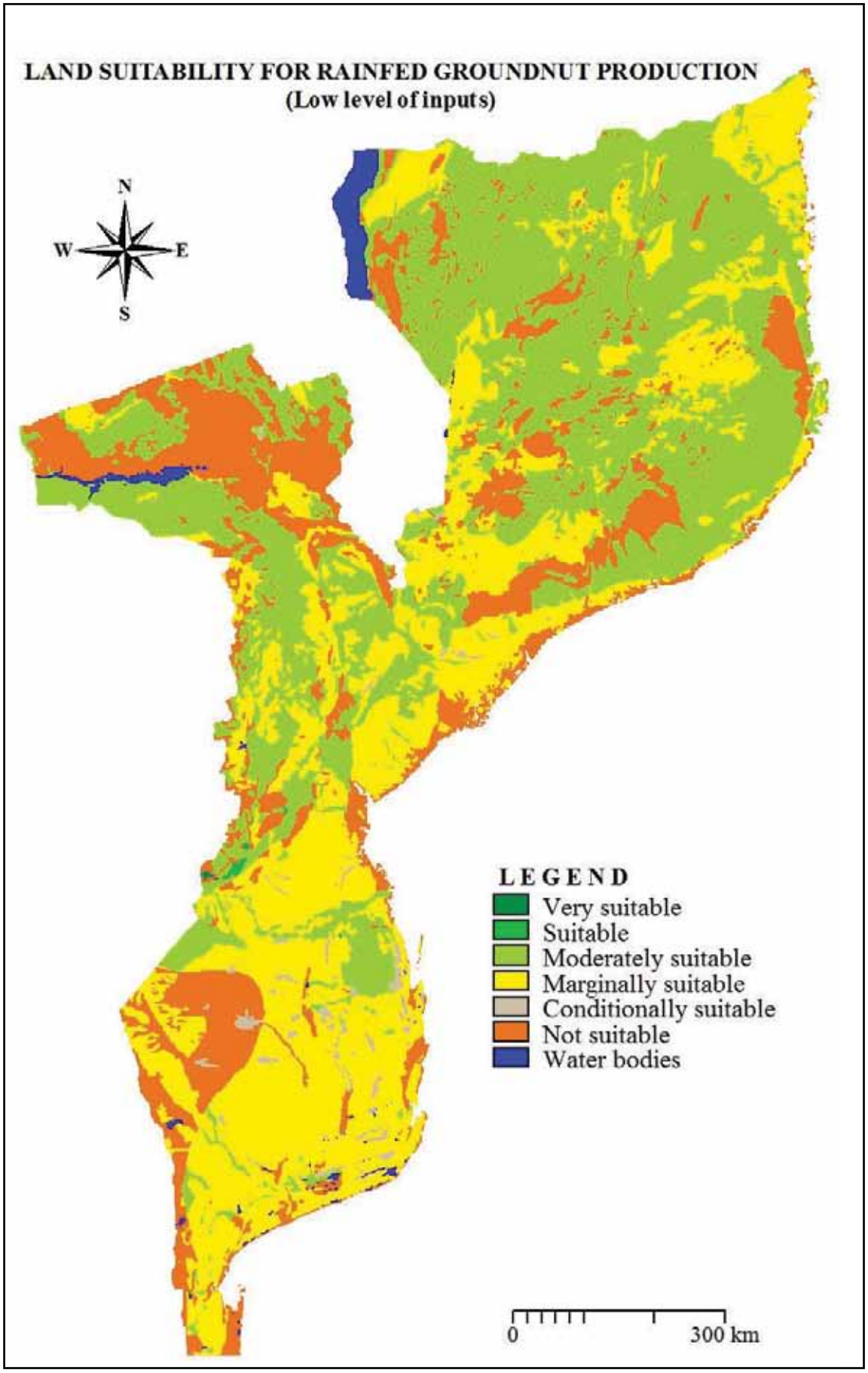

Figure 1. Land suitability for rainfed groundnut production in Mozambique.

- Groundnut seed is not stored for use in the following year due to the perceived threat of pod borer thus forcing the smallholder farmers to sell their produce and depend on external seed sources for the next crop.
- Recurrent use of own-saved seed for sowing results in lower returns to farmers.
- Lack of storage facilities and the non-awareness regarding opportunity cost to increase their incomes.
- Recurrent drought influence produces pods with shriveled kernels leading to inferior quality seeds.

For sustainability of seed production and distribution in Mozambique, it is important that the public research sector be linked with locally operating institutions, such as NGOs, extension services, farmers' associations and other community-based organizations (CBOs). For these interventions to be sustainable, they must be based on training and market development and not on direct government subsidies. During Phase 2 of the project, 20% of the current area will be planted with new improved and high-yielding varieties, with the participation of strategic partners.

Opportunities for assuring delivery of impact

The new strategic plan for agriculture development considers groundnut as one of the strategic crops for Mozambique, both for local consumption as well as for its contribution to the GDP through export. In terms of markets, in many areas local retailers and itinerant traders make up for the bulk of the marketed groundnut, which may then be linked to larger wholesalers and transporters with the responsibility of carrying the product to the final markets, mostly larger cites like Beira, in central Mozambique, and Maputo and other southern towns. Additionally, larger companies (like V & M wholesalers in Nampula) also buy, store and truck groundnut to the south. Sometimes groundnuts are shipped in containers by coastal shipping from Nacala to Beira and Maputo. In Nampula and Zambezia, supported by NGOs like CLUSA, AFRCARE and World Vision, a few farmer associations have been established and became involved in the production and marketing process of groundnut. The lessons learned and knowledge gained during the first phase of TL-II would be an important vehicle to introduce new and high-yielding varieties in major groundnut growing areas in the central northern parts of the country. IKURU, a business company partly owned by producers' associations of Nampula province and the south of Niassa, is promoting groundnut production and marketing.

Strategic partners and their roles

In addition the project will engage a number of partners both in R&D as well as in service delivery to promote use of improved seed in the project target areas. The partners available and their roles are listed in Table 4.

Seed production plan

The seed production plan for groundnut in Mozambique is given in Table 5.

Table 4. Strategic partners and their roles in seed systems.

Partner	Role
National Seed Services, Mozambique	Seed systems support, help collaborating NGOs and CBOs with quality seed production/monitoring
IIAM (Instituto Investigaçao Agraria de Moçambique)	Variety development, evaluation and release; production of breeder and foundation seeds
Department of Agricultural Extension Services	Provision of guidance in crop production technologies and associated packages
Farmers	Users
IKURU	Capacitate farmers formation of associations for collective production and marketing
ICRISAT	Provide improved groundnut germplasm; capacity building through training; research on effective methods for technology dissemination
Private sector (market intermediaries and emerging small-scale seed enterprises and processors)	Processing and commercialization of seed and products

Table 5. Seed delivery plan to cover the required area (20% of national area under groundnut).

Ecology	Demand (ha)	Promising variety	Seed required to reach 20% adoption (t)	Breeder seed 2012		Foundation seed 2013		Certified seed 2014		Certified seed 2015	
				Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
Semi-arid savanna (Nampula, part of Zambezia, Cabo Delgado and part of Niassa)	82,800	Nametil	1324.8	0.06	0.05	2.7	4.0	24.0	36	240.0	360
	55,200	ICGV-SM 01513	883.2	0.19	0.15	16.3	13.0	167.1	117	726.0	1089
	41,400	ICGV-SM 01514	662.4	0.06	0.05	5.0	4.0	51.4	36	240.0	360
	41,400	ICGV-SM 99568	662.4	0.19	0.15	16.3	13.0	167.1	117	726.0	1089
	55,200	JL 24	883.2	0.13	0.10	10.6	8.5	109.3	76.5	483.0	724.5
Tropical humid savanna (North of Zambezia, Tete and part of Niassa)	18,400	Mamane	294.4	0.06	0.05	5.0	4.0	51.4	36	240.0	360
	18,400	CG 7	294.4	0.19	0.15	16.3	13.0	167.1	117	726.0	1089
	9,200	Nametil	147.2	0.01	0.01	0.6	0.5	5.8	4.05	21.3	31.95
Semi-arid savanna (Inhambane, Gaza and Maputo)	55,200	ICGV-SM 99541	883.2	0.06	0.05	5.0	4.0	51.4	36	240.0	360
	41,400	ICGV-SM 99568	662.4	0.19	0.15	16.3	13.0	167.1	117	726.0	1089
	41,400	Nametil	662.4	0.01	0.01	1.3	1.0	12.9	9	21.3	31.95
Total	460,000		7360.0	1.14	0.91	95.1	77.95	974.8	701.6	4389.6	6584.4

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Cowpea

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Introduction

Importance of the crop in Mozambique

The population of Mozambique is expanding rapidly (from 21 million in 2007 to an estimated 28 million in 2020) and for this reason, agricultural productivity must be accelerated in order to improve rural income and satisfy the growing demand for food in both rural and urban areas. Cowpea is widely grown in Mozambique, mainly in warm regions, such as along the costal sand areas and in the lowlands. About 63,000 tons of cowpea is produced annually on 126,000 ha. The grains and tender leaves are eaten. The tender leaves are regularly picked and eaten as spinach. In many areas of the country, farmers grow spreading varieties, which are photosensitive, low grain yielding, but with high biomass which is harvested as vegetable over a long period. This situation can be attributed to the importance that farmers give to the leaves for their household consumption as well as for market. In many parts of the country the importance given to leaves is higher compared to grain. Cowpea provides considerable protein in the people's diet; hence it is often called "meat for poor people" since this protein is the cheapest. From production of this crop, rural families derive food, animal feed and cash together with spillover benefits to their farmlands. Cowpea is an important component of cropping systems in the drier regions and marginal areas of the country. In collaboration with the International Institute of Tropical Agriculture (IITA), the Instituto de Investigação Agrária de Moçambique (IIAM) is testing a range of improved cowpea breeding lines combining multiple disease and insect resistance, drought tolerance and dual-purpose trait with preferred seed types. Maize, cassava and sweet potato are the most common food crops cultivated in the country. Among the most important legumes cultivated in Mozambique, cowpea occupies 17% of the total area.

Cowpea's contribution to national GDP, farmer income, food and nutrition security

Agriculture accounts for 22% of the GDP and provides employment for 81% of labor force. Although the contribution of cowpea to GDP is fairly small, the importance of the crop in rural areas is quite significant. Cowpea is grown in almost all provinces, with Nampula and Zambezia provinces accounting for about 40% of the total cowpea production in the country. No figures are available on the per capita consumption of cowpea probably because it is the leaves that are mostly picked and consumed as vegetable than grains.

Research and development

Variety development

Before 1975, research on legumes was neglected in Mozambique. However, literature references indicate that there was some work conducted on groundnut (Source: Baptista 1934, Wilson 1944, Ferreira 1958) and beans (Carvalho 1970). The two crops were mainly for export to France, Portugal, the Netherlands and South Rhodesia (Source: Baptista 1934, Ferreira 1958). The main focus was variety selection and postharvest handling and storage. Also, it was mentioned that some work was done on organic fertilizer, using cowpea. Ferreira (1958) observed that cowpea was very important in the diet

of the local people and was daily consumed by the household. However, not much has been found in the literature on cowpea research in the country.

Cowpea research at IIAM started in 1982, with the technical assistance of FAO. Emphasis was given to collection of local germplasm. Later there was massive introduction of germplasm from IITA. These are characterized by different attributes such as dual-purpose, resistance to pests, extra-early maturing, resistance to *Striga* and *Alectra,* etc. An IITA selected dual-purpose (leaves and grain) variety IT 18 was released in 1994 (Table 1). This variety is still being grown by many farmers. Recently, the following varieties were released: IT 16, IT97K-1069-6 and IT00K-1263.

Table 1. Characteristic features of common cowpea varieties developed by the Mozambican research system.

Official name of release	Year of release	Source of the materials	Genetic background (parentage, pedigree, ancestry)	Area of potential coverage (ha)	Area of actual adoption estimate (ha)	Spillover national boundaries	Average yield potential on-farm (kg ha^{-1})	Varietal traits (selected characteristics)
IT 18	1994	IITA	IT82E-18	7,060	4,000	Yes	450	High yield
IT 16	2011	IITA	IT82E-16	21,180	8,000	Yes	400	Drought tolerance
IT 1069	2011	IITA	IT97K-1069-6	21,180	3,000	Yes	500	Better yield, drought tolerance and dual-purpose
IT 1263	2011	IITA	IT00K-1263	21,180	3,000	Yes	500	Better yield, drought tolerance and dual-purpose

Major constraints to cowpea production in Mozambique

The major constraints of cowpea production include social, biological, physical and technological environments. Accordingly the major constraints are:

- Biotic stresses: Insect pests (aphids, flower thrips, pod sucking bugs and bruchids), diseases (fungal, bacterial and viral), *Alectra*
- Abiotic stresses: Drought, heat, low soil fertility
- Lack of inputs and poor cultural practices
- Poor pricing and lack of facilities for long-term storage

Planned Phase 2 activities and their contribution to national efforts

In TL-II Phase 2 we plan to bring about a mega impact approach where available cowpea technologies would be implemented in the most important cowpea production environment or agroecologies. We will continue introduction of farmer and market preferred varieties with resistance/tolerance to major biotic and abiotic stresses. A sustainable seed systems model (both community-based and medium-scale private producers) will be developed for the newly released varieties. With the popularization of the new and high-yielding varieties and the introduction of good agronomic practices, we hope to achieve more than 1 t ha^{-1} productivity of cowpea in intervention area which will influence the national productivity from 0.4 t ha^{-1} in 2012 to 0.7 t ha^{-1} by 2015.

Expected outcomes from Phase 2 cowpea improvement

Cowpea farmers and farm practitioners will have higher income. The national cowpea production will increase more than 62,000 tons with productivity of 0.9 t ha^{-1}. There would be excess production over the national demand, which should allow for export to other countries.

Agroecologies for cowpea cultivation in Mozambique

Cowpea is more drought-tolerant than many other crops. It can grow under rainfall ranging from 400 to 700 mm per annum. Adequate rainfall is important during the flowering/podding stage. Cowpea is grown on a wide range of soils but the crop shows a preference for well drained soils, which tend to be less restrictive on root growth. This adaptation to lighter soils is coupled with drought tolerance through reduced leaf growth, less water loss through stomata, and leaf movement to reduce light and heat load under stress. The optimum temperature for growth and development is around 30°C. Varieties differ in their response to daylength, some being insensitive by flowering within 30 days after sowing when grown under any daylength at a temperature around 30°C. Cowpea is more tolerant to infertile and acid soils than many other crops. It is mostly grown in sandy soils of the coastal area, which is marginal for other crops. There are several regions that have more than 40,000 ha of cowpea area but the yield is only 0.25 t ha^{-1} in highest productive regions (data from 2006 to 2008) (Fig. 1).

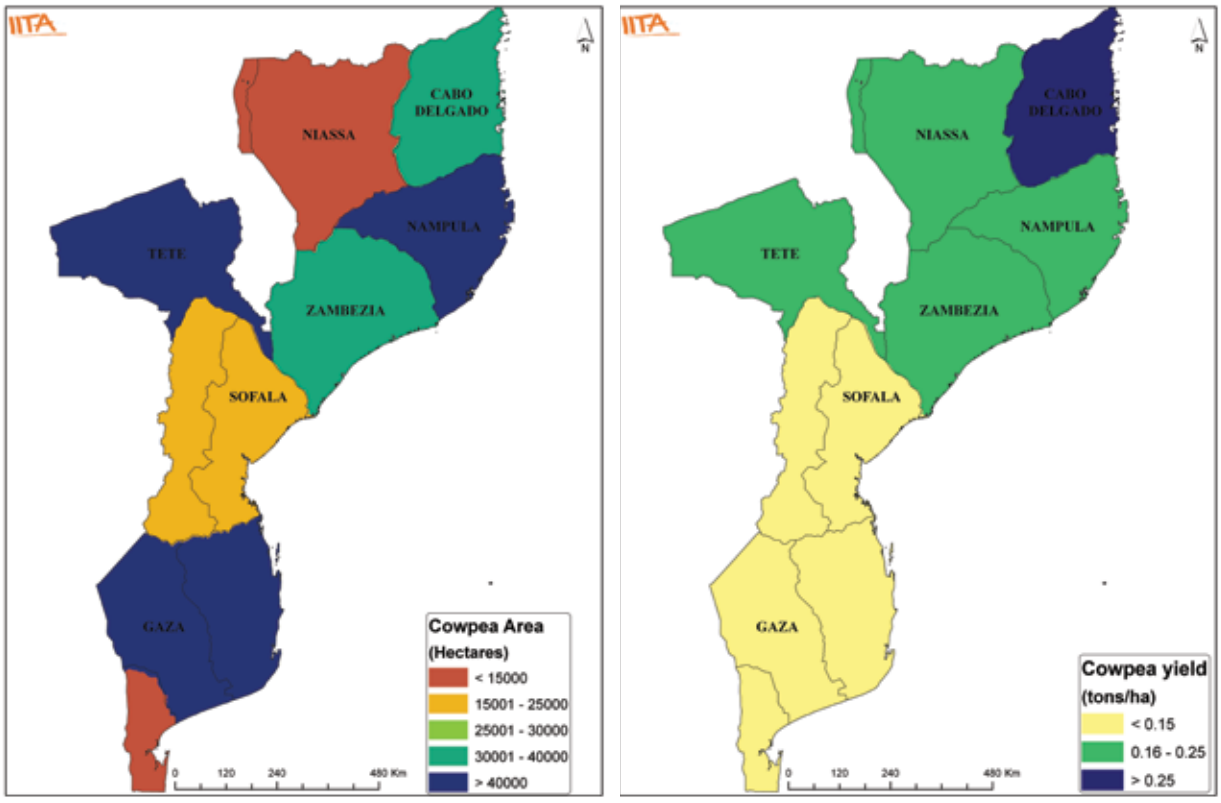

Figure 1. Cowpea production areas and yields in Mozambique.

Seed systems for a legumes green revolution in Mozambique

An effective seed production and delivery system is necessary to make good quality seed available to farmers at the right time and at affordable cost. In Mozambique, there is no formal cowpea seed

production and supply system. Approximately 90% or more of the planting material used is from farmers' own-saved seed. Usually, the few seed companies operating in Mozambique prefer to produce and sell hybrid seed. Seed companies do not show interest in production of self-pollinated crops such as cowpea.

For sustainability of seed production and distribution in Mozambique, it is important that the public research sector be linked with locally operating institutions, such as NGOs, extension services, farmers' associations and other community-based organizations (CBOs). For these interventions to be sustainable, they must be based on training and market development and not on direct government subsidies.

Mozambican seed system strategy (2012–14)

During Phase 2 of the TL-II project, 20% of the current area will be planted with new improved and higher yielding varieties, with the participation of strategic partners.

Area: 335,800 ha

Seed rate (mean): 20 kg ha^{-1}

National demand: 6,716 tons (2012–14)

Capacity to deliver 20% area (67,160 ha) ≃ 1,340 tons

Target of productivity: 1 t ha^{-1} at intervention sites and 0.7 t ha^{-1} at national level

Total production target: >255,200 tons

Opportunities, constraints, partnership and seed production plan

The opportunities, constraints, partners and their role and plan of the seed required to cover 20% of each important cowpea agroecology in Mozambique with improved seed are discussed.

Opportunities

- Functional informal seed system exists
- Good market setup for cowpea in general and cowpea seed in particular
- The new strategic plan for agriculture development considers (cowpea as one of the strategic crops for Mozambique)
- Policy environment that enhances innovative seed system
- Assured availability of suitable varieties with the presence of IITA in Mozambique
- Sufficient land mass suitable for cowpea (millions of ha)
- High consumption level/culture in the country
- Enhanced linkages to NGOs, CBOs and private sector to leverage investments in availing improved legume technologies to farmers
- Work with farmers' associations (eg, IKURU and others), farmer groups through Farmer Field School mode of operation

Constraints

- Dominated by informal system that has technical and infrastructural gaps
- Certification process is not clear for informal seed system
- Total non-existence of mechanization at all steps
- Unpredictability of market price
- Lack of quality seed at all times in an adequate quantity by variety of demand

Partners and their role

- National Seed Services, Mozambique seed systems support, help collaborating NGOs and CBOs with quality seed production/monitoring
- IIAM (Instituto de Investigação Agrária de Moçambique): Variety development, evaluation and release; production of breeder and foundation seeds
- Department of Agricultural Extension Services: Provision of guidance in crop production technologies and associated packages
- Farmers: Users
- IKURU, CLUSA: Encourage farmers to form associations for collective production and marketing
- IITA: Provide improved cowpea germplasm; capacity building through training; research on effective methods for technology dissemination
- Private sector (Lozano Farm, Dengo Comercial, Moz Seed, Fenix Seeds, Semoc): Seed production and distribution

Table 2. Cowpea seed production in Mozambique.

			Breeder seed in 2012		Foundation seed in 2013		Certified seed for use in 2014	
Agroecological demand (ha)	Variety demand	Yield (kg ha^{-1})	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
35300	IT 18	1000	0.056	0.056	2.824	2.824	141.2	141.2
105900	IT 16	1000	0.169	0.169	8.472	8.472	423.6	423.6
105900	IT97K-1069-6	1200	0.082	0.098	5.883	7.060	353.0	423.6
105900	IT00K-1263	1200	0.082	0.098	5.883	7.060	353.0	423.6
	Total		0.389	0.422	23.063	25.416	1270.8	1412.0

Table 3. Certified seed production (t) plan over three years.

Variety	2012	2013	2014
IT 18	83	117	141.2
IT 16	249	349	423.6
IT97K-1069-6	249	349	423.6
IT00K-1263	249	349	423.6
Total	830	1164	1412.0

Seed production plan

The seed production plan for cowpea in Mozambique is presented in Tables 2 and 3. The seed delivery will be handled mainly in a seed revolving or seed loan approach until the bigger impact and demand are established. The higher demand will then be satisfied by seed growers who eventually grow the crop along with technology promotion. By 2014 at least 50% of cowpea farmers at national level will have access to improved seed through the informal seed system organized in a decentralized way. Effective monitoring and support to validate seed quality in a decentralized manner will be carried out by the Seed Department of the Bureau of Agriculture, mandate research centers and the seed enterprises affiliated to the seed scheme in a contractual agreement.

Vision of success for cowpea in Mozambique

The vision of success for cowpea in Mozambique is to attain highest productivity level of more than 1 t ha^{-1} at national and global levels that attributes to the wealth of producer farmers with significant contribution to the home food consumption. The overall production will satisfy the national demand to significantly contribute to the GDP with significant amount of exports and/or agro-processed products.

Soybean

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Introduction

The population of Mozambique is increasing and it is estimated that it will grow from 21 million in 2007 to 28 million in 2020. For this reason, agricultural productivity must increase and crop diversification should be encouraged in order to improve rural income and satisfy the growing demand for food in both rural and urban areas. Mozambique has 10 major agroecological zones varying from arid climate in the south with less than 500 mm mean annual rainfall to tropical humid climate where mean annual rainfall is more than 1800 mm in the central and northern regions stretching from parts of Zambesia, Lichinga, Nampula and Tete provinces. These high rainfall areas have the highest potential for agriculture and the region where various crops grow well. Soybean is among the crops with huge growth potential in the region (Fig. 1) and is becoming a major cash crop for smallholder farmers. It is relatively a new crop in Mozambique and cultivated mainly by smallholder farmers on an average of one-ha farms. Current production is estimated at 31,000 ha (Table 1); however, production is expected to increase over the coming years due to the high demand driven by the domestic poultry and livestock industries, available regional market, attractive prices and a commitment of the government of Mozambique to introduce alternative crops for smallholder crop diversification as farm-gate real prices for important staple food crops including maize have been declining over the past years. In addition, the recent investment support by donors and NGOs in developing and disseminating technological packages have made the soybean a profitable crop and attractive to smallholder farmers. Thus, the contribution of soybean to GDP is likely to be significant in the next few years.

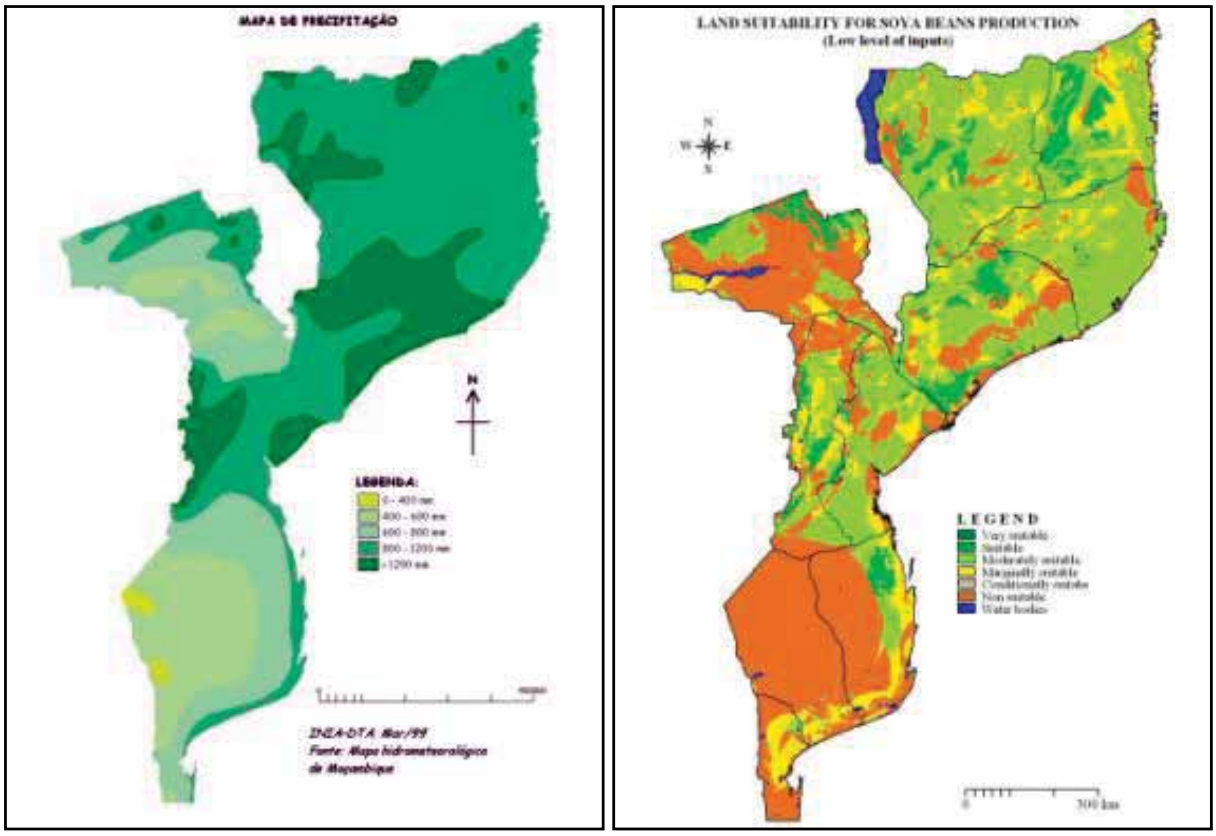

Figure 1. Rainfall pattern (left) and suitable areas for soybean production (right) in Mozambique.

Table 1. Relative importance of the different grain legumes grown in Mozambique.

Crop	Area (ha)	% of total area of the main legumes
Groundnut	315,000	41
Pigeonpea	190,000	25
Cowpea	126,000	16
Common bean	106,000	14
Soybean	31,000	4
Total	768,000	100

State of soybean research in Mozambique

Soybean research in Mozambique started in the early 1980s, in northern highlands of Zambesia Province. This research activity was part of the overall program of the state commercial farm CAPEL (Lioma Agro-Industrial Enterprise). However, the seventeen-year civil war stopped the program and the varieties grown at that time disappeared. These varieties were brought into the country from elsewhere notably Brazil. In the late 1990s, the Instituto de Investigação Agrária de Moçambique (IIAM) (The Agricultural Research Institute of Mozambique) reintroduced some varieties from IITA for evaluation. During the cropping season 2002/03 some promising lines from neighboring countries like Malawi, Zambia and Zimbabwe were introduced for both on-station and on-farm evaluation, in different agroecological zones. The varieties used were: TGx 1740-2F, TGx 1485-1D, TGx 1448-2E, Soya, 427/5/7 and Ocepara-4. The varieties TGx 1740-2F and 427/5/7 performed well.

Farmers who began growing soybean in the late 1990s used the varieties Santa Rosa, Solitaire and Storm, which were introduced from neighboring countries (Zambia, Malawi and Zimbabwe). As a result of the combined effort of IITA and IIAM, the first varieties were released and farmers have more variety options. The released varieties are: Wàmini (TGx 1740-2F), Sana (TGx 1485-1D), Zamboane (TGx 1904-6F), Wima (TGx 1908-8F), Olima (TGx 1937-1F), Ocepara-4, H7, H17 and 427/5/7. The main characteristics of these varieties are presented in Table 2.

Table 2. Major characteristics of the new varieties of soybean.

Variety	Type	Yield (kg ha^{-1})	100-seed weight (g)	Seed color	Region
Wàmini	Determinate	3,000	15	Cream yellow	Central and Northern
Sana	Indeterminate	2,500	15	Cream yellow	Central and Northern
Zamboane	Indeterminate	3,500	15	Cream yellow	Central and Northern
Wima	Indeterminate	3,500	15	Light yellow	Central and Northern
Olima	Indeterminate	3,500	14	Cream yellow	Central and Northern
Ocepara-4	Indeterminate	2,500	14	Cream yellow	Central and Northern
427/5/7	Indeterminate	2,800	15	Cream yellow	Central and Northern
H7	Determinate	3,000	18	Cream yellow	Central and Northern
H17	Determinate	3,500	15	Cream yellow	Central and Northern

Seed production

Area: 36,000 ha

Seed rate (mean): 60 kg ha^{-1}

National demand: 2160 tons (2012–14)

Capacity to deliver 20% additional requirement: 2160 × 0.2 = 432 × 1.2 = 518.4 tons

Target of productivity: 2 t ha^{-1} at intervention sites and 1 t ha^{-1} at national level Total production target: 17280 tons

Major constraints to soybean production

Production constraints are many and diverse due to contrasting agroecologies and include the following:

- Non-availability of improved varieties adapted to various production systems until recently
- Lack of seeds for the farming communities
- Lack of varieties resistant to foliar diseases such as rust
- Inadequate nitrogen fixation of varieties due to non-availability of inoculants
- Limited use of P fertilizers due to limited availability and high prices
- Lack of organized seed production and delivery systems
- Poor seed viability from one season to the next
- Frequent drought in some regions; weak market linkage with producers, processors and consumers.

Opportunities

- The poultry and livestock industries in Mozambique demand more than 100,000 tons of soybean for feed every year. The gap between current production and domestic demand is largely met by imports from Argentina and Brazil.
- Good climatic conditions for soybean production coupled with available land for expansion.
- The major interest and support from donors to improve income and food security and enhance livelihoods of smallholder farmers through research and dissemination of technological packages to boost crop yields.
- The presence of IITA and the collaboration with IIAM on all aspects of soybean research.
- The current government policy is favorable to soybean production. There is shortage of edible oil and the government is looking for local production and processing. In this regard, the government is encouraging the production of oilseed crops.
- There is significant market for edible oil and the annual industrial production is estimated to be as high as 110,000 tons.
- Presence of several NGOs promoting soybean production.
- The regions are currently benefiting from increased investments not only in agricultural production but also through a great opportunity for vertical coordination with a processing unit under installation in central Nampula.

R&D emphasis in Phase 2

- Continue introduction of farmer- and market-preferred varieties with resistance/tolerance to major biotic and abiotic stresses
- Develop a sustainable seed systems model (both community-based and medium-scale private producers) for the new released varieties
- Popularize the new and high-yielding varieties
- Introduce and promote good agronomic practices in soybean production

Seed systems for a legumes green revolution in Mozambique

An effective seed production and delivery system is necessary to make good quality seed available to farmers at the right time and at affordable cost. In Mozambique, there is no formal soybean seed production and supply system. Approximately 60% or more of the planting material used is from farmers' own-saved seed. Usually, the few seed companies operating in Mozambique prefer to produce and sell hybrid maize seed. Seed companies do not show interest in production of self-pollinated crops such as soybean.

For sustainability of seed production and distribution in Mozambique, it is important that the public research sector be linked to locally operating institutions, such as NGOs, extension services, farmers' associations and other community-based organizations (CBOs). For these interventions to be sustainable, training of farmers and stakeholders as well as market development are critical.

During Phase 2 of the project, 20% of the current area will be planted with new improved and high-yielding varieties, with the participation of strategic partners (Table 3). The seed production plan up to 2014 is presented in Table 4 and the key partners for seed distribution in Table 5.

Table 3. Strategic partners and their role in seed systems.

Partner	Role
National Seed Services, Mozambique	Seed systems support, help collaborating NGOs and CBOs with quality seed production and monitoring
IIAM (Instituto de Investigação Agrária de Moçambique)	Variety development, evaluation and release; production of breeder and foundation seeds
Department of Agricultural Extension Services	Provision of guidance in crop production technologies and associated packages
Farmers	Users of released varieties and associated packages
IKURU	Capacitate farmers in formation of associations for collective production and marketing
IITA	Provide improved soybean germplasm; capacity building through training; develop and disseminate technology
Private sector (market intermediaries and emerging small-scale seed enterprises and processors)	Processing and commercialization of seed and products

Table 4. Soybean production plan for soybean in Mozambique.

Ecology	Demand (ha)	Traits: Productivity	Traits: Market	Promising varieties	Seed production (t): Breeder seed	Seed production (t): Foundation seed	Seed to reach 20% adoption (t)	20% additional requirement (*1.2%)	Seed production (t): Year 1 (2012)	Seed production (t): Year 2 (2013)	Seed production (t): Year 3 (2014)
Semi-arid, 800–1200 mm rainfall (Nampula)	3,000	Early maturing, promiscuous	Oil and protein	Sana (TGx 1485-1D)	0.024	0.720	18	21.6	7.2	7.2	7.2
		Early maturing, promiscuous, drought tolerant	Oil and protein	Wàmini (TGx 1740-2F)	0.019	0.648	18	21.6	7.2	7.2	7.2
Tropical humid savanna, 1800–2500 mm rainfall (Nampula, Zambezia, Cabo Delgado)	25,000	Late maturing, promiscuous, drought tolerant, high yielding	Oil and protein	Olima (TGx 1937-1F)	0.08	2.40	60	72	24	24	24
		Early maturing, promiscuous, drought tolerant, high yielding	Oil and protein	Sana (TGx 1485-1D)	0.080	2.40	60	72	24	24	24
		Medium maturing, promiscuous, drought tolerant	Oil and protein	Zamboane (TGx 1904-6F)	0.054	1.96	60	72	24	24	24
		Medium maturing, promiscuous, drought tolerant, high yielding	Oil and protein	Wima (TGx 1908-8F)	0.054	1.96	60	72	24	24	24
		Early maturing, drought tolerant, high yielding	Oil and protein	Wàmini (TGx 1740-2F)	0.065	2.16	60	72	24	24	24
Humid savanna 900–1400 mm rainfall (Zambezia)	8,000	Early maturing, promiscuous, drought tolerant, high yielding	Oil and protein	Wàmini (TGx 1740-2F)	0.026	0.864	24	28.8	9.6	9.6	9.6
		Early maturing, promiscuous, drought tolerant, high yielding	Oil and protein	Sana (TGx 1485-1D)	0.032	0.960	24	28.8	9.6	9.6	9.6
		Medium maturing, promiscuous, drought tolerant, high yielding	Oil and protein	Zamboane (TGx 1904-6F)	0.021	0.785	24	28.8	9.6	9.6	9.6
		Medium maturing, promiscuous, drought tolerant, high yielding	Oil and protein	Wima (TGx 1908-8F)	0.021	0.785	24	28.8	9.6	9.6	9.6
Total					0.476	15.65	432	518.4	172.8	172.8	172.8

Table 5.Key partners for soybean production and distribution.

Seed production	Distribution	Markets
IIAM, IKURU, USEBA, Dengo Commercial, Moz Seeds, Lozane Farm, Phoenix Seeds, SEMOC	IKURU, CLUSA, Technoserve, SDAE, SEMOC	IKURU, SEMOC, Lozane Farm, Moz Seeds

Tanzania

Groundnut

Omari Mponda, Juma Mfaume, Phillipo Mashamba, Patrick Okori and Emmanuel Monyo

Importance of the crop to Tanzania's economy

Relevance to the economy

Tanzania has adopted "*Kilimo Kwanza*" (Agriculture first) as a strategy and approach for agricultural development because 80% of Tanzanians live in rural areas and 70% are employed in agriculture, which contributes 95% of national food requirements (Asfaw and Shiferaw 2009, COSTECH 2009). The strategy is based on ten actionable pillars with clear focus on poverty-reduction. The agricultural sector not only employs the majority of Tanzanians but also contributes 27% to the GDP (ASDP 2005, URT 2010). Groundnut is among the crops that have been identified as strategic crops in order for Tanzania to realize the "Green Revolution". Emphasis should be in the following areas of interventions:

1. The development and/or adoption of cost-effective technologies that would strengthen seed production and delivery systems
2. Development of high-yielding and adapted (drought tolerant, improved nutrition value, pest and disease resistant) varieties
3. Development and dissemination of knowledge and skills for small, medium and large-scale farmers to adopt intensive agricultural technologies
4. Development and/or adoption of value addition technologies to increase value and marketability of groundnut

Production

In Tanzania groundnut is grown by smallholder farmers and is one of the major raw materials for edible vegetable oils in the country. It is one of several oilseeds produced in the country. Groundnut is mainly used as food crop and consumed directly. Because groundnut is both a food and cash crop, large quantities are sold in informal markets. The most important growing regions are Mtwara, Tabora, Shinyanga, Kigoma, Dodoma and Mwanza, where annual rainfall varies between 500 and 1200 mm. The main groundnut growing zones have different rainfall amounts and distribution during the growing season with unimodal distribution in the south and central and bimodal in the northeastern and lake zone covering Morogoro, Mwanza, Arusha and Kilimanjaro. The zones with bimodal rainfall distribution have short rains in November/December and long rains from March to May/June. Groundnut is grown entirely under rainfed condition. The area under groundnut in Tanzania is estimated to be 542,000 ha with a rate of growth of 4.63% per annum. The national average yield is 721 kg ha^{-1} (MAFSC 2011).

Groundnut seeds contain 40–50% oil, 20–50% protein and 10–20% carbohydrates. They are a nutritional source of vitamin E, and of some other minerals for human health. The latter include niacin, falacin, calcium, phosphorus, magnesium, zinc, iron, riboflavin, thiamine and potassium (USDA 2011). Groundnut is useful in the treatment of hemophilia, and can cure stomatitis and prevent diarrhea. It is beneficial for growing children, and for both pregnant and nursing mothers. Kernels are consumed directly as raw, or as roasted or boiled nuts. Some of the extracted oil from the kernel is used as culinary oil. However, some of the crop-extracts are used as animal feed. In other words, almost every

part of the groundnut plant is used in some way. While kernels are used for human consumption, vines are used as fodder for cattle. Sometimes raw items of the crop are used as industrial materials for producing oil-cakes and fertilizer. Literally speaking, all these multiple uses of groundnut plant make it important for both food and cash crop for the available domestic, or worldwide external markets in several developing and developed countries.

Research and development

Historical perspectives

The Research Program for groundnut improvement in Tanzania was started in early 1950s, at Nachingwea and Kongwa to support the then British Overseas Food Corporation (OFC) groundnut scheme. This led to recommendation of groundnut varieties Natal Common and Red Mwitunde, plus a package of agronomic practices. Following the collapse of the OFC in late 1950, an oilseed breeding program that also included sesame and soybean was initiated at Nachingwea. Groundnut research conducted after independence was inconsistent and lacked cohesion. However, activities conducted and recommendations (eg, improved varieties, agronomic practices) made a foundation for a renewed Oilseeds Research Project in 1978 following a bilateral agreement between the Governments of Tanzania and the United Kingdom. In the early 1980s, commodity research programs in the country were begun and Agricultural Research Institute-Naliendele became the coordinating center for Oilseeds Research Program (ORP). The ORP has been operating within the framework of the following main objectives:

1. To identify and develop high-yielding varieties adapted to the main growing areas. They should have desirable attributes such as tolerance to insect pests and diseases of major economic importance.
2. To develop the best cultural practices for different varieties of oilseeds.
3. To identify the major insect pests and diseases of economic importance and develop suitable control measures.
4. To investigate the role of oilseeds in farmers' traditional systems and develop recommendations to improve productivity of these systems.

Variety development

The current emphasis of ORP is in the areas of variety development, agronomy, crop protection, socioeconomics, seed multiplication and delivery systems. During 2006 to 2012 the ORP at Naliendele has received significant support from ICRISAT through McKnight CCRP, TL-I and TL-II Groundnut Breeding Projects. Both projects are now in the second phase. To date the ORP has released nine groundnut varieties since its establishment in 1980, five of them through support from TL-II and CCRP projects. The varieties are Nyota-1983, Johari-1985, Sawia-1998 and Pendo-1998 (released before TL-II). With the support of TL-II and CCRP projects, Tanzania NARS released Mnanje-2009, Mangaka-2009, Nachingwea-2009, Masasi-2009 and Naliendele-2009. The most popular variety in the country is Pendo and this has wide adoption in southern Tanzania and in Nanyumbu district has reached ≥90% adoption. Under the present donor funding the newly released varieties Mnanje-2009 and Mangaka-2009 are becoming popular but more efforts are needed to popularize them and for seed bulking.

Constraints to production

The major constraining factors to the production of groundnut in Tanzania include abiotic stresses such as drought, poor soil fertility and poor agronomic practices. The biotic stresses include groundnut rosette disease, early leaf spot and late leaf spot, and foliar rust and aflatoxin contamination of grain. In a study in Tabora region low price, markets, income, inadequate extension services as well as cultivated land size were identified as key elements leading to low production and the following interventions were recommended (Katundu et al. 2012):

1. Increase the market price of groundnut through value addition.
2. Expand the groundnut market demand by establishing small and medium agro-processing units in groundnut growing areas.
3. Provide groundnut producers with credit for purchase of inputs.
4. Appoint extension officers who are specifically hired to cater services for groundnut production. This calls for another research on how to engage extension officers who should specialize in offering services to groundnut producers.
5. Since groundnut production is deemed as women's business, household heads especially men do not give this crop deserved weight for its production. This has mostly contributed to lower production. It was therefore highly recommended to reverse this trend so as to make it a key determinant of household income.

Planned Phase 2 activities and their contribution to national efforts

TL-II Phase 2 aims at delivering new varieties to farmers of Tanzania who have been growing either old or highly susceptible groundnut varieties. The strategy is to intensify R&D efforts to ensure that newly developed varieties have the right traits, for the right agroecology market and home consumption purposes. In Tanzania the project will focus on Objective 2.

Objective 2. To enhance groundnut productivity and production in drought-prone areas of Tanzania

A breakdown of the major activities by objective are presented below.

1. Full operationalization of groundnut breeding program (participatory variety selection, demonstrations, nuclear and breeder seed production)
2. Development of new high-yielding varieties
3. Activities for farmers, technical and professional staff to upgrade skills and awareness

Project results: The expected outcomes and outputs

Expected outcomes

The focus areas of operation for TL-II Phase 2 are in four major groundnut producing regions – Mtwara, Dodoma, Tabora and Shinyanga. The above activities will significantly contribute to the national efforts in terms of development of new varieties with high-yielding potential and availability of the released varieties to the end-users, the farmers. Hence the efforts undoubtedly will increase production and raise national productivity of groundnut in Tanzania from the average of 721 kg ha^{-1} to 820 kg ha^{-1} by 2016 and increase adoption rate by 20% for newly released varieties that are high yielding and resistant to foliar diseases.

Expected outputs

These will focus mainly on delivering products and services:

1. Production of foundation seeds and strengthening breeder seed production through involvement of other partners in the seed value chain.
2. Enhancing seed delivery to increase diffusion and marketing of seeds.
3. Capacity building of seed producers and agro-seed dealers.

Agroecologies/regions for groundnut production in Tanzania

Groundnut is produced throughout the country but the following are the major production zones: Southern Tanzania (Mtwara, Masasi, Nanyumbu), Central (Dodoma, Bahi, Chamwino, Kongwa), Western (Tabora, Kigoma), Lake Zone (Mwanza, Shinyanga), Northeastern (Kilimanjaro, Arusha) and Eastern Zone (Morogoro). Groundnut is treated by most farmers as a cash crop; hence approximately 75% of the harvest is disposed off to the local market and the remaining for household consumption (Mponda et al. 2011). Dominant varieties in Tanzania are Pendo and local varieties in the South and Pendo, Johari and local varieties in Central zone. The rest of the country is dominated by local varieties. Based on 2009/10 data of Ministry of Agriculture Statistics Division, Lake Zone is the leading groundnut producing zone (30%) followed by Western (14%), Southern (12%), Central (8%) and Southern Highlands (7%).

Seed systems for a legumes green revolution in Tanzania

Increasing seed production and its delivery to farmers has been identified as crucial for increasing productivity of all crops including groundnut. Total improved seed requirement for groundnut for Tanzania is about 120,000 tons per annum, but currently the seed going to the market is about 20,000 tons which is equivalent to 16.7% of the total requirement. As such, most farmers are compelled to use farmer-saved seed for planting in their fields which always give poor yields leading to marginal production and productivity per year. On the other hand, local seed production is 2,000 to 6,000 tons per annum and most of the seeds which are used in the country are imported. The imported seeds are not in all cases of good quality and do not meet the agroecological requirements of the country.

The private sector has been reluctant to produce legume seeds because of low profitability. However, legumes constitute the major source of protein to the bulk of the population in Tanzania and SSA. With the above 20,000 tons that is traded in the market, grain legume contribution could be less than or equal to 1%. Grain legumes have no well defined and developed markets for seed and the legumes research team in Tanzania has recommended the need to adopt seed value chain approach by linking producers, processors and consumers and that linkages between legume breeders, Agricultural Seed Agency (ASA), Tanzania Official Certification Institute and other partners in the seed chain need to be effective in order to move the legume seeds forward. At Naliendele, the groundnut breeding program has piloted “The Groundnut Seed Systems Pathway”. The approach is a participatory seed production and delivery model that has helped to increase the awareness and use of improved groundnut and sesame seeds in southern Tanzania. Under TL-II, the groundnut value chain in Tanzania will be used. The participatory seed model adopted in southern Tanzania builds on rural seed fairs that have capacity to create awareness and effective demand for seed in rural areas. The seed fairs are then strengthened by involvement of farmer research groups who participate in the PVS. Experienced groups, farmers and local institutions are then contracted to produce quality seeds by ASA under the coordination of Naliendele Agricultural Research Institute (NARI). Tanzania Official Certification Institute certifies the seed produced at the request of ASA and NARI. The seed delivery chain involves

District Councils, NGOs, Agricultural Marketing Cooperatives, primary cooperative societies, individual farmers purchasing seeds from NARI, ASA, farmer groups and agro-dealers shops.

Strategic partners and their roles

Undertaking R&D with strong impact orientation requires strategic partnerships with a host of partners. These partners will be needed to improve functionality of the value chains. The diverse partners and their roles are presented in Table 1.

Table 1. Strategic partners and their role.

Partner	Role
TOSCI (Tanzania Official Seed Certification Institute)	Variety release, seed certification services and quality control
ASA (Agricultural Seed Agency)	Seed systems support, help collaborating NGOs and CBOs with quality seed production/monitoring
Department of Research and Development (DRD), Ministry of Agriculture and Food Security	Variety development, evaluation and release; production of breeder and foundation seeds
Department of Agricultural Extension Services	Provision of guidance in crop production technologies and associated packages
Farmers	Users
District Council and local Government Cooperative Unions, Agricultural Marketing Cooperatives (AMCOS), Primary cooperative societies	Capacitate farmers formation of associations for collective production and marketing
NGOs – KMAS, Masasi High Quality Farmers, DCT, DMT, ROSDO	Facilitate grassroots development through provision of inputs and technologies
ICRISAT	Provides improved groundnut germplasm; capacity building through training; research on effective methods for technology dissemination
Private sector (market intermediaries and emerging small-scale seed enterprises and processors)	Processing and commercialization of seed and products

Seed production plan

Groundnut seed production plan for Tanzania is presented in Table 2.

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Table 2. Seed delivery plan to cover 20% of the national area under groundnut.

				Breeder seed 2012		Foundation seed 2013		Certified seed 2014	
Ecology (Zone)	Area (ha)	Promising varieties	Area (ha)	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
Northern	24,780	Pendo	2,480	2.44	2.2	30.00	45	600.00	900
		Mnanje	1,488	1.33	1.2	26.67	40	200.00	300
		Mangaka	496	0.44	0.4	6.67	10	233.33	350
		Nachingwea	496	0.22	0.2	3.33	5	133.33	200
Total			4,960	4	4	67	100	1,167.00	1,750
Central	65,650	Pendo	6,565	0.56	0.5	23.33	35	100.00	150
		Mangaka	2,626	0.28	0.3	20.00	30	100.00	150
		Mnanje	3,939	0.28	0.3	10.00	15	90.00	135
Total			13,130	1	1	53	80	290.00	435
Eastern	5,990	Pendo	599	2.78	2.5	20.00	30	800.00	1200
		Nachingwea	240	1.11	1	10.00	15	333.33	500
		Mnanje	360	1.67	1.5	6.67	10	300.00	450
Total			1199	5.56	5	37	55	1433.33	2150
Southern	88,400	Pendo	8,840	2.22	2	73.33	110	433.33	650
		Mnanje	3536	0.33	0.3	20.00	30	233.33	350
		Mangaka	3536	0.33	0.3	20.00	30	300.00	450
		Masasi	1768	0.44	0.4	20.00	30	166.67	250
Total			17,680	3	3	133	200	1,133.00	1,700
Southern Highlands	78,280	Pendo	7828	1.67	1.5	20.00	30	200.00	300
		Nachingwea	1566	0.33	0.3	10.00	15	166.67	250
		Mnanje	6262	0.22	0.2	6.67	10	133.33	200
Total			15656	2	2	37	55	500.00	750
Lake	156,590	Pendo	15,659	1.44	1.3	23.33	35	200.00	300
		Mnanje	9395	0.33	0.3	10.00	15	133.33	200
		Masasi	6264	0.39	0.4	6.67	10	133.33	200
Total			31,318	2	2	40	60	467.00	700
Western	90,460	Pendo	9,046	1.44	1.3	26.67	40	216.67	325
		Mnanje	5428	0.44	0.4	6.67	10	200.00	300
		Masasi	3618	0.39	0.4	10.00	15	133.33	200
Total			18,092	2	2.1	43	65	550.00	825
Grand total	510,150		102,035	21	19	410	615	5,540.00	8,310

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Cowpea

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Introduction

Importance of the crop in Tanzania

Cowpea is one of the major legumes in Tanzania grown mainly by smallholder farmers, especially women, providing opportunity to lift a large number of farmers out of food and nutrition insecurity and poverty. It is nutritious (high protein content), thrives under low rainfall and poor soil fertility conditions, and can be grown with low capital investment. Cowpea is an important component in Tanzania's cropping system making an important contribution to soil fertility – the major limiting factor to crop productivity in Tanzania's mainly cereal-based cropping system. It is grown in the drought-prone regions of Tanzania and is mostly intercropped with maize. Both grains and tender leaves are consumed. About 63,000 tons is produced annually on 150,000 ha (Fig. 1). Production of cowpea increased at annual rate of 3.4% between the periods from 1985–87 to 2005–07. Projected rate of growth (ROG) in demand is estimated at 4% between 2010 and 2020.

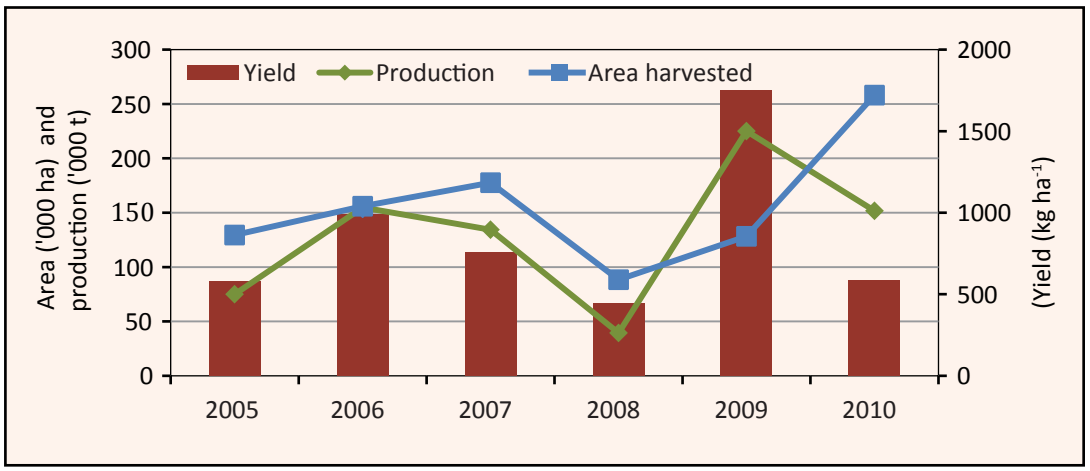

Figure 1. Cowpea area, production and yield in Tanzania during 2005 to 2010 (Source: MoA 2010).

Cowpea's contribution to national GDP, farmer income, food and nutrition security

Cowpea offers higher potentials for food security to the poor as it can be grown in dry areas where most staples (particularly cereals and root and tubers) do not perform optimally. Cowpea is a source of cheap protein and amino acids as compared to cereals. Both the overall demand and supply for cowpea grain in SSA are projected to grow at about 5% per year. The ROG in demand predicted for Tanzania is 3.4%. Data for cowpea trade are not available, but it is possible that almost all of the cowpea produced in Tanzania is used for local consumption. That means cowpea contribution to national GDP is neglected. The economy of Tanzania is overwhelmingly agricultural; in 2006 it contributed 44.7% of the GDP (Source: URT 2007). It relies on smallholder production of crops such as maize, rice, coffee, cotton, cashew and tobacco. Crops such as tea, sisal, and sugarcane are grown in both small and large farms. Other crops which are grown by small-scale farmers include wheat, millets, sorghum, vegetables, banana and cassava. However, only a few crops such as coffee, sisal, tea and sugarcane are grown on large-scale commercial farms. According to a World Bank report (2000), agriculture supports

about 90% of the population living in rural areas. As the urban population in Tanzania is increasing at the rate of 8% per annum, the agriculture sector is expected to increase market output of food crops in order to support the growing urban population (Source: URT 1999). Cowpea consumption is estimated at 14 kg per capita per year.

Research and development

Variety development

Conventional breeding has been in place since four decades. Cowpea breeding is conducted mainly by the Agricultural Research Institute at Ilonga. The cowpea program has the responsibility to conduct research activities including breeding, agronomy and crop protection. The main objective of the cowpea breeding program is to develop high-yielding varieties with drought tolerance and *Alectra* resistance. Several varieties were released by the cowpea breeding unit, which has a harmonious collaborative relationship with IITA's cowpea breeding unit (Table 1).

Table 1. Characteristic features of common varieties developed by the Tanzanian research system.

Official name of release	Year of release	Source of the materials	Genetic background (parentage, pedigree, ancestry)	Area of potential coverage (ha)	Area of actual adoption estimate (ha)	Spillover national boundaries	Average yield potential on-farm (kg ha^{-1})	Varietal traits (selected characteristics)
Tumaini	1982	IITA	TKx9-11D	52,154.7	27,374.3	Yes	800	Indeterminate growth habit, medium seed size with tan color, resistant to cowpea mosaic virus and intermediately resistant to bacterial blight
Fahari	1982	IITA	TVx19-1801F	42,112	19,250.5	Yes	800	Better yield, cream seed color, resistant to cowpea aphid borne mosaic virus
Vuli 1	1987		CROSS 1-6E-2	33,204	10,000		1,000	Red seed color, better yield and resistant to cowpea mosaic virus and intermediately resistant to bacterial blight
Vuli 2	2003	IITA	IT85F 2020	34,500.3	20,200	Yes	1,000	Better yield and white/cream seed color, moderately susceptible to pests, resistant to bacterial blight and cowpea mosaic virus

Major constraints to cowpea production in Tanzania

The major constraints to cowpea production in Tanzania include social, biological, physical and technological environments. Accordingly the major constraints are:

- Biotic stresses: Insect pests (aphids, flower thrips, pod sucking bug, *Maruca,* bruchids), diseases (bacterial, viral and fungal) and *Alectra*
- Abiotic stresses: Drought, heat, low soil fertility
- Poor access to inputs (seed of improved varieties and other agricultural inputs) and output markets (a general lack of market information, poor cultural practices)

- Lack of harvester, thresher, grading and planter machines at affordable level
- Lack of credit

Planned Phase 2 activities and their contribution to national efforts

In TL-II Phase 2 we plan to bring about a mega impact approach where available cowpea technologies would be implemented in most but important cowpea production environments or agroecologies. We are projecting to officially release farmer-preferred drought tolerant lines (IT00K-1263 and ITK99K-1122), at least one variety by 2013. Seeds of six varieties will be produced for use in pair-wise demonstrations in collaboration with farmers. Farmers' varieties will be included in the pair-wise comparisons to be carried out in 10 new communities. One stakeholders' workshop was held before planting and a second one at maturity/harvest time. New crosses involving adapted varieties and elite sources of *Alectra*/drought resistance/tolerance in Tanzania will be generated. The plan set at the end of the phase is to achieve productivity of cowpea of more than 1 t ha^{-1} in intervention areas and to influence the national productivity from 0.5 in 2012 to 0.8 t ha^{-1} by 2014.

Expected outcomes from Phase 2 cowpea improvement for production and productivity

Cowpea farmers and farming practitioners will have higher income. The national cowpea production will increase more than 80,000 tons by 2014 and with productivity of 0.8 t ha^{-1}. There would be excess production over the national demand which should allow for export to other countries.

Agroecologies for cowpea cultivation in Tanzania

Cowpea is grown mainly in mid altitude agroecologies of Tanzania (Fig. 2). The characteristics of the major agroecologies are given in Table 2. There are several regions with cowpea occupying more than 8,000 ha and there are regions with average productivity level greater than 0.6 t ha^{-1} (Fig. 3).

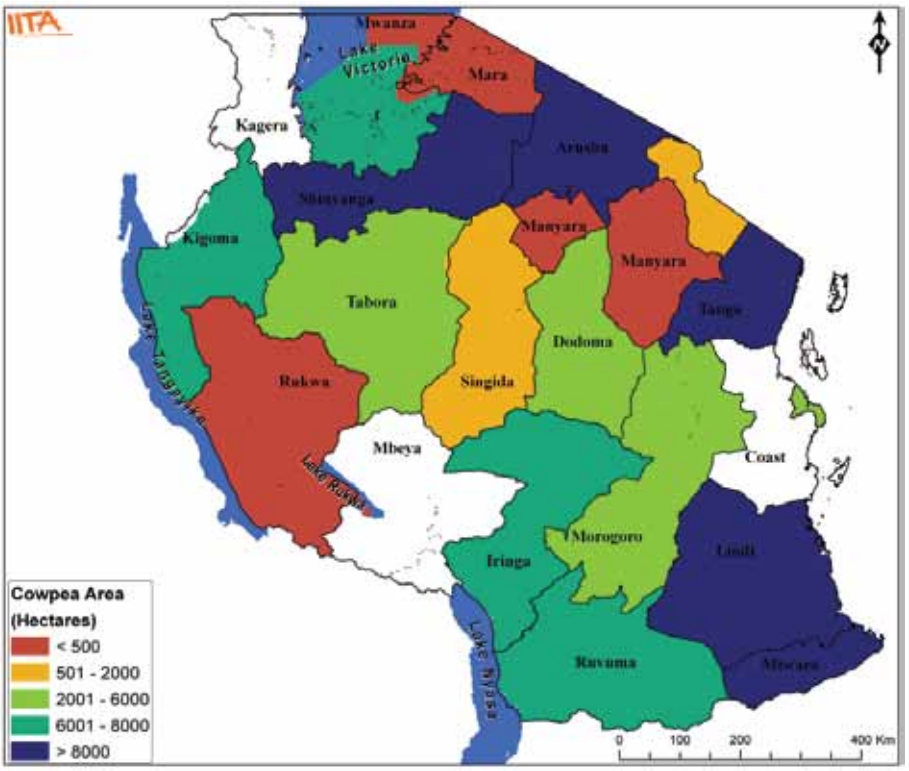

Figure 2. Cowpea production areas in Tanzania.

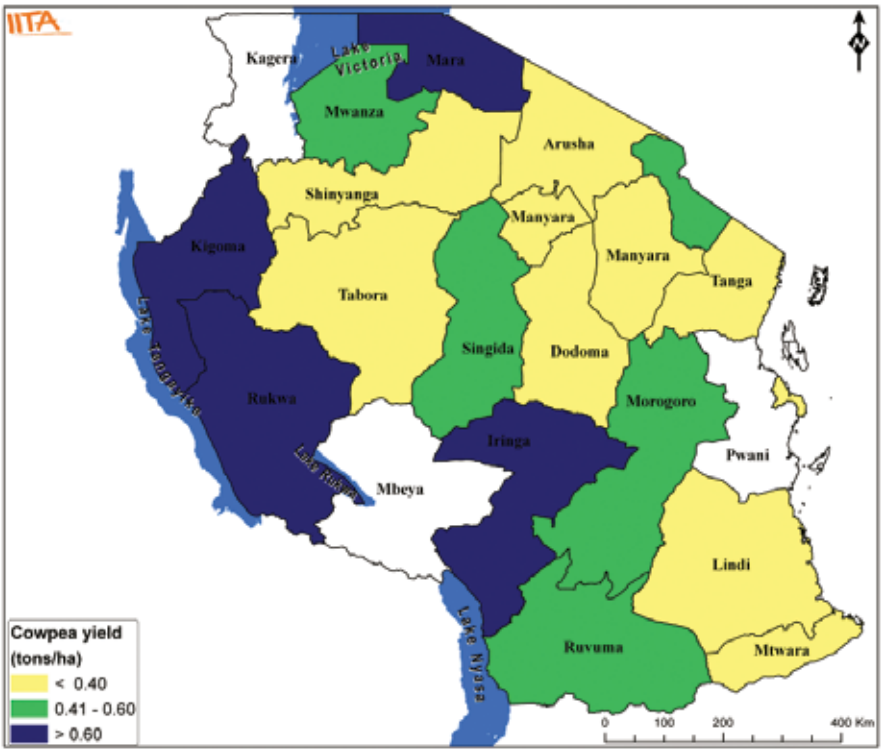

Figure 3. Cowpea yield distribution in Tanzania.

Table 2. Characteristics of agroecological zones (AEZ) of Tanzania.

AEZ	Characteristics
Eastern	Altitude 50 to 1000 m amsl; rainfall 600 to 1200 mm per year, temperatures 20°C to 30°C; soils vary with physiography, sandy along the coast and clayey in the eastern plateau and mountain blocks, shallow to very deep, well and poorly drained.
Western	Latitude 4 to 7° South and longitude 31 to 34° East; temperatures range from a mean minimum of 16.6°C in June to mean maximum of 37.7°C in October; soils are 80–90% sand (Ferric acrisol), with low organic carbon ranging between 0.4 and 0.8%; altitude is about 1199 m amsl, rainfall ranges from 700 to 1000 mm and the rainy season is followed by a long dry season (5 to 6 months).
Northern	Altitude ranges between 900 and 1600 m amsl. It is cut through the middle from North to South by the Rift Valley. Temperature ranges from 13°C to 25°C, and the seasons are wet and dry seasons. Latitude 3.3667 S and longitude 36.6833 E. Major soils in the subhumid uplands include Eutric Andosols, Mollic Fluvisols and Alic Andosols. Dominant soils of the semi-arid lowlands include Eutric Nitisols, Haplic Cambisols and Calcic Vertisols.
Southern	Altitude 100 m amsl; annual rainfall 500 to 900 mm; soils have a wide range, sandy and clay; temperature 20°C to 30°C.
Southern Highlands	70° to 90° South and 300° to 380° East; area 245,000 km^2 (28.5% of mainland Tanzania). Altitude ranges from 400 to 3000 m amsl; annual rainfall ranges from 600 mm (in some parts) to over 2600 mm on the mountains and along Lake Nyasa. The climate varies from tropical to temperate; rainfall pattern is unimodal, with the rainy season starting in October/November through April/May. Most soils are well drained and generally fairly heavy but tend to be acidic with low to medium levels of nutrients and low organic content.
Lake	Altitude of 1198 m amsl; longitude of 33° 01'E and latitude of 02° 42'S. Temperatures range from 15.4°C to 29.1°C. Rainfall unreliable, bimodal and ranges between 750 mm in dry areas and 1,200 mm in wet areas. Soils can be classified into three major groups: (a) sandy soils derived from granite, (b) red loams derived from limestone, and (c) block clay soils.
Central	The central zone is a plateau between 1000 and 1500 m amsl. Annual rainfall varies between 500 and 800 mm. Consists of gently undulating plains with some rocky hill and low scarps associated with the formation of the rift valleys. Soils include well drained sands of low fertility on the uplands and alluvial hard pan.

Seed systems for a legume's green revolution in Tanzania

Seed system is a well established entity in Tanzania since the early 1980s. Agricultural Seed Agency (ASA), Tanseed, NGOs and seed companies are the institutions serving the seed production in the cereal-based cropping system. As a business institution, the enterprise works with cereals (maize, rice, sorghum and pearl millet) and to a limited extent some legumes. Therefore the major actors in the seed system of cowpea are the informal seed sector (seed grower associations, farmers' unions, individual farmers, etc).

The government has enacted the Agricultural Sector Development Strategy (ASDS) to create a favorable environment for commercial activities; delineate public/private roles including continued public financing for core agricultural services with increased private delivery through contracting arrangements; decentralize service delivery responsibilities to local governments; and focus on the preparation and implementation of District Agriculture Development Plans. Seed production is being promoted and producers are being linked to agro-dealers.

Tanzanian seed system strategy (2012–14)

With all functional key stakeholders in place, the seed production (informal seed system dominated) strategy of cowpea in Tanzania is given below.

Area: 129,558 ha

Seed rate (mean): 20 kg ha^{-1}

National demand: 2,591 tons (2012–14)

Capacity to deliver 20% total area: 25,912 ha $\simeq$ 518 tons

Target of productivity: 1 t ha^{-1} at intervention sites and 0.8 t ha^{-1} at national level

Total production target: >108,800 tons

Opportunities, constraints, partnership and seed production

The opportunities, constraints, partnership and plan of the seed required to cover 20% of each important cowpea agroecology in Tanzania with improved seed are discussed.

Opportunities

- Good market setup for cowpea in general and cowpea seed in particular
- Policy environment that enhances innovative seed system
- Availability of suitable varieties in the major growing areas
- Sufficient land mass suitable for cowpea (millions of ha)
- High consumption level/culture in the country

Constraints

- Drought
- Lack of farmer/market preferred improved varieties
- Field and storage pests (bruchids)
- Seed availability
- Lack of awareness (the new varieties are not known to many farmers)
- Susceptibility to notorious weeds (eg, *Alectra*)

Partners

The key partners and their role are given in Table 3.

Table 3. Patners and their role.

Partner	Role
Department of Research and Development (DRD), Ministry of Agriculture and Food Security, ARI-Ilonga, SUA	Variety development, evaluation and release; production of breeder and foundation seed
IITA	Provides improved legume germplasm/breeding populations; capacity building through training; research on effective methods for technology dissemination
Farmer cooperatives	Seed production and dissemination
NGOs (Dioceses, CARE, World Vision, CRS, Africare, WVI), KMAS, Dutch Connection District Councils	Facilitate introduction of new varieties; development of legumes market value chain; resource contribution; informal seed production and dissemination of proven technologies
Private sector in Lake Zone	Processing and commercialization of seed and products
Farmers	End-users of technologies in terms of high-yielding varieties and management practices
Tanzania Official Seed Certification Institute (TOSCI)	Variety release, seed certification services and quality control
Agricultural Seed Agency (ASA)	Seed systems support, helping collaborating NGOs and CBOs with quality seed production/monitoring
Department of Agricultural Extension Services	Provision of guidance in crop production technologies and associated packages

Seed production plan

Cowpea seed production plan for Tanzania is presented in Tables 4 and 5.

The seed delivery will be handled mainly in a Quality Declared Seed (QDS) under supervision of ASA. The higher demand will then be satisfied by seed growers that eventually grow along with the technology promotion. And by 2014 at least 50% of cowpea farmers at national level will get seed access through the informal seed system arranged already at accessible points in a decentralized way. Effective monitoring and support to validate seed quality in a decentralized manner will be served by ASA, mandate research centers, TOSCI and the extension services affiliated to that seed scheme in a contractual agreement.

Table 4. Cowpea seed production in Tanzania from 2012 to 2014.

			Breeder seed in 2012		Foundation seed in 2013		Certified seed for use in 2014	
Agroecology (Demand ha)	Variety (Demand %)	Yield (kg ha^{-1})	Area (m^2)	Production (kg)	Area (ha)	Production (t)	Area (ha)	Production (t)
Eastern (54792)	Tumaini (30)	1500	77.93	11.69	0.58	0.87	43.83	65.75
	Fahari (20)	1400	63.90	8.95	0.45	0.63	31.31	43.83
	Vuli-1 (15)	1700	26.77	4.55	0.23	0.39	19.34	32.88
	Vuli-2 (35)	1800	52.61	9.47	0.47	0.85	42.62	76.72
Western (16796)	Tumaini (80)	1500	63.70	9.56	0.48	0.72	35.83	53.75
	Vuli-2 (20)	1800	9.22	1.66	0.08	0.14	7.46	13.43
Southern	Tumaini (60)	1500	61.14	9.17	0.46	0.69	34.39	51.59
Highlands (21495)	Fahari (40)	1400	50.13	7.02	0.35	0.49	24.57	34.40
Southern (28465)	Fahari (30)	1400	49.79	6.97	0.35	0.49	24.40	34.16
	Vuli-1 (20)	1700	18.54	3.15	0.16	0.27	13.40	22.78
	Vuli-2 (50)	1800	39.05	7.03	0.35	0.63	31.63	56.93
Northern (2514)	Vuli-1 (24)	1700	1.96	0.33	0.02	0.03	1.42	2.41
	Vuli-2(38)	1800	2.62	0.47	0.02	0.04	2.12	3.82
	Tumaini (38)	1500	4.53	0.68	0.03	0.05	2.55	3.83
Lake (27476)	Tumaini (33)	1500	42.98	6.45	0.32	0.48	24.18	36.27
	Vuli-1 (28)	1700	25.05	4.26	0.21	0.36	18.10	30.77
	Vuli-2 (39)	1800	29.40	5.29	0.26	0.47	23.81	42.86
Central (10430)	Tumaini (25)	1500	12.36	1.85	0.09	0.14	6.95	10.43
	Fahari (17)	1400	10.34	1.45	0.07	0.10	5.07	7.10
	Vuli-1 (22)	1700	7.47	1.27	0.06	0.10	5.40	9.18
	Vuli-2 (36)	1800	10.30	1.85	0.09	0.16	8.34	15.02
Total			659.80	103.12	5.16	8.13	406.72	647.87

Table 5. Certified seed production (t) plan over three years.

Variety	2012	2013	2014
Fahari	40	80	119.48
Tumaini	80	170	221.61
Vuli-1	30	70	98.01
Vuli-2	70	150	208.78
Total	220	470	647.87

Vision of success for cowpeas in Tanzania

Highest productivity level (>0.8 t ha^{-1}) will be attained at national and global levels that attributes to the wealth of producer farmers with significant contribution to the home food consumption. The overall production will satisfy the national demand and contribute to the GDP with significant amount for exports and/or agro-processed products.

Common bean

Sostene Kweka, Michael Kilango, Magdalena Williams, Jean-Claude Rubyogo and Steve Beebe

Introduction

The agriculture sector of Tanzania accounts for 46.2% gross domestic product (GDP); food crops contribute 65% of the agricultural GDP. In Tanzania, agriculture grew only by 4% per year in the last decade while the population growth was 3% to 4%. The growth rate in agriculture was low to bring significant improvement in income of people (Source: Policy forum 2009).

Common bean (*Phaseolus vulgaris*) together with maize and rice are the major food crops of smallholder farmers in Tanzania. It is the leading leguminous crop, accounting for 78% of land under legumes. Per capita bean consumption is 19.3 kg, contributing 16.9% protein and 7.3% calorie in human nutrition (Source: Rugambisa 1990) and 71% of leguminous protein in diets (Source: Grisley 1990). It is estimated that over 75% of rural households in Tanzania depend on beans for daily subsistence (Source: Xavery et al. 2006, Kalyebara and Buruchara 2008). The crop residues are used as livestock feed and source of organic matter to enhance soil fertility.

About 1.25 million ha of bean are planted per year, with the main production areas located in the northern zone particularly the Arusha region, the great lakes region in the west and in the Southern Highlands. Tanzania is the largest producer in Sub-Saharan Africa and the world's seventh largest producer of common bean. The area occupied by common bean is second to maize accounting for nearly 11% of the total cultivated land. Total production is approximately 933,000 tons of production each year, while national demand is estimated at 724017 tons. Hence Tanzania is a net exporter of common bean. The crop is grown by smallholder farmers particularly women under quite diverse farming systems and agroclimatic conditions for both household food requirements and income generation (Source: Bosch 1992).

Common bean production and national demand have been increasing (Fig. 1). The area under bean production has been increasing at an average rate of 11% per annum over the last decade. On the other hand, yield growth rates have been increasing from 0.48 t ha^{-1} in 1970 to 0.77 t ha^{-1} in 2001–07 (Source: Katungi et al. 2010). Greater improvements in productivity are expected between 2014 and 2020.

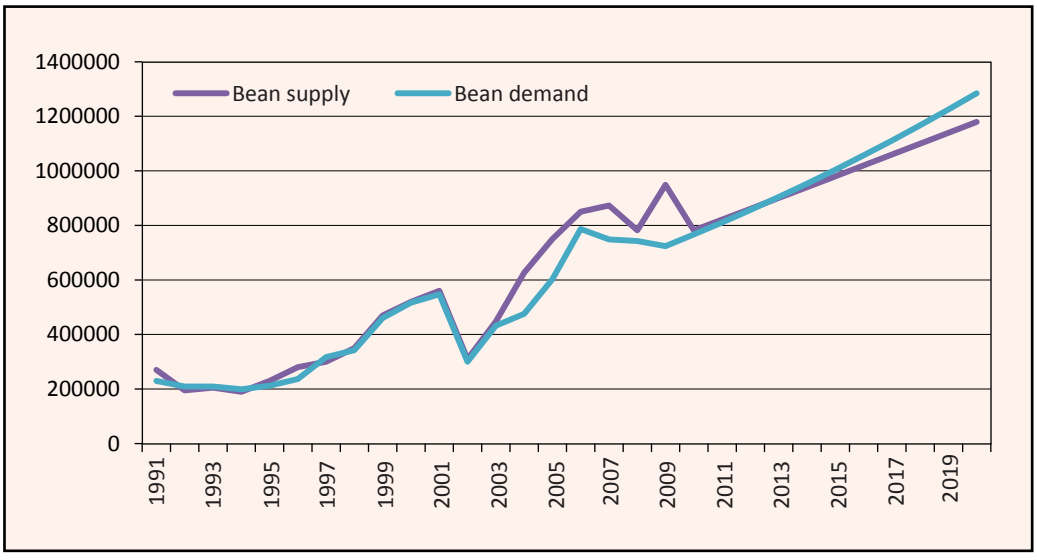

Figure 1. Trends in common bean production (tons) and demand (tons) in Tanzania during 1991–2020 (Source: www.FAOSTAT.org, 2011).

Research and development

The Agricultural Research System in Tanzania is divided into 7 Agroecological Zones: Eastern, Northern, Western, Lake, Southern, Southern Highlands and Central Zones. Each zone has specific mandate crops depending on the zone priorities (Fig. 2). However, during the colonial period, the main emphasis was on cash crops. Research on the main food crops, including beans, gained importance after independence. The Bean Research Program of Tanzania was formally initiated in 1977 though bean research work begun as early as 1965.

The current overall objective of agricultural research and development in Tanzania is to promote sustainable food security, income generation, employment, growth and export enhancement by developing and disseminating appropriate and environment friendly technologies, with emphasis on sustainability of production systems and maintaining the productivity of natural resources. Bean research contributes to this goal through engaging in breeding and research on integrated crop management (ICM) for higher productivity. Bean research in Tanzania has been conducted in close collaboration with the International Center for Tropical Agriculture (CIAT) which started as early as 1973 (Source: Hillock et al. 2006). Varieties released since 1975 are listed in Table 1.

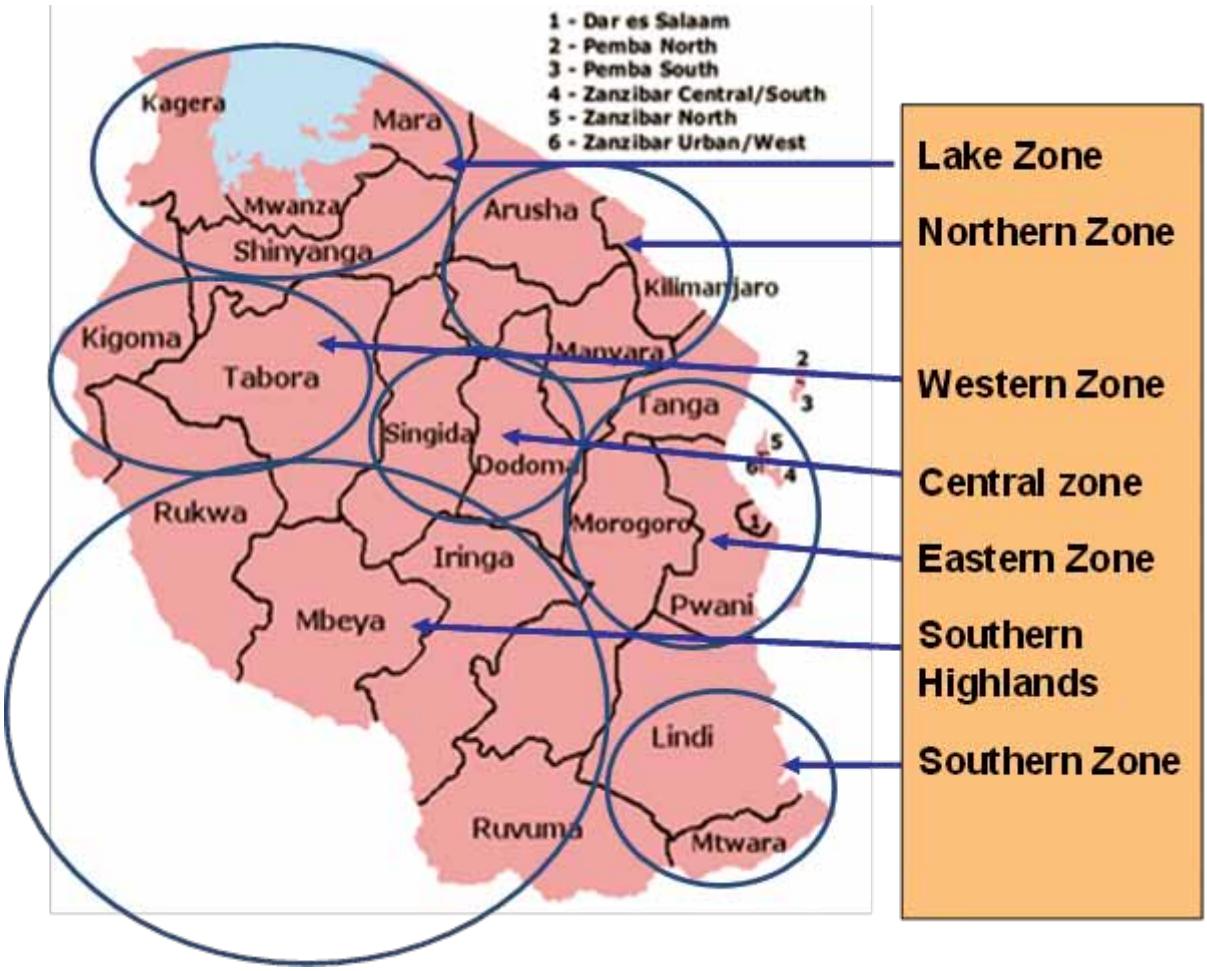

Figure 2. Common bean production zones of Tanzania.

Table 1. Common bean varieties released in Tanzania since 1975.

Variety	Year released	Origin ID code	Yield potential (t ha^{-1})	Area planted (%)	Seed type	Characteristics
Kabanima	1975		2.1	3.6		
Lyamungu 85	1985	CIAT bank (=T23)	2–2.5	8	Large, red/brown, Calima type	Tolerant to drought and diseases
Lyamungu 90	1990	CIAT bank, Colombia bank G 5621	2–2.7	8	Large, red mottle, Calima type	Tolerant to drought and diseases
Ilomba	1990	Local line			Small, brown	
Uyole 90	1990	CIAT	2–2.5		Medium, cream/ brown stripe	
SUA 1990	1990	G 5476	2–2.5		Small, beige	
Selian 94	1994	Tanzania local selection	2–2.5		Medium, pink with red spots	
Uyole 94	1994	Tanzania (=Red kasukanywele)	2–3		Large, cream/ dark red	Tolerant to angular leaf spot and rust
Njano	1996	Introduction = EA1 2525	2–3		Medium, orange	Tolerant to angular leaf spot and rust
Uyole 96	1996	CIAT introduction	2–2.5	6	Large, dark red kidney	Tolerant to angular leaf spot and rust
JESCA	1997	CIAT bank acc. G 14369	2–2.5	5	Large, purple, rounded	Drought tolerant, early maturing
EP4-4 (ROJO)	1997	CIAT bank acc. G 14369			Medium, dark red	
Selian 97	1998	TMO110 × PVA782	2–2.5	2	Large, dark red kidney	
Uyole 98	1999	Bred at Uyole	2–3		Medium, orange	Tolerant to anthracnose, angular leaf spot, halo blight, rust and common bacterial blight
Kablanketi	1999			0.39		
Uyole 03	2003	DRK124	2–2.5	2	Large, sugar type	Tolerant to anthracnose, angular leaf spot and halo blight
Urafiki	2003	Kabanima × GN	2.5–3	2	Medium, dark red kidney	Tolerant to some of the major diseases with quick recovery
Wanja	2003	A197	1.5–2	5	Large, khaki	Escape from stress due to its early maturity
Uyole 04	2004	7068/2	2.5–3	3.72	Medium, cream	Tolerant to anthracnose, angular leaf spot and halo blight
BILFA-Uyole	2004	CIAT	2–2.5	0.39	Medium, Calima	Tolerant to anthracnose, angular leaf spot and halo blight
Calima 2009	2009	PLXCIAT	2–2.5	0.45		Tolerant to anthracnose and angular leaf spot
Kabanima	1979	PI XCIAT	2–2.5		Medium, red mottled	Tolerant to anthracnose, angular leaf spot and rust, early maturing
Uyole 84	1984	Pure local	3–4.5		Small, cream	Tolerant to anthracnose, halo blight, angular leaf spot and common bacterial blight
Calima-Uyole	2011	Others	2–3		Medium, red mottled (Cranberry)	Tolerant to anthracnose and angular leaf spot
PASI	2012		2–3		Large, khaki	Tolerant to angular leaf spot
ROSENDA	2012		2–3.5		Large	Tolerant to angular leaf spot
Fibea	2012		2–3.5		Large, khaki	Tolerant to angular leaf spot

Agroecology

Common bean is widely grown across the country. The highest concentrations are located in the Northern Zone (Kilimanjaro, Arusha, Manyara, Tanga regions), Southern Highlands Zone (Mbeya, Ruvuma, Iringa, Rukwa regions), Lake Zone (Kagera region) and Western Zone (Kigoma) (Table 2). The main growing zones have different rainfall amounts and distribution during the growing season with unimodal distribution (November/December to March/April) in the South, Central and Western zones and bimodal in the northeastern and Lake zones. Bimodal rainfall regions have two seasons, the short season in November/December and long rains from March to May/June.

Table 2. Area under bean production zones and dominant varieties.

Bean production zone	Bean area (ha)	Promising varieties
Northern Zone (Kilimanjaro, Arusha, Manyara, Tanga regions)	370153	Lyamungu 85, Lyamungu 90, Selian 94, JESCA, Selian 97, Selian 05, Selian 06, Cheupe
Southern Highlands and Southern Zone (Mbeya, Ruvuma, Iringa, Rukwa regions)	365661	Wanja, Urafiki, Calima Uyole, Roba1, NRIE27 and PASS
Southern Zone (Lindi and Mtwara)	3683	JESCA
Lake Zone (Kagera, Mara and Mwanza region)	307951	Lyamungu 09, Selian 06, Uyole Nyano
Eastern Zone (Morogoro)	25813	Rojo, Ushindi, Pesa, and SUA 90,
Shinyanga	35168	JESCA
Central Zone (Dodoma, Singida, Tabora)	43269	
Western Zone (Kigoma)	98302	Lyamungu 09, Selian 06, Uyole Nyano
Total	1250000	

Constraints

Biophysical constraints

Major constraints to common bean production are:

- Limited access to genetically high-yielding varieties
- Diseases notably, angular leaf spot, common bacterial blight, common bean mosaic virus, rust, anthracnose, halo blight and root rot
- Insect pests (bean stem maggot, aphids and bruchids)
- Poor soil fertility (low N, low P, Al, Fe and Mn toxicity, low exchangeable bases)
- Terminal drought

Socioeconomic and institutional constraints

- Poor access to inputs (seed of improved varieties, labor, complementary agro-chemicals, land, etc) and output markets (generally lack of market information). This results from poor product grading and standardization; inadequate market infrastructure (high transport cost, high transaction costs and inadequate storage facilities); and unstructured market of inputs and outputs. Consequently, farmers get low farm-gate price due to long value chain and poor quality standards of their produce.
- Low access to extension information; sometimes the desirable varieties are not adopted by farmers due to lack of information or awareness.

- Lack of infrastructure like storage facilities to support growth of long distance trade.
- Lack of credit and inadequate government policy support toward bean crop despite its importance (cash and food/nutritional security especially for the poor and women). Agricultural research in NARS is constrained by low numbers of scientists with the relevant experience and lack of reliable techniques or infrastructure (such as laboratories for screening purpose, irrigation facilities) not adequately provided.

Opportunities

There are ample opportunities to improve the production of common bean in Tanzania.

- The government has enacted the Agricultural Sector Development Strategy (ASDS) to create favorable environment for commercial activities; delineate public/private roles including continued public financing for core agricultural services with increased private delivery through contracting arrangements; decentralize service delivery responsibilities to local governments; and focus on the preparation and implementation of District Agriculture Development Plans.
- The government has adopted the policy of "*Kilimo Kwanza*" as the country's green revolution to transform its agriculture into a modern and commercial sector through investment in both public and private organizations, in rural infrastructure such as roads, irrigation, inputs such as high-yielding seed varieties and fertilizer, and improved technology.
- High priority (Priority 1) accorded to the crop by Government of Tanzania.
- Additional on-going initiatives promoting sustainable intensification of common beans with cereals [SIMLESA, USAID's Feed the Future (FtF) in Tanzania] provide great advantage for synergies for this project.
- Growing bean export market in the neighboring countries and overseas.
- PABRA bean regional networks which provide opportunity of exchange of experience/skills, adapted germplasm and other technologies, and complementary funding.
- Presence of strategic partners/role (Table 3).

Seed systems strategy

In line with "*Kilimo Kwanza*" – green revolution, agriculture sector to grow by 10%. The vision of bean research in Tanzania is to increase bean yields from 0.77 t ha^{-1} to at least 1 t ha^{-1} and increase export earnings from beans as well as its contribution to food security. Bean seed production plan for Tanzania is given in Table 4.

R&D emphasis for TL-II Phase 2

- Develop and introduce effective ICM strategies for common bean production.
- Strengthen research on new introduced drought resistant lines.
- Release and promote improved/preferred varieties.
- Intensify seed production and strengthen community-based seed systems.
- Help to develop plans for commercialization.

Table 3. Partners and their role in the seed system.

Partner	Role
DRD (Department of Research and Development, Ministry of Agriculture and Food Security)	Variety development, evaluation and release; production of breeder and foundation seed.
CIAT[1]	Provide improved common bean germplasm/breeding populations; capacity building through training of NARS; research on effective methods for technology dissemination and provision of financial assistance to NARS to conduct research based on mutual proposed activities between donors and NARS.
Farmer Cooperatives/Groups	Seed multiplication and dissemination.
NGOs (Dioceses, CARE, World Vision, CRS, MVIWATA, FARM AFRICA, MIFIPRO, INCOMET, ADP, KMAS) and District Councils	Facilitate introduction of new varieties; development of legumes market value chain, resource contribution; informal seed production and dissemination of proven technologies.
Private sector: Zenobia Ltd, Meru Agro, International Tanseed Ltd	Processing and commercialization of seed and products.
Farmers	End-users of technologies in terms of high-yielding varieties, management practices and seed multiplication.
TOSCI (Tanzania Official Seed Certification Institute)	Variety release, seed certification services and quality control; collaborating with NGOs and CBOs in Quality Declared Seed (QDS) production/monitoring.
ASA (Agricultural Seed Agency)	Mass seed production of different crops (Basic seed production, Certified seed production, Foundation seed production).
District Councils (Department of Agricultural Extension Services)	Provision of guidance in crop production technologies and associated packages.
ECABREN/SABRN/ WECABREN	ECABREN/SABRN/WECABREN in partnership with customers and diverse research and development stakeholders seeks to contribute to the social welfare and economic growth of the people in East and Central Africa and Southern Africa while protecting natural resource base by providing acceptable and marketable bean based technologies and strengthening institutional capacity to adequately address existing and emerging bean research and development agenda in the region.
Ministry of Agricultural and Food Security (MAFS)	Promote efficient and effective services to the agricultural sector in collaboration with all stakeholders.
Traditional Irrigation Improvement Program	Contribute to a durable and gender-balanced improvement of standard of living of the community in traditional irrigated areas in Tanzania through sustainable development of catchments with regard to irrigation, natural resources management, soil and water conservation, afforestation, participatory land-use planning and organizational development.
Tanzania Food and Nutrition Centre (TFNC)	Formulate, initiate and promote development policies and plans, regulations and legislation for improvement of nutritional status of Tanzania community; promote nutrition of the socioeconomical deprived and nutritionally vulnerable groups; promote community participation in managing and controlling nutritional problems in the country; promote applied and basic nutrition and research; and promote private sector involvement in nutrition intervention.

Continued

Table 3. *Continued.*

Partner	Role
Participatory Agricultural Development and Empowerment Project (PADEP)	The overall development objective of the project is to increase farm incomes and reduce food insecurity, thereby contributing to reduction of rural poverty. The project immediate objectives are to: (i) Strengthen the capacity of rural communities and farmers' groups to plan and implement agricultural development sub projects; and (ii) Strengthen the capacities of rural service providers of Local Authorities and national level to provide more responsive assistance to community and farmers' needs.
Agricultural Marketing Services Development Project (AMSDP)	Strengthen about 1000 producers groups to enable them to have a better bargaining position and more leverage on policy formulation to identify marketing opportunities and to improve price negotiation for both buying and selling products. Establish links among producers groups, grassroots institutions, processors, local marketing chains and exporters.
Tanzania Social Action Fund (TASAF)	TASAF Components: Community Development Initiatives (CDI), Public Works Program (PWP) and Institutional Development (ID) The CDI component will support community demand-driven initiatives that improve the accessibility to and the delivery of socioeconomic services and enhance the capacity of communities and other stakeholders involved in the process. The objective of the PWP, a safety net scheme, is to provide a cash transfer for targeted beneficiaries, while increasing/ improving the infrastructure assets in targeted areas, and enhancing the beneficiaries' skills for future employment.
Mass Media: TBC, ITV, Star TV, Local radio FM	Assist in broadcasting/promoting agricultural based technologies to the end-user.
Agricultural Marketing Systems Development Program (AMSDP)	Facilitate the process of establishing appropriate policies, regulations and legislation, improve market information systems and institutionalize the analysis and monitoring of policy impact at national and local government levels; empower groups of smallholder farmers and small-scale traders/processors and link them with the market; facilitate access to credit by smallholders for storing produce and medium-scale traders and processors for increasing the size and efficiency; rehabilitate and maintain market infrastructure especially rural and village roads. AMSDP coordination unit consulted partner agencies (PA) to facilitate implementation of this developmental program for selected districts in Northern and Southern zones of Tanzania. The Traditional Irrigation and Environmental Development Organization (TIP) is one of the PAs that implements AMSDP in Arumeru district (Northern Tanzania).
Rural Financial Service Program (RFSP)	Improvement of the managerial capacity and performance of grassroots micro-financial institutions (MFIs), the rural financial systems development and the empowerment of the rural poor; monitoring and evaluation and management and coordination. The target group is drawn from the poor households in the 21 program districts. Specifically, the program targets poor rural households including farm households and the landless; community-based organizations (CBOs), Upatu and other solidarity groups, and the rural MFIs that serve them, viz, Savings and Credit Societies (SACCOS) and Savings and Credit Associations (SACAs).
Mtandao wa Vikundi vya Wakulima Tanzania (MVIWATA)	Develop a strong representation of farmers' interests in confronting their own problems mainly on participatory communication, lobbying and advocacy, organizational strengthening in providing agronomic services and marketing strategies.
SUA (Sokoine University of Agriculture)	Bean based technologies; training for degree and non-degree courses.

1. CIAT is an agricultural center, internationally mandated for undertaking bean research.

Table 4. Common bean seed production plan for Tanzania.

Ecology	Seed demand	Desired traits[1]	Varieties	Available breeder and foundation seed (t)	Seed production (t)			Seed to reach 20% adoption (t)	Estimate of seed produced (t)			Key partner	Primary role
					Breeder seed	Foundation seed	Certified seed		2012	2013	2014		
Northern	170000 ha (13,600 tons of seed)	Resistant to anthracnose, ALS, RR, CBB, HB and BCMV	Lyamungu 85	4.2	16	233	3497	3746	937	1311	1498	ASA, TOSCI, Zenobia Ltd, Mviwamo Farmer Groups, Tanseed International, District Councils	Seed production
		Resistant to anthracnose, ALS, RR, CBB, HB and BCMV	Lyamungu 90	3.2	16	233	3497	3746	937	1311	1498	ASA, TOSCI, Zenobia Ltd, Mviwamo Farmer Groups, Tanseed International, District Councils	Seed distribution
		Resistant to anthracnose, ALS, RR, CBB, HB and BCMV	Selian 94	1	16	233	3497	3746	937	1311	1498	ASA, TOSCI, Zenobia Ltd, Mviwamo Farmer Groups, Tanseed International, District Councils	Markets
		Early maturing, resistant to anthracnose, ALS, rust, CBB, HB and BCMV	JESCA	2.5	16	233	3497	3746	937	1311	1498		
		Resistant to anthracnose, ALS, rust, CBB, HB and BCMV	Selian 97	1	7	104	1554	1665	416	583	666		
Southern Highlands	247010 ha (19,761 tons of seed)	Early maturing, resistant to ALS, rust, anthracnose and BCMV	Urafiki	2.3	15.64	234.6	3519	3769	937	1344	1498	ASA, Tumaini University, ARI Uyole Farm, SUBA Seed Co, INCOMET, Kipato Seed Co, Farmers' organization, Southern Highlands seed growers	Seed production
		Tolerant to low soil fertility, can escape the effects of drought by being harvested before the end of rains	Wanja	3.1	15.64	234.6	3519	3769	937	1344	1498		

Continued

Table 4. *Continued.*

Ecology	Seed demand	Desired traits[1]	Varieties	Available breeder and foundation seed (t)	Seed production (t)			Seed to reach 20% adoption (t)	Estimate of seed produced (t)			Key partner	Primary role
					Breeder seed	Foundation seed	Certified seed		2012	2013	2014		
		Resistant to pests (pod borer), fairly tolerant to ALS, anthracnose and rust	Uyole 96	4	15.6	234.6	3519	3769	937	1344	1498		
		Tolerant to low soil fertility, resistant to ALS, CBB, BCMV and rust	Calima Uyole	1	12.5	188.2	2823	3024	756	1058	1210		
		High yielding, tolerant to low soil fertility, resistant to drought	Njano Uyole	4	23.4	351	5270	5644	1361	1976	2258		
		Resistant to anthracnose, rust and BCMV, dense in iron and zinc	Uyole 04	2.5	17.6	263	3952	4233	1058	1482	1693		
		Resistant to ALS, anthracnose and rust	Pasi	0.2	1.3	19	282	302	76	106	121		
		Tolerant to low soil fertility, resistant to ALS, anthracnose, rust and BCMV	NRI-E27	0.2	1.3	19	282	302	76	106	121		
		Resistant to ALS, anthracnose, BCMV, CBB and rust	Roba	0.2	1.3	19	282	302	76	106	121		
Lake zone		High yielding, tolerant to low soil fertility, resistant to drought	Njano Uyole	1.5	55	821.2	12,318	13194	3299	4618	5278	Wapendanao, Sisimuka, Biija mpola, Mshikamano, ONJAMI Kolping Society of Tanzania, Itente, Maisha mapya, Tujikomboe, BRAC and SAFO	Seed production
		Resistant to anthracnose, ALS, RR, CBB, HB and BCMV	Lyamungu 90	1.5	55	821.2	12,318	13194	3299	4618	5278		

1. ALS = Angular leaf spot; RR = Root rot; CBB = Common bacterial blight; HB = Halo blight; and BCMV = Bean common mosaic virus.

Chickpea

Robert Kileo, Ganga Rao and Said Silim

Introduction

Chickpea provides unique opportunity of enhancing legume production in Africa as it does not compete for area with other major legumes being a dry-season (postrainy season) legume. There is not much choice of legumes for growing on the residual moisture in the postrainy season, the conditions and season in which chickpea is grown. Chickpea is indeed a bonus crop in Tanzania. After harvest of maize/rice in Tanzania, the land is normally left fallow until the next cropping season (rainy season). Chickpea is planted immediately after the harvest of cereals and grows on residual moisture thus giving farmers a second crop (where only one crop would traditionally be grown), hence income and nutrition.

The bulk of chickpea produced in Eastern Africa is consumed locally, adding to the nutrition of people; and surplus is being exported to earn foreign exchange. Tanzania exports a substantial amount of its chickpea produced, up to 21000 tons with a value of US$ 7 million. Chickpea has more diversified uses than any other food legume. The green leaves are used as leafy vegetable and are superior to spinach and cabbage in mineral content. The green immature seed is used as a snack or vegetable. Selling green pods for green seed is highly profitable as these are sold around US$ 1 to US$ 1.5 per kg and weigh 2–3 times higher than dry seed. The dry seed splits and flour are used in a variety of other preparations like *githeri*, stew, *mandazi*, cake, *samosa*, doughnuts, buns, *chapati* and grits.

Research and development

Research on chickpea in Tanzania began with seed money from CGIAR-Canada Linkage Fund (CCLF), which allowed the evaluation of large number of accessions and the selection of potential varieties for further testing. The TL-II project (funded by BMGF) gave an impetus to enhance research and through on-farm, farmer participatory variety selection (FPVS) and demonstrations and sustainable seed systems resulted in landmark fast track release of the first set of varieties (Table 1).

The TL-II Project Phase 1 which started in September 2007 and ended in August 2011 focused mainly on chickpea germplasm development, FPVS, varietal dissemination, capacity building, seed multiplication and production. The work was carried out in Shinyanga and Mwanza regions. Overall, TL-II Phase 1 contributed to increased chickpea yields, farmers' income, increased utilization/nutrition and improved livelihoods through (a) availability of improved germplasm that is high yielding and tolerant to fusarium wilt; (b) increased dissemination, up-scaling and adoption of the improved germplasm; (c) infrastructure and capacity building; and (d) increased linkages and partnerships.

Table 1. Characteristic features of varieties released in Tanzania[1].

Variety	Year of release	Pedigree	Potential area (ha)	Average on-farm yield potential (kg ha^{-1})	Varietal traits
Ukiriguru 1 (Desi)	2011	ICCV 97105	29000	1600	Medium seed size, medium maturity (earliness), resistance to fusarium wilt, market opportunities
Mwanza 1 (Desi)	2011	ICCV 00108	36000	1800	
Mwangaza (Kabuli)	2011	ICCV 92318	20000	1900	
Mwanza 2 (Kabuli)	2011	ICCV 00305	18000	1500	

1. Released by Ukiriguru Agricultural Research Institute, Lake Zone, Tanzania.

Agroecologies of chickpea cultivation

Chickpea in Tanzania occupies about 105,000 ha and is mostly grown in Lake, Western and Northern Zones (Table 2).

Table 2. Major chickpea growing areas in Tanzania.

Zone	Regions	Area (ha)
Lake Zone	Shinyanga, Mwanza, Mara, Kagera	80,000
Western Zone	Tabora, Kigoma	15,000
Northern Zone	Arusha, Manyara	10,000
Total		105,000

Seed systems

In Eastern and Southern Africa, baseline studies indicated that very limited awareness existed on improved chickpea varieties, due to consistent failure of public sector to supply good quality source seed and the lack of interest by the private sector to engage in legume seed production; in addition, most often, seed is produced in high potential areas or areas with infrastructure for storage and processing far away from the area of utilization, leading to high transaction costs. Requirements for high seeding rates further limit the spread of new varieties.

To overcome these constraints, investments have been made in breeder and foundation seed production, and proceeds from seed sales were employed to re-capitalize seed revolving funds to support subsequent seed production cycles. Foundation seed has been marketed to private companies and NGOs for further seed production and dissemination. Most of the farmers rely on own-saved seed and access to seed of improved varieties either through informal networks or relief seed. The survey also revealed the existence of two seed supply systems, ie, informal, which is usually non-market based seed supply system and the quasi-formal, mainly market-based seed supply system. The informal seed supply sources included own-saved seed, gifts from family and friends, farmer-to-farmer seed exchanges and others. The importance of quasi-formal supply seems to increase with the availability of new farmer-preferred varieties, which helps in emergence of seed markets for improved varieties.

Seed production target

Total area: 105,000 ha

Seed rate (mean): 90–120 kg ha^{-1} based on seed size

National seed demand: 11,466 tons (2012–14) to cover 105,000 ha

Capacity to deliver 20% total area: 21,000 ha

Total seed required to cover targeted area of 21,000 ha $\simeq$ 2064 tons

Opportunities, constraints, partnerships and seed production plan

Opportunities

- Farmers in the target areas have recognized that chickpea is a drought tolerant crop and hence can be used to mitigate the effects of climate change. Furthermore, most of the improved materials have tolerance to fusarium wilt coupled with early maturity to catch up with the huge Indian market. This creates a big demand for seed of the improved materials.

- There is available market and demand for the seed and grain within and outside the country.
- Few private seed companies have taken up production of seed but due to increase in demand some are now becoming interested to produce quality seed.
- The four new varieties released and their seed availability through sustainable seed systems planned under TL-II, CGIAR Research Program on grain legumes and national level support will contribute significantly to seed availability.
- The country has also embarked on *Kilimo Kwanza* as Tanzania's Green Revolution to transform its agriculture into a modern and commercial sector. Some of its actionable pillars like political will to push agricultural transformation, enhanced financing for agriculture and incentives to stimulate investments in agriculture can support the seed plan.

Major production constraints

- Pests and diseases and their dynamism: Fusarium wilt, collar rot, pod borer, bruchids
- Waterlogging, drought
- Seed supply inadequacy, picking green chickpea, poor cultural practices
- Lack of harvester, thresher, grading and planter machines at affordable level

Key partners

The key partners and their role in the seed system are given in Table 3.

Table 3. Key partners and their roles in the chickpea seed roadmap implementation.

Partner	Role
Research Institutions (LZARDI, SARI)	Germplasm development, variety release, produce breeder seed, dissemination
TOSCI – Tanzania Official Seed Certification Institute	Seed certification and quality control
ASA – Agricultural Seed Agency	Foundation and certified seed production, marketing
ICRISAT-TL-II	Funding, provide improved germplasm, capacity building, facilitate seed production and distribution, up-scaling
Extension services	Advisory services, farmers' mobilization and dissemination
Local government authorities/policy makers	Farmers' mobilization, supportive policy, funding, dissemination/up-scaling
NGOs, CBOs, farmers' associations	Mobilization of farmers, group formation, facilitate access to loans, inputs and markets, advisory services
Agro-dealers	Advisory services, inputs/seed availability, loans to farmers
Seed companies (Kilimo market)	Seed production, marketing and distribution
Contract farmers	Produce quality seed
Individual farmers	Seed buyers and users, grain producers and buyers, dissemination/up-scaling

Seed production plan

The seed production plan for chickpea in Tanzania is presented in Tables 4 and 5.

Table 4. Chickpea seed roadmap for Tanzania.

Ecology (Zone)	Demand (ha)	Promising varieties	Yield potential on-farm (t ha^{-1})	Seed rate (kg ha^{-1})	Total area to be covered (ha)		Breeder seed in 2012		Foundation seed in 2013		Certified seed in 2014		Total seed required to reach 20% adoption (t)
					Zone wise	Variety wise	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)	
Lake Zone	80,000	4			16,000		3.36	5.63	55.7	93.7	936	1584	1584
	24,000	Mwanza 1	1.6	90		4800	0.85	1.36	15.2	24.3	270	432	432
	24,000	Ukiriguru 1	1.8	90		4800	0.6	1.08	12	21.6	240	432	432
	16,000	Mwangaza	1.9	120		3200	0.81	1.54	12.8	24.3	202	384	384
	16,000	Mwanza 2	1.5	105		3200	1.1	1.65	15.7	23.6	224	336	336
Western	15,000	4			3000		0.57	0.93	9.7	16.2	169	282	282
	9,730	Mwanza 1	1.6	90		1946	0.35	0.55	6.2	9.9	109	174	175
	2,270	Ukiriguru 1	1.8	90		454	0.06	0.11	1.1	1.98	23	41	41
	2,270	Mwangaza	1.9	120		454	0.11	0.21	1.7	3.2	27	51	51
	730	Mwanza 2	1.5	105		146	0.05	0.08	0.7	1.1	10	15	15
Northern	10,000	4			2000		0.43	0.71	7	11.6	117	198	198
	3,000	Mwanza 1	1.6	90		600	0.11	0.18	1.9	3.0	34	54	54
	3,000	Ukiriguru 1	1.8	90		600	0.08	0.14	1.5	2.7	30	54	54
	2,000	Mwangaza	1.9	120		400	0.1	0.19	1.6	3.0	25	48	48
	2,000	Mwanza 2	1.5	105		400	0.14	0.21	2.0	3.0	28	42	42
Total	105,000				21000		4.36	7.27	72.4	121.5	1222	2064	2064

Table 5. Certified seed production (t) plan over three years.

Variety	2012	2013	2014
Mwanza 1	99	165	397
Ukiriguru 1	79	132	317
Mwangaza	73	121	289
Mwanza 2	59	98	236
Total	310	516	1238

Vision of success

Based on the calculations made from different sources, chickpea area has increased during the last couple of years. This shows that there is a very big potential for the crop to grow and contribute to the GDP of the country through export. The climate change crisis and good prices offered have forced farmers to adopt the crop in many parts of the country. Recently farmers have started selling green chickpea in the local markets, while a number of agro-dealers are selling quality seed to farmers. Some local restaurants are also serving green chickpea along with or instead of green pea. These are new avenues which can increase demand and success of the crop.

Pigeonpea

Stephen Lyimo, Rose Ubwe, Joseph Mligo, Mishek Makenge, Ganga Rao and Said Silim

Introduction

Tanzania is among the top ten producers of pigeonpeas in the world. The area and production of pigeonpea in the country from 2005 to 2011 are shown in Figure 1. Overall, the area and total production have increased over the years due to expansion but productivity or yield per unit area has not changed much despite use of improved materials due to poor crop husbandry practices and drought conditions.

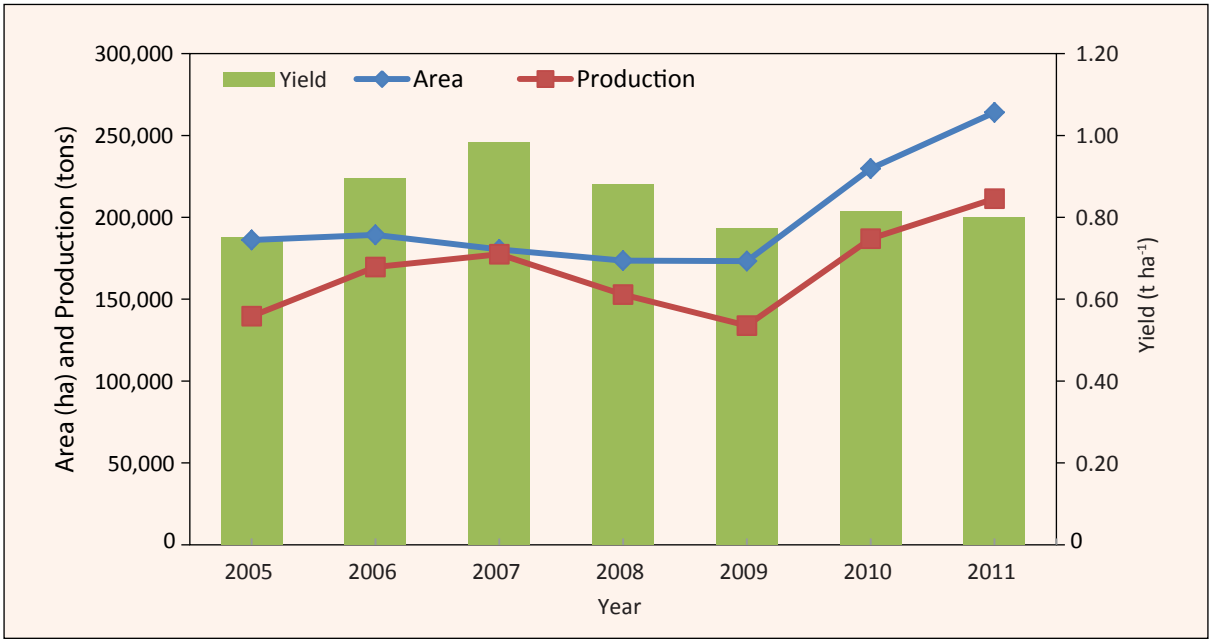

Figure 1. Trends in pigeonpea area, production and yield in Tanzania during 2005 to 2011 (Source: FAO Stats, Statistics Unit-MAFSC, http://www.kilimo.go.tz/agricultural statistics/ Basic Data 2005–2010, district profiles and communication with extension services).

Since 1996/97 to date there have been several pigeonpea projects like PIMASA, TL-II, IFAD, AGRA and recently SIMLESA which were/are being implemented in the Northern, Central and Eastern Zones. These projects contributed a lot to uptake of improved pigeonpea through awareness creation, seed production and distribution. For example, partners in TL-II Phase 1 Project produced and distributed about 270 tons of certified/quality declared seed. A Soil Health Program Project under AGRA also distributed about 32 tons of certified/quality declared pigeonpea seed to farmers in 2010/11 and 2011/12. Such an amount of seed alone could be planted in more than 30,000 ha.

According to Shiferaw et al. (2005), the adoption rate for improved pigeonpea in Babati which is one of the early target areas was about 34%. Field estimates in the same area in 2010 indicated that about 80% of the farmers were planting improved pigeonpea materials. The national adoption rate is however, estimated at about 20%. At the farm level, farmers are being paid an average of about 650–750 TSH per kg grain which is about 40–47 US cents. Farmers who adopted the technology have improved their income and livelihoods by building improved houses, sent their children to schools and colleges, built secondary schools, bought motor bikes/bicycles, bought spare parts for their tractors, started small and medium businesses, bought improved cattle/goats and some agro-dealers are now selling pigeonpeas, etc.

About 60–80% of the pigeonpea produced in the country is sold as dry grain whereas the remaining portion is consumed at household level while green and dry, and some left as "seed" for the following season. However, farmers in Moshi have recently found market for green pigeonpea in Kenya, and have started utilizing the opportunity.

Research and development

Pigeonpea research started in the early 1980s at ARI, Ilonga by collecting and evaluating local and introduced genetic materials from ICRISAT which were suitable and potential for Tanzania. On station and multilocational breeding trials including screening for fusarium wilt resistance were done for early-, medium- and long-duration lines to determine high-yielding and fusarium wilt resistant lines. Agronomic field trials on maize/pigeonpea and sorghum/pigeonpea intercropping were also conducted to determine yield, optimum plant population, spacing and time of sowing.

Collaborative research work for the crop started in the 1990s with different partners in the Northern, Eastern and Lake Zones. The key partners were extensionists, local government authorities, Sasakawa Global 2000, ICRISAT, TechnoServe, contract farmers, farmers' groups, private seed companies/estates, NGOs, the Agricultural Seed Agency (ASA) and the Catholic Relief Services (CRS). The main focus in the research was participatory variety testing/selection, establishing sustainable seed supply systems through private sector contract farming, screening for fusarium wilt, improved management practices, and initiatives to enable farmers to access local and external markets through formation of Producer Market Groups (PMGs). Three improved pigeonpea varieties released in Tanzania are listed in Table 1.

Table 1. Improved pigeonpea varieties released in Tanzania.

Variety/Line	Year released	Maturity period
Komboa (ICPL 87091)	1999	Short duration (110–120 days)
Mali (ICEAP 00040)	2002	Long duration (180–270 days)
Tumia (ICEAP 00068)	2003	Medium duration (140–180 days)

The TL-II Project Phase I, which started in September 2007 and ended in August 2011 focused mainly on pigeonpea germplasm development, farmer participatory variety selection (FPVS), varietal dissemination, capacity building, seed multiplication and production. The work was carried out in Kilosa, Babati and Karatu districts in Morogoro, Manyara and Arusha regions respectively. Overall, TL-II Phase 1 contributed to increased pigeonpea yields, farmers' income, increased utilization/nutrition and improved livelihoods through (a) availability of improved germplasm that is high yielding and tolerant to fusarium wilt; (b) increased dissemination, up-scaling and adoption of the improved germplasm; (c) infrastructure and capacity building; and (d) increased linkages and partnerships. Four varieties belonging to long (ICEAP 00053, ICEAP 00932) and medium maturity (ICEAP 00554, ICEAP 00557) groups are in the pipeline for immediate release.

Agroecologies of pigeonpea cultivation in Tanzania

The total area under pigeonpea cultivation in 2011 was 264,090.26 ha (Fig. 2). Most of the pigeonpea is produced in the Southern, Northern and Central Zones which contribute about 80.06% of the total production (Fig. 2).

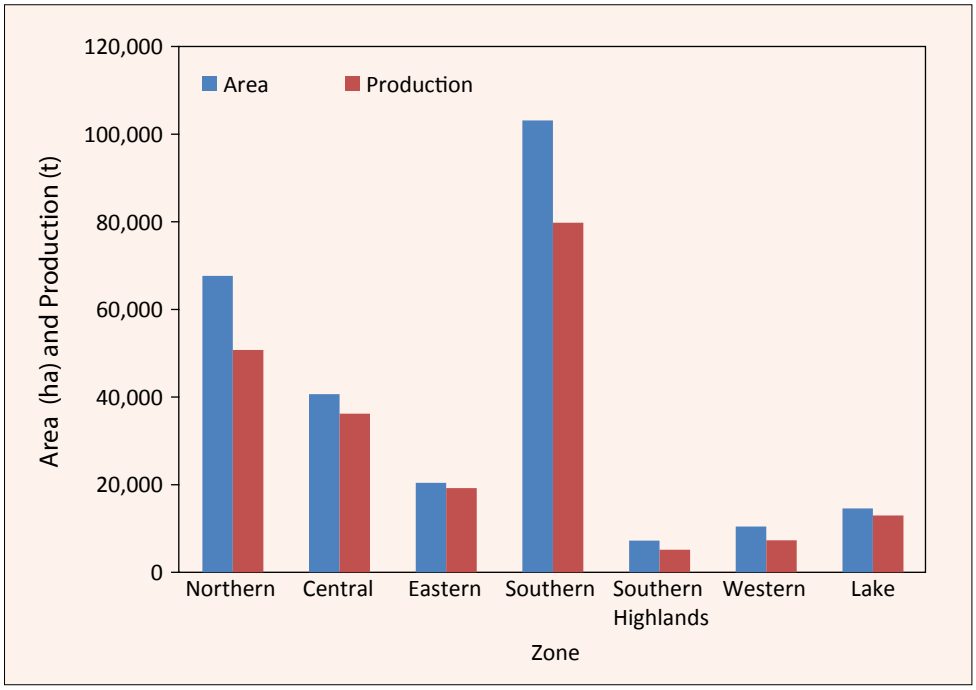

Figure 2. Pigeonpea area and production in different zones of Tanzania in 2011.

Seed systems

In Tanzania, seed production and marketing is largely by the informal sector (96%) with the formal sector accounting for about 4% (Source: Temu and Mtenga 2001). The informal seed systems include borrowing from neighbors/relatives, exchanging or purchasing stored food grains that are then used as seed by farmers. On the other hand, the formal seed system constitutes traders or stockists/agro-dealers selling certified seed. The ASA is the main seed organization mandated with the production of breeder, foundation and certified seeds for publicly developed crop varieties. The private seed companies mainly deal with hybrid maize and vegetable seeds where the market demand is high.

There is also the semi-formal seed production and supply system through the government's extension and research organizations that distribute seed to farmers in their course of conducting research (eg, on-farm trials and on-farm demonstrations). The informal and semi-formal seed production and distribution/marketing systems have been popular due to the deficiencies arising from the formal seed sector (eg, high price and non-production of seeds of legumes considered having low commercial potential by the formal sector).

Kilimo Sasakawa Global 2000 and ICRISAT initiated some collaborative efforts in the mid-1990s with extensionists, farmers' groups, TechnoServe, CRS, plantation estates, contract farmers and NGOs who started to produce quality pigeonpea seed and grain. Recently other partners like TL-II, private seed companies (Zenobia, Rotian Seed, Miombo estates, Krishna Seed Company, Kibodya Estate, Tanseed International), ASA and Soil Health Program under AGRA have facilitated availability of certified/quality and foundation pigeonpea seed.

Seed production targets

Total area: 264,090 ha

Seed rate (mean): 10 kg ha^{-1}

National seed demand: 2640 t (2012–14) to cover 264,090 ha

Capacity to deliver 20% of total area: 56,201 ha

Total seed required to cover targeted area of 56,201 ha ≃ 563 t

Opportunities, constraints, partnership and seed production plan

The opportunities, constraints, partnership and plan of the seed required to cover 20% area of each of the important pigeonpea growing areas are discussed.

Opportunities

- Farmers in the target and spillover areas have recognized that pigeonpea is a drought tolerant crop and most of the improved materials have tolerance to fusarium wilt coupled with early and synchronous maturity to catch up with the huge Indian market.
- The price offered by middlemen and traders for pigeonpea grain has been stable and relatively good over the years due to interventions from various partners like ICRISAT, TechnoServe, CRS and AGRA.
- There is available market and demand for the seed and grain within and outside the country.
- Right now there are more than 10 big companies/estates producing quality seed and grain for sale excluding community-based organizations (CBOs), NGOs, PMGs, farmers' groups and contract farmers. Hence all these sources should be able to contribute significantly to the seed plan.
- There is a conducive policy environment for seed production and the government is also in the process of granting exclusive rights to private seed companies as well as allowing them to produce foundation seed. This will certainly promote availability of seed to marginal areas where there was demand but unavailability as well as increased production of foundation seed are considered the major bottlenecks for certified seed production.
- The four genotypes in pipeline are expected to be released, as all of them have undergone on-farm testing and farmers' evaluation for a very long time and have been greatly accepted by farmers. This will contribute significantly to seed availability for all maturity periods.
- The country has also embarked on *Kilimo Kwanza* as Tanzania's Green Revolution to transform its agriculture into a modern and commercial sector. Some of its actionable pillars like political will to push agricultural transformation, enhanced financing for agriculture and incentives to stimulate investments in agriculture can support the seed plan.

Constraints

Several studies conducted in the country and especially in the Northern Zone indicated that the major constraints for pigeonpea production are:

- Diseases and field/storage pests
- Lack of high-yielding varieties
- Lack of formal markets coupled with grain traits preferred by farmers, and domestic, regional and international markets
- Seed systems that would support varietal diffusion
- Agronomic and pest management practices

Key partners

The key partners and their role are given in Table 2.

Seed production plan

Pigeonpea seed production plan for Tanzania is presented in Tables 3 and 4.

Table 2. Key partners and their roles in the pigeonpea seed strategy implementation.

Partner	Role
Research institutions (Ilonga, SARI, Naliendele, Uyole)	Germplasm development, variety release, produce breeder seed, dissemination
TOSCI – Tanzania Official Seed Certification Institute	Seed certification and quality control
ASA – Agricultural Seed Agency	Foundation and certified seed production, marketing
ICRISAT-TL-II	Funding, provide improved germplasm, capacity building, facilitate seed production and distribution, up-scaling
AGRA-Soil Health Program	Funding, facilitate seed production and distribution, up-scaling, capacity building
Extension services	Advisory services, farmers' mobilization and dissemination
Local government authorities/policy makers	Farmers' mobilization, supportive policy, funding, dissemination/up-scaling
NGOs, CBOs, Farmers' associations (MUVIMAHA, MUVIBAHA, UVIKI), Juhudi farmers' group, Kilimo market, African Farmers Service Centre	Mobilization of farmers, group formation, facilitate access to loans, inputs and markets, advisory services
Agro-dealers	Advisory services, inputs/seed availability, loans to farmers
Seed companies (Kibodya Farm, Tanseed International, Zenobia, Krishna, Miombo Farm, Southern Highland Seed Growers)	Seed production, marketing and distribution
Export Trading and Kamal Agro Ltd	Purchase of quality seed and grain, processing of grain
Contract farmers	Produce quality seed
Individual farmers	Seed buyers and users, grain producers and buyers, dissemination/up-scaling

Vision of success

Based on the estimate made from different sources, the pigeonpea area has increased during the last couple of years. This shows that there is a very big potential for the crop to grow and contribute to the GDP of the country bearing in mind that about 60–80% of the produce is sold outside the country especially to India. The climate change crisis and good prices offered have forced farmers to adopt pigeonpea in many parts of the country. The low rainfall received in many parts of the country leads to low cereal productivity especially of maize and wheat resulting in low income for the smallholders. Such low productivity and income makes farmers to shift to legumes production especially pigeonpea which is drought tolerant, and in most cases intercrop it with cereals mainly maize or sorghum. Furthermore, yields and income obtained from pigeonpea intercropped with maize in some pilot areas like Babati, Karatu, Kilosa, Kondoa, Arumeru, Hai and Moshi have improved smallholder farmers' livelihoods very much in several ways. Studies supported by the Soil Health Program under AGRA in the Northern, Central and Eastern Zones of the country have also shown that the yields of maize and pigeonpea can be increased twofold when farmers apply small amounts of P-based fertilizers like Minjingu fertilizers which are locally available at planting. The cost-benefit ratios obtained by such farmers were also about 2. Such high cost-benefit ratios have attracted farmers to adopt the practice and thus further improve their livelihoods.

Recently farmers have started selling green pigeonpea in the local markets, while a number of agro-dealers are selling quality seed to farmers. Also, some local restaurants are serving green pigeonpea along with or instead of green pea. These are new avenues which can increase demand and success of the crop.

Table 3. Pigeonpea seed roadmap for Tanzania.

Ecology (Zone)	Demand (ha)	Promising varieties	On-farm yield potential (t ha^{-1})	Seed rate (kg ha^{-1})	Area to be covered		Breeder seed 2012		Foundation seed 2013		Certified seed 2014		Seed to reach 20% adoption (t)
					Total (ha)	Per variety (ha)	Area (m^2)	Production (kg)	Area (ha)	Production (t)	Area (ha)	Production (t)	
Northern	67,650	4			16,913		200	20	2	2	170	170	170
	33,825	Mali	1	10		6,765	80	8	0.8	0.8	68	68	68
	16,915	ICEAP 00053	1	10		3,383	40	4	0.4	0.4	34	34	34
	16,915	ICEAP 00554	1	10		3,383	40	4	0.4	0.4	34	34	34
	16,915	ICEAP 00557	1	10		3,383	40	4	0.4	0.4	34	34	34
Central	40,670	3			8,134		90	9	0.9	0.9	81	81	81
	20,335	Mali	1	10		4,067	50	5	0.5	0.5	41	41	41
	10,170	ICEAP 00053	1	10		2,034	20	2	0.2	0.2	20	20	20
	10,170	ICEAP 00554	1	10		2,034	20	2	0.2	0.2	20	20	20
Eastern	20,410	3			4,082		40	4	0.4	0.4	40	40	40
	10,205	Mali	1	10		2,041	20	2	0.2	0.2	20	20	20
	5,105	Tumia	1	10		1,021	10	1	0.1	0.1	10	10	10
	5,105	Komboa	1	10		1,021	10	1	0.1	0.1	10	10	10
Southern	103,120	4			20,624		240	24	2.4	2.4	208	208	208
	25,780	Mali	1	10		5,156	60	6	0.6	0.6	52	52	52
	25,780	Tumia	1	10		5,156	60	6	0.6	0.6	52	52	52
	25,780	ICEAP 00554	1	10		5,156	60	6	0.6	0.6	52	52	52
	25,780	Komboa	1	10		5,156	60	6	0.6	0.6	52	52	52
Southern Highlands	7,220	3			1,444		20	2	0.2	0.2	15	15	15
	3,610	Mali	1	10		722	10	1	0.1	0.1	7	7	7
	1,805	Tumia	1	10		361	5	0.5	0.05	0.05	4	4	4
	1,805	ICEAP 00554	1	10		361	5	0.5	0.05	0.05	4	4	4
Lake	14,590	3			2,918		40	4	0.4	0.4	29	29	29
	7,295	Mali	1	10		1,459	20	2	0.2	0.2	15	15	15
	3,650	Tumia	1	10		730	10	1	0.1	0.1	7	7	7
	3,650	ICEAP 00554	1	10		730	10	1	0.1	0.1	7	7	7
Western	10,430	3			2,086		30	3	0.3	0.3	20	20	20
	5,215	Mali	1	10		1,043	10	1	0.1	0.1	10	10	10
	2,610	Tumia	1	10		522	10	1	0.1	0.1	5	5	5
	2,610	ICEAP 00554	1	10		522	10	1	0.1	0.1	5	5	5
Total	264,090				56,201	56,201	660	66	6.6	6.6	563	563	563

Table 4. Certified seed production (t) plan over three years.

Variety	2012	2013	2014
Mali	31	54	128
ICEAP 00053	8	14	32
ICEAP 00554	18.5	31	72.5
ICEAP 00557	5	9	20
Tumia	11.5	20	46.5
Komboa	9	16	37
Total	83	144	336

Uganda

Groundnut

Kalule Okello, Patrick Okori and Emmanuel Monyo

Importance of the crop to Uganda's economy

Production

Groundnut (*Arachis hypogaea*), also known as peanut, is the second most important grain legume after beans (*Phaseolus vulgaris*) in Uganda. The traditional groundnut varieties are of the red Valencia type, but of a very mixed nature ranging from large-seeded Manyema group (eg, Roxo) to small-seeded group (eg, Red Beauty) (Busolo-Bulafu 2004). Currently, the cultivated area under groundnut is estimated to be nearly 260,000 ha with production generally reducing due to a number of production related factors including among others the availability of improved seed (Fig. 1). Most of the crop is produced in the eastern and northern part of the country. The average farm size of groundnut per household in Uganda is estimated at 0.15 ha, according to UBOS (2010).

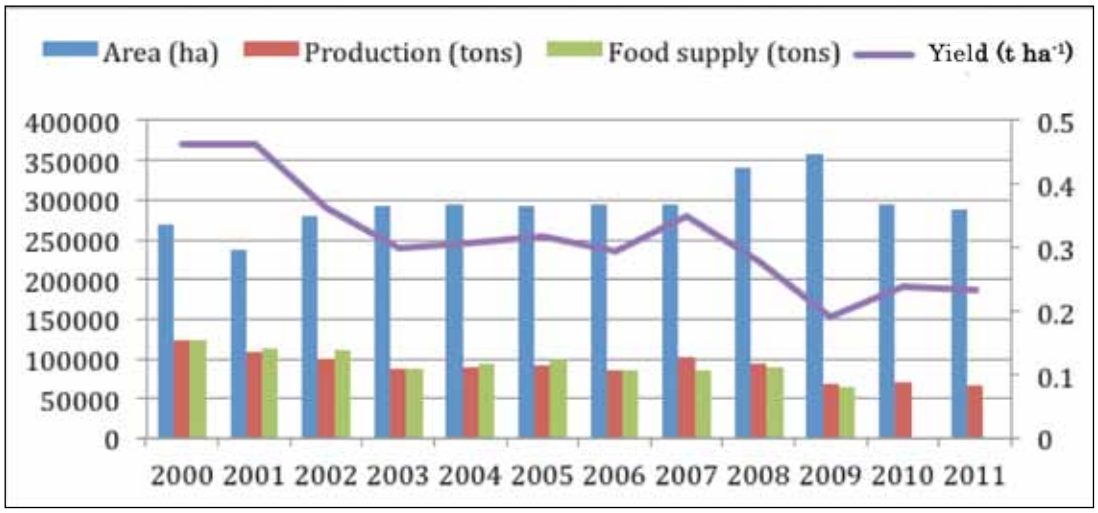

Figure 1. Groundnut production trend in Uganda.

Role in the economy

Groundnut seeds contain 40–50% fat, 20–50% protein and 10–20% carbohydrate depending on the variety. With the cost of animal protein becoming increasingly prohibitive, groundnut is becoming an even more important source of protein. Groundnut seeds are also a nutritional source of vitamin E, niacin, falacin, calcium, phosphorus, magnesium, zinc, iron, riboflavin, thiamine and potassium. Groundnut is consumed raw, roasted, blanched, as peanut butter, crushed and cooked with several traditional dishes as a stew or as *binyebwa*, a cooked paste. Groundnut haulms (straw, stems) are also commonly used as animal feed.

Groundnut thrives under low rainfall and as a legume, it improves soil fertility by fixing nitrogen. Therefore, the crop generally requires few inputs, making it appropriate for cultivation in low-input agriculture by smallholding farmers (Smartt 1994). Groundnut is also used as a trap crop in the

management of *Striga* weed on cereals (sorghum and maize) in eastern Uganda. As a cash crop, it gives relatively high returns for limited land area and is well adapted to the hot, semi-arid conditions of Uganda. These multiple uses of groundnut make it an excellent cash crop for domestic markets as well as for foreign trade. The returns from groundnut greatly surpass those reported for soybean and are less uncertain than those of sunflower (Laker-Ojok 1996). A number of factors contribute to this. First, the area planted with groundnut far exceeds that of soybean and sunflower. This increases the potential for large-scale national benefits. Secondly, the markets for groundnut are better established. Groundnut is highly valued on the domestic market and its export market has been flourishing in recent years. Uganda can therefore save a lot of foreign exchange from the import of sunflower and soybean vegetable oils if it can turn to wide-scale oil extraction from groundnut. Currently, vegetable oil extraction is mainly from sunflower yet groundnut is the most established oilseed crop and its production is continually increasing at a rate higher than all the other oilseed crops – sunflower, soybean and sesame (Okello et al. 2010).

Research and development

Variety development

Background

Groundnut research in Uganda is conducted at National Semi-Arid Resources Research Institute (NaSARRI), located in eastern Uganda. The national groundnut improvement program at the Institute takes leadership in groundnut research in Uganda. The goal of the national groundnut improvement program is to provide clients with desired varieties with both market and consumer traits (high yielding, high quality, resistant to major pests and diseases, short to medium maturity and tolerant to drought) together with improved production packages.

Focal activities

In order to generate these benefits, research activities focus on cultivar development, germplasm management (collection, maintenance and conservation), breeding activities (characterization for yield and adaptability), as well as maintenance and generation of appropriate crop management technologies for sustained production.

Constraints to groundnut production

The major activity at the NaSARRI is breeding for traits that improve production (input traits) and those that affect quality or use products (output traits) (Page et al. 2002).

Input traits

The breeding program targets a number of biotic and abiotic stresses that singly or collectively can cause significant yield losses in groundnut. The major biotic stresses are diseases mainly groundnut rosette, early and late leaf spots, rust and aflatoxin accumulation in grain. The major pests include aphids which are vectors for rosette virus disease, leaf miners and thrips that destroy foliage. Among the abiotic stresses, drought associated with rainfall insufficiency is the most significant factor affecting groundnut production. Drought poses a threat to groundnut production because 70% of the crop area occurs in the semi-arid tropics characterized by low and erratic rainfall. The use of low-yielding seed varieties and increased and/or continued cultivation on marginal land have also negatively affected

productivity. The overall political instability especially in eastern and northern Uganda and the frequently unsupportive oilseed policies have also influenced reduction in groundnut productivity.

Output traits

Confectionery groundnuts are becoming very popular and big bold sweet groundnuts are selected for this emerging market. The national groundnut research program works closely with farmers and in collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), development partners, USAID supported Peanut Collaborative Research Support Program (PCRSP) and Alliance for a Green Revolution in Africa (AGRA) to develop suitable cultivars for the country. Since 1966, the groundnut improvement program has released 24 varieties, suitable for both farmers and the market (Table 1). The commercial varieties being promoted are the Serenut series (Serenuts 1–14).

The improved varieties address some of the input traits highlighted. However, the market and field stability of those varieties, in light of emerging stresses, calls for continuous research while at the same time keeping crop improvement, quality and safety linked to practical applications. Emerging issues like aflatoxin contamination, leaf miners and damage are being addressed together with deployment of novel breeding approaches like molecular breeding to complement conventional breeding and increase the efficiency of cultivar development. Additionally, to maintain or increase market share, producers and exporters need to adapt the type of groundnut being cultivated to consumer requirements.

Table 1. Groundnut varieties released during 1966 to 2011 by the national groundnut research program[1].

Variety	Time to maturity (days)	Yield (kg ha^{-1})	Year of release	Other remarks
Red Beauty	90–100	1900–2500	1966	Multiline of Red Valencia
Acholi white	80–90	1900–2500	1966	Virginia, off white seed
Roxo	100–110	2000–2700	1969	Red manyema, Venezuela
Tatu	100–110	1900–2400	1969	Spanish
Manipintar	110–120	2600–3600	1969	Virginia
Bukene	90–100	1800–2600	1970	Spanish
Mwituude	100–110	2000–2400	1970	Virginia
Makulu Red	110–120	2000–2800	1970	Virginia, red seed
Amasoga	110–120	1800–2300	NA	Local
Igola-1	125–130	3000–3500	1995	Virginia, striped
Serenut 1R	100–110	2500–3700	1998	Virginia, red seed
Serenut 2	100–110	2500–3500	1998	Virginia, tan seed
Serenut 3R	90–100	2500–2900	2002	Spanish, red seed
Serenut 4T	90–100	2500–2900	2002	Spanish, tan seed
Serenut 5R	100–110	2500–3000	2010	Virginia, red seed
Serenut 6T	90–100	2500–3000	2010	Spanish, tan seed
Serenut 7T	100–110	2500–3700	2011	Virginia, tan seed
Serenut 8R	100–110	2500–3700	2011	Virginia, red seed
Serenut 9T	100–110	2500–3700	2011	Virginia, tan seed
Serenut 10R	100–110	2500–3700	2011	Virginia, red seed
Serenut 11T	100–110	2500–3700	2011	Virginia, tan seed
Serenut 12R	100–110	2500–3700	2011	Virginia, red seed
Serenut 13T	100–110	2500–3700	2011	Virginia, tan seed
Serenut 14R	100–110	2500–3700	2011	Virginia, red seed

1. Source: Okello et al. (2010), NASARRI Groundnut Department variety release report, 2011.

Planned Phase 2 activities and their contribution to national efforts

TL-II Phase 2 aims at delivering new varieties to farmers of Uganda who have been growing either old or highly susceptible groundnut varieties. The strategy is to intensify research and development (R&D) efforts to ensure that newly developed varieties have the right traits, for the right agroecology market and home consumption purposes. The net benefit to communities will be high-yielding varieties that strengthen livelihood strategies of farm households in Uganda and the wider region. A breakdown of the major activities by objective are presented below.

Objective 2. To enhance groundnut productivity and production in drought-prone areas of Uganda

Activities planned to be conducted under this objective include:

- Evaluation of germplasm with ICRISAT for common input traits such as drought, groundnut, late leaf spot and rust in elite Valencia, Spanish bunch and Virginia bunch genotypes.
- Conducting 50 pair-wise evaluation of new varieties (3 Virginia, 2 Spanish) to identify released varieties farmers prefer most.
- Conduct Farmer Participatory Variety Evaluation trials among groundnut producing communities to identify new advanced breeding lines (4 Virginia advanced progenies).

These activities will be conducted in northern and eastern parts of Uganda (Fig. 2), the major groundnut producing regions of the country. The activities to be conducted will include among others: (a) holding decentralized planning meetings with partners; (b) taking an inventory of existing seed production and diffusion systems (actors and their role, diffusion channels, existing varieties); (c) high quality seed multiplication (both private and on-station); (d) train farmers, extension officers in commercial groundnut production; (e) supply seed to partners; (f) establishment of partners based field demonstrations; (g) make follow-up visits to seed multipliers during the growing period; (h) seed quality assessment (establish benchmark); (i) prepare seasonal report on first and second rains results and first short rain results; and (j) development and production of outreach materials and distribution of existing groundnut seed production manual.

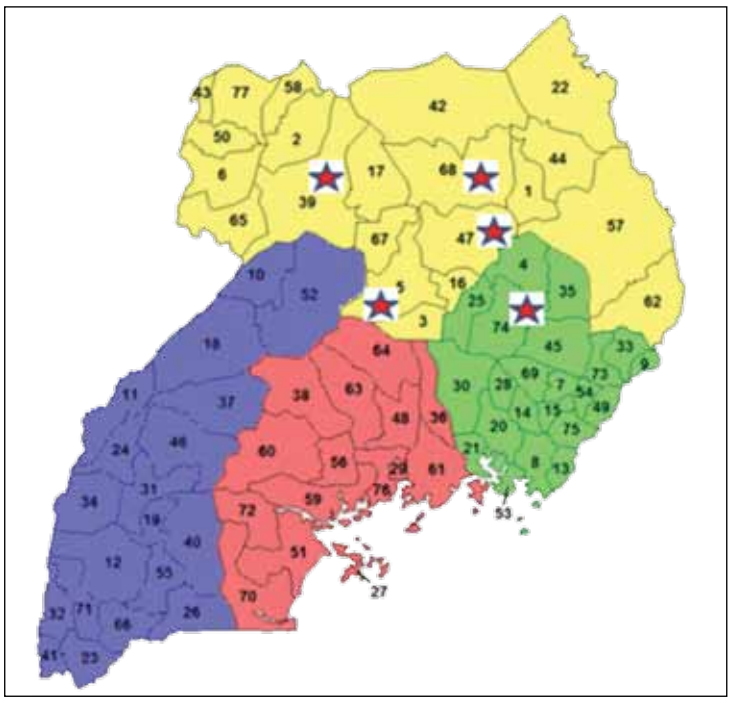

Figure 2. Map of Uganda showing location of TL-II Phase 2 project areas of focus.

Project activities are conducted in Lira (47), Apac (5), Amuru (39), Soroti (74), Serere (74) and Pader (68). The figures in parentheses are target farm communities who will be involved in FPVS. In these activities five groundnut varieties will be promoted (Table 2).

Table 2. Released groundnut varieties to be promoted.

Variety	Time to maturity (days)	Yield (kg ha^{-1} in shell)	Attributes
Serenut 2 (ICGV 90704)	100–110	3000–3500	Drought tolerant, rosette resistant, high yield
Serenut 3R (ICGV-SM 93530)	100–110	2500–3000	Short maturity duration, dark red seed, 48% oil content
Serenut 5R (ISGV-SM 99566)	90–100	2500–3000	Rosette resistant, drought tolerant, medium sized red seed, 42% oil content
Serenut 8R (SGV 99019)	100–110	3000–3500	Rosette resistant, drought tolerant, red seed, medium-large seeds
Serenut 11T (SGV 99031)	100–110	3000–3500	Rosette resistant, drought tolerant, big/giant bold, uniform tan seed, sweet, soft pods

Project results: the expected outcomes and outputs

Vision of success for groundnut in Uganda

Promotion and wide adoption of improved groundnut varieties will increase production and productivity which will ultimately lead to better food value, nutrition and surplus production for commerce. Identification of key stakeholders and willingness of all the partners involved in the project coupled with the conducive environment for R&D will make this vision a reality.

Expected outcomes

The expected outcomes from the project will include but are not limited to: (i) increased farmers' groundnut productivity (yield per unit area) in various agroecological areas contributing to their improved overall food and nutrition security and household income; (ii) increased quantity and quality of groundnut produced, consumed and sold (increased household income) by farmer/communities and others; (iii) enhanced knowledge and skills of seed producers, NARS and other participating partners in decentralized, farmer-led seed production and delivery system; (iv) increased access to and utilization of high-yielding groundnut varieties and information by a wide range of farmers/farming communities in the various agroecologies; (v) stronger partnership and linkages forged among the key stakeholders for better sharing of available resources for wider coverage and dissemination of high-yielding groundnut varieties; and (vi) increased social benefits resulting from change of attitude towards production of groundnut seeds and grain as profit making enterprise.

Expected outputs

The project is expected to generate a number of outputs including the establishment of a practical, functional and sustainable community-based, farmer-led groundnut seed enterprise; increased access by the farming communities and other stakeholders to high-yielding, improved groundnut varieties; increased knowledge and skills of stakeholders and intended beneficiaries in seed production (management and utilization), institutional and organizational development and entrepreneurship and business skills; enhanced knowledge in establishing and supporting decentralized seed production and

supply schemes; multiplication of adequate foundation/breeder seed of the improved high-yielding varieties and accessibility by the farmer groups for production of quality seeds; and establishment of pilot site platforms for interactions among stakeholders to create strong and sustainable partnerships and linkages among stakeholders and allow for sharing of experiences on decentralized seed production and supply with other interested organizations.

Agroecologies for groundnut cultivation in Uganda

Groundnut production occurs in all the major agroecological regions of Uganda but there are varietal variations from region to region due to consumption preferences. Groundnut is grown mainly in the Eastern, Northern unimodal rainfall zones and in Southern parts of Uganda. Table 3 shows the major agroecological areas and the types of groundnut varieties being produced in those areas. It should be noted that in spite of the release of the 24 high-yielding groundnut varieties in Uganda, many farmers still do not have access to seeds of improved varieties due to lack of information and their availability in required quantities. A number of the newly released varieties have potential for wider adaptation and uses. Yields are still very low, because of several other compounding traits that affect production mentioned in other sections of this document. Eastern and Northern Uganda prefer tan seeded type whereas in the Central, Western and Southern region, red is the preferred seed coat type for consumption. The varieties with red seed testa are more preferred over the tan colored seed and they command higher premium prices in the market.

Seed systems for groundnut green revolution in Uganda

Groundnut seed systems like any other legume is less attractive to private sector due to bulky and low multiplication ratio (1:8), quick loss of seed viability, high cost of transportation, low profit margin and the self-pollinated (>98%) nature of the crop. Therefore the task of availing farmer improved groundnut varieties requires large quantities at the right price and the task is generally undertaken by public sector seed services. The private sector undertakes seed production only when there is large demand especially from international bodies, relief organizations and at the time of disaster. This erratic nature of demand compounds demand estimation. The TL-II Phase 2 has adopted a community-based system approach whereby organized groups and individual farmers will be empowered with knowledge of commercial seed production and conservation, provided with foundation seed, monitored and linked to both market and research.

Table 3. Summary of agricultural systems of Uganda and preferred seed coat types of groundnut.

Farming system/agroecologies	Districts covered	Preferred seed coat type
Banana/coffee system	Bundibugyo, parts of Hoima, Kabarole, Mbarara, Bushenyi, Mubende, Luweero, Mukono, Masaka, Iganga, Jinja, Kalangala, Mpigi and Kampala	Red
Banana/millet/cotton system	Kamuli, Pallisa, Tororo, parts of Masindi and Luweero	Red and tan/white
Montane system	Kabale, Kisoro, parts of Rukungiri, Bushenyi, Kasese, Kabarole, Bundibugyo, Mbarara, Mbale and Kapchorwa	Red
Teso system	Soroti, Kumi, Kaberamaido	Tan and red
Northern system	Gulu, Amuru, Nwoya, Lira, Apac, Amolatar, Oyam, Kitgum, Pader, Lamwo and Agago	Tan and red
Pastoral system	Kotido, Moroto, parts of Mbarara, Ntungamo, Masaka and Rakai	Tan and red
West Nile system	Moyo, Arua and Nebbi	Tan and red

Strategic partners and their roles

The project will engage a number of partners both in R&D as well as in service delivery to promote use of improved seed in the project target areas. The partners available and their role are listed in Table 4.

Table 4. Strategic partners and their role.

Partner	Role
National Agricultural Research Organization	• Varietal development, evaluation and release • Production of breeder and foundation seed • Capacity building • Seed maintenance, production and distribution
CGIAR, ICRISAT	• Provision of improved germplasm/breeding populations • Capacity building • Research on effective methods for technology dissemination
National Agriculture Advisory Services (NAADS)	• Extension services related to crop management, crop protection and conservation • Seed distribution
NGOs (World Vision, Care International, CRS, VEDCO, Self-Help Africa, etc)	• Seed production and dissemination • Technology delivery and promotion • Capacity building among farmers • Credit access and social rehabilitation programs
Government and private universities	• Technology generation • Training
Seed companies (Pearl, FICA, NASECO, Victoria Seeds)	• Seed production and dissemination • Technology promotion
Peanut-CRSP	• Technology generation and promotion
AGRA	• Technology generation and promotion • Seed systems
Agricultural Marketing (AGMARK)	• Capacitate farmers' formation of associations for collective production and marketing
USTA (Ugandan Seed Testing Association)	• Variety release, seed certification services and quality control
Farmers	• Partnership in FPVS trials • End-users of technologies (uptake and adoption)

Seed production plan

To enable the increase in groundnut production and productivity in the targeted agroecological regions, the project intends to produce and supply foundation, certified and quality declared groundnut seed to farmers in the targeted regions to cover 20% of the area under groundnut production with improved varieties through the utilization of farmer groups, individual small and large-scale farmers, NGOs and seed companies where applicable. The seed production and delivery plan to enhance groundnut production and productivity is outlined in Table 5.

Table 5. Groundnut seed roadmap for Uganda.

Ecology (Zone)	Demand (ha)	Promising varieties	Seed required to cover 20% adoption area (t)	Breeder seed 2012		Foundation seed 2013		Certified seed 2014		Certified seed 2015	
				Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
Northern and eastern region	81030	Serenut 2	1,296	0.20	0.160	7.20	10.8	81.00	97.2	675.00	810
	64824	Serenut 3R	1,037	0.20	0.157	7.80	11.7	87.75	105.3	850.50	1020.6
	48618	Serenut 5R	778	0.25	0.200	9.00	13.5	101.25	121.5	1,984.50	2381.4
	32412	Serenut 8R	519	0.04	0.035	18.00	27	202.50	243	2,693.25	3231.9
	32412	Serenut 11T	519	0.25	0.200	9.00	13.5	101.25	121.5	101.25	121.5
Westren and Central	21484	Serenut 3R	344	0.25	0.200	1.07	1.6	10.67	12.8	85.33	102.4
	25780	Serenut 5R	412	0.29	0.230	1.23	1.84	12.27	14.72	98.13	117.76
	38670	Serenut 8R	619	0.44	0.350	1.87	2.8	18.67	22.4	149.33	179.2
Total	345230		5,524	1.92	1.53	55.16	82.74	615.35	738.42	6,637.30	7964.76

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Common bean

Michael Ugen, Stanley Nkabulo, Jean-Claude Rubyogo and Steve Beebe

Introduction

Importance of the crop in Uganda

Common bean (*Phaseolus vulgaris*) ranks first among the legumes grown and consumed throughout Uganda. It is a major source of food and income for the rural smallholder farmers. The crop is the most important source of protein for over 30 million people in Uganda; it provides up to 25% of the total calories and 45% of the total human dietary protein (Pachico 1993, Mauyo et al. 2007). For those in need of immediate food remedies, like in war ravaged areas, as was the case in Northern Uganda, parts of DRC and southern Sudan, common bean is the first crop of choice as it takes a short time (60–80 days) to grow the early-maturing varieties.

Production trends

Common bean production in Uganda has been increasing with area expansion as the main source of growth. During 2001 to 2010, area under common bean increased by 28.7% resulting in an increase of 7.7% in bean supply (Fig. 1) as yield stagnated due to a range of biophysical constraints, soil fertility, drought and pests and diseases being the most important (Opio et al. 2001, Kimani et al. 2006). Area under common bean is projected to continue growing at a high rate in the next few years in response to the growing population and increasing bean trade from the country (Table 1).

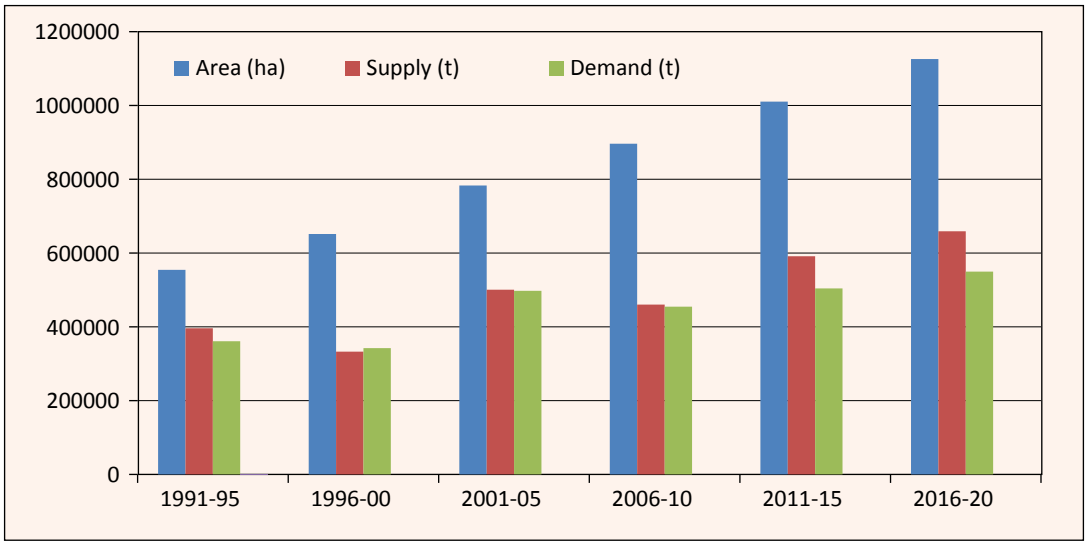

Figure 1. Bean production trend during 1991–2020.

Common bean contribution to GDP and food and nutritional security

Uganda ranks eighth in bean production in the world with estimated bean production of 464,105 tons (Source: FAOSTAT 2012) and the crop has gained a major dominance in terms of quantity and monetary value among Uganda's exports covering 1,142,660 ha. It is ranked fourth in terms of export volume and eighth among crops in terms of export value (Table 1).

Table 1. Composition of exports (US$ million) from 1998 to 2008 in Uganda[1].

Commodity	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08
Coffee	306.7	186.9	109.6	85.3	105.5	114.1	144.5	173.4	228.5	301.6
Cotton	10.8	22.5	14.1	18.0	16.9	42.8	41.3	12.9	19.7	19.3
Tea	22.7	31.9	35.9	26.9	29.5	39.3	33.1	25.6	45.9	46.0
Tobacco	22.9	22.4	27.6	32.3	39.9	36.2	36.2	30.6	46.7	59.7
Fish products	47.6	24.8	66.6	107.5	111.4	118.1	169.6	192.8	182.9	162.7
Gold	27.9	39.4	58.5	56.7	48.2	58.5	71.3	101.6	116.1	60.6
Flowers	7.2	8.3	13.2	15.9	17.0	27.2	31.7	32.7	32.6	37.3
Electricity	12.3	13.8	16.7	13.9	15.5	12.6	8.3	4.7	6.3	11.2
Maize	6.1	4.0	6.1	13.1	8.2	18.8	13.3	23.7	27.9	25.3
Hides and skins	6.6	6.1	22.7	19.6	4.2	5.9	6.4	7.3	14.7	17.8
Cobalt		7.3	12.8	10.9	1.9	2.7	13.7	19.4	16.6	17.7
Beans	4.6	4.8	2.0	1.5	5.5	4.9	4.3	8.3	5.8	5.7
Others	73.7	87.7	72.4	72.5	104.3	166.1	212.6	167.8	207.3	450.6
Total	549.1	459.9	458.3	474.0	508.5	670.9	886.3	1042.5	1520.5	1752.3

1. Source: Government of Uganda (2008).

Agroecologies for bean cultivation in Uganda

Beans are produced in all the major agroecological regions of Uganda but the types of bean grown vary from one region to another, depending on the preferences of the farmers and consumers in that region (Fig. 2). To a large extent, all regions grow the red mottled bean varieties, which are highly marketable within and outside Ugandan borders. They have thus been given emphasis in the breeding program. The major bean varieties grown in each agroecological zone, major production districts, production area and amounts produced are indicated in Table 2.

Figure 2. Bean agroecologies in Uganda.

Table 2. Types of bean varieties preferred in different agroecological regions of Uganda.

Agroecological region	Major production districts and varieties	Preferred market class bean types
Central (parts of western and eastern tall grass)	Major production districts: Mpigi, Mubende, Wakiso Average production: 77954 tons Dominant varieties: K132 (Nambale), NABE 1, Kanyebwa and NABE 4	Medium to large red mottled, sugar and yellow seed
Eastern region (parts of eastern tall grass and Mt Elgon regions)	Major production districts: Kamuli, Mabale, Kapchorwa, Sironko, Iganga, Busia Average production: 32000 tons Dominat varieties: K132, Kanyebwa, Otawa, NABE 13, NABE 12C and Kamwanyi	Sugar, medium to large red mottled, small to medium red and brown seed and climbers
Northern region (northern central, northern short grass and northwestern tall grass)	Major production districts: Lira, Apac, Gulu, Kitgum Average production: 105053 tons Dominant varieties: Yellow, NABE 2 (Black), Black (Ucuk) and K132	Red mottled; small and medium red, brown, yellow, tan/khaki, cream, sugar, carioaca; small white/navy, pintos, purple, black. Nearly all types of available beans can be grown in this region.
Southwestern region (southwestern highlands, southwestern tall grass and western highlands)	Major production districts: Masaka, Rakai, Lyantode, Mbarara Kisoro, Masisndi, Hoima, Kabale, Kamwenge, Kasese Average production: 136,352.26 tons Dominant varieties: NABE 12C, NABE 10C, NABE 13, NABE 14, K132 and Kanyebwa	Medium to large red mottled, small to medium red, large red kidney, yellow, tan/khaki, cream, sugar, purple, black; climbers and all kinds of sugar bean.

A number of the newly released varieties have potential for wider adaptation and use, and others for orientation to the region's many micro agroecological and market niches. Due to the availability of a number of niches, farmers are increasingly becoming interested in improved bean varieties which are particularly fast maturing and respond to the intermittent rainfall. However, lack of access to seed of improved varieties is a major hindrance to the utilization of new bean varieties. This problem has contributed to persistent low bean yields in the country.

The formal seed sector although available in the country produce certified seed in centralized facilities and very little of the seed produced reach the rural hard-to-reach farmers who are the majority of the population. This problem and its effects are especially acute and chronic for crops (which for various reasons and factors are not attractive to commercial seed companies) such as the self-pollinating crops including beans despite their huge potential to contribute to economic growth and livelihood improvement in Uganda and Africa as a whole. This scenario, therefore, allows very few farmers access to improved seeds.

TL-II intends to use all available mechanism and channels to enhance the availability of quality seed to farmers using decentralized production and distribution channels with inbuilt quality assurance and quality control through farmer/seed producer training.

To enable the increase in bean production and productivity in the targeted agroecological regions, the project intends to produce and supply foundation, certified and quality declared bean seed to farmers in the targeted regions to cover 15% of the area under bean production with improved varieties through the utilization of farmer groups, individual small- and large-scale farmers, NGOs and seed companies where applicable.

Major constraints to common bean production in Uganda

- Pests (bruchids, bean stem maggots, leaf eaters, grubs, cut worms, etc) and diseases (root rot, anthracnose, angular leaf spot, bean common mosaic virus, common bacterial blight, etc)
- Declined soil fertility
- Drought: Drought is becoming very prominent especially in the upper central, mid-eastern, mid-western and northern semi-arid areas of Uganda. Like the neighboring countries in the East and Central African region, rainfall is the primary determinant of crop production in Uganda. However, rainfall is highly variable in most parts of the country and this unreliability has given rise to unpredictable intermittent and sometimes terminal drought (Source: DWD 1995) as farmers are surrounded with lots of uncertainties during the cropping season. Drought in these various parts of Uganda has very often seriously affected crop production (Source: NEMA 2001) and has led to serious dry bean yield losses. Uganda's dryland area, commonly referred to as the "Cattle Corridor", stretches along a broad swath across the country from the southwest to the northeast encompassing 84,000 km^2. The drylands cover more than a dozen of the country's 97 districts. They include (from southwest to northeast) Ntungamo, Mbarara, Rakai, Sembabule, Mubende, Kiboga, Nakaseke, Luwero, Nakasongola, Kamuli, Soroti, Katakwi, Nakapiripirit, Moroto and Kotido districts. The dryland area receives irregular and low rainfall, experiences periodic and extreme drought, and is considered to encompass some of the country's most fragile ecosystems.

  With Uganda having less than 1% of its arable land under irrigation (Source: Kizza 2001), small-scale poor producers living in these drought prone areas, with obviously no hope of utilizing irrigation, have faced drastic reduction in dry bean yield in the last few years (Source: Wortmann et al. 1998). This has caused food and income insecurity through both acute and chronic effects (Source: Sakurai and Reardon 1997). It is envisaged that if not addressed, drought will gravely undermine the potential of beans as a food security crop, source of income and source of dietary protein for Ugandans living in these semi-arid lands.

Common bean variety development in Uganda

In Uganda, research work on dry beans was initiated as early as 1920, mostly on agronomic aspects and yield trials. Breeding did not begin until after 1960 and was halted in the early 1970s because of the civil strife that engulfed the country for nearly fifteen years. During this time, there was a complete destruction of the country's economy and the whole agricultural research system. Before the civil strife, several varieties such as Banja, Mutike, Canadian Wonder, Bukalasa, K20 (also known by many farmers as Nambale) had been bred and released but most varieties had reached only a few farmers probably those near the research stations where the varieties were being tested. The reasons for the delayed distribution were the absence of an efficient extension system and seed market outlets by that time.

Bean breeding was restarted in 1985/86 with the aim of increasing productivity of the crop by developing acceptable varieties. But unlike the other parts of the world where breeding objectives are broad based, in Uganda, dry bean breeding was mainly focused on the production of cultivars resistant to pests and diseases which were seen as the major limiting factors to high yield production. This initial work was undertaken at the then Kawanda Agricultural Research Institute (KARI) but in the early 1990s, bean research work was transferred to National Agriculture and Animal Research Institute-Namulonge, which was later named National Crops Resources and Research Institute (NaCRRI)-Namulonge under the Uganda National Bean and Development Program (UNBDP), located at the Institute. The broad goal of the bean improvement program is to improve and stabilize yields through restoring resistance in released bean varieties and new genotypes with acceptable consumer and

market qualities, development and promotion of good crop management practices for contributing to poverty alleviation, and food and nutrition security of the rural and urban poor.

Presently, breeding for resistance to various diseases is underway at NaCRRI-Namulonge and a number of major abiotic and biotic stresses are being tackled in addition to other traits such as yield, taste, cooking ability, marketability, early maturity, etc, as preferred by both farmers and final consumers in the market. Some of the diseases being addressed so far include angular leaf spot, anthracnose and root rot, these being the major constraints. In addition, some work is underway to address some pests like the aphids and storage bean weevils (bruchids). As new problems crop up the breeding program intervenes to counteract such problems. Currently the bean program is making interventions into new research areas such as climate change (drought tolerance) and bio-fortification which are of global concern and emerging production constraints. The national bean program researchers are working closely with farmers in collaboration with the International Center for Tropical Agriculture (CIAT) and other African bean research programs through the Pan-African Bean Research Alliance (PABRA) to develop cultivars suitable for specific production and market niches and share knowledge and research products.

Since 1994 to 2012, twenty-nine new and higher yielding cultivars have been released (Table 3). These are suitable for both farmers and the market and include K131, K132, NABEs 1, 2, 3, 4, 5, 6, 7C, 8C, 9C, 10C, 11, 12C, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24C, 25C, 26C and 27C. K132 is the most commonly cultivated variety in terms of area planted across most of the bean producing regions. It is an improved variety developed with materials from CIAT and released in 1994. NABE 4 and NABE 12C are other improved varieties occupying significant bean area. In addition to these varieties, landraces are also still largely grown in Uganda, the most abundant being the oval shaped and pink and red tan mottled bean cultivars commonly referred to as *Kanyebwa* possibly because of their close resemblance to groundnut which in the local dialect is called *binyebwa*. The other local cultivars are the yellow-seeded round and kidney shaped varieties commonly referred to as the Masindi yellow possibly due to the fact that they were first grown or appreciated by the people living within and around Masindi district. The released varieties and the landraces can be differentiated from their different growth habits and characteristics.

Planned Phase 2 activities and their contribution to national efforts

The activities planned for Phase 2 will revolve around breeding, screening and selecting for high-yielding and drought tolerant bean cultivars and concurrently promote adoption of currently available higher yielding more water and nutrient efficient improved varieties. It is believed that this will significantly stabilize and increase yields beyond current attainable levels. The promotion of these water-use efficient drought tolerant bean varieties will therefore be essential in addressing nutritional, food security and income problems of small-scale and resource-poor farmers exposed to the ravages of drought and its effects. The planned Phase 2 activities and the expected outcomes are discussed.

Screening for drought tolerance

Drought screening of at least 46 lines (black and red seeded) to be undertaken during the off-season planting (late May to early June 2012). Two trials will be conducted on-station at Namulonge, one with irrigation and the other without irrigation. In each trial, each line will be planted in 4 m × 1 m rows and replicated 2 or 3 times. Further testing of the selected lines for drought tolerance will be conducted in the subsequent seasons. This will be followed by multilocational testing in Preliminary and Advanced Yield Trials (PYT/AYT) using participatory variety selection (PVS) in drought-prone areas for selected lines through National Performance Trials (NPTs) and eventual variety release possibly by the end of 2014 or early 2015. These new varieties will be subsequently disseminated to drought-prone areas.

Table 3. Characteristics of common bean varieties officially released by Uganda bean research program.

Official name of release	Year of release	Source of material	Area of potential coverage	Spillover national boundaries	Average yield potential (on-station) (t ha^{-1})	Varietal traits (selected characteristics)
K20 (Nambale)	1970	CIAT		Yes		Bush, 95 days to maturity
K131 (Kabalira)	1994	CIAT	Best suited for high altitude area >1500 m	Yes	2– 2.5	Bush, 85–90 days to maturity, best suited for high altitude area >1500 m, drought tolerant to bean common mosaic virus (BCMV), small tan/khaki seed
K132 (CAL96, Kawomera)	1994	CIAT	Best suited for low-mid altitude area	Yes	1.5–2	Bush, large-seeded red mottled, 80–90 days to maturity, tasty and swells on cooking, cooks fairly fast, best suited for low-mid altitude area
NABE 1 (OBA 1)	1995	CIAT	Best suited for low-mid altitude area	Yes	1–1.5	Bush, medium-size seed, red mottled, 80–90 days to maturity, tasty and swells on cooking, cooks fairly fast
NABE 2 (MCM 1015)	1995	CIAT		Yes	2–2.5	Bush, small black seed, 85–90 days to maturity, resistant to BCMV and drought tolerant
NABE 3 (MCM 2001)	1999	CIAT		Yes	2–2.5	Bush, small red seed, 85–90 days to maturity, resistant to BCMV
NABE 4 (POA)	1999	CIAT	Best suited for low-mid altitude area	Yes	2– 2.5	Bush, medium-size red mottled seed, 80–90 days to maturity, tasty and swells on cooking, cooks fairly fast
NABE 5 (SUGAR 73)	1999	CIAT		Yes	2–2.5	Bush, large red speckled sugar bean, 80–85 days to maturity
NABE 6 (UBR92)	1999	CIAT		Yes	2–2.5	Bush, small white seed, 85–90 days to maturity, drought tolerant
NABE 7C (G685, Vunikingi)	1999	CIAT	Mid to high altitude	Yes		
NABE 8C (Ngwinurare)	1999	Rwanda	High altitude	Yes	2.5–3.5	Climber, large red seed, 90–110 days to maturity
NABE 9C (Gisenyi)	1999	Rwanda	High altitude	Yes	2.5–3.5	Climber, large white/black speckled seed, 90–115 days to maturity
NABE 10C (G2333, Umubano)	1999	CIAT	Low/high altitudes	Yes	2.5–4	Climber, small red seed, 90–110 days to maturity, tolerant to anthracnose
NABE 11C (AFR 721)	1999	CIAT	Mid to high altitude	Yes		Climber, 103 days to maturity
NABE 12C (SUG 31)	1999	CIAT	Mid to high altitude	Yes	2.5–35	Climber, large red speckled sugar bean, 90–110 days to maturity, tasty and swells on cooking, large attractive fresh pods, cooks fast, tender leaves
NABE 13 (RWR1946)	2006	Rwanda	Mid to high altitude	Yes	1.5–2.5	Bush, large red, vigorous growth habit, tolerant to bean root rot, tolerant to low soil fertility, 80–90 days to maturity

Continued

Table 3. *Continued.*

Official name of release	Year of release	Source of material	Area of potential coverage	Spillover national boundaries	Average yield potential (on-station) (t ha^{-1})	Varietal traits (selected characteristics)
NABE 14 (RWR2075)	2006	Rwanda	Mid to high altitude	Yes	1.5–2.5	Bush, large red seed, vigorous growth habit, tolerant to bean root rot and low soil fertility, 80–90 days to maturity
NABE 15	2009	NaCRRI	Suitable for all regions	No	1.8–2	Bush, medium red speckled sugar bean, early maturity (60–70 days), tolerant to bean anthracnose, tasty and swells on cooking
NABE 16	2009	NaCRRI	Suitable for all regions		2–2.5	Bush, medium red mottled seed, early maturity (65–75 days), tolerant to bean anthracnose, tasty and swells on cooking
NABE 17	2012	NaCRRI		No	2–2.5	Indeterminate bush, highly palatable, large red mottled seed, early maturity (58–75 days), tolerant to anthracnose, BCMV, angular leaf spot (ALS), and other diseases
NABE 18	2012	NaCRRI	Northern Uganda market	No	2–2.5	Determinate bush, highly palatable, large dark red kidney, early maturity (63–78 days), resistant to anthracnose, BCMV and ALS and tolerant to root rot
NABE 19	2012	NaCRRI		No	2–2.5	Indeterminate bush, highly palatable, medium red mottled kidney seed, early maturity (61–70 days), resistant to anthracnose, BCMV and ALS and tolerant to most other diseases
NABE 20	2012	NaCRRI		No	1.6–2.2	Indeterminate bush, highly palatable, pink with red tan mottled medium seed, early maturity (58–70 days), resistant/tolerant to anthracnose, BCMV, ALS and most other diseases
NABE 21	2012	NaCRRI		No	1.5–2	Determinate bush, highly palatable, medium dirty yellow with red tan mottled sugar bean, early maturity (58–70 days), tolerant to anthracnose, BCMV, ALS and most other diseases
NABE 22	2012	NaCRRI	Northern Uganda market	No	1.5–2	Determinate bush, highly palatable, medium kidney dark purple white mottled seed, maturity (58–70 days), resistant to anthracnose, BCMV and ALS and tolerant to root rot and most other diseases
NABE 23	2012	NaCRRI		No	2–2.5	Determinate bush, highly palatable, large pink red tan speckled sugar bean, kidney seed shape, early maturity (64–75 days), tolerant to anthracnose, BCMV, ALS, root rot and most other diseases
NABE 26C	2012	NaCRRI		No		Climber, dark red mottled seed, early maturing, tolerant to pythium root rot
NABE 27C	2012	NaCRRI		No		Climber, large pinkish seed, pink pods at physiological maturity
NABE 28C	2012	NaCRRI		No		Climber, red mottled seed, attractive long and large fresh pods
NABE 29C	2012	NaCRRI		No		Climber, very attractive red seed with shape similar to NABE 12C, pod shape similar to that of NABE 12C, but slightly shorter, clean pods at physiological maturity

Seed systems for common bean green revolution in Uganda

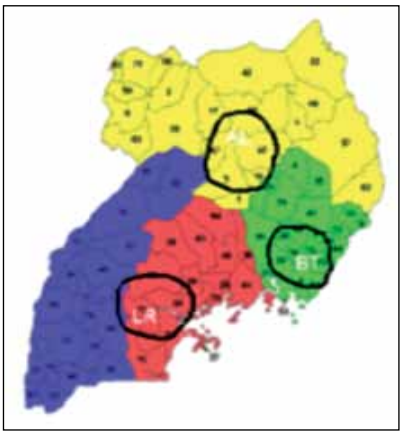

Figure 3. Map of Uganda showing location of TL-II Phase 2 project areas of focus.

Activities will be undertaken in three preselected regions in Uganda namely Apac and Lira (AL) districts in the northern region, Busia and Tororo (BT) districts in Eastern region and Lyantode and Rakai (LR) districts in Southern Uganda (Fig. 3). The activities to be conducted will include among others (a) holding decentralized planning meetings with partners (15 people in each site); (b) taking an inventory of existing seed production and diffusion systems (actors and their role, diffusion channels, existing varieties); (c) seed multiplication (both private and on-station); (d) training of trainers (partners) in seed production and modality or organizing seed producers; (e) supply seed to partners; (f) establishment of partners based field demonstrations; (g) holding centralized and several decentralized/partners seed systems (decentralized field days); (h) make follow-up visits to seed multipliers during review and data collection; (i) seed quality assessment (establish benchmark); (j) collect and verify data from partners: partners network of seed multipliers; partner seed multiplication results (total of farmer multiplier results); (k) prepare seasonal report on first and second rains results and first short rain results; and (l) development and production of outreach materials and distribution of existing bean seed production manual. In these activities three bean varieties will be promoted (Table 4).

Table 4. Released dry bean varieties to be promoted.

Variety	Time to maturity (days)	Yield (kg ha^{-1})	Year of release	Remarks (traits)
K131	85–90	2–2.5	1994	Tolerant to drought and bean common mosaic virus, high yield
NABE 15	60–70	1.5–2	2010	Early maturity, anthracnose resistant, good market class, high yield
NABE 16	65–75	2–2.5	2010	Early maturity, anthracnose resistant, good market class, high yield

Ugandan seed system strategy (2012–14)

With all functional key stakeholders in place, the seed production strategy for Ugandan common bean is described.

Seed production target

Total bean area harvested: 1,142,660 ha (Source: FAOSTAT 2012)

Seed rate: 80 kg ha^{-1}

National demand: 504,249 tons

Capacity to deliver 20% area: 150,000 tons, approximately 280,000 ha

Target of productivity: 800 kg ha^{-1} at national level and 1200 kg ha^{-1} at intervention level

Total production target: approximately 1,300,000 ha, 600,000 tons

Opportunities, partnership and seed production plan

The target is to cover 35% of each important common bean agroecology in Uganda with improved seed.

Opportunities

To achieve this output and production, the project will utilize some of the opportunities available. Some of these are:

- Taking advantage of already existing farmer groups and the fact that they already have experience in the use of new varieties and seed production
- Farmers' willingness to adapt new technologies
- Availability of land for production especially in northern Uganda as farmers recover/settle from the insurgency
- Availability of both internal and external market (Southern Sudan and Kenya)
- Government initiative with NAADS (National Agriculture Advisory Services) where bean is one of the major crop for food and income generation

Partners

The project will leverage resources by forging partnership with business-based partners and NGOs to promote use of improved seed in the project target areas. The partners available include:

- Seed companies to enhance seed production and distribution (see Table 5)

Table 5. Partners and their role in the seed system.

Partner	Role
CIAT	Provision of germplasm, technical backstopping, seed systems research, training of partners, development of training resources
SHUPO	PVS, seed production, dissemination, training, marketing of seed, extension, development of promotional manuals
NASECO	PVS, foundation seed production, dissemination, training, marketing of seed, extension, development of promotional manuals
PEARL	PVS, seed production, dissemination, training, marketing of seed, extension, development of promotional manuals
CEDO	PVS, seed production, dissemination, training, marketing of seed, extension, development of promotional manuals, nutrition education
Victoria Seeds Company	PVS, foundation seed production, dissemination, training, marketing of seed, extension, development of promotional manuals
Buganyanya ZARDI	Regional germplasm evaluation, demonstration, variety promotion, training, catalyzing local partnership for seed production, foundation seed production
Bukedea (PKWI Farmer to Farmer Coop Ltd)	Decentralized seed production, seed dissemination, training of farmers
Hunger Project (Mbale)	Decentralized seed production, seed dissemination, training of farmers
Kayongo in the Karamoja region	Decentralized seed production, seed dissemination, training of farmers
Caritas in Tororo and Bulambuli	Decentralized seed production, seed dissemination, training of farmers

- Farmer groups and association to speed up the process of mobilizing communities for seed uptake and adoption
- NGOs to assist in technology delivery and capacity building among farmers; also to leverage resources such as support of credit access and social rehabilitation programs
- NAADS to support farmer training and seed distribution
- Zonal research institutes in target area to assist in seed maintenance, production and distribution

Seed production plan

The seed production and delivery plan to enhance bean production and productivity in Uganda is outlined in Table 6.

Expected outputs and outcomes

TL-II Phase 2 will generate a number of outputs:

- Practical, functional and sustainable community-based, farmer-led bean seed enterprises will be established.
- Institutional and organizational entrepreneurial and business skills (enterprise development) will be enhanced to support decentralized seed production and supply schemes (hopefully this system can be duplicated elsewhere by other partners).
- Multiplication of adequate foundation/breeder seed of the improved high-yielding varieties in sizeable quantities which should be easily accessed by the farmer groups for production of quality seeds.
- Pilot site platforms will be established for interactions among stakeholders to create strong and sustainable partnerships and linkages among stakeholders and allow for sharing of experiences on decentralized seed production and supply with other interested organizations.

The expected outcomes of TL-II Phase 2 are:

- Increased access to high-yielding and better adapted bean varieties, information and crop management practices by diverse groups (women and men, rich and poor) in the various agroecologies
- Increased utilization of high-yielding bean varieties and information
- Increased bean productivity (yield per unit area) in various agroecological areas contributing to their improved overall food and nutrition security and household incomes
- Increased quantity and quality of bean produced, consumed and sold (increased household income) by farmer/communities and others

Table 6. Seed delivery plan to cover the required area (15% of national area under beans) in Uganda.

		Traits		Released		Breeder seed in 2012		Foundation seed in 2012		Certified seed for use in 2014 – Area (ha)	Seed to reach 15% adoption – Production (t)			
Ecology	Demand (ha)	Productivity (t ha^{-1})	Market	Varieties	Area to be covered (ha)	Area (ha)	Production (t)	Area (ha)	Production (t)			Seed production	Distribution	Markets
Northern region (Apac & Lira): Moisture stress	154200 × 15%	1.5	Early maturity, anthracnose resistant, market class	NABE 15	9,240	1.65	2.47	30.90	46.35	579.75	870.00	Research, farmer groups, NGOs, seed companies, contract farmers	Research, NAADS, seed companies, extension, farmer groups, NGOs	Research, NAADS, seed companies, extension, farmer groups, NGOs
		1.5	Early maturity, anthracnose resistant, market class	NABE 16	8,085	1.44	2.16	27.08	40.58	507.00	761.25			
		1.5	Tolerant to drought, resistant to BCMV	K131	5,775	1.03	1.55	19.35	29.03	362.25	543.75			
South Western region (Lyantonde and Rakai): Moisture stress	194600 × 15%	1.5	Early maturity, anthracnose resistant, market class	NABE 15	17,505	3.13	4.69	58.58	87.90	1,098	1,647.75			
		1.5	Early maturity, anthracnose resistant, market class	NABE 16	11,670	2.09	3.12	39.08	58.58	732.00	1,098.00			
Eastern region (Busis & Tororo): Moisture stress	38800 × 15%	1.5	Early maturity, anthracnose resistant, market class	NABE 15	3,510	0.63	0.94	11.78	17.63	220.50	330.00			
		1.5	Early maturity, anthracnose resistant, market class	NABE 16	2,340	0.42	0.63	7.80	11.78	147.00	220.50			

Pigeonpea

Yuventino Obong, Ganga Rao and Said Silim

Introduction

Uganda is one of seven major pigeonpea producing countries in Africa and the cultivated area is 90,000 ha. Average yields are estimated at more than 1000 kg ha^{-1}, much higher than the average of less than 770 kg ha^{-1} in Sub-Saharan Africa (SSA). So far, Uganda is the only country that reaps more than 1 t ha^{-1} among SSA countries (according to FAOSTAT, 2012).

The UBOS data for the 2008/09 crop season show that about 88% of pigeonpea was produced in Northern region, with about 20% grown in Eastern region (Table 1). Commonly grown pigeonpeas are the local cultivars (Apio Elina, Agogi and Adong) and the improved varieties Sepi-I and Sepi-II (Serere pigeonpea I and II).

Table 1. Pigeonpea growing areas in Uganda.

Agroecology/Region	Area (ha)
Northern	75,680
Eastern	7,740
Central	1,720
Western	860

The UBOS data for the 2008/09 crop season indicate that depending on the crop, about 32–52% of the grain is used for consumption, with sales ranging from 6% for pigeonpea to about 32% each for common bean and groundnut. Currently, Uganda is a net exporter of grain legumes. Available data show that the country obtains modest amounts of revenue from international trade in grain. However, contribution by pigeonpea was not indicated. Average export earnings in 2007–09 were estimated at about US$ 10.5 million, the bulk (85%) of which was attributed to common bean, with soybean a distant second.

Uganda did not participate in the first phase of TL-II. The inclusion of pigeonpea has provided an opportunity for revitalization of pigeonpea crop in Uganda. With the rate of growth of production by 5.65%, 196 tons is expected by 2015 with the accompanying demand of 124 tons. By 2020 production is expected to reach 253 tons with demand of 151 tons (Table 2).

Table 2. Projected production and national demand of pigeonpea in Uganda[1].

Description	2010	2015	2020	ROG (%)
Production (t)	145	196	253	5.65
Demand (t)	105	124	151	3.8

1. Source: Calculated from various sources; ROG = Rate of growth.

Pigeonpea research in Uganda

The pigeonpea varieties grown are mainly long-duration landraces with small grains that take long to cook and are low yielding. In the collaborative work between ICRISAT and NARO, a number of varieties were evaluated and two varieties Sepi I (Kat 60/8) and Sepi II (ICPL 87091) were released in 1999. NARS in Uganda and ICRISAT collected germplasm from Uganda in 2002, and ICRISAT evaluated them the following year in Kenya. Those which were promising were crossed with the ICRISAT's best medium-

duration varieties which are high yielding, bold seeded, have aroma and cook fast and these new varieties are now ready for evaluation in Uganda.

Many farmers are still planting low-yielding, late-maturing varieties (Agogi, Adong and Agali) that take 9 months to mature. The pigeonpea program has released two improved varieties, Sepi I and Sepi II (Table 3). The two released varieties are in limited quantities and are not pure. Farmers are therefore in need of lines with high potential. Hence high-yielding varieties (ICEAP 00068, ICEAP 00554, ICEAP 00557 and ICEAP 00850) from those released in other countries in Eastern and Southern Africa were selected for on-farm evaluation for the farmer-preferred traits in Uganda. This is an opportune moment for pigeonpea project in Northern Uganda (Lango and Acholi regions) where civil war has ended and farmers are going back to their original homes and would require improved technologies for improving their livelihoods.

Table 3. Pigeonpea varieties released and their characteristics.

Variety	Pedigree	Year of release	Special varietal attributes	Recommended agroecologies	Yield potential (t ha^{-1})
Sepi I	Kat 60/8	1999	Medium maturing	Country wide	2
Sepi II	ICPL 87091	1999	Short duration, multiple cropping	Country wide	2

Agroecologies for pigeonpea cultivation in Uganda

The bulk of pigeonpea production in Uganda is in the Northern region (88%), followed by Eastern region (9%) (Table 1 and Fig. 1). Pigeonpea is mostly grown as an intercrop with maize and cassava or in rotation. The major pigeonpea growing districts in the Northern region are Lira, Apac, Gulu, Kitgum and Arua. In the Eastern region pigeonpea is grown in Soroti, Kumi, Katakwi and surrounding districts while in the Western region it is grown in Masindi and Hoima.

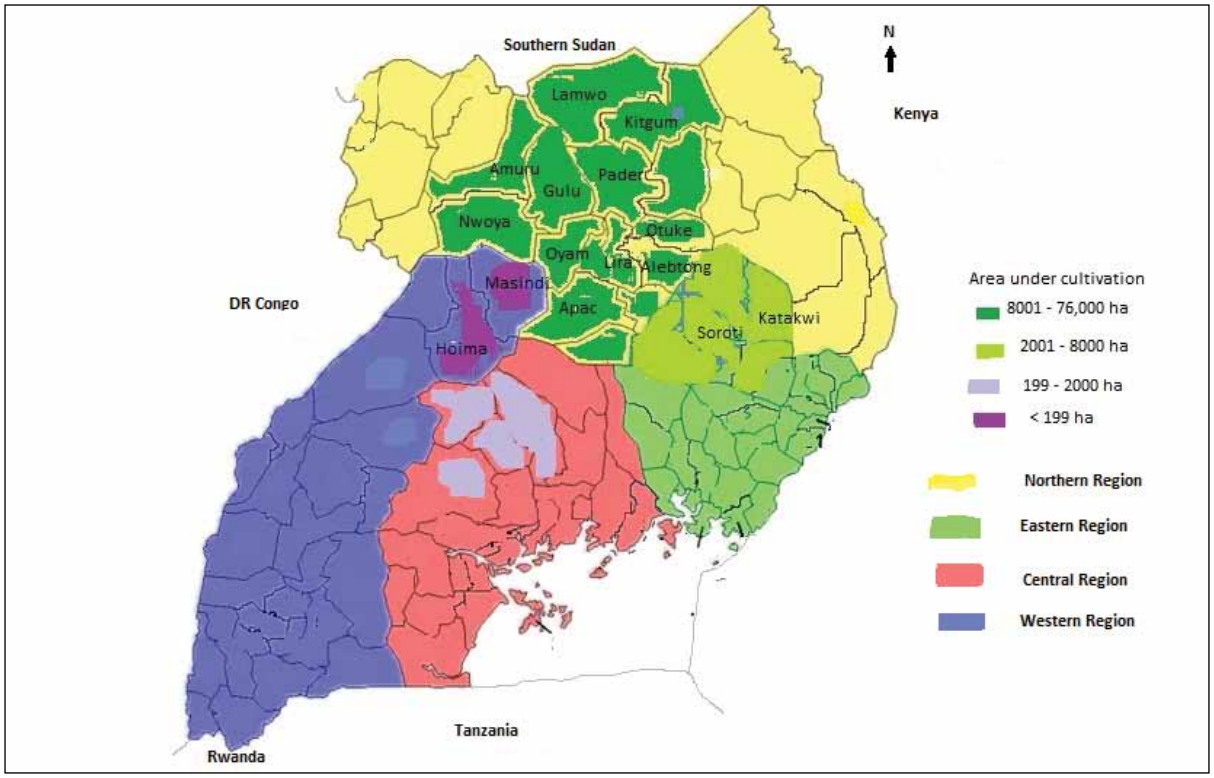

Figure 1. Major pigeonpea growing agroecologies in Uganda.

Seed systems

Large seed companies are not interested to engage in grain legume seed production because of low margin of profit. Most pigeonpea farmers recycle their own-saved seed for up to five years creating low market seeds of improved varieties. Much attention should therefore be paid to strengthening community-based and farmer-level seed production and delivery systems through farmer participatory variety selection (FPVS) and demonstrations.

Seed production targets

Total area: 86,000 ha

Seed rate (mean): 10 kg ha^{-1}

National seed demand (mean): 860 tons (2012–14) to cover 86,000 ha

Capacity to deliver 15% of total area = 12,910 ha

Total seed required to cover targeted area of 12,910 ha $\simeq$ 151 tons

Opportunities, constraints, partnership and seed production plan

The target to cover 15% of pigeonpea in each agroecology is discussed.

Opportunities

- High demand for pigeonpea locally, regionally and internationally
- Private sector interest, especially processors to support and enhance pigeonpea production to meet local demand
- Government has placed pigeonpea among strategic legume crops for promotions
- Availability of suitable varieties at all maturity levels
- Potential to expand to non-traditional pigeonpea growing areas due to climate change

Constraints

Key technical constraints for pigeonpea are shortage of improved varieties coupled with limited access to seed of improved varieties. Many farmers are still planting low-yielding, late-maturing varieties that take 9 months to mature. Management practices and pests [pod suckers, pod borer (*Helicoverpa armigera*)] and diseases are causes of low productivity and production.

Socioeconomic and organizational constraints include limited coverage of current interventions, high marketing transaction costs due to lack of grades and standards, and limited access of farmers to irrigation for investment in seed production, unstructured inputs and outputs markets and lack of quality seed as per the demand.

Other constraints are:

Policy environment around availability of legumes seed, seed markets and grain markets that include, lengthy variety release process, lack of grading and standards for tropical legume grains, lack of incentive for private investment in seed production and decline in investment in agricultural research and development.

Key partners

The key partners and their role in the seed system are given in Table 4.

Table 4. Partners in pigeonpea seed systems and their roles.

Partner	Role
National Agricultural Research Organization	Varietal development, evaluation and release; production of breeder and foundation seeds
ICRISAT	Provide improved germplasm/breeding populations; capacity building through training; research on effective methods for technology dissemination
National Agriculture Advisory Services (NAADS)	Extension services related to crop management; crop protection
NGOs (such as World Vision, Care International, CRS, VEDCO, etc)	Seed production and dissemination; promotion
Government and private universities	Research
Seed companies (including FICA, NASECO, Victoria Seeds, CEDO)	Seed production and dissemination; promotion
Pulse CRSP	Research
Agricultural Marketing – AGMARK	Capacitate farmers formation of associations for collective production and marketing
USTA (Ugandan Seed Testing Association)	Variety release, seed certification services and quality control
Farmers	End-users of technologies in terms of high-yielding varieties, management practices

Seed production plan

Pigeonpea seed production plan for Uganda is presented in Tables 5 and 6.

Vision of success

Significant proportions of farmers (over 70%) in target areas have access to good quality seed of improved varieties and are empowered through increased income from pigeonpea. Fast track release of a new set of medium-duration varieties will add to the choice to farmers. Involvement of all the stakeholders along the value chain will also bring in new seed producers interested in production and seed sale. Local level leaders and policy makers in Uganda will be aware of the benefits of adopting new pigeonpea varieties along with improved agronomic package.

Table 5. Seed roadmap for pigeonpea in Uganda.

Ecology (Zone)	Demand (ha)	Promising varieties	On-farm yield potential (t ha^{-1})	Seed rate (kg ha^{-1})	Area to be covered (ha)		Breeder seed in 2012		Foundation seed in 2013		Certified seed in 2014		Seed to reach 15% adoption (t)
					Total	Per variety	Area (m^2)	Production (kg)	Area (m^2)	Production (t)	Area (m^2)	Production (t)	
Northern	75,680	4			11,300		130	13	1.3	1.3	133	133	133
	22,667	Sepi-I	1	10		3400	40	4	0.4	0.4	40	40	40
	22,667	ICEAP 00554	1	10		3400	40	4	0.4	0.4	40	40	40
	22,667	ICEAP 00557	1	10		3400	40	4	0.4	0.4	40	40	40
	7,333	ICEAP 00850	1	10		1100	10	1	0.1	0.1	13	13	13
Eastern	7,740	4			1160		13	1.3	0.13	0.13	13	13	13
	2,333	Sepi-I	1	10		350	4	0.4	0.04	0.04	4	4	4
	2,333	ICEAP 00554	1	10		350	4	0.4	0.04	0.04	4	4	4
	2,333	ICEAP 00557	1	10		350	4	0.4	0.04	0.04	4	4	4
	733	ICEAP 00850	1	10		110	1	0.1	0.01	0.01	1	1	1
Central	1,720	4			300		3.3	0.33	0.033	0.033	3.3	3.3	3.3
	600	Sepi-I	1	10		90	1	0.1	0.01	0.01	1	1	1
	600	ICEAP 00554	1	10		90	1	0.1	0.01	0.01	1	1	1
	600	ICEAP 00557	1	10		90	1	0.1	0.01	0.01	1	1	1
	200	ICEAP 00850	1	10		30	0.3	0.03	0.003	0.003	0.3	0.3	0.3
Western	860	4			150		1.7	0.17	0.017	0.017	1.65	1.65	1.65
	300	Sepi-I	1	10		45	0.5	0.05	0.005	0.005	0.5	0.5	0.5
	300	ICEAP 00554	1	10		45	0.5	0.05	0.005	0.005	0.5	0.5	0.5
	300	ICEAP 00557	1	10		45	0.5	0.05	0.005	0.005	0.5	0.5	0.5
	100	ICEAP 00850	1	10		15	0.2	0.02	0.002	0.002	0.15	0.15	0.15
Total	86,000				12,910	12,910	148	14.8	1.5	1.5	151	151	151

Table 6. Certified seed production (t) plan for three years.

Variety	2012	2013	2014
Sepi-I	6.8	11.4	27.3
ICEAP 00554	6.8	11.4	27.3
ICEAP 00557	6.8	11.4	27.3
ICEAP 00850	2.3	3.3	8.9
Total	22.7	37.4	90.8

Zimbabwe

Common bean

Bruce Mutari, Goodwil Makunde and Steve Beebe

Introduction

Importance of the crop in Zimbabwe

Common bean (*Phaseolus vulgaris*) is a well known protein source which is consumed directly by many people in Zimbabwe. Beans are mainly consumed as dry or fresh grain, and are currently promoted based on high micronutrient (Zn and Fe) content, which suits malnourished children, pregnant women and young children. Common bean is among the top five crops that provide a high income to farmers and traders. The crop is traded in informal markets as well as in supermarkets. On average Mbare market (Musika) trades dry beans worth US$ 10,000 a month. Dry packed grain as well as locally canned beans are common in supermarkets. The price for grain at informal markets ranges from US$ 800 to US$ 1,000 per ton depending on quality of the grain. Trade is not limited within the country but is expanded to South Africa, Malawi, Zambia, Mozambique and Tanzania.

The level of genetic diversity of common bean in Zimbabwe is high, but some farmers grow local landraces, which are low yielding, resulting in low productivity at smallholder farmer level. The average demand for beans is estimated at 180,000 tons per annum to satisfy an average domestic consumption of 12 kg per capita per annum. This demand is likely to go up as there are initiatives involving NGOs and government agencies through the Ministry of Health and Child Welfare and Food and Nutrition Council to promote production and consumption of common bean. Currently the bean seed demand is estimated at 3,800 tons, and this is also likely to go up with the demand to produce more beans for consumption and markets.

Trends in bean production

In Zimbabwe, crop assessment reports are mainly focused on food security crops such as maize and wheat. Funding for assessments is under FAO. Common bean is grown under different production systems, rainfed and irrigated. Most of the irrigated crop and crops in gardens are never reported but estimated to occupy 30,000 ha annually. Common bean in gardens had been reported under the umbrella term horticultural crop and it is difficult to get accurate area under production. In general, the area under bean production has been variable over the years, with some downward trends in recent years. The decline in production can be attributed to shortage of seed in the market, poor marketing of the bean varieties and dry spells (drought) which have significantly affected bean production for the past years. Although production statistics for common bean are scanty, it is estimated that approximately 120,000 ha are planted to a bean crop every year and the average yield is 0.5 t ha^{-1}, which translates into a total production of 60,000 tons.

Research and development

Variety development

Both public and private breeding programs contribute to bean research in Zimbabwe. Universities through student projects also contribute to the research work in Zimbabwe. The national breeding program under the auspices of the Crop Breeding Institute (CBI) is housed at DR&SS in Harare and private seed companies are also in Harare while their research sites are all over bean growing areas. Seed Co, PANNAR Seeds, Agriseeds, Sandbrite and Progene Seeds are actively involved in either breeding or marketing of the bean products. Zaka Seeds, a community-based company, has also joined hands in popularizing improved new varieties since 2011.

Bean breeding activities for the national breeding program are focused on developing improved bean varieties that are high yielding (3,000 kg ha^{-1} low-veld winter production and 2,400 kg ha^{-1} for summer high- and middle-velds production) and have acceptable grain market classes (large seeded sugar, red and calima in descending order and small white). In addition, the varieties should have good levels of resistance to important biotic and abiotic constraints. In particular the biotic constraints in focus are diseases (angular leaf spot and common bacterial blight) and pests (storage pest *Zabrotes subfasciatus*; and field pest bean stem maggot). Among the abiotic constraints the focus is on tolerance to low soil fertility and resistance to drought and heat. Another attribute that is under consideration in the breeding program is nutrition quality, particularly for high Fe and Zn content in the grain.

Alongside the variety development activities, the bean team in Zimbabwe is also developing integrated soil fertility management (ISFM) as well as integrated pests and diseases management (IPDM) practices.

To date, a total of 8 new bean varieties have been introduced in the market over the past few years (Table 1). These varieties were released by different institutions: Cardinal (calima) and Speckled Ice (sugar) from Progene Seeds; NUA45 (calima) and Gloria (sugar) + Iris (carioca) from the CBI; Bounty (sugar) from Seed Co; and other varieties from PANNAR which include PAN127 and PAN148. The other seed companies, viz, Sandbrite Seeds, Agriseeds, ARDA seeds, SIRDC, NTS and Zaka Seeds are marketing CBI varieties. These companies are involved in production of certified and standard grade seed in different bean growing regions.

Farmers and consumers prefer bean varieties based on seed size, color, taste and cooking time. The commonly preferred varieties are the large-seeded, red and the sugar type (cream with red speckles). Most of the released bean varieties meet these requirements.

Production constraints

The list of constraints that impede the bean value chain in Zimbabwe are listed below:

- Drought – farmers have no resources for supplementary irrigation
- Lack of access to seed
- Lack of appropriate postharvest handling and utilization techniques (value addition)
- Poor diffusion of information on available bean technologies, including varieties
- Lack of credit facilities to facilitate business initiatives
- Lack of market information
- High cost of production
- Prevalence of diseases under rainfed conditions

Table 1. Common bean varieties in Zimbabwe.

Variety	Original code	Source	Year of release	Responsible institution	Optimal production altitude range (m amsl) (rainfed)	Time to maturity (days)	Grain yield (t ha^{-1})	Special attributes
Iris	MCM5001	CIAT	1998	DR&SS	600–1200	90	3.5	Drought tolerant, early maturing, carioca
Cardinal	CIM9314-17	CIAT	2007	Progene Seeds	600–1200	95	4	High yielding, wide adaptation, calima
Speckled Ice	SUG131	CIAT	2007	Progene Seeds	600–1200	94	3.5	Wide adaptation, sugar market class
NUA45	NUA45	CIAT	2010	DR&SS	600–1200	90	2.4	Good taste, rich in Fe and Zn, high yielding, quick to cook, calima
Gloria	PC655-SS3	ARC-GCI	2010	DR&SS	600–1200	93	2.4	High yielding, attractive seed color
Bounty		Seed Co		Seed Co	600–1200	96	2.0	High yielding, sugar market class
PAN148		PANNAR		PANNAR	600–1200	90	2.1	Widely adapted, resistant to bean common mosaic virus (BCMV), sugar market class
PAN127		PANNAR		PANNAR	600–1200	94	1.6	Moderately tolerant to rust and resistant to BCMV, sugar market class

Planned Phase 2 activities

In Zimbabwe the planned activities will be implemented by engaging the key stakeholders in the bean value chain, through strategic planning to resolve the critical constraints and unlock the available opportunities. This requires various partners to put their ideas together and commit resources to resolve the constraints, and pave a way for a successful bean value chain. The processes will also require capacity building while mainstreaming culture and gender into project work plans.

Access to sufficient quantities of bean seed of preferred improved varieties as well as promotion of other eco-efficient non-variety bean production technologies will be one of the priority areas. Knowledge empowerment for farmers on bean production technologies will play a big role in production and productivity increase. This will be achieved through training of extension personnel and lead farmers. Participatory variety selection (PVS) will be implemented to identify farmer and consumer preferred varieties and traits. Field days and demonstrations will be conducted to create awareness and demand for the newly released improved varieties and associated bean production technologies.

Expected outcomes

Phase 2 of the project aims at ensuring national self-sufficiency in bean and surplus for sale. This is expected to translate into improved household food and nutrition security and more income from bean sales at local as well as regional markets.

Agroecological zones

The bean crop is grown across many parts of Zimbabwe under rainfall or irrigation conditions. The production environments are categorized into agroecologies (high, medium and low-velds) according to altitude and rainfall, as described in the Africa Bean Atlas (which is under revision) (Fig. 1). In the low-veld zone (below 1000 m amsl), beans are not cultivated during the rainy season, because the night temperatures are too high for pollen to remain viable, and instead these areas produce beans during the postrainy season, under residual moisture or irrigation.

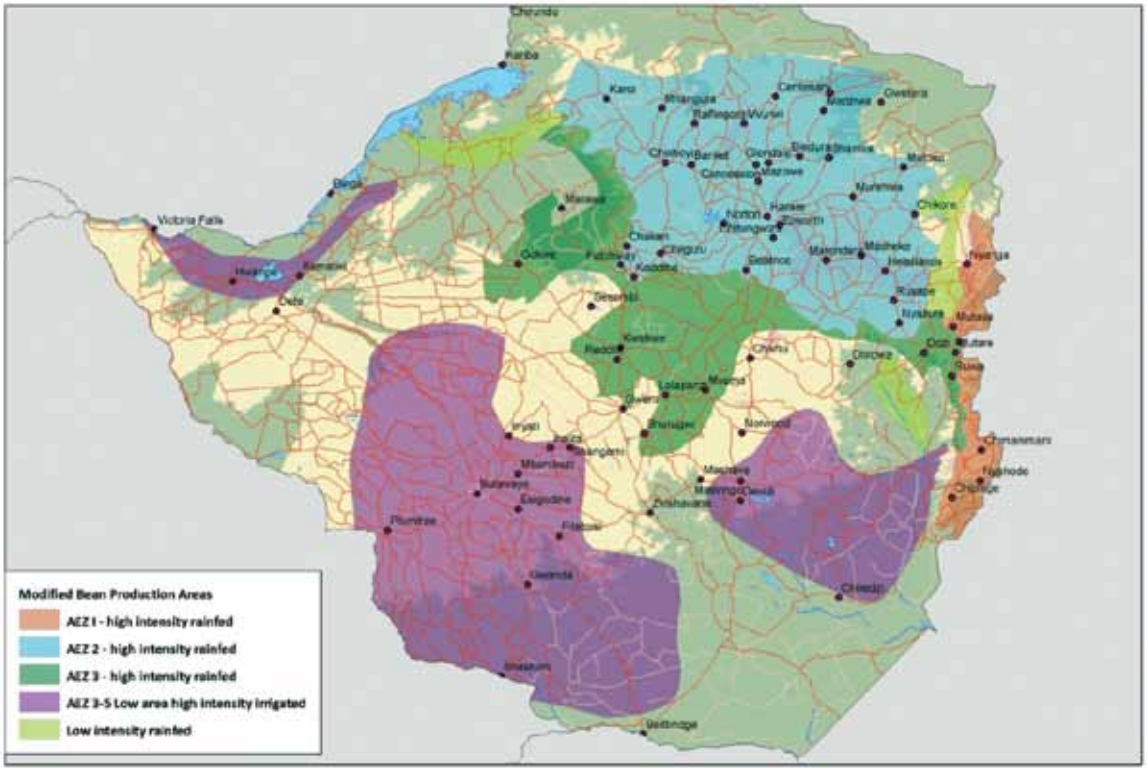

Figure 1. A map showing the revised bean production zones of Zimbabwe.

Seed systems

In Zimbabwe, there are some private seed companies that develop their own bean varieties (Seed Co and PANNAR), which complement the government's effort through the CBI to make available improved bean varieties to the farming community. As such seed availability is tackled from various fronts. The seed companies, CBI, extension agents (government, NGOs and farmer unions) and marketing institutions need to work together to increase the quantity of seed in the market. The whole chain of seed production needs to be strengthened (breeder seed, foundation seed, certified/standard grade seed).

Opportunities

- Willingness of partners (NGOs and the private sector) to try small seed pack strategy
- Availability of private seed companies for production of breeder, foundation and certified seed
- Willingness of NARS breeder to work with the private sector to produce more breeder seed
- Existence of farmer groups/associations, for example, Zimbabwe Farmers Union (ZFU), Zaka Seeds (community-based company)
- Farmers are willing to experiment with new products
- Demand for seed is high
- Existence of extension agencies country wide (both NGOs and government)

Constraints

- Unavailability of seed of improved varieties
- High input costs
- Lack of capacity to produce sufficient breeder seed to meet the demand
- Poor diffusion of information on available bean technologies, including seeds
- Poor infrastructure for seed production
- Lack of credit facilities to facilitate business initiatives (massive seed production)
- Lack of seed market information
- High cost of seed production
- Poor product packaging (no small packs)
- Prevalence of diseases under rainfed conditions affect seed quality
- Aging equipment and facilities at research sites and other seed production sites

Strategic partnerships and roles

Partners will be involved to enhance organization of proper target groups in the targeted areas and to popularize improved high-yielding bean varieties with acceptable end-user traits and associated improved bean production technologies. The key partners and their roles are described in Table 2.

Table 2. Key partners in the bean value chain and their roles.

Partner	Role
Department of Agricultural Research & Special Services and universities	Variety development, evaluation and release; production of breeder and foundation seed; develop integrated crop management technologies
Seed companies – Seed Co, PANNAR Agriseeds, Sandbrite, Progene Seeds, ARDA Seeds, SIRDC, NTS and Zaka Seeds	Facilitate processing and commercialization of bean seed and products
Farmers' organization/associations (Zimbabwe Farmers Union)	Capacitate farmers formation of associations for collective production and marketing; seed systems support; help collaborating NGOs and CBOs with quality seed production/monitoring
NGOs	Provision of guidance in crop production technologies and associated packages
CGIAR center – CIAT	Provide improved bean germplasm/breeding populations; capacity building through training; research on effective methods for technology dissemination
Farmers	End-users of technologies in terms of high-yielding varieties and management practices
Department of Extension (Agritex)	Support to farmer field schools to impart knowledge and skills for increased production on farm

Seed production plan

The total bean area is estimated at 120,000 ha, of which 40% or 48,000 ha is targeted. At a seed rate of 80 kg ha^{-1}, this will require 3840 tons. The goal yield is 1 t ha^{-1}, for a national production of 120,000 tons. The bean seed roadmap in Table 3 is based on these estimates.

Table 3. Bean seed production system plan to reach 40% adoption by 2015.

							Breeder seed (2013)		Foundation seed (2014)		Certified seed (2015)	
Agroecology	Area covered (%)	Variety	Seed rate (kg ha^{-1})	Yield (kg ha^{-1})	Area (ha) (100%)	Target area (ha) (40%)	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
High- and low-veld	100		80	1000	120000	48000	25	25	307	307	3840	3840
	28	Gloria	80	1000	33600	13440	7	7	86	86	1075	1075
	27	NUA 45	80	1000	32400	12960	7	7	83	83	1037	1037
	20	VTTT 925/9/2/1	80	1000	24000	9600	5	5	61	61	768	768
	20	MG 38	80	1000	24000	9600	5	5	61	61	768	768
	5	Iris	80	1000	6000	2400	1	1	15	15	192	192

Grain Legumes Strategies for Western and Central Africa

Burkina Faso

Groundnut

Amos Miningou, Bonny Ntare and Jupiter Ndjeunga

Groundnut is a major source of protein for humans and the haulm is used for feeding livestock. It is also a source of income for the farmers, retailers and women who make and sell groundnut-based products. Based on the agricultural crop statistics 2005–10, groundnut is produced on 372,940 ha in Burkina Faso with an average annual production of 283,000 tons. Household surveys by the Ministry of Agriculture and Water Resources in 2005 showed that 71% of the households cultivate groundnut followed by sesame and soybean. Agriculture plays a central role in Burkina Faso, employing over 70% of the population and contributing more than 30% to GDP. The demand, expected growth and proportion of production sold are presented in Table 1. The trends in area, production and yield are presented in Figure 1.

Table 1. Parameters for groundnut production in Burkina Faso[1].

Parameter	Value
Average area (ha)	408,229
Average production (tons)	304,465
Average yield (current) (kg ha^{-1})	752
Average yield (2015) (kg ha^{-1})	1500
National demand (tons)	185,352
Expected growth of production (%)	3
Proportion of production sold (%)	53

1. Source: FAOSTAT 2007–11.

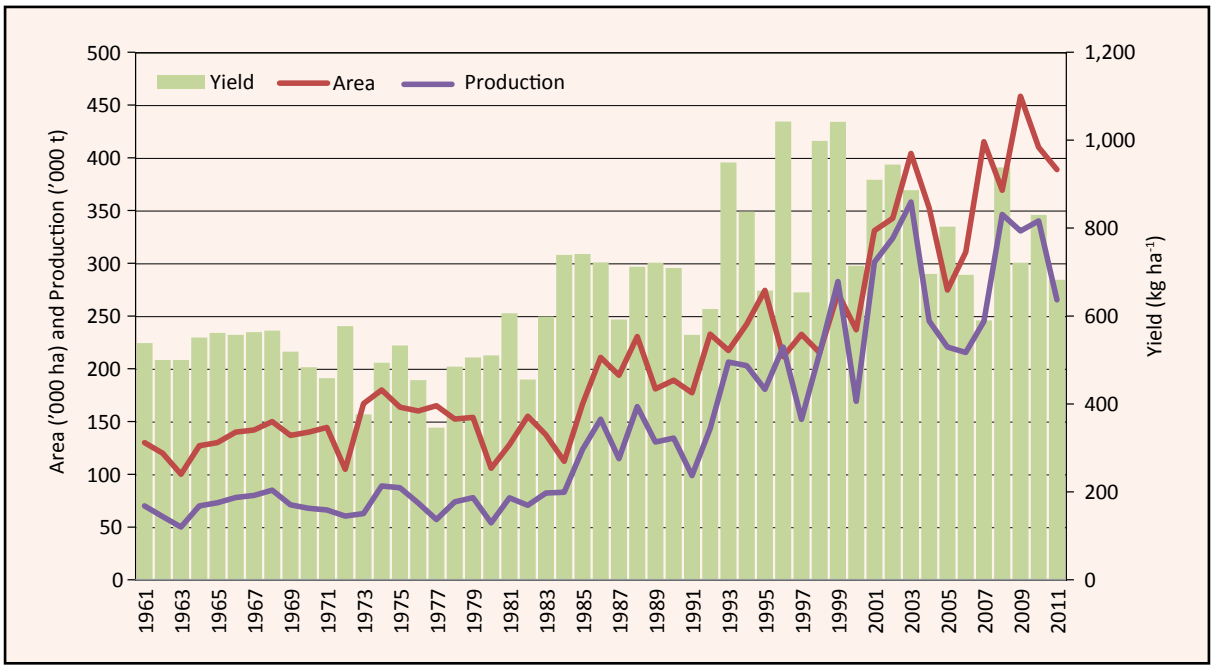

Figure 1. Trends in area, production and yield of groundnut in Burkina Faso (1961–2011).

Agroecologies

Groundnut is largely grown in the savanna zone with rainfall ranging from 700 to 900 mm. The major groundnut regions are presented in Figure 2.

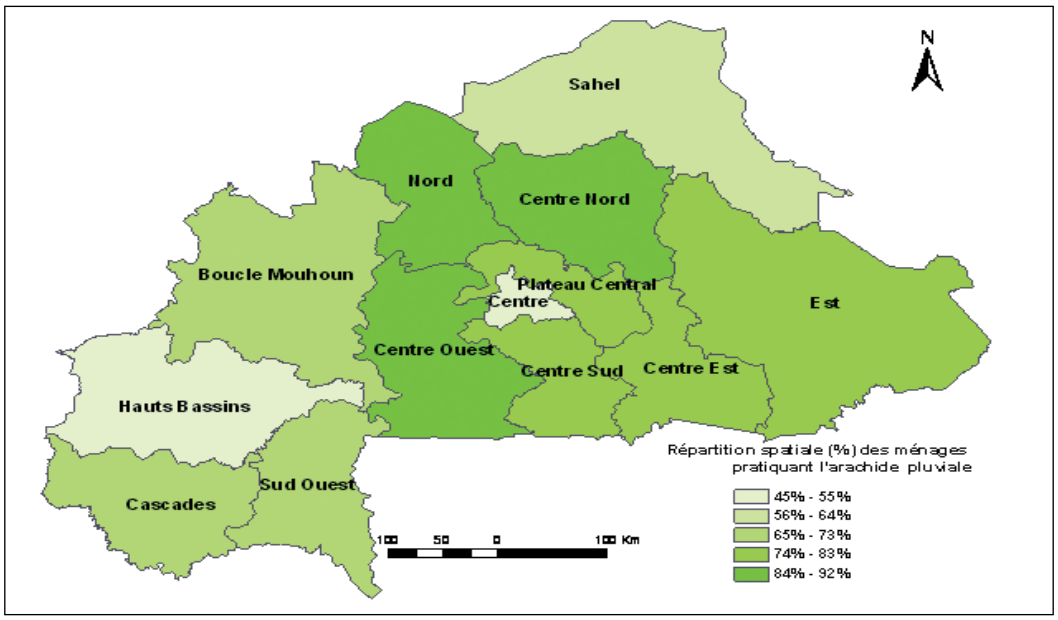

Figure 2. Distribution of groundnut in Burkina Faso.

The dominant varieties are:

South-West (110–135 days): 59-426, 69-101, RMP 12, RMP 91

East and Center (80–100 days): CN 94 C, TS 32-1, QH 243 C, TE 3, ICG (E) 104, SH 470

Seed system

Constraints

Biotic and abiotic constraints

The major constraints are given in Table 2.

Table 2. Major constraints to groundnut production in Burkina Faso.

Region	Key constraints
South-West	Low soil fertility, storage, early leaf spot, late leaf spot, rosette, rust, foliar insects
Center	Drought, low soil fertility, storage, termites, early leaf spot
East	Drought, low soil fertility, storage, termites, early leaf spot

Socioeconomic constraints

- Lack of availability and access to seed of new improved varieties
- Poor access to agricultural equipment to expand production area

- Difficulties in accessing fertilizers and insecticides
- Labor constraints for weeding and harvesting
- Poorly developed market and volatile prices
- Poor access to credit and input delivery system
- Poor road infrastructure to transport produce to markets
- Poorly developed processing industry
- Lack of coordination of actors along the groundnut value chain

Organizational constraints

- Inadequate availability of quality seed
- Uncertainty in the quality and timely availability of fertilizers, fungicides and pesticides
- Difficulty in accessing credit by farmers
- Poor organization of farmers
- Lack of policies to reduce fluctuations in market price and gap between the farm-gate price and price paid by the consumers

Strategic partners

The strategic partners and their role are presented in Table 3.

Table 3. Strategic partners and their role in groundnut seed system.

Partner	Role
Ministry of Agriculture	Policy formulation
National Seed Services	Seed policy
University of Ouagadougou	Research collaboration, degree training
INERA	Research, variety development
Farmers' associations	Seed production
Burkina Council of Oil Crops	Regulate groundnut sector
NGOs	Seed production and technology transfer
International research institutes (ICRISAT)	Technology development, backstopping in training, technical skills in priority areas, research collaboration

Capacity building needs

Burkina Faso needs support to produce seed and make it available to farmers, for training for using new molecular genetic tools in groundnut improvement, to generate enhanced germplasm and for equipment and infrastructure (cold room to store the germplasm material, vehicle to facilitate monitoring and evaluation, greenhouse to make crosses, equipment for laboratories).

Special cultural/gender considerations

Groundnut is mainly grown by smallholder farmers, and women play a major role in the production, processing and marketing of groundnut products. Groundnut is often regarded as a woman's crop and

is the major source of income under their control. However, they only produce small surpluses for the market, which is typically sold at the farm-gate to local traders, often soon after harvest when prices are very low. Harvesting and processing are generally done by women.

Processing and storage requirements and market opportunities

There is a need for proper drying facilities as well as grading equipment and storage. Due to lack of appropriate storage, farmers sell their produce immediately after harvest to reduce losses from rain and rodents. By selling the produce shortly after harvest the profit accruing to farmers is low as prices are reduced during the period. The use of PICS technology is already being promoted in Burkina Faso and farmers can now store their groundnuts for a longer period and release grains to the market gradually rather than the previous practice of selling off the bulk shortly after harvest. There are regional market opportunities for groundnut products in the ECOWAS countries.

Key policies recently implemented/needed

The World Bank has supported groundnut research in Burkina Faso in the past five years. The government needs to support research on groundnut to maintain the germplasm and develop new varieties.

Key issues for competitiveness

High productivity and aflatoxin control are key issues for groundnut improvement. High-yielding, disease and drought resistant varieties will increase the production. There is a need to strengthen the value chain of groundnut to make it competitive.

Mechanization needs

Generally farmers are poorly equipped with agricultural implements in Burkina Faso as in other countries in SSA. Harvesting is largely by hand and processing is by use of rudimentary tools not amenable to large-scale processing at the local level. The low level of equipment has significant implications on the potential for expanding groundnut cultivation in the country. There is a need for affordable farm equipment to expand the area planted as well as harvesting and processing equipment to minimize postharvest losses.

Possible interventions to increase production and productivity

The promotion of improved varieties of groundnut as well as agronomic practices that make adequate use of available resources will enhance increased production and productivity. A select group of farmers should be trained in production of quality seed of improved varieties. Through such training the farmers will be well positioned to be sources of quality seed for other farmers at the time of planting. Availability of quality seeds of improved varieties remains a major concern that should be addressed by policy makers.

Monitoring and evaluation

- Annual review meetings of stakeholders
- Monitoring tours and visits to experimental sites will be encouraged among scientists
- Annual progress reports of the project
- Institutional work planning and review meetings

Perspectives for Phase 2

As Burkina Faso did not participate in Phase 1 it is expected that support from this phase will provide an opportunity to expose farmers to improved groundnut through farmer participatory variety selection (FPVS), and the national program will be enhanced with diverse genetic resources from which appropriate material will be selected for local adaption. Some of the varieties identified for drought tolerance during Phase I of the project would be made available to farmers to evaluate in their various farms. There are chances that some of the lines may be found to be well adapted and readily acceptable to the farmers. Scientists and technicians are expected to gain skills in the use of new tools of molecular breeding methodologies and data management.

Seed strategy

The groundnut seed system in Burkina Faso is very weak due to lack of sustained variety maintenance and breeder seed production. All seed produced in Burkina Faso are from farmer-saved seed or purchased from markets. With implementation of TL-II the strategy is to purify and produce breeder seed of old varieties. New varieties introduced from ICRISAT will be evaluated in participatory trials and seed production program will start with selected varieties. The groundnut seed roadmap for Burkina Faso is presented in Table 4.

Table 4. Groundnut seed roadmap for Burkina Faso.

Ecology	Demand (ha)	Promising varieties	Breeder seed (t)	Seed production (t)		Seed to reach 20% adoption (t)	Certified seed production by 2015 (t)
				Breeder seed	Foundation seed		
Sahelian							
Sahel	2,525			0.303	3	30	152
Total	2,525			0.303	3	30	152
Sudanian							
East Central	54,658			6.559	66	656	3,279
West Central	30,098	CN 94C		3.612	36	361	1,806
Mouhoun	29,610	TS 32-1		3.553	36	355	1,777
North	25,499	QH 243C	15	3.060	31	306	1,530
North Central	21,537	SH 470P	15	2.584	26	258	1,292
Center	4,305	Te 3	15	0.517	5	52	258
Central plateau	18,397			2.208	22	221	1,104
Total	184,104		45	22.092	221	2,209	11,046
Northern Guinea							
East	57,584	69101		6.910	69	691	3,455
High basin	24,186	59426		2.902	29	290	1,451
Cascades	16,967	RPM 12		2.036	20	204	1,018
South west	11,532	RMP 91		1.384	14	138	692
Center south	26,353			3.162	32	316	1,581
Total	136,622			16.395	164	1,639	8,197
Grand total	323,251		45	38.79	389	3,878	19,395

Cowpea

Issa Drabo, Christian Fatokun, Ousmane Coulibaly and Ousmane Boukar

Introduction

Importance of the crop in Burkina Faso

Cowpea is the most important grain legume in Burkina Faso and is grown across different agroecologies. The crop provides an inexpensive source of protein to millions of resource-poor people in those regions. The haulms provide fodder for livestock and residues improve the fertility of the otherwise marginal soils. Cowpea is mainly grown as an intercrop with cereals. About 378,000 tons is produced annually on about 804,000 ha. The average yield of the crop in farmer fields is very low and is less than 500 kg ha^{-1} (Fig. 1). Yield increased at 0.9% per year from 1985–87 to 2005–07. Cowpea remains one of the major sources of income to the farmers, retailers and women despite its low yield, which is attributable to several constraints. These include insect pests, diseases, low soil fertility, drought and *Striga.*

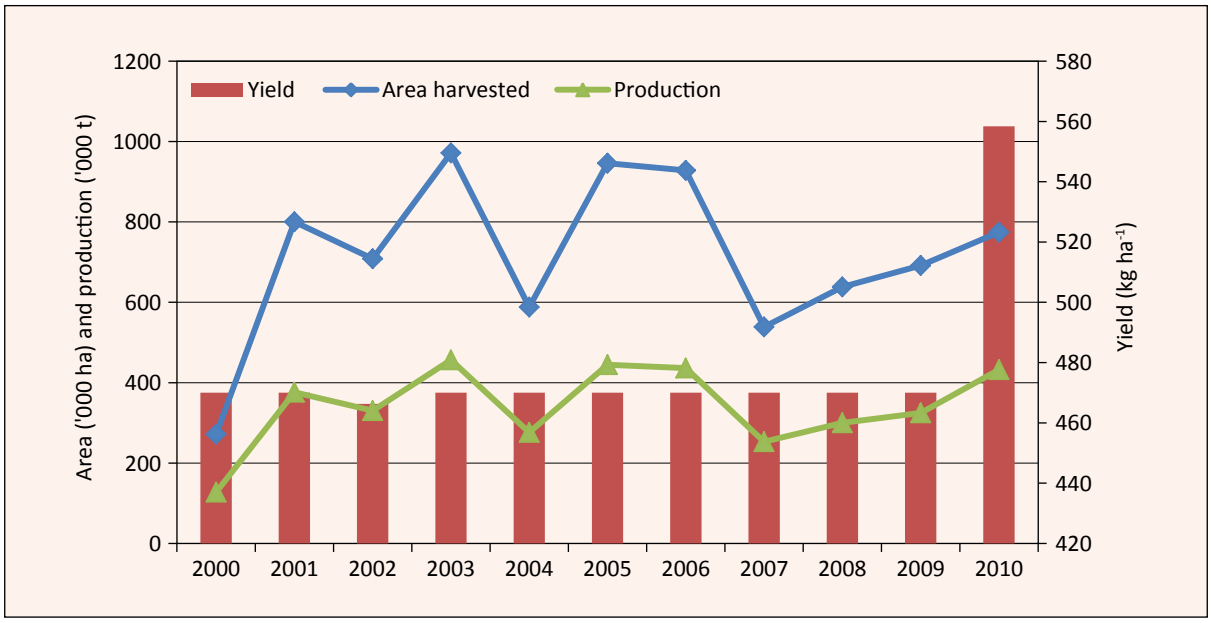

Figure 1. Cowpea area, production and yield in Burkina Faso during 2000 to 2010 (Source: FAOSTAT 2012).

Burkina Faso is the third largest cowpea producer with 6.1% of the world's total production. The projected rate of growth (ROG) for cowpea in Burkina Faso was 4.2% in area, 0.9% in yield and 5.9% in production (Abate 2010). Cowpea area expansion may be attributed to the need for more production to meet the growing national and regional demand fuelled by growing income and population. The national demand is projected to grow at a rate of 3.87% during 2010 to 2020 (Table 1). Most of the cowpea produced in the country is consumed locally but some are exported to Nigeria to meet the country's shortfall in its cowpea requirements. Cowpea producer prices were relatively stable (US$ 350–400 per ton) throughout the period between 1991 and 2008.

Cowpea's contribution to national GDP, farmer income, food and nutrition security

The cowpea price for Burkina Faso was relatively stable throughout the last two decades. About 30% of the Ghanaian cowpea imports come from Burkina Faso and the rest from Niger (Coulibaly et al. 2010). The area planted to cowpea is projected to be more than 1 million ha by 2019. The national demand would also grow at the rate of 2.7% per annum. This means that the country would continue to be a net exporter of cowpea through 2020. It is apparent that Burkina Faso exports significant amounts of cowpea to neighboring countries but organized data on trade among the countries in the sub-region are wanting. The latest FAOSTAT report (July 2012) does not provide data on cowpea trade.

Table 1. Projection of cowpea production and demand in Burkina Faso[1].

Year	Area ('000 ha)	Yield (kg ha^{-1})	Production ('000 t)	Demand ('000 t)	Balance[2] ('000 t)
2010	787	471	371	36	335
2011	809	473	383	27	356
2012	833	475	396	28	368
2013	856	478	409	29	379
2014	881	480	422	31	392
2015	906	482	436	32	404
2016	932	484	451	33	418
2017	959	486	466	35	431
2018	986	488	481	36	445
2019	1,014	490	497	38	459
2020	1,043	492	514	39	474
ROG (%)	2.86	0.44	3.31	2.70	3.38

1. Source: TL Bulletin (2012).
2. Difference between production and demand.

Burkina Faso is considered as a country that is suffering from endemic poverty regarding some major macro-economic indicators like the economic growth rate, the gross domestic product (GDP) per capita and the human development index. As a matter of fact in 2003 the break-even point of poverty was 82672 FCFA per capita per year and 46.4% of the population were living below this break-even point. Poverty is essentially a rural phenomenon with 52.3% of the rural population living below the break-even point versus 19.9% in the urban area.

The rural sector is a determinant component of the economy of Burkina Faso through its tremendous contribution to the creation of wealth and employment in the rural area, the establishment of the food and nutrition security as well as its weight in the country's export. The rural sector occupies nearly 90% of the active population, contributes nearly 40% in the GDP (agriculture 25%, livestock 12%, forestry and fishing industry 3%) and about 80% in the country's export return. The economic growth of Burkina Faso depends on the evolution of the agricultural activity which also remains very dependent on the vagaries of the agroclimatic conditions. Four (traditional grain, cotton, fruit and vegetables, oilseed plants) of the six sectors selected by the government as being priority sectors were the lever of the country's economic growth for a long time, before facing the difficulties that led to the reduction in the production and therefore the export during 1980 to 1990. A 10% contribution in the growth of the agriculture sector by 2010, and at least 3% improvement per annum in the household income came from these sectors and helped to reduce significantly the poverty in the rural area.

The grain market is characterized by unstable supply just as the production. In normal years, the marketable cowpea supply ranges between 50,000 tons and 60,000 tons. It is essentially absorbed (90%) by the national demand. Cowpea is sold in different types of markets, which are qualified on

the basis of their main function of supply markets, gathering markets, urban markets and border markets. However there is no specialized market for cowpea whose commercialization is linked to that of cereals. Utilization market is characterized by the supply and the demand of products made from cowpea or products which have cowpea as an ingredient. Commercial cowpea utilization absorbs 20,000 to 25,000 tons of cowpea yearly.

Research and development

Variety development

Cowpea research started in 1978 with financial support of CRDI in collaboration with IITA. Currently, a multidisciplinary team of breeders, pathologists, entomologists and virologists is contributing to the development of high-yielding varieties adapted to Burkina Faso. The main objectives of cowpea research are:

- Crop improvement: Develop early- to medium-maturing varieties resistant to *Striga*, aphids, thrips and *Maruca* and tolerant to drought. These varieties should also possess large grains.
- Grain storage: Disseminate the triple bag technology (PICS bags)
- Capacity building: Train certified seed producers in seed technology

Variety development is well established. A total of 21 varieties have been released during 1982 to 2011 (Table 2). Those released in recent years include IT86F-2246 (2005); Melakh and IT98K-205-8 (2006); and KVx 442-3-25 and KVx 775-33-2 (2011).

Table 2. Characteristic features of common cowpea varieties developed by the Burkina research system.

Official name of release	Year of release	Source of the materials	Genetic background (parentage, pedigree, ancestry)	Spillover national boundaries	Average yield potential (on-farm) (kg ha^{-1})	Varietal traits (selected characteristics)
IT 98K-205-8	2006	IITA	IT 98K-205-8	Yes	1200	High yield, early maturity, *Striga* resistance
Gorom local	1982	BF	Local	Yes	1500	*Striga* resistance, good taste
IT 81D-994	1986	IITA	IT 81D-994	Yes	1500	*Striga* resistance, fodder
KN 1	1982	IITA	Vita7	Yes	1500	High yield, adapted to high rainfall area
Kvx 775-33-2	2010	BF		No	1500	*Striga* resistance
Kvx 442-3-25	2010	BF		No	1700	High yield, *Striga* resistance
Kvx 61-1	1986	BF+IITA	Gorom local x TVx 3236	No	1500	Sweet, *Striga* resistance
Kvx 745-11P	2000	BF+IITA	Vita 3 x Gorom local x IAR71	No	1000	High fodder and grain yields, *Striga* resistance
Kvx 771-10	2008	BF		No	1500	*Striga* resistance, large seeds
Telma	1985	IITA	IT86F-2246	Yes	9 t (fresh pods)	Vegetable cowpea

Major constraints to cowpea production

The major constraints to cowpea production include social, biological, physical and technological environments. Accordingly the major constraints are:

1. Biotic stresses: Insect pests (aphids, thrips, pod sucking bugs, *Maruca*, bruchids), diseases (bacterial, fungal, viral) and *Striga*
2. Abiotic stresses: Drought, heat, low soil fertility
3. Poor access to input and output markets, poor agronomic practices
4. Labor constraints for weeding and harvesting

Planned Phase 2 activities and their contribution to national efforts

In TL-II Phase 2 we plan to bring about major impact through available cowpea technologies that would be implemented in most important cowpea production environments or agroecologies of Burkina Faso. At the end of the phase it is expected that cowpea productivity in intervention areas would be more than 1.2 t ha^{-1} thus increasing national productivity from 0.5 in 2012 to 0.9 t ha^{-1} by 2014.

Expected outcomes from Phase 2 cowpea improvement for production and productivity

Cowpea farmers and farm practitioners will have higher income. The national cowpea production will increase to more than 422,000 tons with productivity of 0.9 t ha^{-1}. There would be an excess production over the national demand (projected to be 31,000 tons) which should allow for export to other countries.

Agroecologies for cowpea cultivation

Three great climatic areas are characterized in Burkina Faso: (i) the Sahel area which stretches in the North of the country between the latitudes 13°5' and 15°3' North and which is characterized by low rainfall (less than 600 mm), high temperatures and a vegetation of thorny shrub; it is the livestock area par excellence; (ii) the Soudan-Sahel area which is situated in the middle between 11°3' and 13°5' North latitude, and which receives an average rainfall of 750 mm; (iii) the Soudan-Guinean area which stretches in the South between 9°3' and 11°3' North latitude and characterized by relatively abundant rainfall and average temperatures that are relatively low. At the present time there is an inclination towards aridity of the Northern part, characterized by a diminution of the crop growing period from 20 to 30 days and 100 mm displacement of the isohyets Southward compared with the 1960s. The rainfall is featured by important spatial-temporal irregularities between years with a declining trend. Cowpea is grown in the three agroecologies. The main zone of cowpea production is the Soudan-Sahel zone where more than 70% of national production is obtained. Since cotton is mostly produced in the Soudan-Guinean zone, the government's policy is to boost cowpea production in the Soudan-Sahel and Sahel zones. It is in these two agroecologies that improved cowpea technologies are being disseminated. Figures 2 and 3 show cowpea area and productivity in the different agroecologies based on 2006–08 data. There are several regions that have more than 12,000 ha and regions with more than 0.75 t ha^{-1}, which is more than 50% above the average yield in Africa.

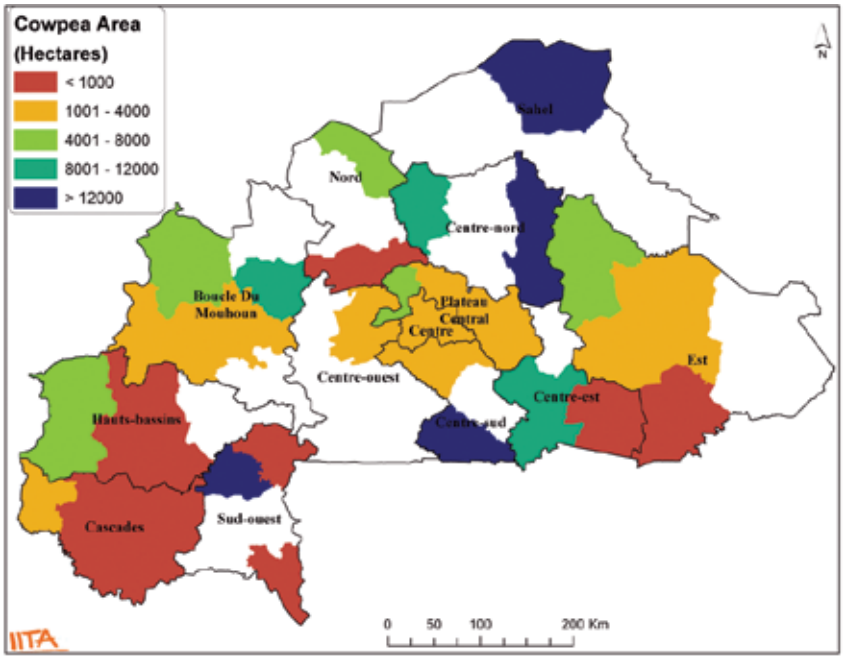

Figure 2. Cowpea area in different agroecological zones of Burkina Faso.

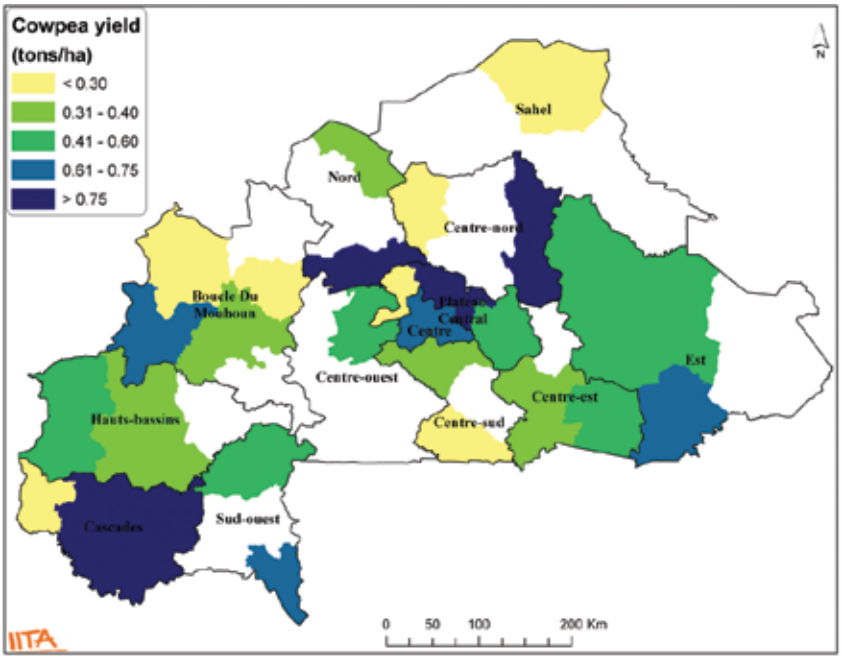

Figure 3. Cowpea yield distribution in different agroecological zones in Burkina Faso.

Seed systems for a legume green revolution in Burkina Faso

As in almost all the African countries, the seed system in Burkina Faso is dominated by the informal system. Almost all the available seeds (95%) come from the informal system. In the perspective of agricultural modernization and intensification, promotion of the production and the use of quality seeds of improved varieties occupy an important place in agricultural policies, strategies and programs in Burkina Faso. The government is conscious that the use of these seeds constitutes the first production factor; it is one of the optimum conditions contributing up to 40% of the productivity increase.

In the informal sector, which is unfortunately more widespread, the main constraints and difficulties are:

- Poor basic knowledge and capacities of conservation and storage
- Mixture of seeds from different varieties
- Lack of awareness about the importance of seed quality

In the absence of appropriate measures such as those mentioned above for the removal of the barriers that induce a very low level of use of improved varieties, the outputs will remain low; the agriculture products' sensibility to climatic variations will accentuate with reduction of the range of varieties that are being used. For improvement of the quality seed production at the local level, the following arrangements should be considered:

- Reinforcement of INERA's capacities for the creation of varieties that are well-adapted to the agroecological conditions of the country and with organoleptic characteristics preferred by the consumers' requirements.
- Rationalize the requirement of foundation seed through the development of functional links (contractual) between INERA and foundation seed users.
- Reorganization and re-establishment of the seed sector through the National Seed Service reinforcement (human and material resources).
- Adoption of measures allowing the law n°010-2006/AN referring to the plants seeds regulation in Burkina Faso to be functional through the enforcement of the relevant laws and the finalization of the different orders (signature and implementation).
- About 90% of farmers continue to use the seeds from their own selection/production which are non-performing cultivars and varieties. Sensitization of the farmers permit the poor income farmers to have access to certified seed (subsidies of the certified seed or spreading of the production techniques of the available seeds).

Potential opportunities for improving seed health, local seed production and supply for resource-poor farmers:

- Seed health issues in the seed certification scheme by the National Seed Service
- Training the staff involved in seed certification on seed health issues:
  - Detection of seed-borne pathogens in laboratory
  - Use of appropriate conditions and methods in seed health testing
  - Enhancement of the capacity of National Seed Service in seed testing facilities and equipment

Seed system strategy (2012–14)

With all functional key stakeholders in place, the cowpea seed production (informal seed system dominated) strategy of Burkina Faso is devised below:

Area: 714,156 ha

Seed rate (mean): 20 kg ha^{-1}

National demand: 14,283 tons (2012–14)

Capacity to deliver 20% area: 142,831 ha $\simeq$ 2,850 tons

Target of productivity: 1.2 t ha^{-1} at intervention sites and 0.9 t ha^{-1} at national level

Total production target: >799,850 tons

Opportunities, constraints, partnership and seed production plan

The target is to cover 20% of each important cowpea agroecology in Burkina Faso with improved seed.

Opportunities

- Good market setup for cowpea in general and cowpea seed in particular
- Policy environment that enhances innovative seed system
- Availability of suitable varieties at national and regional levels
- Sufficient land mass suitable for cowpea (millions of ha)
- High consumption level/culture in the country

Constraints

- Low quantity of breeder and foundation seeds produced by INERA due to the absence of a functional link between research and the farmer seed producers [absence of a firm contract between the institution and the users (UNPS-BF)] and insufficient funds available for research.
- Insufficiency of human resources (in quality and quantity) and the material means at the level of National Seed Service in order to ensure adequately all the activities that would allow an appropriate seed certification.
- Low enforcement of the law n°010-2006/AN concerning plants seeds regulation in Burkina Faso. As a matter of fact all the implementation decisions are still in the form of projects. The consequences are among other things the absence of an official species and variety catalog where the plant description should be registered; it is the keystone of all the seed legislation.
- Lack of credit facility.
- Absence of steady markets for agricultural products leading to the absence of motivation for the investment in quality inputs that will permit increased seed production and enhance its quality.
- Low use of infrastructure and appropriate storage means.
- High cost of transactions for seed production, distribution and trading.
- Lack of knowledge about seed-borne diseases by farmers.

Partners and their role

- Ministry of Agriculture: Policy formulation
- National Seed Services: Seed policy
- University of Ouagadougou: Research collaboration, degree training for human capacity
- INERA: Research, variety development
- Farmers' associations: Seed production
- NGOs: Seed production and technology transfer
- International research institutes (eg, IITA): Technology development, backstopping in training, technical skills in priority areas, research collaboration

Seed production plan

Cowpea seed production plan is presented in Tables 3 and 4. The seed delivery will be handled mainly in a seed revolving or seed loan approach until the bigger impact and demand are established. The higher demand will then be satisfied by seed growers that eventually grow along with technology promotion. By 2014 at least 50% of cowpea farmers at national level will have access to seed through the informal seed system organized in a decentralized way. Effective monitoring and support to validate seed quality in a decentralized manner will be carried out by the Bureau of Agriculture Seed Department, the mandate research centers and the seed enterprises affiliated to the seed scheme in a contractual agreement.

Table 3. Cowpea seed production in different agroecological regions in Burkina Faso.

Agroecology (Demand) (ha)	Variety demand	Net yield (kg ha^{-1})	Breeder seed in 2012		Foundation seed in 2013		Certified seed for use in 2014	
			Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
Sudan savanna (300,667)	IT 98K-205-8	1000	0.037	0.037	1.864	1.864	93.212	93.212
	Kvx 442-3-25	1000	0.060	0.060	3.007	3.007	150.328	150.328
	Kvx 61-1	1000	0.182	0.182	9.114	9.114	455.708	455.708
	Kvx 745-11P	1000	0.032	0.032	1.620	1.620	81.016	81.016
	Kvx 771-10	1000	0.051	0.051	2.567	2.567	128.336	128.336
	Kvx 421-2J	1000	0.025	0.025	1.252	1.252	62.596	62.596
	Telma	1000	0.093	0.093	4.629	4.629	231.472	231.472
North Guinea savanna (244,606)	Kvx 61-1	1000	0.040	0.040	2.017	2.017	100.86	100.86
	Kvx 745-11P	1000	0.187	0.187	9.338	9.338	466.904	466.904
	KN 1	1000	0.035	0.035	1.770	1.770	88.476	88.476
	Kvx 771-10	1000	0.055	0.055	2.757	2.757	137.86	137.86
	IT 81D-994	1000	0.074	0.074	3.686	3.686	184.324	184.324
Sahel savanna (6,848)	IT 98K-205-8	1000	0.011	0.011	0.548	0.548	27.392	27.392
Total			0.883	0.883	44.170	44.170	2208.484	2208.484

Table 4. Certified seed production (t) plan over three years.

Variety	2012	2013	2014
IT 98K-205-8	105	110	120.604
IT 81D-994	3	55	184.324
KN 1	4	49	88.476
Kvx 421-2J	25	50	62.596
Kvx 442-3-25	70	125	150.328
Kvx 61-1	400	500	556.568
Kvx 745-11P	375	520	547.92
Kvx 771-10	10	198	266.196
Telma	5	150	231.472
Total	997	1757	2208.484

Vision of success for cowpea in Burkina Faso

Higher productivity level (>1.2 t ha^{-1}) will be attained at national level that contributes to the wealth of producer farmers and ensures better food and nutrition at the home level. The overall production will satisfy the national demand, allow for some quantity for export and/or agro-processing thus contributing significantly to the GDP.

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Ghana

Groundnut

Richard Oteng-Frimpong, Bonny Ntare and Jupiter Ndjeunga

Introduction

Groundnut occupies the largest cultivated land covered by legumes in Ghana on an area of 353,376 ha (Source: SRID-MoFA 2011). Legumes occupy 15% of the total land area under cultivation in Ghana. Of this groundnut covers 60% of the total area. Over the years (1985–2007) the growth rate of groundnut declined in yield (−0.7%) while production increased (6.1%). Ghana exported 3701 tons of groundnut valued at US$ 2 million (Source: FAOSTAT 2010).

Generally groundnut is intercropped with sorghum, pearl millet, maize and cassava. In few areas it is grown in pure stand or on ridges. Besides generating income for farmers, groundnut provides an inexpensive source of high quality dietary protein and edible oil which has helped in reducing malnutrition in the country. Groundnut protein is fast becoming important as food and feed sources in Ghana, where protein from animal sources are not within the means of the majority of the populace. It is an important source of biologically fixed nitrogen and provides fodder to farm animals in drier savanna areas.

The major biotic and abiotic constraints are foliar diseases (early and late leaf spots), rust, rosette, low soil fertility and erratic rainfall. In the northern part of Ghana where majority of the crop is produced, cultivation is done by mainly women in smallholder farms under rainfed conditions. The area and production statistics are presented in Table 1 and Figure 1.

Table 1. Groundnut production in Ghana.

Parameter	Value
Average area (ha)	347,791
Average production (t)	450,592
Average yield (current) (kg ha^{-1})	1,294
Average yield (2015) (kg ha^{-1})	1500
National demand (t)	293
Expected growth in production (%)	3
Proportion of production sold (%)	60

Research and development

Research on groundnut in Ghana is conducted by CSIR institutes specifically Savannah Agriculture Research Institute (SARI) and Crops Research Institute (CRI). This research is done in collaboration with the universities. In previous years SARI has collaborated with ICRISAT and this has resulted in the release of many good varieties including four new varieties in 2005 alone. These varieties are Kpanieli, Nkatiesari, Gusie Balin and Edorkpo-Munikpa. Other varieties such as Manipintar, Chinese, Sinkarzei, F-Mix, etc were all released before 1990.

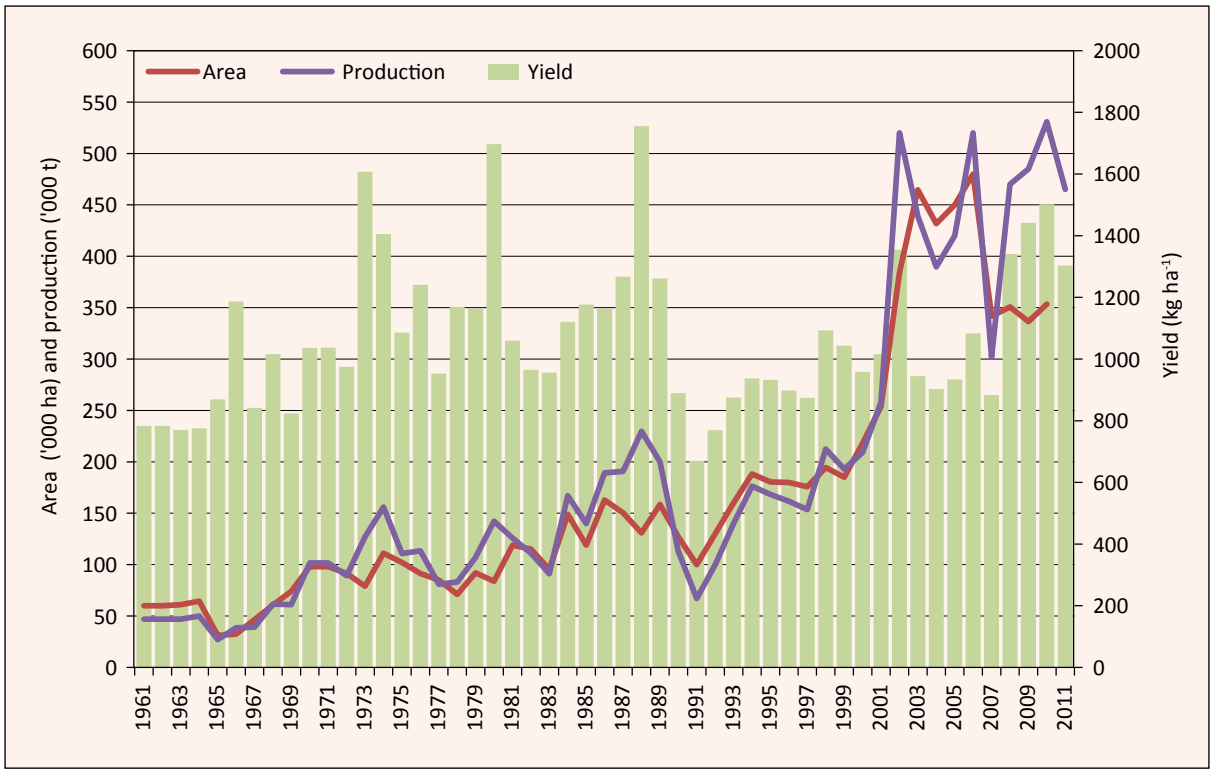

Figure 1. Trends in area, production and yield of groundnut in Ghana (1961–2011).

Constraints to groundnut production

The major constraint to the adoption of these varieties has been the availability of improved seed and accessibility to the resource-poor farmer due to the poorly developed seed systems. The most common and widely adopted variety is Chinese. The high adoption is mainly due to its ability to produce more pods in a relatively short time (90 days) compared to other varieties. However, it is highly susceptible to early leaf spot and late leaf spot.

Socioeconomic constraints

- Lack of improved varieties
- Lack of inputs such as fertilizers and improved seeds
- Land tenure system not favorable to women
- Lack of appropriate machinery for expanded planted area
- Poor market access and credit facilities

Organizational constraints

Improving the adoption of superior varieties by farmers require a rapid dissemination of improved varieties and agronomic practices. Usually this is through farmer field schools and demonstrations. It is also essential to link farmers to markets and credit institutions to acquire farm equipment and inputs (seed, fertilizer and pesticides). An efficient and sustainable crop improvement program especially in molecular breeding is also required to ensure that the time required for variety development is reduced. In most cases these activities cannot be done due to administrative issues with funds and in some cases personnel for the various activities.

Perspectives for TL-II Phase 2

Baseline surveys will be conducted in the major groundnut producing agroecologies to provide first-hand information on the situation of groundnut production and limitations in the current system. This information will be handy in the future when instituting measures to overcome the problems and improve the livelihoods of resource-poor farmers.

It is expected that the national program will be enriched with new diverse materials from ICRISAT for local selection and adaptation in different agroecologies. New superior varieties will be identified through this collaboration together with farmers through participatory variety selection (PVS). Such varieties will satisfy important production requirements such as tolerance to foliar diseases, early maturity, dual-purpose (grain and fodder), etc.

The national program has developed and released a range of varieties with various attributes. These are still on the shelf and need to be known by the farmers. Resources from this phase will be used to establish farmer participatory varieties (FPVs) trials at key sites to identify farmer preferred traits and varieties. Field demonstrations and open days will be adopted in the FPVs trials and this will ensure that more farmers are introduced to improved varieties in the target agroecologies. A range of seed multiplication and delivery schemes will be tested and it is believed that a well-built informal seed system will be established in farming communities to supply seeds to farmers. Efforts will be made to produce breeder seed of selected varieties to produce foundation seed that will ensure availability of other classes of seed. Capacity building (human and infrastructure enhancement) is crucial for an efficient breeding program. Capacity building needs will be assessed and improvements made where most needed.

Groundnut agroecologies in Ghana

Groundnut is an important oilseed crop and is grown in all the agroecologies, from the dry savannah regions to the moist forest areas and the coastal savannah zone along the coast. Almost 85% of the area under groundnut cultivation and the bulk of the production is from the Guinea Savanna and Sudan Savanna zones in the northern region. These zones represent 30% of the total land area of Ghana and harbor 17% of the population of about 24 million (according to the 2010 census provisional figures).

Groundnut occupies a total of 148,000 ha in the Sudan Savanna agroecology (annual rainfall <1000 mm) (Fig. 2). In the Guinea Savanna agroecology (annual rainfall 900 to 1100 mm) the crop occupies a land area of 126,481 ha. A total of 43,356 ha in the transitional agroecology (annual rainfall up to 1300 mm) of Ghana is cultivated with groundnut. Though the crop is grown in other ecologies, the area occupied is not significantly large enough to be considered as a major growing area.

Seed system

Current situation

Though variety development requires a lot of investments, adoption rate by farmers are low especially in Sub-Saharan Africa. This is largely due to poor and inefficient local seed systems. Groundnut in Ghana like other legume crops suffers from a poorly developed seed system and a general lack of interest by the private sector to engage in commercial production. As a result of the inbred nature of the crop, farmers are able to recycle their seeds with little or no segregation in the offspring. This does not encourage them to return to seed producers to acquire new seed which is usually at a cost. This accounts for the general lack of interest by the private sector to engage in legume seed production as profit is generally low.

Sudan Savanna zone (148000 ha under groundnut cultivation)
Guinea Savanna zone (126481 ha under groundnut cultivation)
Transitional zone (43356 ha under groundnut cultivation)

Figure 2. Groundnut cultivation zones in Ghana.

Alternative to the current "seed system"

- Interested farmers in the various farming communities will be identified and partnered to produce seeds. The partnership will involve the supply of improved seeds either as foundation or breeder seed. Training will also be organized for such selected farmers on how to produce seeds to meet the required standards for certified seed. Such farmers will be encouraged to use appropriate packaging that preserves seed quality. The packages will also be of small and portable sizes so that the farmers can buy some for their plots.
- The seed farmers (producers) will be allowed to recycle the seeds for three years after which they will have to return to the institute to get new stock. A monitoring system will be put in place to

ensure that seed fields are inspected at various stages to obtain the necessary purity for certified seed. This strategy will ensure that seeds are available and accessible to the resource-poor farmers. Cost of transporting seeds to farmers will be reduced and seeds will be cheap and affordable to the majority of farmers in the community.

This strategy is expected to cover over 20% of the total land area grown to groundnut in each agroecology in Ghana. To achieve this, a total of 2023 tons of seed will be required for the Guinea Savanna agroecology. The Sudan Savanna and the Transitional agroecology will require 2368 tons and 693 tons of improved seed respectively to cover 20% of the total land area cultivated with groundnut. Achieving this will not be an easy task and requires a lot of partnership and work. The following partners have been identified and it is believed that the activities of these partners will ensure that this target is achieved.

Strategic partners and their roles

CSIR-SARI is instituting measures that will ensure that a lot more farmers are exposed to improved varieties. In collaboration with the partners given in Table 2, CSIR-SARI aims to cover 20% of the total area occupied by groundnut in the various agroecologies with improved varieties.

Table 2. Strategic partners and their role in the seed system.

Strategic partner	Role
CSIR (Savanna Agricultural Research Institute)	Conduct research to test and adapt new varieties in the Guinea and Sudan Savanna agroecologies; organize PVS and demonstrations to select new varieties for the various agroecologies and introduce improved varieties to a lot more farmers
CSIR (Crops Research Institute)	Conduct research to test and adapt new varieties in the Forest and Transitional agroecologies; organize PVS and demonstrations to select new varieties for the various agroecologies and introduce improved varieties to a lot more farmers
ICRISAT	Provide enhanced groundnut germplasm on request and technical backstopping in human resources development, knowledge sharing and communication
Ministry of Food and Agriculture (MoFA)	Formulation of agricultural policies, provision of extension services and technology transfer; also undertakes inspection of seed fields for certification through its Seed Inspection Unit
National Varietal Release Committee	National body mandated to assess a variety before it is released
Grains and Legumes Development Board	Mandated to produce and distribute quality foundation seed to registered seed growers for the production of certified seed to farmers
Seed Producers Association of Ghana (SEEDPAG)	An association of seed growers that receives foundation seed from the Grains and Legumes Development Board to produce certified seed for farmers
Farmer-based organizations (FBOs)	Test and adopt improved varieties and management techniques in partnership with research and MoFA.
NGOs	Strengthening farmers' associations
Private sector (market intermediaries and emerging small-scale seed enterprises and processors)	Processing and commercialization of seed and products

Opportunities available for the new system to be effective

Groundnut is a very important crop in Ghana being cultivated in most agroecologies in the country. The seed system approach will use farmers identified in the various communities to produce and market improved seeds.

- The importance here is that the seed will be produced very close to the target farmers and will not require bulk transport. This will make the seed cheaper, available and accessible to the majority of farmers. This method is also expected to improve adoption among farmers as it will appear that the technology they are adopting is coming from one of their own.
- The seed policy in Ghana requires that certified seeds are sold at a higher price compared to grain. This will be enough motivation to get people to be involved in the production of seed as they can earn twice the money than that obtained from a field grown for grain with the same level of inputs.
- Groundnuts and processed products are on high demand. For example, Ghana Nuts is a nut and seed factory specializing in value addition for both local and export markets. There is also high demand for livestock feed which is made from the residue of the processed nuts.
- Varieties specially adapted to each agroecology will be identified and recommended for adoption. Partners including MoFA and research institutes (SARI, CRI) have qualified personnel with the requisite skill to ensure that varieties that are released are available and accessible and conform to the required purity standard at all times. Other partners like the Variety Release Committee will recommend the final release of each superior genotype as a new variety.
- The Grains and Legumes Development Board is a creation of the government under MoFA. The board receives breeder seed from researchers and multiplies them. It then supplies foundation seed to private seed growers to produce certified seed.

Significance of the planned activities in the strategy

The seed production plan is presented in Tables 3, 4 and 5.

The use of improved seeds will ensure that yield per unit area is increased using the same set of inputs. It will ensure food security and increased income. Increased income from the sale of groundnut would reduce environmental degradation as wood cutting and charcoal burning activities for income generation will get reduced. The haulms are good fodder for livestock, which in turn will produce manure to enhance soil fertility and animal productivity.

Resistant varieties to biotic and abiotic stresses will enhance optimal use of natural resources and avoid indiscriminate use of pesticides. The promotion of a wide range of varieties will enhance genetic diversity of the crop thus promoting biodiversity. The use of improved varieties coupled with measures to minimize aflatoxin contamination will lead to better quality products (contamination free) and thus safeguard consumers' food-safety. Early-maturing (less prone to end-of-season water shortages) and drought tolerant varieties will help farmers to cope better with climate change.

With the projected rate of growth (ROG) of 3% in production and an increase in national demand by 1.9%, Ghana is expected to export about 48,000 tons of groundnut by 2015 (Source: Abate et al. 2012). This will contribute a substantial sum of money to the economy. Achieving this will require the use of improved seeds and therefore the need for this strategy to be implemented cannot be underestimated.

Table 3. Groundnut seed production plan for Ghana.

Ecology	Demand (ha)	Varieties available	Seed available (t)	Breeder seed (t)	Foundation seed (t)	Seed for 20% adoption (t)
Southern Guinea Savanna	223080	Nkatiesari Kpanieli Edorkpo-Munikpa Gusie-Balin	0.1 0.019	55.7	446.16	3569
Northern Guinea Savanna	104470	Nkatiesari Edorkpo-Munikpa Gusie-Balin		26.12	208.94	1671.52
Derived savanna	17610	Chinese		4.4	35.22	281.76
Forest zone	8216	Adepa		2.1	16.4	131.5

Table 4. Groundnut seed production (t) goal.

Seed class	2012	2013	2014
Breeder seed	0.87	6.96	55.7
Foundation seed needs	6.97	55.77	446.16
Certified seed needs	55.77	446.16	3569.00

Table 5. Potential quantities (t) of groundnut seed (of different classes) produced by stakeholders.

Stakeholder	Breeder seed	Foundation seed	Certified seed
SEEDPAG			3000
CSIR-SARI	40		
Grain and Legumes Development Board		446.16	
FBOs			600
PCRSP	15.77		

Cowpea

Haruna Mohammed, Christian Fatokun, Ousmane Coulibaly and Ousmane Boukar

Introduction

Importance of the crop in Ghana

Cowpea (*Vigna unguiculata*) is the second most important legume crop in northern Ghana after groundnut. An average of 143,000 tons is produced annually on about 156,000 ha. Ghana is the fifth highest producer of cowpea in Africa. Ghana ranks fourth highest in the world, after Peru, Cameroon and Uganda for cowpea yields (Fig. 1). It also has the fastest growing production of the crop in Africa. Annual rates of growth for cowpea area, yield and production for the period from 1985–87 to 2005–07 were −0.1%, 39.6% and 39.8%, respectively. It has been projected that the rate of growth of cowpea production during 2010 to 2020 would be 11.1%.

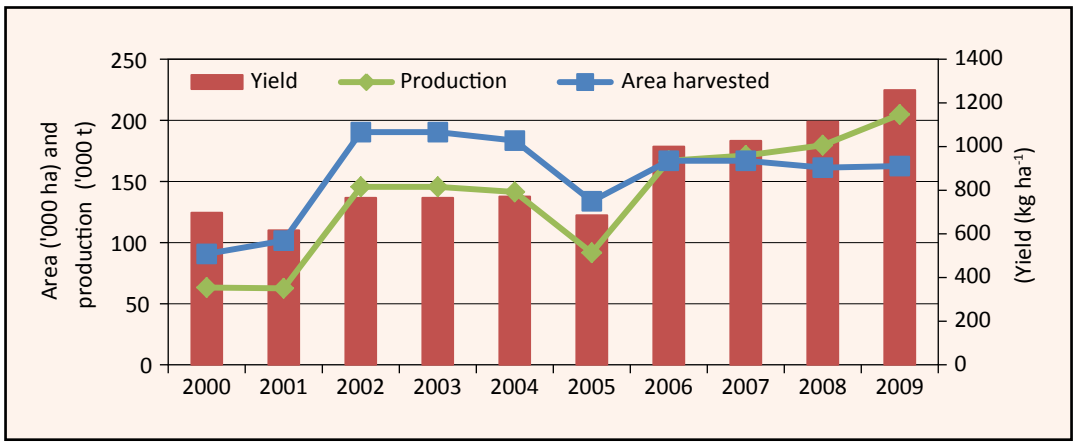

Figure 1. Cowpea area, production and yield in Ghana during 2000 to 2009 (Source: MoFA 2010).

The dry grain with about 23–25% protein serves as a cheap source of protein for both rural and urban consumers whereas livestock benefit from the residue left over after the grain is harvested. Rural families that make up the larger part of the population of northern Ghana derive food, animal feed and cash income from cowpea production. The major biotic constraints are insect pests and diseases, nematodes and parasitic weeds particularly *Striga* (*S. gesnerioides*), which can cause yield losses ranging from 15% to 100% depending on the level and severity of infestation and susceptibility/resistance of the variety. The abiotic constraints are drought and low soil fertility.

Cowpea contribution to national GDP, farmer income, food and nutrition security

Cowpea is an important crop in Ghana. Cowpea demand is increasing because of high population growth mainly in the urban areas. Farmers store and sell more than 60% of the produced cowpea when prices go up during the off-season (Source: CORAF/WECARD Cowpea Report, 2011).

The gross domestic product (GDP) of the country is US$ 409 per capita per year (Source: Mishili et al. 2007). Farmers receive total net income of GH¢ 673.462 or US$ 481 per ha of cultivated cowpea (Source: PRONAF 2010). The per capita consumption of cowpea in the country is about 9 kg per year (Source: Coulibaly et al. 2010).

Cowpea is an important source of food for the population. Processed products (cowpea flour, cowpea cake, cowpea fritters, different dishes with cowpea, cowpea chips, etc) are sold in village markets and well appreciated by consumers.

Households generate annual income of about GH¢ 760–800 through increased production due to two or three production cycles per year of improved cowpea varieties. For the whole of northern Ghana an additional income of GH¢ 15 million to GH¢ 16 million is generated yearly, of which at least 40% goes to women farmers. The fertility of the soils in Ghana is expected to increase as a result of increased production of cowpea varieties with high biological nitrogen fixing ability and resistance to *Striga gesnerioides.* This will reduce the amount of money spent on inputs such as chemical fertilizers resulting in increased income of smallholder farmers and increased productivity of both legume and cereal crops bringing about reduction of hunger and food insecurity in the country. Malnutrition and infant mortality are expected to drop significantly through increased consumption of cowpea from the current level of 9 kg per capita to 15 kg per capita by more households. The expected increased production and per capita consumption should lead to improved nutrition and livelihood.

Research and development

Variety development

Conventional breeding of cowpea has been in place since the 1970s. But full-fledged research started at CSIR-SARI in 1981, using local diversity and elite lines obtained from IITA. Characterization and evaluation of the assembled materials were carried out. The germplasm pool in the early breeding program had emphasis on higher yields and earliness. Hence varieties that were introduced or developed were early maturing with improved yields compared to the local types, until recently when these varieties were overridden by other important traits such as, seed coat color, cooking ability, intercropping, drought tolerance and *Striga* tolerance (Table 1). Variety development is a well established scheme in research, where on average each variety has taken 6 to 8 years in its development.

Major constraints to cowpea production in Ghana

The major constraints to cowpea production include social, biological, physical and technological environments. These are:

- Biotic stresses: Insect pests (aphids, flower thrips, *Maruca*, pod sucking bugs, bruchids), diseases (bacterial, fungal and viral), *Striga* and *Alectra*.
- Abiotic stresses: Drought, heat, low soil fertility
- Lack of inputs such as fertilizers, appropriate insecticides and improved seed, poor agronomic practices
- Lack of appropriate machinery for expanding planted area

Planned Phase 2 activities and their contribution to national efforts

In TL-II Phase 2, we plan to bring about major impact through improved cowpea technologies that would be implemented especially in the important cowpea production environments or agroecologies. At the end of this project it is expected that productivity of cowpea should reach at least >1.5 t ha^{-1} and the national productivity should increase from 0.6 in 2011/12 to 0.9 t ha^{-1} by 2014/15.

Table 1. Characteristic features of common cowpea varieties developed by the Ghanaian research system.

Official name of release	Year of release	Source of the material	Genetic background (parentage, pedigree, ancestry)	Area of potential coverage (ha)	Area of actual adoption estimate (ha)	Spillover national boundaries	Average yield potential on-farm (kg ha^{-1})	Varietal traits (selected characteristics)
Marfo-tuya	2002	SARI cross	Sumbrisogla/ 518-2	3,176	1,500	Yes	600	High fodder/grain yield
Padi-tuya	2008	SARI cross	SARC 3-122-2	5,335	2,600	Yes	400	High grain yield, erect, vines good for fodder
Songotra	2008	IITA	IT97K-499-35	12,706	6,500	Yes	600	High grain yield, *Striga* resistant, high fodder yield
Zaayura	2008	SARI cross	SARC 4-75	1,588	800	Yes	600	Resistant to aphids, high fodder and grain yields
Baawutawuta	2008	IITA	IT95K-193-2	1,588	800	Yes	400	High grain yield, *Striga* resistant
Apagbaala	2002	SARI cross	Prima/TVU 4552// CBE	5,335	2,600	Yes	600	High fodder/grain yield, susceptible to *Striga* and aphids
IT94K-440-3	NR[1]	IITA	IT94K-440-3	-	-	-	400	Resistant to aphids and thrips
IT97K-499-38	NR	IITA	IT97K-499-38	-	-	-	350	Good grain yield, early maturing, combined resistance to *Striga* and *Alectra*
IT97K-499-39	NR	IITA	IT97K-499-39	-	-	-	350	Good grain yield, early maturing, combined resistance to *Striga* and *Alectra*
Bengpla	1992	IITA	IT83S-818	1,018	500	Yes	400	High grain yield, early maturing (55–60 days)
Vallenga	1985	IITA	IT82E-16	1,018	500	Yes	350	High grain and fodder yields, vines, good for fodder

1. NR = Not officially released.

Expected outcomes from Phase 2 cowpea improvement for production and productivity

Cowpea farmers and farm practitioners will have higher income. The national cowpea production will increase to more than 265,000 tons with productivity of 0.9 t ha^{-1}. There would be an excess production over the national demand which should allow for export to other countries.

Agroecologies for cowpea cultivation in Ghana

Cowpea is mainly grown in the Savanna zone (Derived savanna, Southern Guinea savanna and Northern Guinea savanna) of northern Ghana, which constitutes about 41% of Ghana's landmass. Figure 2 depicts cowpea production area and yield in Ghana.

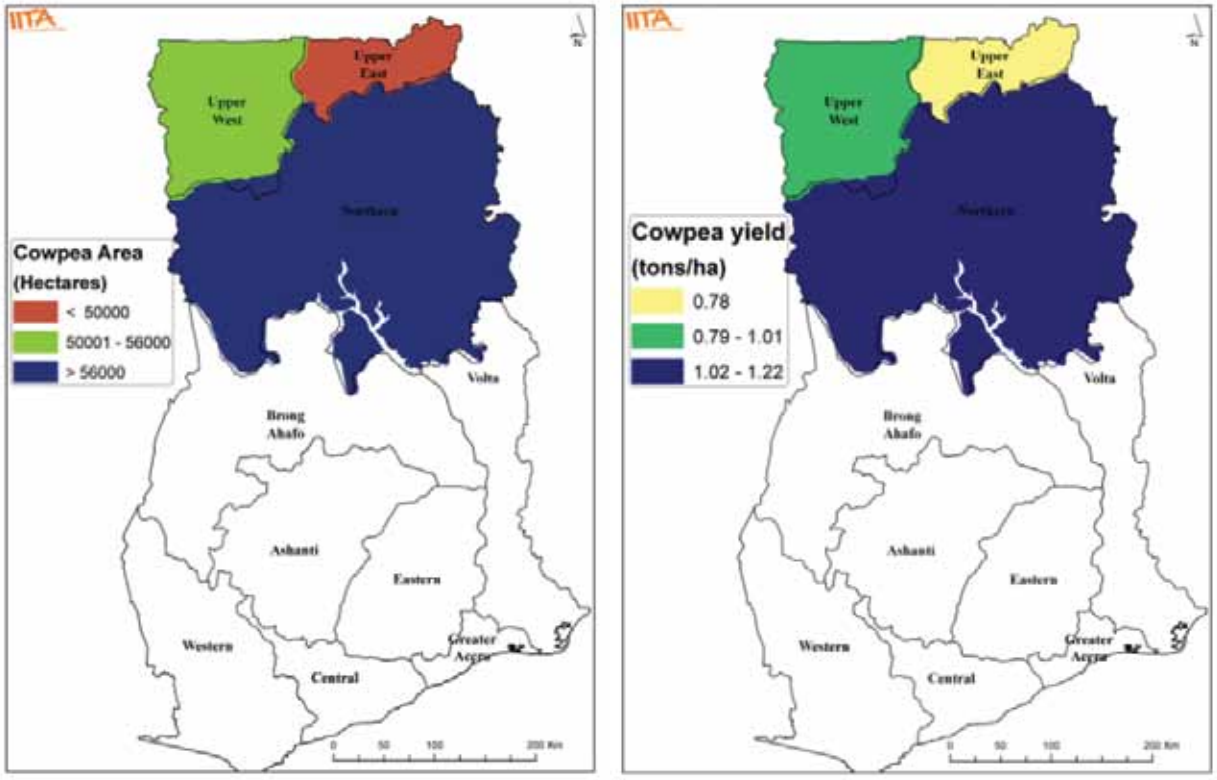

Figure 2. Cowpea production areas and productivity in Ghana.

Seed system for cowpea

The Seed Producers Association of Ghana (SEEDPAG) is coordinating and managing the production, distribution and marketing of seeds of various crops. A new seed law was enacted in 2011 that paved the way for establishment of more private seed companies which will make the seed industry more competitive and efficient. Cowpea breeder seed will be produced mostly by CSIR-SARI and CSIR-CRI while foundation and certified seeds will mostly be handled by Grains and Legumes Development Board, SEEDPAG and farmer-based organizations. However, as business entities, these enterprises work in more than 85% of the cases with the staple crops, which are mostly cereals (maize, sorghum, millets and rice). Therefore, legumes in general and cowpea in particular have about 25% seed demand shortfall that needs to be met.

The private sector as is common with self-pollinated crops is poorly involved in cowpea seed production. Hence the alternative cowpea seed system pathway appears to be the informal seed system.

Ghanaian seed system strategy (2012–14)

With all functional key stakeholders in place, the seed production (informal seed system dominated) strategy of Ghanaian cowpea is projected.

Area: 158,337 ha

Seed rate (mean): 20 kg ha^{-1}

National demand: 3,167 t (2012–14)

Capacity to deliver 20% area: 31,667 ha ≃ 630 tons

Target of productivity: 1.5 t ha^{-1} at intervention sites and 0.9 t ha^{-1} at national level

Total production target: >161,500 tons

Opportunities, constraints, partnership and seed production plan

The target is to cover 20% of each important cowpea agroecology in Ghana with improved seed.

Opportunities

- Well developed informal seed system experience and existence of certified associations
- New law that enhances innovative seed system
- Availability of suitable varieties at major production areas (>9)
- Sufficient land mass suitable for cowpea (millions of ha)
- Increasing consumption level/culture in the country

Constraints

- Dominated by informal system that has technical and infrastructural gaps
- Certification process is not clear for informal seed system
- Complete absence of mechanization at all steps
- Unpredictability of market price
- Lack of quality seed at all times in an adequate quantity by variety of demand

Partners and their role

- Ministry of Food and Agriculture (MoFA): Formulation of agricultural policies, provision of extension services and technology transfer
- Women In Agricultural Development (WIAD): Conduct training of trainers (TOT) on various recipes of cowpea
- IITA: Provide improved cowpea germplasm on request and technical backstopping in human capacity development, knowledge sharing and communication
- Universities: Conduct training of project staff at masters and PhD levels and assist in the development of improved varieties
- Farmers' organizations: Test and adopt improved varieties and management techniques and production of grains for the processing industry
- NGOs in agriculture: Strengthen farmers' associations and promote the utilization of cowpea
- Seed Producers Association of Ghana (SEEDPAG): Production, distribution and marketing of seed

- Ghana Agro-dealers Association: Facilitates the acquisition of agro-chemicals for crop production
- Private sector (market intermediaries and emerging small-scale seed enterprises and processors): Processing and commercialization of seed and products.

Seed production plan

Cowpea seed production plan for Ghana is presented in Tables 2 and 3.

Table 2. Seed production in different agroecologies in Ghana.

			Breeder seed in 2012		Foundation seed in 2013		Certified seed 2014	
Ecology (Demand ha)	Variety demand	Yield (kg ha^{-1})	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
Southern Guinea Savanna (105264)	Marfo-tuya	1000	0.033	0.033	1.315	1.315	52.6	52.6
	Padi-tuya	1000	0.066	0.066	2.632	2.632	105.2	105.2
	Songotra	1000	0.115	0.115	4.605	4.605	184.1	184.1
	Zaayura	1000	0.033	0.033	1.316	1.316	52.6	52.6
	Baawutawuta	1000	0.033	0.033	1.316	1.316	52.6	52.6
	Apagbaala	1000	0.049	0.049	1.974	1.974	78.9	78.9
Derived Savanna (41876.949)	Bengpla	1000	0.033	0.033	1.304	1.304	52.25	52.25
	Apagbaala	1000	0.079	0.079	3.14	3.14	125.4	125.4
	Vallenga	1000	0.019	0.019	0.79	0.79	31.35	31.35
Northern Guinea Savanna (11678.404)	Padi-tuya	1000	0.007	0.007	0.292	0.292	11.678	11.678
	Songotra	1000	0.013	0.013	0.511	0.511	20.437	20.437
	Zaayura	1000	0.005	0.005	0.219	0.219	8.759	8.759
	Baawutawuta	1000	0.005	0.005	0.219	0.219	8.759	8.759
	Apagbaala	1000	0.005	0.005	0.219	0.219	8.759	8.759
Total			0.496	0.496	19.853	19.853	793.392	793.392

Table 3. Certified seed production (t) plan over three years.

Variety	2012	2013	2014
Apagbaala	168.764	189.623	213.059
Baawutawuta	48.603	54.610	61.359
Bengpla	41.388	46.503	52.25
Marfo-tuya	41.664	46.814	52.6
Padi-tuya	92.579	104.021	116.878
Songotra	162.014	182.038	204.537
Vallenga	24.833	27.902	31.35
Zaayura	48.603	54.610	61.359
Total	628.448	706.121	793.392

The seed delivery will be handled mainly in a seed revolving or seed loan approach until the bigger impact and demand are established. The higher demand will then be satisfied by seed growers that eventually grow along with the technology promotion. And by 2014 at least 50% of cowpea farmers at national level will get seed access through the informal seed system arranged at accessible points in a decentralized way. Effective monitoring and support to validate seed quality in a decentralized manner will be served by the Seed Inspection Unit (SIU) of MoFA, mandate research centers and SEEDPAG, and enterprises affiliated to the seed scheme in a contractual agreement.

Vision of success for cowpea in Ghana

Highest productivity of cowpea of 2 t ha^{-1} will be obtained at national and global levels that attributes to the wealth of producer farmers with significant contribution to the home food consumption. The overall production aims at satisfying the national demand to significantly contribute to the GDP with significant amount of exports and/or agro-processing.

Mali

Groundnut

Ondie Kodio, Bonny Ntare and Jupiter Ndjeunga

Introduction

Mali is a major groundnut producer in West Africa with production estimated at 332,000 tons in 2004–10. Growth in production is estimated to be about 4.41% per annum mainly due to area growth of 4.44% per annum (Source: Ndjeunga et al. 2010). Groundnut area and production in Mali are presented in Table 1 and Figure 1.

Table 1. Groundnut production in Mali[1].

Parameter	Value
Average area (ha)	347,791
Average production (t)	328,730
Average yield (current) (kg ha^{-1})	944
Average yield (2015) (kg ha^{-1})	1200–1500
Expected growth of production (%)	5.1
Proportion of production sold (%)	68

1. Source: FAOSTAT (2007–11).

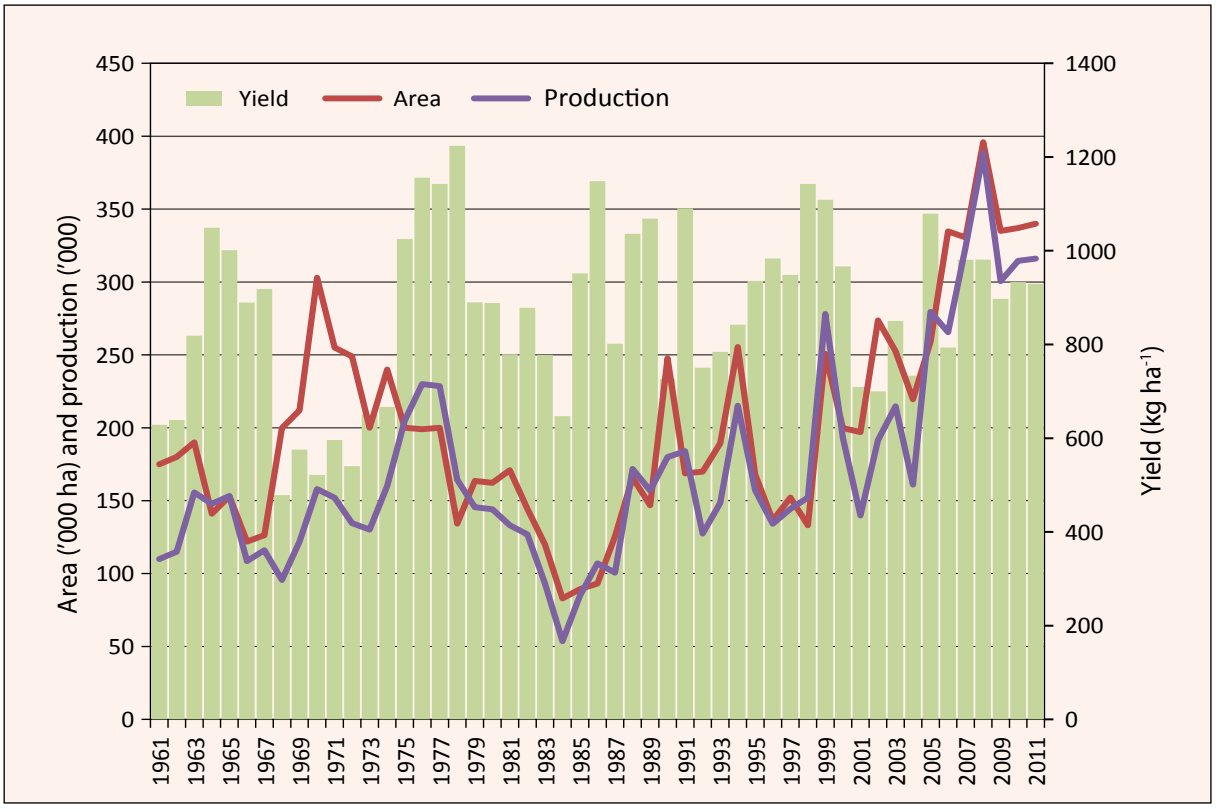

Figure 1. Trends in area, production and yield of groundnut in Mali (1961–2011).

Crop improvement

There has been no research on groundnut improvement in the national program of Mali. However since 1995, ICRISAT has introduced a wide range of new varieties which have been evaluated both on station and on-farm resulting in the release of several varieties, including ICG (FDRS) 10, ICG (FDRS) 4), ICG 7878, Fleur 11, ICGV 86015 and ICGV 86124. These have not yet been largely adopted by farmers and are planted on about 3% of the groundnut area. Since 1998, the ICRISAT breeding program has been conducting joint research with the national program and attempts made to enhance capacity through training of technicians and most recently by appointing a groundnut breeder at MSc level. It is hoped that the national breeding program will be able to benefit from these efforts. Old varieties such as 47-10 (Kalasobani) and 28-206 are still grown by farmers.

Agroecologies

Groundnut production is concentrated in the west, south and parts of the center, covering the regions of Kayes, Koulikoro, Sikasso and Segou. These regions account for 97% of the area and 98% of groundnut production in Mali. Average annual rainfall ranges from 400 to 800 mm. Kayes is the most important groundnut producing region, accounting for 33% of area and 35% of groundnut production in Mali. This is followed by Koulikoro which accounts for 21% of groundnut area and 24% of groundnut production.

Major constraints

These can be grouped in biotic/abiotic and socioeconomic constraints. The main abiotic constraint is drought especially in the Sahel/dry savanna regions of Kayes, Koulikoro and Segou and low soil fertility. Among the biotic constraints are foliar diseases, termites and aflatoxin contamination.

The socioeconomic constraints include:

- Lack of availability and access to seed of new improved varieties
- Poor access to agricultural equipment to expand production areas
- Difficulties in accessing fertilizers and pesticides
- Labor constraints for weeding, harvesting and threshing
- Poorly developed markets and volatile prices
- Lack of organized input delivery system
- Poor road infrastructure to transport produce to markets
- Poorly developed processing industry
- Lack of coordination of actors along the value chain

Strategic partners

The strategic partners and their role in the seed system are given in Table 2.

Table 2. Strategic partners and their role.

Partner	Role
National Seed Service	Seed systems support, helping community-based organizations (CBOs) and farmers' associations with seed storage infrastructure
Institut d'Economie Rurale (IER)	Variety development, evaluation and release, breeder and foundation seed production
Department of Agriculture	Seed regulation and quality control
Rural Development Projects, non-governmental organizations (NGOs), CBOs and Farmer organizations	Technology testing and delivery, production of certified seed, processing and marketing
Farmers	Users
Banque Nationale de Développement Agricole (BNDA) du Mali and Savings and Loan Associations	Providing credit to organized producers
LABOSEM	Ensure seed quality and certification
IARCs (ICRISAT)	Provide enhanced germplasm and capacity building through training in priority skills of NARES; produce breeder seed of released varieties
Private sector (market intermediaries and emerging small-scale seed enterprises and processors), including Faso Kaba and Comptoir 2000	Processing and commercialization of seed and products

Capacity building needs

There is in general a lack of critical mass of researchers for groundnut research in Mali. There is a need to train breeders, seed technologists and crop protection specialists to reinforce the current staff. There is insufficient infrastructure for routine phenotyping such as screen houses, meteorological station and irrigation facilities to enhance crop improvement.

Special cultural/gender considerations

Both men and women are involved in the production and marketing of legumes. Women are responsible for almost 100 percent of harvesting and processing of groundnut. Women often lack good land to produce groundnut and are usually not involved in decision-making on variety choices.

Processing and storage requirements and market opportunities

There are processing opportunities for groundnut for oil extraction and production of cake for animal feed. Groundnut paste is a major ingredient in sources accompanying cereal-based meals. Considering the adverse effects of aflatoxin contamination on human health, policy makers need to be sensitized to impose food safety regulations. A national campaign is needed to sensitize the population about the dangers of aflatoxin. The bottom line is minimizing aflatoxin contamination through use of best-bet pre- and postharvest management. Domestic and regional market opportunities for groundnut seed and other products exist and need to be tapped.

Key policies (recently implemented/needed)

- The 10-year plan to achieve the Millennium Development Goals (2006–15)
- The Poverty Alleviation/Reduction strategy (2007–11)
- The economic and social development program (2008–12)
- The Agricultural Orientation Law (adopted by parliament in 2006)
- The agricultural research strategic plan
- Harmonized seed policies and regulations awaiting act of parliament
- Co-organization of capacity building activity for the sustainable agriculture project (PRECAD), and CPDS participation in the national cereals and legumes market at Ségou in 2009 and 2010
- The Feed the Future Program supported by USAID is anchored on value chains

In all the above national initiatives, research on legume crops and in particular groundnut is well emphasized for semi- and industrial development. They also aim to provide an enabling environment to encourage private sector to invest in agro-processing and seed production for several crops.

Key issues for competitiveness (reducing production costs, increasing market value)

- Large-scale adoption of improved (and market preferred) varieties
- Increasing yields and meeting basic quality standards
- Seed supply arrangements should emphasize schemes with low transaction investment costs targeting village seed system to maintain and distribute seed
- Warehousing facilities to allow farmers keep their produce until prices are favorable as they tend to collapse at harvest.

Mechanization as it relates to timely planting/harvesting and processing

Farmers are largely poorly equipped with agricultural implements. Most (about 80%) own hand tools and less than 5% own a complete set of animal traction equipment (ie, a pair of bullocks, a plow and multipurpose equipment and a seeder) for production. Harvesting is largely done by hand and processing is done with rudimentary tools not amenable to large-scale processing at the local level. The low level of equipment has significant implications on the potential for expanding groundnut cultivation in the country. Groundnut is labor intensive such that returns to labor for groundnut crop enterprise may be lower than the opportunity cost of labor. In this case the returns to investment in small mechanization in the form of simple animal traction may be high. Access to production and processing equipment is essential to increase productivity and profitability of groundnut.

Monitoring and evaluation

Monitoring and evaluation is done at several administrative levels: production, area and yield from national statistics, household surveys and reports. Socioeconomists at ICRISAT and IER monitor adoption of improved technologies and innovations and especially varieties at national level. There are annual work planning and review meetings at sub-regional and national levels where progress of work is reported.

Perspectives for Phase 2

Building on the solid foundation made in Phase 1, successful intervention will be scaled up to other regions of Mali. Linkages with similar programs such as PASS and the West Africa Seed Program (WASP) will be strengthened to maximize synergies. The opportunities to sustain the outputs of Phase 1 exist.

Seed systems

A range of improved varieties selected by farmers is available and the national research program is responsible for production of breeder seed of preferred varieties. Subsequent stages from foundation seed production to distribution of certified seed is managed mainly by commercial cooperatives and community enterprises. Small and medium-scale seed suppliers such as Faso Kaba and Comptoir 2000 have emerged and are potential producers of foundation seed. The presence of CBOs and individual entrepreneurs empowered on variety selection and maintenance should ensure a continuous supply of good quality seed. However, farmers' groups will need to be better organized, with more effective leadership at national level to achieve more coordinated production and marketing of legume seeds. NGOs will have an important role to play in facilitating stronger coordination, and in helping stimulate value addition at the local level through agro-processing activities and innovation platforms. Currently ICRISAT is the major source of breeder seed of recently released varieties in the major two regions of Mali. The groundnut seed production plan for Mali is given in Table 3.

Table 3. Groundnut seed production roadmap for Mali.

Ecology	Demand (ha)	Promising varieties	Seed available (t)		Seed production (t)		Seed to reach 20% adoption (t)	Seed production (t)
			Breeder seed	Foundation seed	Breeder Seed	Foundation seed		
Kayes/ Sudan/ Sahel	148,369	Fleur 11 JL 24 ICGV 86015 ICGV 86124	0.05 0.08 0.1 0.12	0.5	23.74	237.4	2374	1900
Sikasso/ Guinea	80,128	ICGV 86124, Fleur 11 28-206 JL 24 ICGV 86015						
Koulikoro/ Sudan	74,007	ICG (FDRS)4 ICGV 86015 Fleur 11 ICGV86124	1	0.8 1	10.84	117.4	1183	946
Ségou/ Sudan	34,425	Fleur 11 JL 24 ICGV 86124			5.51	55.1	551	441
Mopti/ Sahel	16,647	Fleur 11 JL 24 ICGV 86124			0.67	24.6	264	211
Toumbouctou/ Sahel	100	Fleur 11			0.016	0.16	1.6	2
Total	353,679		1.35	2.3	40.776	434.66	4373.6	3500

Cowpea

Mamadou Touré, Christian Fatokun, Ousmane Coulibaly, Alpha Kamara and Ousmane Boukar

Introduction

Importance of cowpea in Mali

Cowpea is one of the major legumes grown in Mali. It is the most consumed and most cultivated food legume in Mali after groundnut. It is an important source of protein in the diet and cash income. Crop residues of this crop are important sources of animal feed, especially for ruminants. Cowpea is mainly grown as an intercrop with pearl millet and sorghum, especially in the drought-prone areas of Ségou and Mopti regions. However, monocropping cowpea is becoming popular as its economic importance is increasing. For example, cowpea monocrop has taken off in Central Mali through an integrated rural development project, which supplied improved seeds, fertilizers and pesticides on credit to farmers (Source: Coulibaly 1987). It plays an important role in food security of rural and urban populations. Cowpea is consumed throughout the year. The demand of cowpea in Mali is estimated at 23,000 tons per year. Mali produces 75,000 tons annually on about 261,000 ha (Fig. 1). The rate of growth for the period from 1985–87 to 2005–07 for cowpea area, yield and production were estimated at 3.2%, 3.3% and 8.8%, respectively. It has been projected that production of cowpea would grow at the rate of 5.9% during 2010 to 2020. Producer prices for Mali were relatively stable throughout the period during 1991 to 2008 (Source: Abate et al. 2012).

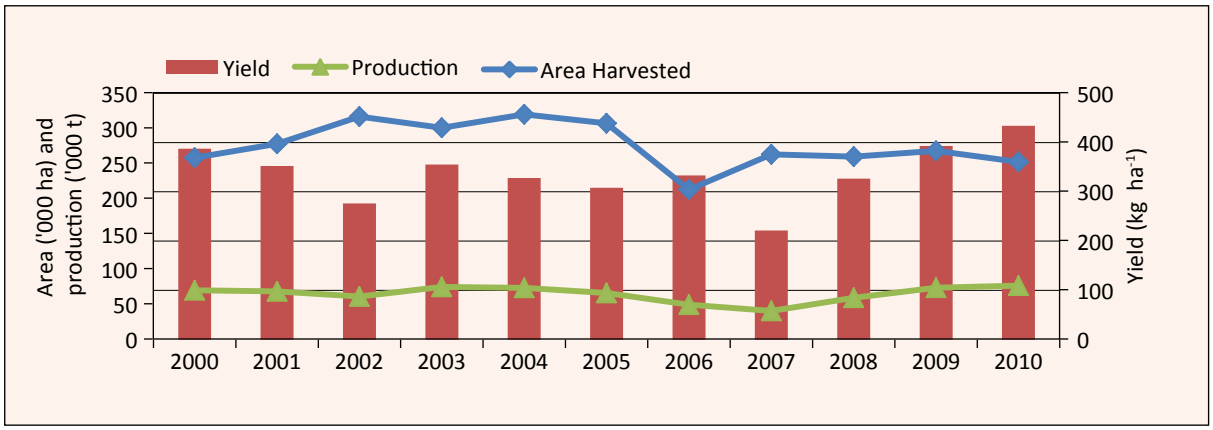

Figure 1. Cowpea area, production and yield in Mali during 2000 to 2010 (Source: FAOSTAT 2012).

Cowpea contribution to national GDP, farmer income, food and nutrition security

The value chain of cowpea starts with the production by small-scale farmers; and in the Sahelian countries like Mali, farmers typically sell their marketable surplus grains to rural assemblers, who in turn sell to urban wholesalers directly or through commission agents (Source: Langyintuo et al. 2003). Commission agents sell grain on behalf of their clients (rural assemblers), and provide storage but do not take any price risk associated with the storage function as the commission fee paid to the commission agent by rural assemblers varies. It is often about 2% of the wholesale price (Source: Langyintuo et al. 2003). Impact assessment studies in Mali showed that cowpea production and protection research products have reached large number of people and this is generating a substantial economic benefit. The average income per hectare of cowpea is about 178,000 FCFA per year at a cost of production of 54,000 FCFA (input and seed costs). Moreover, the price of cowpea could vary from 275 to 500 FCFA

during the year. The CRSP storage technologies developed in Cameroon are now extended in many Sub-Saharan African countries including Nigeria, Niger, Burkina Faso, Mali, Senegal, Chad, Zimbabwe and Mozambique. These technologies will allow farmers to sell their crop during the period when the price will be high. The consumption per capita per year is about 1.6 kg. The expected growth of production is 5.9% (Source: Abate et al. 2012) while the proportion of production sold is 50%.

Research and development

Variety development

Cowpea breeding in Mali is conducted mainly by the Institute of Rural Development (IER), which was created in 1960. IER's cowpea program has the responsibility to conduct research activities including breeding, agronomy and crop protection. The main objective of the cowpea breeding program is to develop high-yielding varieties with drought tolerance and *Striga* resistance. Several varieties were released by the cowpea breeding unit, which has a harmonious collaborative relationship with IITA's cowpea breeding unit (Table 1).

Table 1. Characteristic features of common varieties developed by the Malian research system.

Official name of release	Year of release	Source of the material	Genetic background (parentage, pedigree, ancestry)	Area of potential coverage (ha)	Area of actual adoption estimate (ha)	Spillover national boundaries	Average yield potential (on-farm) (t ha^{-1})	Varietal traits (selected characteristics)
Korobalen	1998	IITA	IT89KD-374	29,444	43,264	Yes	1–1-5	Medium maturing, resistant to *Striga*
Suvita2	1994	INERA	Local from Burkina	21,031	21,632	Yes	1.5	Medium maturing, resistant to *Striga*
Cinzana Telimani	2003	IER	Suvita2/Tvu 79/Suvita 2	21,031	21,632	Yes	1.5	Early maturing, resistant to *Striga*
Djèmani	1993	IER	IAR 1696/ NIBAN	29,444	28,843	Yes	1.5	Late maturing, resistant to yellow mosaic virus
Dounanfana	1993	IER	IAR 1696/ NIBAN	29,444	28,843	Yes	2	Late maturing, resistant to yellow mosaic virus
IT90K-372-1-2	2002	IITA	IT90K-372-1-2	29,444	14,421	Yes	1–1.5	Medium maturing, resistant to *Striga*
Jiguiya	2011	IITA	IT97K-499-35	33,650	28,843	Yes	1.5	Early maturing, resistant to *Striga*
Sangaraka	1998	IITA	IT89KD-245	29,444	36,053	Yes	2	Medium maturing, resistant to *Striga*
Yèrè Wolo	1993	IER	IAR 1696/ NIBAN	29,444	28,843	Yes	2	Late maturing, resistant to yellow mosaic virus

Major constraints to cowpea production

The major constraints to cowpea production include social, biological, physical and technological environments:

- Biotic stresses: Insect pests (aphids, flower thrips, pod sucking bugs and bruchids), diseases (bacterial, viral and fungal) and *Striga*
- Abiotic stresses: Drought, heat, low soil fertility

- Difficulties in accessing inputs (improved seed, pesticides and fertilizers), poor cultural practices
- Labor constraints for weeding and harvesting

Planned Phase 2 activities and their contribution to national efforts

In TL-II Phase 2, we plan to bring about a major impact through improved cowpea technologies that would be implemented especially in the important cowpea production environments or agroecologies. At the end of this project it is expected that the productivity of cowpea should reach at least >1 t ha^{-1} and to increase the national productivity from 0.3 in 2012 to 0.8 t ha^{-1} by 2014.

Expected outcomes from Phase 2 cowpea improvement for production and productivity

Cowpea farmers and farm practitioners will have higher income. National cowpea production will increase to more than 23,000 tons with productivity of 1 t ha^{-1}. There would be an excess production over the national demand, which should allow for export to other countries.

Agroecologies for cowpea cultivation in Mali

Cowpea production in Mali is concentrated in the Sudan Savanna and Sahel Savanna agro-zones. Data from 2006 to 2008 were used to map the area under cowpea and cowpea productivity in these areas (Figs. 2 and 3). There are regions with more than 75,000 ha under cowpea cultivation and there are some with average productivity level up to 1 t ha^{-1}.

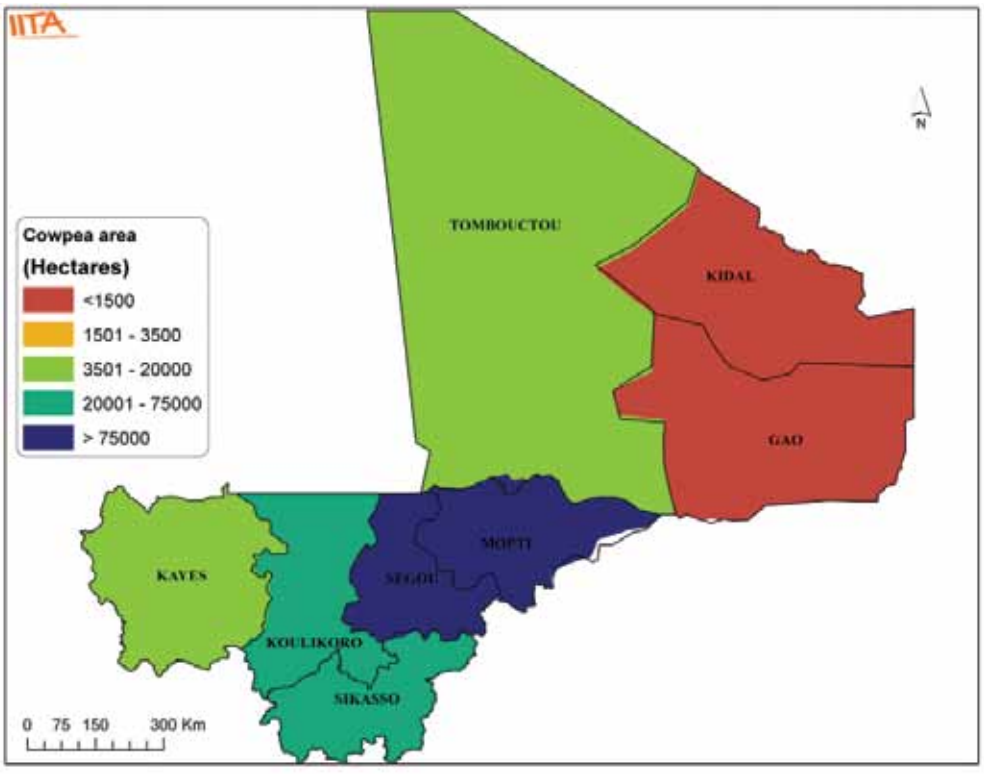

Figure 2. Cowpea production areas in Mali.

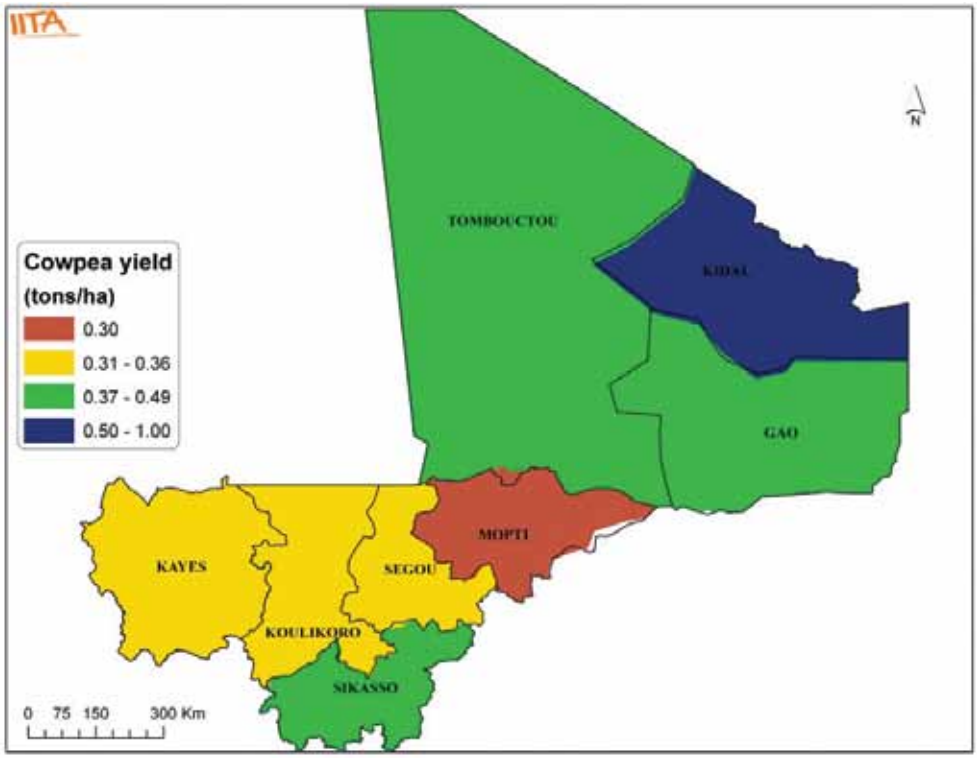

Figure 3. Cowpea yield distribution in Mali.

Seed systems for a legume green revolution in Mali

In Mali, grain markets have been liberalized with measurable success, but the liberalization of seed markets for sorghum, millet and cowpea (the staple crops) has proven to be more difficult. Despite continuous progress by scientists in breeding well-adapted, high-yielding commercial seed varieties, only an estimated 10% of Mali's millet and cowpea area and less than 20% of its sorghum area has been planted with certified seed. This is because many smallholders have limited or no access to certified seeds and they have also been long accustomed to generating their own seed or supplying each other with seed according to clan or ethno-linguistic group. Traditionally, these informal seed systems work quite well, but researchers were surprised to discover that in areas subject to harsh agroclimatic conditions, successive crop failures have caused village seed systems to break down, and local grain markets have become important sources of seed. This finding led IFPRI researchers to examine seed transactions in a dozen weekly markets in the Sahel region of Mali. They found that no certified seed is available in these markets, but that grain suitable for seed is being sold primarily by female vendors who are also farmers. Because the vendors bring unmixed seed directly from their granaries, the purchasers know the provenance and can depend on their quality, which is especially important in harsh environments where the range of adaptability is very limited. Grain color plays an important role in the preference of consumers. The predominant grain color in visited markets is white. Sixty-four percent of cowpea varieties used by farmers are white and 79% are black eyes.

Over the years, scientists at IER have developed a number of cowpea varieties that are resistant to *Striga* and tolerant to drought. These varieties require a minimum spray with insecticides to protect them against insect attack. These varieties are however, not widely adopted because of lack of high quality seeds. At planting, there is a shortage of quality seeds and farmers plant whatever grain they get, which leads to poor stands and low yields. Private seed companies that produce and market cowpea seed are not many. Only one seed company (Faso Kaba) is producing and marketing improved cowpea seed in Mali. Farmers mostly rely on NGOs to source and distribute improved cowpea seeds in

the main producing areas. However, recently other companies are getting involved in seed production. These include: Comptoir 2000, Nako Shi and Coop Semence.

With the increased adoption of improved (and market preferred) varieties, seed system needs to be established to increase the production of cowpea in Mali. Seed supply arrangements should emphasize schemes with low transaction investment costs targeting village seed system to maintain and distribute seed.

Malian seed system strategy (2012–14)

The TL-II has facilitated an innovation platform in Mali to enhance cowpea seed production in the various regions of Mali. The platform consists of NGOs, a major seed company (Faso Kaba) and IER. IER evaluates and adapts high-yielding varieties and produces foundation seed of selected varieties after their official release. The NGOs are involved in large-scale demonstration and dissemination of the improved varieties across the regions. They also strengthen community seed schemes to produce and market seeds of improved cowpea varieties. Cowpea area, demand and other parameters are given below.

- Area: 251,390 ha
- Seed rate (mean): 20 kg ha^{-1}
- National demand: 5,028 tons (2012–14)
- Capacity to deliver 20% area: 50,278 ha ≃ 1,000 tons
- Target of productivity: 1 t ha^{-1} at intervention sites and 0.8 t ha^{-1} at national level
- Total production target: >211,160 tons

Opportunities, constraints, partnership and seed production plan

The target is to cover 20% of each important cowpea agroecology in Mali with improved seeds.

Opportunities

- New law that enhances innovative seed system
- High demand for cowpea as part of the daily staple
- Good market access for cowpea
- Availability of suitable varieties in major cowpea growing areas
- Favorable ecology (drylands) for cowpea production

Constraints

- Low yield because of biotic and abiotic stresses
- Lack of insecticides to protect the cowpea crop
- Limited seed production and marketing opportunities
- Low capacity of national seed certification laboratory
- Insect pests from field to the store
- Poor seed distribution systems (lack of seed dealers in communities)

Partners and their role

- IER: Responsible for the improvement of cowpea; provides laboratory and other technical services to agricultural organizations, farmers, agro-based industries and others needing these services
- National Seeds Service: Seed policy
- Labo Sem: Regulatory seed laboratory
- IITA: Technology development, backstopping in training, technical skills in priority areas, development of joint projects and production of foundation seed
- NGOs such as SNV, World Vision, CRS, Millennium Development Village Project: Carry out technology dissemination activities especially in rural areas and promote community seed production and seed marketing
- Departments of Ministry of Agriculture in the various regions: Field demonstration, farmer training and varietal dissemination
- Seed companies (Faso Kaba, Comptoir 2000): Produce and market certified seeds
- World Vision, Africare, Millennium Development Village, SG2000: Extension
- Farmers and farmers' organizations, CPDS (Cooperative Seeds Producers Association): End-users

Seed production plan

Cowpea seed production plan for Mali is presented in Tables 2 and 3.

Table 2. Cowpea seed production plan for Mali.

			Breeder seed in 2012		Foundation seed in 2013		Certified seed for use in 2014	
Region (Demand ha)	Variety demand	Yield (kg ha^{-1})	Area (ha)	Production (kg)	Area (ha)	Production (t)	Area (ha)	Production (t)
Mopti (83150)	Korobalen	1000	1299.22	129.92	5.20	5.20	207.88	207.88
	Suvita2	1000	1299.22	129.92	5.20	5.20	207.88	207.88
Ségou (67288)	Korobalen	1000	700.92	70.09	2.80	2.80	112.15	112.15
	Sangaraka	1000	700.92	70.09	2.80	2.80	112.15	112.15
	Cinzana Telimani	1000	700.92	70.09	2.80	2.80	112.15	112.15
Koulikoro (67233)	Djèmani	1000	525.27	52.53	2.10	2.10	84.04	84.04
	Dounanfana	1000	525.27	52.53	2.10	2.10	84.04	84.04
	Yèrè Wolo	1000	525.27	52.53	2.10	2.10	84.04	84.04
	Korobalen	1000	525.27	52.53	2.10	2.10	84.04	84.04
Sikasso (20790)	Djèmani	1000	162.42	16.24	0.65	0.65	25.99	25.99
	Dounanfana	1000	162.42	16.24	0.65	0.65	25.99	25.99
	Yèrè Wolo	1000	162.42	16.24	0.65	0.65	25.99	25.99
	Korobalen	1000	162.42	16.24	0.65	0.65	25.99	25.99
Kayes (12248)	Korobalen	1000	191.38	19.14	0.77	0.77	30.62	30.62
	Cinzana Telimani	1000	191.38	19.14	0.77	0.77	30.62	30.62
Tombouctou (1583)	Korobalen	1000	49.50	4.95	0.20	0.20	7.92	7.92
Gao (82)	Korobalen	1000	0.85	0.09	0.00	0.00	0.14	0.14
	Jiguiya	1000	0.85	0.09	0.00	0.00	0.14	0.14
	IT90K-372-1-2	1000	0.85	0.09	0.00	0.00	0.14	0.14
Total			7886.75	788.68	31.55	31.55	1261.88	1261.88

Table 3. Certified seed production (t) plan over three years.

Variety	2012	2013	2014
Korobalen	200	340	468.73
Suvita2	70	140	207.88
Sangaraka	30	70	112.15
Cinzana Telimani	45	80	142.77
Djèmani	30	70	110.03
Dounanfana	30	70	110.03
Yèrè Wolo	30	70	110.03
Jiguiya	0.08	0.10	0.14
IT90K-372-1-2	0.08	0.10	0.14
Total	435.16	840.2	1261.88

The quantity of seed will be produced mainly by Faso Kaba, other small-scale seed companies and community seed producers supported by the NGOs. IER will work with NGOs to produce foundation seed. The NGOs will support seed dissemination and marketing activities.

Vision of success for cowpea in Mali

The vision of success for cowpea in Mali is to attain highest productivity level of >1 t ha^{-1} at national and global levels that attributes to the wealth of producer farmers with significant contribution to the home consumption. The overall production will satisfy the national demand (about 23,000 tons) to significantly contribute to the GDP with significant amount of exports and/or agro-processed products.

Niger

Groundnut

Adamou Moutari, Jupiter Ndjeunga and Bonny Ntare

Introduction

Groundnut is an important crop mainly due to its contribution to poverty reduction and food security. It is a basic food and cash crop and contributes to livestock feeding. From recent surveys (Source: Ndjeunga et al. 2010) in the major groundnut regions of Niger groundnut is planted on about 15% of total cultivated area in Niger and contributes 66% of household cash revenue. It accounts 31% of the total value of crop production in Niger. Groundnut is a major source of dietary protein, oil/fat, and vitamins such as thiamine, riboflavin and niacin. Groundnut paste is an important source of calories for small children, particularly those being weaned. Groundnut cake and haulms (straw, stems) are used as livestock feed, helping to increase livestock productivity. The crop season is short (June–September) and the end-of-season drought is frequent. Some key statistics are presented below. The national demand and expected growth of production are presented in Table 1 and trends in area, production and yield are presented in Figure 1.

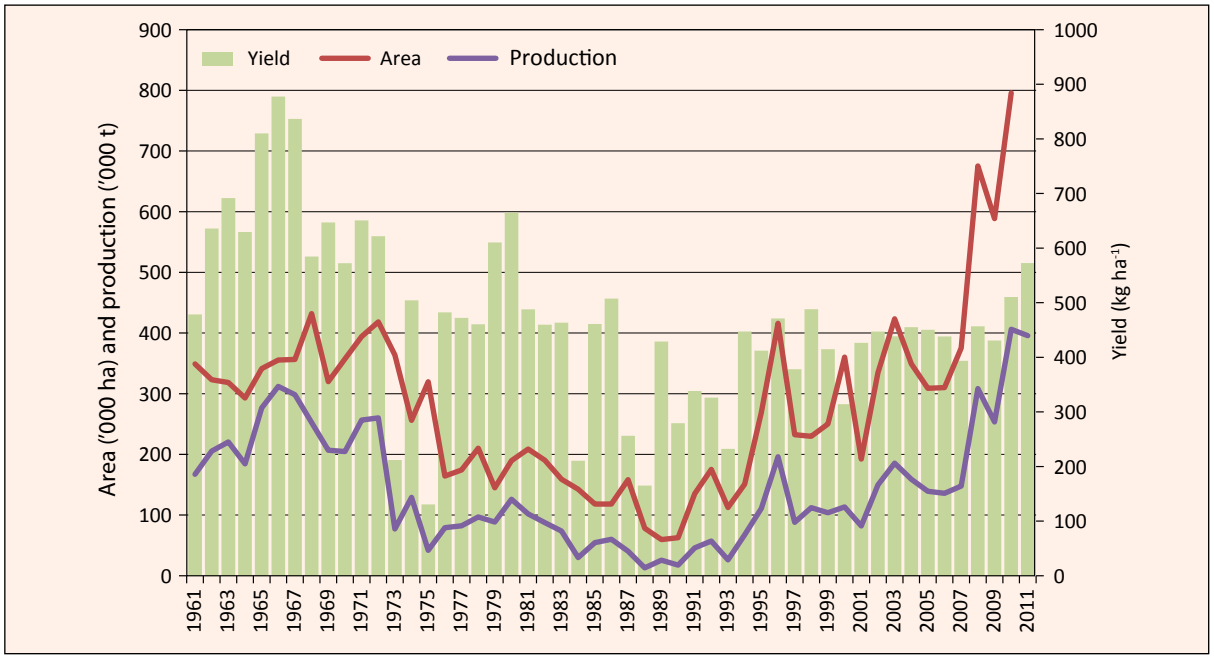

Figure 1. Trends in area, production and yield of groundnut in Niger during 1961 to 2011.

Table 1. National demand and growth in production of groundnut in Niger[1].

Parameter	Value
Average area (ha)	625,213
Average production (t)	302,319
Average yield (current) (kg ha^{-1})	473
Average yield (2015) (kg ha^{-1})	600
National demand (t)	229,206
Expected growth of production (%)	4.46
Proportion of production sold (%)	76

1. Source: FAOSTAT (2005–08).

Research and dissemination process

Groundnut research in Niger was initiated by IRHO, a French research organization in 1960 with essential introduction of germplasm from other French territory stations such as Bambey in Senegal and Niangoloko in Burkina Faso. Groundnut improvement was boosted by the establishment of ICRISAT in Niger in 1988. Due to lack of technical staff on groundnut research, the use of germplasm from ICRISAT has been limited. However, through projects implemented by ICRISAT including TL-II, the varieties are now being adopted by farmers.

The most widely grown groundnut variety in Niger is 55-437 followed by TS 32-1. However, four new varieties including Fleur 11, RRB, J 11 and ICG 9643 were released in 2011. Among these RRB is the most popular. The last release of varieties in the national catalog was more than two decades.

Agroecologies

The arable land in Niger is a thin belt bordering Nigeria, Benin and Burkina Faso below the Sahara desert. It is predominantly Sahelian with a very short growing cycle (June–September). Groundnut is largely grown under rainfed conditions in the regions of Dosso, Maradi and Zinder (Table 2) all lying in the Sahel savanna agroecology with average annual rainfall of 400–600 mm. These regions account for more than 75% of groundnut production in Niger.

Table 2. Agroecological zones and biotic constraints of groundnut production in Niger.

Region	Area (ha)	Key biotic and abiotic constraints
Dosso	21,006	Poor soil fertility, drought, rosette and aphids
Maradi	175,000	Same as above
Zinder	136,155	Same as above

Seed system

Socioeconomic constraints

These include poorly organized producers, limited access of farmers to inputs especially seeds of improved varieties and fertilizers at affordable prices, and high labor costs for planting, weeding and harvesting. Poor access roads to farms makes movement of produce to markets expensive and also leads to middle men exploiting the rural community-based farmers. In such situations farmers are unable to derive the most benefit from their efforts.

Organizational constraints

There are no strong farmers' associations involved with production of groundnut. However, under the TL-II projects, women groups in the region of Dosso have emerged and are supplying about 65% of the newly released varieties. The process of crop variety registration and release is still very slow and could be frustrating. However, TL-II is committed to facilitating the variety registration and release process.

Strategic partners

The strategic partners and their role in the seed system are given in Table 3.

Table 3. Strategic partners and their role.

Strategic partner	Role
ICRISAT	Technology development (varieties and crop management options) in partnership with NARES and ARIs, breeder seed production and variety maintenance; Assessment and identification of sustainable seed delivery systems in partnership with NARES; Assist in the promotion of measures to reduce aflatoxin contamination; Provide training in priority skills [data management, impact assessment methodology, breeding methodology and farmer participatory variety selection (FPVS)].
Institut National de Recherche Agronomique du Niger (INRAN)	Technology development and deployment with backstopping from ICRISAT; Ensure the production of breeder and/or foundation seeds; Evaluate technologies using the FPVS methodology; Facilitate the release of new varieties.
Ministry of Agriculture (SICCLA)	Formulate seed laws and regulations as well as overall inputs (fertilizers, pesticides, etc).
Ministry of Agriculture (including Extension Services)	Formulate agricultural policies in the Rural Development Strategy; Ensure the delivery of technologies and advisory extension services.
Association of Private Seed Producers of Niger	Coordinate seed production and marketing of certified/commercial seed.
Small-scale vegetable oil processing units	Processing of groundnut – oil and cake, soap and paste; Provide market for groundnut grain.
NGOs such as World Vision and SNV	Promote improved farming practices and link farmers with markets.
Farmers' associations/Small-scale seed producers	Assist in the evaluation of FPVS trials; Monitor village-level seed production.
AGRA and WASA	Support the development of seed enterprise and agro-dealers (enhancing the capacity of local seed traders); Training agro-dealers (local seed traders) in marketing and small-scale business management.

Capacity building needs (staff, infrastructure)

- Training of technicians in basic integrated crop management
- Degree related training at MSc and PhD levels to enhance the legume breeding program

Strengthen phenotyping for drought tolerance Special cultural/gender considerations

- At least 40% of groundnut plots are managed by women.
- More than 90% of small-scale processors are women.
- Increased groundnut production will empower women through increased income and better nutrition of children.

Processing and storage requirements and market opportunities

Demand for groundnut and its products is high especially edible oil, paste and cake. Currently there are small-scale processing units constrained by processing equipment and consistent supply of good quality groundnut seed. Access and availability of appropriate equipment would improve quality and quantity of these products.

Key policies (recently implemented/needed)

Implemented: Harmonization of regional seed policies and regulations.

Needed: Encourage private companies like OLGA oil to invest in contractual arrangements with producers to increase volume by guaranteeing buying the produce and an agreed price. Protect the local processing industries from competition with other imported vegetable oils of unknown quality. The opportunities through the presidential initiative of 3Ns (Nigerien (ne)s Nourir Nigerien) should boost groundnut production.

Key issues for competitiveness (ie, reducing production costs, increase market value)

- Promotion of a wide range of productive varieties and crop management options to increase productivity
- Development of sustainable seed production and delivery schemes to increase access and availability of seed of preferred varieties
- Promote the adoption of best-bet pre- and postharvest techniques to minimize aflatoxin contamination to improve access to international markets for groundnut
- Increased awareness of the dangers of aflatoxin contamination to improve health of rural and urban consumers

Mechanization as it relates to timely planting/harvesting and processing

All production operations (land preparation, planting, weeding and harvesting) are done manually by using hand tools that severely limit area planted. Thirty-three percent of producers own a plow, less than 1% owns a seeder and 52% own oxen. Groundnut production is a labor intensive enterprise. In this case, the returns to investment in small mechanization in the form of simple animal traction may be high. Access to suitable machinery for various small-scale field operations is essential to increase productivity and profitability.

Environmental/sustainability issues

A range of improved varieties and exploitation of environment-friendly and sustained technologies (resistant varieties) will contribute to the preservation of biodiversity. Availability of resistant varieties with high productivity will reduce the need for pesticides and thus contribute to a safe and healthy environment. Also higher groundnut yields and creation of commercialization opportunities will lead to environmental benefits. Growth in income and employment (eg, labor for farming, crop processing and trade) will reduce the pressure on marginal lands using sustainable agricultural practices. Poverty is a major contributor to environmental degradation, and by reducing poverty, cultivation of groundnut will ease the pressure on natural resources in the fragile, drought-prone areas.

Monitoring and evaluation

- Groundnut production, area cultivated and yield are monitored every year through survey of about 2,500 farm households in Niger. This sample is found to be highly representative.
- Annual sub-regional review and planning meetings are organized.
- Groundnut varieties are monitored by ICRISAT using key resource persons involved in technology development and delivery.
- A good monitoring system needs to be put in place at the national level.

Perspectives for Phase 2

Niger is one of the countries where Phase 1 of the project was implemented for groundnut. Activities will continue with more vigor in Phase 2 of TL-II. Efforts will be made to increase the level of drought tolerance and facilitate the process of variety release and registration to ensure that farmers have access to improved crop varieties.

The seed strategy

The seed roadmap for groundnut in Niger is presented in Table 4. The total amount of seed is estimated to cover 23% of the demand. This can only be attained assuming no drought spells during the four years. However, considering that the frequency of drought in Niger is high risk, this may be mitigated by using available irrigation facilities at the various seed farms. More secure sites such as Bengou Research Station will be used. The Sudan savanna will be more used for seed production than as at present. The possibility of using seed farms where there are irrigation facilities will be explored.

Table 4. Groundnut seed production plan for Niger[1].

			Current seed stocks by class in 2012 (t)					Projected stock by class in 2013 (t)					Projected stock by class in 2014 (t)					Projected stock by class in 2015 (t)				
AEZ	Region	Variety	Breeder	Basic	R1	R2	R3	Breeder	Basic	R1	R2	R3	Breeder	Basic	R1	R2	R3	Breeder	Basic	R1	R2	R3
Sudanian	Dosso	55-437	0.843	0.72	11.2	0		0.086	8.43	49.35	112	0	0.086	0.86	84.3	493.5	1120	0.086	0.86	8.6	843	4935
		RRB	0.046	0.44	12.5	4.35		0.092	0.46	6.7	125	43.5	0.092	0.92	4.6	67	1250	0.092	0.92	9.2	46	670
		J 11	0.05	0	0.8	0.35		0.1	0.5	2.5	8	3.5	0.1	1	5	25	80	0.1	1	10	50	250
		TS 32-1	0.05	0.315	0.35	0		0.1	0.5	5.65	3.5	0	0.1	1	5	56.5	35	0.1	1	10	50	565
		Fleur 11	0.05	0.14	0.85	1		0.1	0.5	3.9	8.5	10	0.1	1	5	39	85	0.1	1	10	50	390
		ICG 9346	0.05	0	0.2	0		0.1	0.5	2.5	2	0	0.1	1	5	25	20	0.1	1	10	50	250
Total			1.089	1.615	25.9	5.7		0.578	11.29	70.6	259	57	0.578	5.78	108.9	706	2590	0.578	5.78	57.8	1089	7060
Sudano-Sahelian	Maradi	JL 24	0.264	2.2	1.5	0			2.64	22	15	0	0	0	26.4	220	150	0	0	0	264	2200
		T 169-83	0.067	0	0	0			0.67	0	0	0	0	0	6.7	0	0	0	0	0	67	0
		T 181-83	0.045	0	0	0			0.45	0	0	0	0	0	4.5	0	0	0	0	0	45	0
		T 177-83	0.078	0	0	0			0.78	0	0	0	0	0	7.8	0	0	0	0	0	78	0
		55-437	0	2	12	0			0	20	120	0	0	0	0	200	1200	0	0	0	0	2000
		Fleur 11			1.3				0	0	13	0	0	0	0	0	130	0	0	0	0	0
		RRB			0.2				0	0	2	0	0	0	0	0	20	0	0	0	0	0
		ICG 86124		0.2							0											
Total			0.454	4.4	15	0	0	0	4.54	42	150	0	0	0	45.4	420	1500	0	0	0	454	4200
Sudano-Sahelian	Zinder Tillaberi	55-437	0	0																		
		JL 24	0	0.2	0.2	0			0	2	2	0	0	0	0	20	20	0	0	0	0	200
		T 169-83	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0
		T 181-83	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0
		T 177-83	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0
		55-437	0	0.2	4	0			0	2	40	0	0	0	0	20	400	0	0	0	0	200
		ICG 8612		0.2	0				0	2	0	0	0	0	0	20	0	0	0	0	0	200
		RRB			0				0	0	0	0	0	0	0	0	0	0	0	0	0	0
		ICG 86124		0							0											
Total			0	0.6	4.2	0	0	0	0	6	42	0	0	0	0	60	420	0	0	0	0	600

1. R1, R2 and R3 are registered seed classes.

Cowpea

Moutari Adamou, Abdou Souleymane, Christian Fatokun, Ousmane Coulibaly, Alpha Kamara and Ousmane Boukar

Introduction

Importance of the crop in Niger

Cowpea is one of the most important grain legumes in Niger, which is the second largest producer of cowpea in Africa. The bulk of cowpea produced in Niger is sold to neighboring countries, mostly Nigeria. About 764,000 tons are produced annually on about 4,132,000 ha (Fig. 1). Local consumption of cowpea has increased significantly in recent years and this is bound to have positive impact on the people's nutrition and health. Cowpea haulms are used as animal feed to increase livestock productivity. Farmers often grow long-duration spreading varieties for fodder (Source: Singh et al. 2003). Major production areas are Dosso (Soudan savanna), Maradi and Zinder in the Sahel, where the annual rainfall is 400–600 mm. These regions account for about 80% of cowpea production in the country. Crop productivity of cowpea is very low. The annual growth rate of cowpea yield from 1985–87 to 2005–07 was about 2.5% whereas the area has been growing at 7.4%. It has been projected that production of cowpea in Niger would grow at 4.2% between 2010 and 2020. The current national demand for cowpea is 142,000 tons but this is expected to increase at the rate of 3.7% per year.

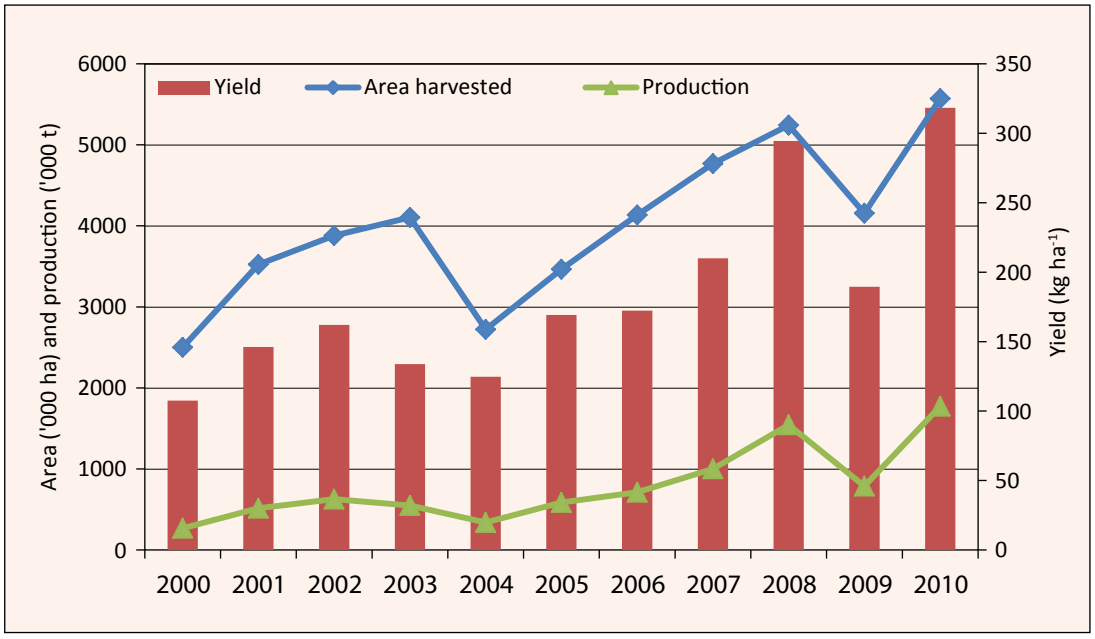

Figure 1. Cowpea area, production and yield in Niger during 2000 to 2010 (Source: FAOSTAT 2012).

Cowpea contribution to national GDP, farmer income, food and nutrition security

West Africa is the main producer of cowpea with Nigeria being highest followed by Niger. Cowpea consumption in Niger is 7.82 kg per capita per year. Cowpea is an important cash crop in Niger. It constitutes the second largest agricultural product in Niger after onions. Over the period 2001–05 cowpea contributed about 12% of the monetary value of the total national exports of the country (Source: Ibro 2011). Farmers sell more than 88% of the produce in most of the cases. Niger is the

largest cowpea exporter in the world with an estimated 215,000 tons exported annually, mainly to Nigeria. Prices in the markets are attractive except for sales immediately after harvest when the supply is greater than demand.

Cowpea production in SSA is projected to grow at nearly 3% per annum – from 6 million tons in 2010 to 8 million tons in 2020. Niger is predicted to be among countries which continue to dominate cowpea production in SSA. High rate of growth (4.2%) is projected for the country.

Despite its contribution to cash income for farmers and to the national budget, cowpea is becoming more and more a national food crop which can significantly enhance the food security of the 66% poor farmers in Niger. It is widely consumed by both rural and urban inhabitants under different types of uses. In general cowpea grain can be cooked alone or mixed with rice and consumed as the main meal in the household. The grains can also be processed into flour which is used for a variety of recipes. Among these we can distinguish "Kossai", a breakfast meal well known in the whole sub-region of West and Central Africa which contributes significantly to women income. The daily quantity of cowpea processed into "Kossai" was estimated up to 3,500 kg in the three main cities of the country including Niamey, Maradi and Zinder (Source: Ibro et al. 2008). This represents a market of 3,800 tons annually for these three cities.

Development of cowpea production, which concerns five regions of Niger (Zinder, Maradi, Tahoua, Tilaberi and Dosso), is principally justified because of its good export market value. Cowpea is exported unfinished and provides more income to producers and traders. The average income from grains is US$ 147 ha^{-1}. The grains are however difficult to store due to weevil attack. Chemicals are therefore applied to protect the grains in storage. The PIC Storage technology is being promoted in the country among cowpea growers and traders. State intervention in the cowpea sub-sector is mainly the regulation of trade (about 30 major traders). Many active informal distribution and sales channels of cowpea do exist.

Cowpea from Niger is exported mainly to the following countries: Nigeria (strong demand, continuous growth), Ghana, Benin and Togo (lower export levels and market growth). Prices and production vary widely from one year to the next (Source: EU 2002).

Research and development

Variety development

INRAN (Institut National de la Recherche Agronomique du Niger) is the national agricultural research center of Niger created in 1975 to replace the then French organizations (IRAT, IRFA, AFFT, etc) which were conducting agricultural research. Research in food crops (millets, sorghum, cowpea, groundnut) started before 1928 with IRAT, but important cowpea breeding efforts only started after the creation of INRAN. The main objectives of the program are to develop cowpea varieties resistant to *Striga*, insect pests (aphids, thrips) and tolerant to drought and low soil fertility. A longstanding harmonious working relationship exists between INRAN and IITA scientists in cowpea research and this will enhance progress in this project. Several improved cowpea breeding lines were registered in the country as shown in Table 1.

Major constraints to cowpea production in Niger

The major constraints of cowpea production include social, biological, physical and technological environments.

Table 1. Characteristic features of common cowpea varieties developed by the Niger research system.

Official name of release	Year of release	Source of the material	Genetic background (parentage, pedigree, ancestry)	Area of potential coverage (ha)	Area of actual adoption estimate (ha)	Spillover national boundaries	Average yield potential (on-farm) (kg ha^{-1})	Varietal traits (selected characteristics)
IT90K-372-1-2	2002	IITA	IT90K-372-1-2	148,315	3,500	Yes	300	Semi-erect, white grain, moderately resistant to aphids
IT99K-573-1-1	2008	IITA	IT99K-573-1-1	111,236	2,000	Yes	350	Semi-erect, white grain, resistant to *Striga*, high grain yield
IT98K-205-8	2008	IITA	IT98K-205-8	111,236	2,000	Yes	300	Resistant to *Striga* and drought, high grain yield, early maturity
IT89KD-374-57	2002	IITA	IT89KD-374-57	148,315	3,500	Yes	350	Tolerant to aphids and drought
IT97K-499-38	2008	IITA	IT97K-499-38	111,236	2,000	Yes	400	Semi-erect, resistant to *Striga* and drought, high grain yield, early maturity
IT97K-499-35	2008	IITA	IT97K-499-35	111,236	2,000	Yes	400	Semi-erect, white grain, resistant to *Striga* and drought, high grain yield, early maturity

- Biotic stresses: Insect pests (aphids, flower thrips, pod sucking bugs, *Maruca*, bruchids), diseases (bacterial and viral) and *Striga*
- Abiotic stresses: Drought, heat, low soil fertility
- Poorly organized producers, limited access of farmers to inputs, especially seeds of improved varieties, insecticides and fertilizers at affordable prices
- High labor costs for planting, weeding and harvesting

Planned Phase 2 activities and their contribution to national efforts

In TL-II Phase 2 we plan to bring about a mega impact approach where available cowpea technologies would be implemented in most, especially important cowpea production environments or agroecologies. The target set at the end of the phase is to achieve productivity of cowpea of 0.9 t ha^{-1} in intervention areas and to influence the national productivity from 0.2 (current level) to 0.5 t ha^{-1} by 2014.

Expected outcomes from Phase 2 cowpea improvement for production and productivity

Cowpea farmers and farming practitioners will obtain higher income, and national cowpea production will increase to more than 862,455 tons by 2014 with productivity of 0.5 t ha^{-1}. There would be excess production over the national demand which should allow for more export to other countries.

Agroecologies for cowpea cultivation in Niger

In Niger cowpea is grown mainly in the Sudan Savanna and Sahel Savanna agroecologies. There are regions with cowpea coverage of more than 90,000 ha but there are very few regions where the average productivity levels are 0.21 to 0.36 t ha^{-1} (Figs. 2 and 3). Niger is one of the countries with very low cowpea grain yield. The possible reason for this observation is that the farmers plant cowpea at very low population density. In addition, the cultivated areas are overestimated. Cowpea is usually grown as intercrop with sorghum, millets and groundnut and areas attributed to cowpea may be areas where the crops are grown together.

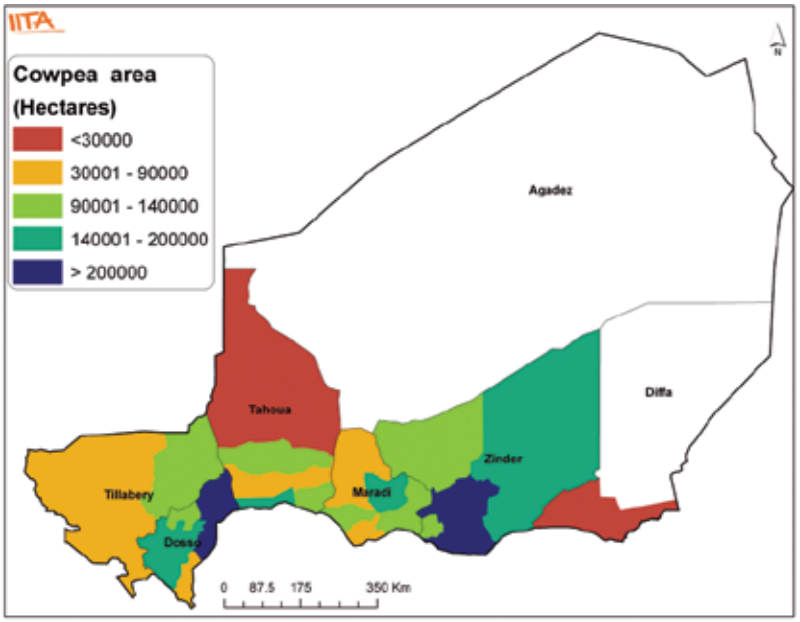

Figure 2. Cowpea production areas in Niger.

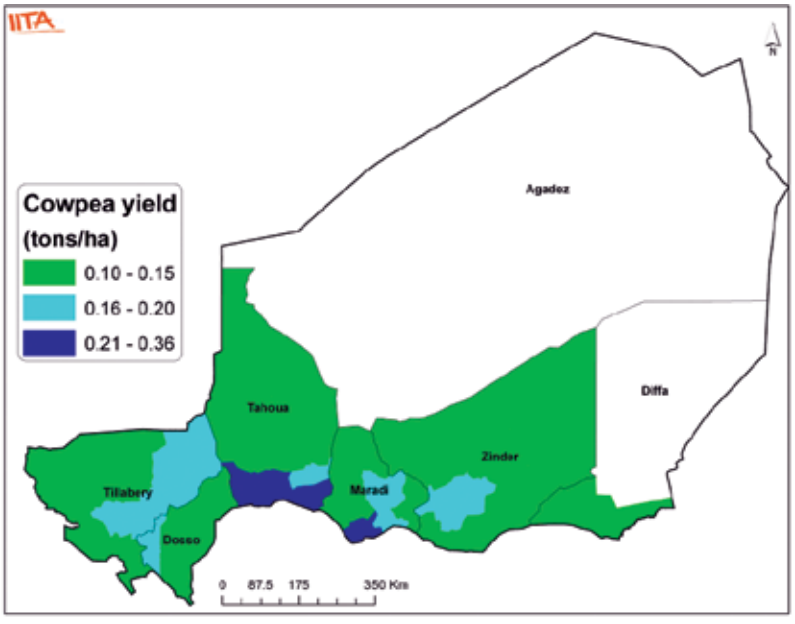

Figure 3. Cowpea yield distribution in Niger.

Seed systems for a legumes green revolution in Niger

Niger Republic is a leading cowpea producer in the world, second to Nigeria, but all of its cowpea is produced in the short rainy season (June–September). At planting, there is a shortage of quality seeds and farmers plant whatever grain they get, which leads to poor stands and low yields. Private seed companies that produce and market cowpea seed are not many. Only one seed company (Alheri Seed) used to produce and market improved cowpea in Niger. Other private seed companies such as Fusaha, APPSN and Manoma SA which are producing mainly cereal seeds have also started recently to produce legume seeds. In general farmers mostly rely on NGOs to source and distribute improved cowpea seeds in the main producing areas of Dosso, Maradi and Zinder. Cowpea yields are low because of drought, the parasitic weed *Striga* and a number of diseases and insect pests. Through collaboration with the main research institution INRAN, IITA has developed a number of improved cowpea varieties that combine resistance to multiple biotic and abiotic stresses particularly drought and *Striga*. Despite the availability of improved varieties, adoption is low in Niger Republic because of shortage of seeds and lack of information on their availability in areas they are produced.

With the suggested promotion of a wide range of productive varieties and crop management options, cowpea productivity could be increased. To increase access and availability of seed of preferred varieties, the development of sustainable seed production and delivery schemes should be undertaken. The development of the cowpea seed sub-sector and closing the yield gap between on-station and farmers' fields through improved agronomic practices and better insect pest control should be targeted.

Niger seed system strategy (2012–14)

The TL-II has built a seed production and distribution platform in Niger Republic to enhance production and effective distribution of cowpea in the country. The main organizations on this platform are the National Agricultural Research Institute (INRAN), Alheri Seed Co, Ministry of Agriculture and the Dutch NGO, SNV. It is expected that more NGOs will join the platform later. INRAN produces and supplies foundation seed to Alheri Seed Co and the NGOs involved in agricultural development in the country. While Alheri produces and sells certified seed, the NGOs particularly SNV and World Vision will disseminate the varieties through the establishments of demonstration plots, and also undertake production of seeds through the community seed schemes and promotion of seed marketing.

Seed production target

Area: 4,774,250 ha

Seed rate (mean): 20 kg ha^{-1}

National demand: 95,485 tons (2012–14)

Capacity to deliver 20%: 945,850 ha ≃ 19,097 tons

Target of productivity: 0.9 t ha^{-1} at intervention sites and 0.5 t ha^{-1} at national level

Total production target: 2,769,000 tons

Opportunities, constraints, partnership and seed production plan

The target is to cover 20% of each important cowpea agroecology in Niger with improved seed.

Opportunities

- High consumption level/culture in the country
- High demand for cowpea as part of the daily staple
- Good market access for cowpea
- Liberalization of foundation seed production
- Availability of suitable varieties in major cowpea growing areas
- Favorable ecology (drylands) for cowpea production
- Cowpea haulm as fodder for livestock

Constraints

- Dominated by informal system that has technical and infrastructural challenges
- Total non-existence of mechanization at all steps
- Unpredictability of market price
- Low yield because of biotic and abiotic constraints
- Seed production and marketing is only picking up gradually
- Low capacity of national seed council to certify seed
- Insect pests from field to the store
- Poor seed distribution systems (lack of seed dealers in communities)
- Irregular rains especially early in the season

Partners and their role

- IITA: Technology development (varieties and crop management options) in partnership with NARES and ARIs; assessment and identification of sustainable seed delivery systems in partnership with NARES; provide training in priority skills (data management, impact assessment methodology, breeding methodology and PVS)
- Institut National de la Recherche Agronomique du Niger (INRAN): Technology development with backstopping from IITA; ensures the production of breeder and/or foundation seeds; evaluates technologies using the PVS methodology; facilitates the release of new varieties
- Ministry of Agriculture (SICCLA): Formulates seed laws and regulations as well as overall inputs (fertilizers, pesticides, etc)
- Ministry of Agriculture (including Extension Services): Formulates agricultural policies in the Rural Development Strategy; ensures the delivery of technologies and advisory extension services
- Association of Private Seed Producers of Niger: Coordinates seed production and marketing of certified/commercial seed
- NGOs such as SNV, World Vision, Africare, KKM, IFAD/IRDAR, IFAD/PPILDA: Promote improved farming practices and link farmers with markets
- Farmers' associations/small-scale seed producers: Assist in the evaluation of FPVS trials; monitor village-level seed production

- AGRA and WASA: Support the development of seed enterprise and agro-dealers (enhancing the capacity of local seed traders); provide training to agro-dealers (local seed traders) in marketing and small-scale business management

Table 2. Seed roadmap for cowpea in Niger.

			Breeder seed in 2012		Foundation seed in 2013		Certified seed for use in 2014	
Agroecological demand (ha)	Variety demand	Yield (kg ha^{-1})	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
Sahel Savannah (Maradi) 1425046	IT90K-372-1-2	900	0.52	0.47	23.46	21.11	1055.59	950.03
	IT89KD-374-57	900	0.52	0.47	23.46	21.11	1055.59	950.03
	IT98K-205-8	900	0.52	0.47	23.46	21.11	1055.59	950.03
	IT97K-499-35	900	0.52	0.47	23.46	21.11	1055.59	950.03
	IT97K-499-38	900	0.52	0.47	23.46	21.11	1055.59	950.03
	IT99K-573-1-1	900	0.52	0.47	23.46	21.11	1055.59	950.03
Sudan Savannah (Dosso) 1161065	IT90K-372-1-2	900	0.42	0.38	19.11	17.20	860.05	774.04
	IT89KD-374-57	900	0.42	0.38	19.11	17.20	860.05	774.04
	IT98K-205-8	900	0.42	0.38	19.11	17.20	860.05	774.04
	IT97K-499-35	900	0.42	0.38	19.11	17.20	860.05	774.04
	IT97K-499-38	900	0.42	0.38	19.11	17.20	860.05	774.04
	IT99K-573-1-1	900	0.42	0.38	19.11	17.20	860.05	774.04
Sahel Savannah (Zinder) 1121783	IT90K-372-1-2	900	0.41	0.37	18.47	16.62	830.95	747.86
	IT89KD-374-57	900	0.41	0.37	18.47	16.62	830.95	747.86
	IT98K-205-8	900	0.41	0.37	18.47	16.62	830.95	747.86
	IT97K-499-35	900	0.41	0.37	18.47	16.62	830.95	747.86
	IT97K-499-38	900	0.41	0.37	18.47	16.62	830.95	747.86
	IT99K-573-1-1	900	0.41	0.37	18.47	16.62	830.95	747.86
Total			8.14	7.32	366.21	329.59	16479.53	14831.58

Table 3. Certified seed production (t) plan over three years.

Variety	2012	2013	2014
IT99K-573-1-2	1200	1800	2471.93
IT98K-205-8	1200	1800	2471.93
IT90K-372-1-3	700	1300	2471.93
IT89KD-374-57	750	1400	2471.93
IT97K-499-39	700	1350	2471.93
IT97K-499-36	700	1300	2471.93
Total	5250	8950	14831.58

Seed production plan

Cowpea seed production plan for Niger is presented in Tables 2 and 3. The quantity of seed will be produced mainly by Alheri Seed Co, other small-scale seed companies and community seed producers and three seed companies that are now actively involved in cowpea seed production. IITA and INRAN will supply the foundation seed to the various seed companies.

Vision of success for cowpea in Niger

Highest productivity level of cowpea of >0.5 t ha^{-1} will be attained at national and global levels that attributes to the wealth of producer farmers with significant contribution to home consumption. The overall production will satisfy the national demand to significantly contribute to the GDP with significant amount of exports and/or agro-processing.

Nigeria

Groundnut

Candidus Echekwu, Bonny Ntare, Jupiter Ndjeunga and Hakeem Ajeigbe

Introduction

Nigeria is the largest groundnut producing country in West Africa accounting for 51% of the production in the region. The country produces 10% and 39% of the World and Africa's total production respectively. Prior to 1980s, groundnut production declined significantly due to rosette incidence and drought. However, since 1984, production has been increasing at a growth rate estimated to be 8% resulting both from area expansion (6%) and increased productivity of 2% (Source: Ndjeunga and Ibro 2010) (Fig. 1). Groundnut is a major cash crop for many households accounting for 21% of rural cash earnings and is a major source of employment. Due to insufficient groundnut seed, processors and marketers for example, in Kano state source groundnut from neighboring countries such as Chad. This year round demand means farmers can easily increase production without fear of market glut. The current demand for groundnut is more than 3.7 million tons and this is expected to grow at 8.2% per year (Table 1). The proportion of the crop sold is 47% thus contributing to household income. The role of groundnut in enhancing rural household livelihood is important and has been well documented. Groundnut increases the total value of production per hectare by increasing cereal production (intensifying cereal-based cropping systems through intercropping, relay cropping and rotation) with biological nitrogen fixation (BNF). By raising food production through BNF of cereal crops, it also increases food security. Groundnut is a nutritious and safe food and contributes to improved health of the rural population. It is rich in protein, oil and micronutrients such as iron and zinc. Their amino acid profiles complement those of cereals, such that consuming them together raises the nutritional effectiveness of both. High iron and zinc contents are especially beneficial for women and children at risk of anemia and have proven to be genetically malleable.

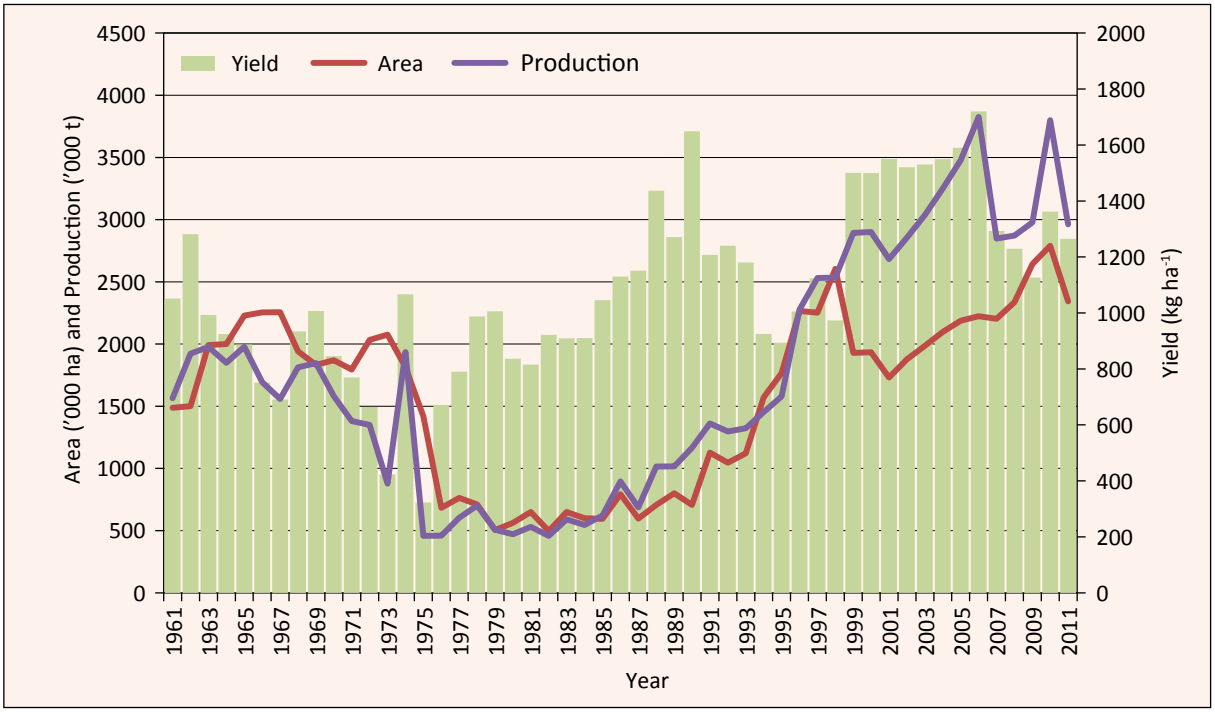

Figure 1. Trends in groundnut area, production and yield in Nigeria during 1961–2011 (Source: FAOSTAT 2012).

Table 1. Area and production of groundnut in Nigeria[1].

Parameter	Value
Average area (ha)	2,462,872
Average production (t)	3,091,946
Average yield (current) (kg ha^{-1})	1,255
Average yield (2015) (kg ha^{-1})	1,750
National demand (t)	3,720,298
Expected growth of production (%)	8.12
Proportion of production sold (%)	47

1. Source: FAOSTAT (2007–11).

Agroecologies for groundnut production in Nigeria

Traditional groundnut commercial producing areas encompass the Sahel, Sudan, Northern Guinea and most parts of the Southern Guinea vegetation zone. The major groundnut producing states are Kano, Katsina, Kaduna, Jigawa, Sokoto, Zamfara and Kebbi in the Northwest; Adamawa, Bauchi, Yobe and Borno in the Northeast; and Benue, Plateau, Taraba, Nasarawa, FCT Abuja, Kogi, Niger and Kwara in the Central zone (Table 2).

Table 2. Major constraints to groundnut production in Nigeria[1].

Ecology/States	Area ('000 ha)	Key constraints
Sudan-Sahel savanna (Kano, Katsina Jigawa, Sokoto, Zamfara, Borno)	712	Rosette, drought, aflatoxin contamination
Northern Guinea savanna (Kaduna Bauchi, Benue, Taraba)	391	Rosette, early and late leaf spots
Southern Guinea savanna (Plateau, Niger, Nasarawa)	327	Rosette, early and late leaf spots

1. Source: ADP reports, 1998.

Groundnut research and dissemination process

The Institute for Agricultural Research (IAR) of Ahmadou Bello University at Samaru has the national mandate to conduct groundnut improvement research. Prior to 1992, breeding work was undertaken by IAR. About 20 varieties were developed or adapted and were officially released and listed in the national catalog. Most of the varieties were medium to late maturing and were grown in the dry savannah region of Northern Nigeria. Among these the most dominant were 55-437, RRB, RMP 12, RMP 91 in the Sudano-Sahel zone, T28-204, Spanish 205, M25.68, 69-101, F452.4 in the Northern Guinea zone and RMP 12, RMP 21, 55-437 in the Southern Guinea zone. Except for 55-437 and RRB, which are early maturing (90 days to maturity), all are late maturing requiring more than 120 days to attain maturity and thus susceptible to end of season drought in the short season Sahel-Sudan savanna zones. The early-maturing varieties are still popular but are highly susceptible to groundnut rosette disease, rendering them risky in case of rosette epidemics.

Since most of the varieties could not escape drought and were susceptible to the rosette virus, research was focused on the development of early-maturing varieties tolerant/resistant to the rosette virus. Since 1990, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), IAR, the University of Georgia and the Peanut-CRSP developed and tested 44 groundnut varieties less

susceptible to foliar diseases and most importantly resistant/tolerant to rosette. These varieties were tested in multiplication trials in partnership with the State Agricultural and Rural Development Authorities (ADRAs) of Kaduna, Kano, Katsina and Jigawa states. From this program, three varieties [UGA 2 (SAMNUT 21), M 572.80I (SAMNUT 22) and ICGV-IS 96894 (SAMNUT 23)] were formally released in 2001. Likewise, further research efforts in the same states led to the identification of three other promising varieties including ICIAR 19BT, ICIAR 7B and ICIAR 6AT. These are early maturing and resistant to groundnut rosette. ICIAR 19 BT was released as SAMNUT 24 in 2011 bringing the total number of registered groundnut varieties in Nigeria to 24. Effort is underway to popularize the new varieties through the TL-II project.

Socioeconomic and organizational constraints

Despite the availability of new improved groundnut varieties, access to these by farmers is still limited by socioeconomic challenges including:

- Limited availability of improved seeds due to absence of seed marketers
- Lack of organized credit and input delivery system
- Labor constraints for weeding, harvesting and threshing
- Poorly developed markets which lead to volatile prices
- High transport costs from farms located mainly in rural communities to markets
- Poorly motivated extension agents and only very few NGOs with interest in agriculture operate in the country

The farmers who grow groundnut are generally not well organized. The agricultural development programs in different states do not make deliberate efforts to promote formation of strong farmers' groups that could constitute pressure groups in their respective states. The few farmers' organizations that exist have support of government to some extent and are therefore not strong enough to challenge unpopular policies. The weak organizational structures also make it difficult for farmers to have good prices for their produce. Often the farmers are at the mercy of middlemen who purchase farm products and transport to urban areas where they sell at high prices.

Strategic partners

The strategic partners and their role in groundnut seed system are given in Table 3.

Capacity building needs (staff, infrastructure)

- Degree and non-degree training for staff in research institutions on data management, impact assessment and breeding techniques.
- Support for the development and use of molecular marker tools to improve breeding efficiency

Special cultural/gender considerations

Support for women involved in processing: Small-scale groundnut oil extractor facility is a means of income generation for women in *pudah* as well as the old women and young girls who sell the oil and *kulikuli* (cake) at home and in the rural markets. Women are in complete control of preparing and marketing groundnut-based foods. They derive a lot of income from these activities. In addition, their children who consume these food products are generally healthy.

Table 3. Strategic partners and their role in the seed system.

Partner	Role
Federal Department of Agriculture and Agricultural Research Council of Nigeria	Policy formulation and supervision of commodity-based agricultural research institutions
Institute for Agricultural Research (IAR)	Responsible for the improvement of groundnut and other oilseed crops, provide laboratory and other technical services to agricultural organizations, farmers, agro-based industries and others needing these services; research into the total farming systems and problems of production of all agricultural crops grown in the North West zone of the country; maintain strong Agricultural Extension Liaison with Federal and State Ministries of Agriculture and Agro-based Industries, Agricultural Development Projects (ADPs) and other end-users of research results in the zone
ICRISAT	Technology development, backstopping in training, technical skills in priority areas, development of joint projects, variety maintenance and breeder seed production
NGOs such as SG 2000 and CRS	Technology dissemination especially in rural areas
Private seed companies and farmers	All groundnut sub-sector operations are under the control of the private sector operators; production of the crop is mainly by small holders who are unorganized; marketing, processing and trade are carried out by individual farmers, merchants and private companies

Processing and storage requirements and market opportunities

Groundnut processing is carried out at the small, medium and industrial levels in Nigeria. There is a large market for all the extracted oil from groundnut. The cakes that remain after oil extraction are used to produce highly nutritious animal feeds. In processing on a small scale, simple tools such as mortar and pestle or motorized oil extractor are used and cake is obtained as a by-product that could be used in different ways.

Storage of groundnut is not a major problem if the pods are well dried. Dried groundnut pods are stored in bags for months after harvest without damage. The shelled nut is also stored in bags and can be kept for a long time without insect damage.

Key policies (recently implemented/needed)

There was a recent review of the National Agricultural Seed policy geared towards liberalizing the seed sub-sector and encouraging a more active role for the private sector in the seed industry. The other recent policy thrust is the promotion of research to develop high-yielding, drought tolerant, pest and disease resistant varieties of different crops. IAR works on groundnut and there is a strong collaboration with the TL-II Project. Development of improved varieties and their evaluation in fields are jointly carried out. The institutions collaborate to ensure that new improved varieties get registered and disseminated. The extension services of the NARS and the ADPs also promote crop production and storage practices that reduce the level of aflatoxin contamination in groundnut. There is a recent policy shift in the federal Ministry of Agriculture to focus R&D along the commodity chain. The groundnut commodity chain is on board in 2013 fiscal year.

Key issues for competitiveness (ie, reducing production costs, increase market value)

High-yielding, disease resistant, drought tolerant groundnut varieties with high oil content are available in Nigeria. The continued adoption and production of these varieties will depend on the profitability of their production. The profitability will depend on the cost of production and various prices of their products (grain and haulm) which are invariably dependent on their market demand. The use of appropriate harvesting techniques and good storage will also minimize aflatoxin contamination and improve the market for groundnut.

Mechanization as it relates to timely planting/harvesting and processing

Groundnut production is labor intensive. Farmers are largely poorly equipped with agricultural implements. Most (about 80%) own hand tools and less than 5% own complete sets of animal traction equipment (ie, a pair of bullocks, a plow and multipurpose equipment and a seeder) for production. Harvesting is largely by hand and threshing and processing are by use of rudimentary tools not amenable to large-scale processing at the local level. The low level of equipment has significant implications on the potential for intensification. In this case the returns to investment in small mechanization in the form of simple animal traction may be high. Access to production and processing equipment is essential to increase productivity and profitability.

Monitoring and evaluation

To fully assess the impact of the groundnut sector the Agricultural Monitoring and Evaluation Unit (AMEU) conducts monitoring/evaluation of activities of the agencies involved in the program implementation by using appropriate indicators and formats. The AMEU's role is linked with all implementing agencies and even processors, exporters, etc to be able to determine the supply/demand perspectives. Sub-regional and national work planning meetings are held yearly to review and report progress.

Perspectives for Phase 2

Currently the adoption rate of groundnut varieties released in the last 10 years is estimated at 22% of the farmers accounting for 13% of the groundnut area planted. There is therefore large adoption gap implying that there is potential to increase adoption of modern groundnut varieties based on awareness or promotion. The activities implemented in Phase 1 of the project will continue in Phase 2 in Nigeria. The process of release and registration of crop varieties will be sustained by TL-II as in Phase 1. The application of new molecular tools to crop improvement will be initiated and tested in the second phase based on results obtained from activities carried out in the TL-I project. More efforts will be put on production of adequate quantities of breeder, foundation and various classes of certified seeds as shown in the seed plan presented in Table 4.

The planned seed production is based on a seeding rate of 70 kg of seed and quantities to cover 20% groundnut area and 20% adoption rate. The projected certified seed is predominantly from the research institutions including IAR, ICRISAT and Bayero University of Kano. Efforts will only cover 10% of the area covered. To cover this gap, efforts will be made to engage more partners including the seed companies and ADPs and use all possible niches with irrigation facilities.

Table 4. Groundnut seed production plan for Nigeria.

Ecology	Demand (ha)	Promising varieties	Seed available (t)		Seed to reach 20% adoption (t)	Seed production goal (t)								
						Breeder seed			Foundation seed			Certified seed		
			Breeder seed	Foundation seed		Year 2012	Year 2013	Year 2014	Year 2012	Year 2013	Year 2014	Year 2012	Year 2013	Year 2014
Sudan savanna	776609	Samnut 21	0.15	4.618	10873	0.15	1.07	2.14	4.618	1.71	24.49	59.37	22.04	314.87
		Samnut 22	0.15	1.57		0.15	1.07	2.68	1.57	1.71	30.61	20.19	22.04	393.59
		Samnut 23	0.15	2.57		0.15	1.07	2.68	1.57	1.71	30.61	20.19	22.04	393.59
		Samnut 24	0.10	3.618		0.10	0.71	2.14	3.618	1.14	24.49	46.52	14.69	314.87
Northern Guinea savanna	1138541	Samnut 21	0.15	2.1	15940	0.15	1.07	2.14	2.1	1.71	24.49	27.00	22.04	314.87
		Samnut 22	0.15	0.57		0.15	1.07	2.14	0.57	1.71	24.49	7.33	22.04	314.87
		Samnut 23	0.15	0.57		0.15	1.07	2.14	0.57	1.71	24.49	7.33	22.04	314.87
Sahel savanna	168360	Samnut 23	0.15	0.1	2357	0.15	1.07	2.14	0.1	1.71	24.49	1.29	22.04	314.87
		Samnut 24	0.10	2.1		0.1	0.71	2.14	2.1	1.14	24.49	27.00	14.69	314.87
Southern Guinea savanna	1767875	Samnut 21	0.15	0.57	24750	0.15	1.07	2.14	0.57	1.71	24.49	7.33	22.04	314.87
		Samnut 22	0.15	0.57		0.15	1.07	2.14	0.57	1.71	24.49	7.33	22.04	314.87
		Samnut 23	0.15	0.57		0.15	1.07	2.14	0.57	1.71	24.49	7.33	22.04	314.87
Derived savanna	105042	Samnut 21	0.15	0.57	1471	0.15	1.07	2.14	0.57	1.71	24.49	7.33	22.04	314.87
		Samnut 22	0.15	0.57		0.15	1.07	2.68	0.57	1.71	30.61	7.33	22.04	393.59
		Samnut 23	0.15	0.57		0.15	1.07	2.68	0.57	1.71	30.61	7.33	22.04	393.59
Total					55390							260.18	315.92	5037.9

Cowpea

Olusoji Olufajo, Muhammad L Umar, Christian Fatokun, Ousmane Coulibaly, Alpha Kamara and Ousmane Boukar

Introduction

Importance of the crop in Nigeria

With an estimated 45% share of the global cowpea production and over 55% of the production in Africa, Nigeria is the largest producer and consumer of cowpea worldwide. The major cowpea producing states are Kano, Katsina, Kaduna, Jigawa, Sokoto, Zamfara and Kebbi in the Northwest; Adamawa, Bauchi, Yobe and Borno in the Northeast; Benue, Plateau, Taraba, Nasarawa, FCT Abuja, Kogi, Niger and Kwara in the North Central zone. About 2,885,000 tons of grains are produced annually on 4,346,000 ha (Fig. 1) which amounts to an average yield of about 664 kg ha^{-1}. Cowpea accounts for about 9.7% of the total area planted to the major crops (about 12) in Nigeria. It constitutes one of the major sources of dietary protein. It also provides cash income for subsistence farmers, retailers and food vendors in rural and urban areas. Cowpea grains are processed into different forms for human consumption such as *akara* or *kosai*, etc. All the cowpea produced in the country is consumed and the shortfall is augmented with imports from neighboring countries, mainly Republic of Niger. The haulm is quality fodder for livestock. The current demand for cowpea grains is nearly 3.2 million tons and this is expected to grow at 3.6% per year. Nigeria is projected to remain net-importer of cowpea through 2020. Producer prices in Nigeria have undergone several fluctuations from 1996 to 2008. For example, the price fell from US$ 2065 per ton in 1996 to US$ 451 per ton in 2000; it was US$ 697 per ton in 2008 (Source: Abate 2012).

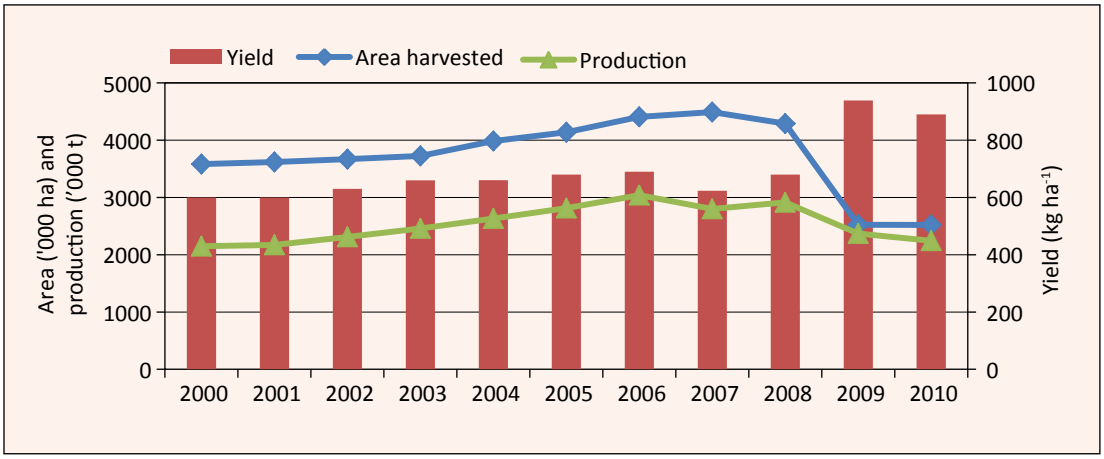

Figure 1. Trends in cowpea area, production and yield in Nigeria during 2000 to 2010 (Source: FAOSTAT 2012).

Cowpea contribution to national GDP, farmer income, food and nutrition security

Cowpea is an important cash and food crop in Nigeria. Farmers sell more than 90% of their produce. The bulk of cowpea is produced in dry savanna areas while its consumption is throughout the country. The agricultural gross domestic product (GDP) is contributed by crops (85%) while the agriculture sector contributes about 40% of the GDP (Source: NFSP 2008). Cowpea has been for many years a crop that combats food insecurity. Cowpea processors have been supported so that they can not only

provide a ready market for Nigerian farmers, but also meet shifting consumer demand patterns. The main preferred traits of improved cowpea varieties are high yield potential, pest/disease resistance, good performance under poor rainfall, superior storage pest resistance, large grain size, rough white or brown seed coat, stable yield, early maturity and drought tolerance.

In Nigeria, the project Maximizing Agricultural Revenue of Key Enterprises in Target Sites (MARKETS) has started working with farmers in Kano and Niger states, introducing seeds of high-yielding varieties and training farmers through on-farm demonstrations. Cowpea is an important cash crop in Nigeria and provides income to rural households through country internal commercialization. Little information is available on cowpea trade, perhaps because it is not traded internationally. However, considering a projected deficit of 1,331,000 tons in 2010 and the 2007–09 average price for Sub-Saharan Africa (SSA) of US$ 472.20 per ton (Source: FAOSTAT), Nigeria's current import of cowpea is estimated at approximately US$ 628,498,200 per year. In 2010 cowpea production was 2,242,800 tons with projected deficit of 1,331,000 tons; thus Nigeria imported about 59% of its production. The domestic trade of cowpea concerns about 80% of the total production and the income per ha is around US$ 465.

In Nigeria, 71% of male-headed households reported lack of cash availability to purchase cowpea. Producer price fluctuation is a major drawback for cowpea development (Fig. 2). Prices in Nigeria fell from US$ 2,065 per ton in 1996 to US$ 451 per ton in 2000. Household net-sellers account for 7% of cowpea trade/sales in Nigeria. The National Price Transmission in Kano and Lagos is shown in Figure 3. More than 10,865,951 persons benefit from cowpea production and the per capita consumption of cowpea in Nigeria is 30.8 kg per year. The cowpea supply and demand in Nigeria during the next two decades are shown in Figure 4.

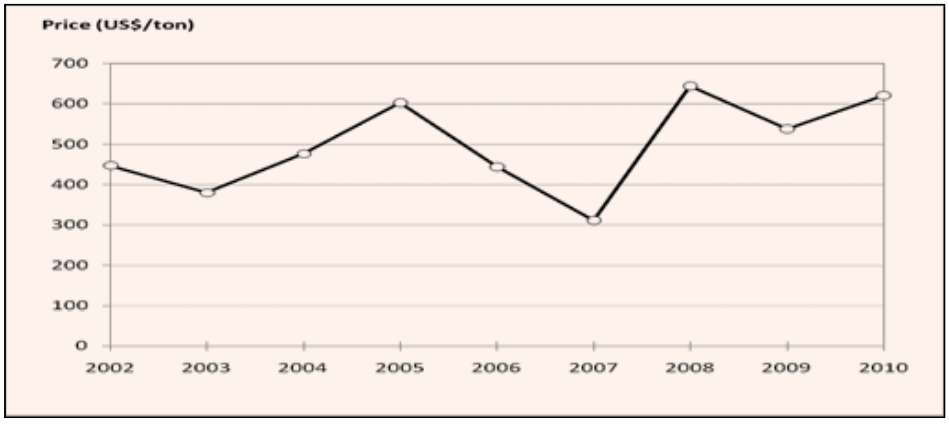

Figure 2. Cowpea price trend in Nigeria during 2002 to 2010.

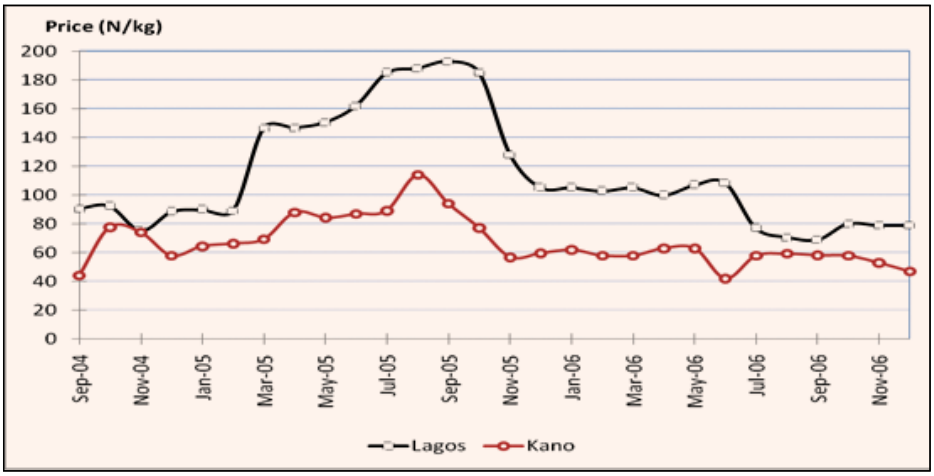

Figure 3. National price transmission in Kano and Lagos from September 2004 to November 2006.

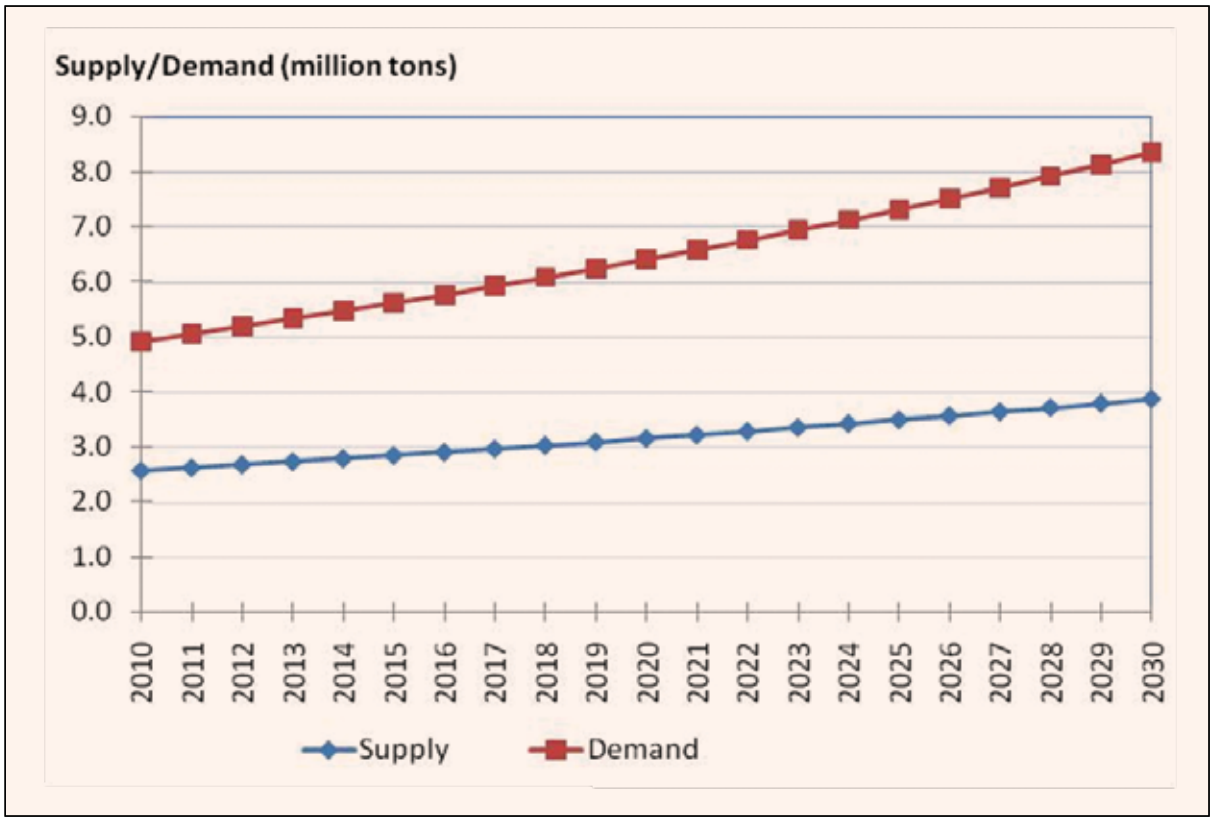

Figure 4. Cowpea supply and demand in Nigeria from 2010 to 2030.

Cowpea research and development

Variety development

Cowpea breeding in Nigeria started in the early 1960s at Moor Plantation, Ibadan. Preliminary work was conducted in collaboration between Nigerian and USAID scientists. In addition to cowpea genetic improvement in Moor Plantation and in University of Makurdi, active cowpea research in breeding, agronomy, economics, pathology and food science is done by the Institute for Agricultural Research (IAR) based in Zaria in north central Nigeria with strong collaboration with IITA under different programs such as Cowpea Project for Africa (PRONAF) and the TL-I and TL-II projects among others. This collaboration has contributed to the release of several improved varieties with farmers' and consumers' preferences (Table 1).

Major constraints to cowpea production in Nigeria

The major constraints to cowpea production include social, biological, physical and technological environments. The major constraints are:

- Biotic stresses: Insect pests (aphids, flower thrips, pod sucking bugs, *Maruca*, bruchids), diseases (bacterial, viral and fungal), *Striga* and *Alectra*
- Abiotic stresses: Drought, heat, low soil fertility
- Poor access to inputs such as seeds of improved varieties, wholesome insecticides and fertilizers
- Lack of organized credit and input delivery system

Table 1. Characteristic features of common varieties developed by the Nigerian research system.

Official name of release	Year of release	Source of the materials	Genetic background (parentage, pedigree, ancestry)	Area of potential coverage (ha)	Area of actual adoption estimate (ha)	Spillover national boundaries	Average yield potential (on-farm) (kg ha^{-1})	Varietal traits (selected characteristics)
IT89KD-288	2009	IITA	IT89KD-288	109,383	240,526	Yes	700	Grain yield, medium maturity, dual-purpose, resistant to aphids and bruchids, intercropping
IT89KD-391	2009	IITA	IT89KD-391	72,922	120,263	Yes	700	Grain yield, medium maturity, tolerant to aphids
IT90K-277-2	2008	IITA	IT90K-277-2	109,383	240,526	Yes	700	Grain yield, medium maturity, field resistant to anthracnose, bacterial blight, brown blotch and viruses
IT93K-452-1	2005	IITA	IT93K-452-1	72,922	120,263	Yes	600	Grain yield, early maturity, field resistant to major insects, heat tolerant
IT97K-499-35	2008	IITA	IT97K-499-35	182,305	72,158	Yes	700	Grain yield, early maturity, combined resistance to *Striga* and *Alectra*
IT98K-573-2-1	2011	IITA	IT98K-573-2-1	91,152	241	Yes	700	Grain yield, early maturity, *Striga* resistant
IT98K-573-1-1	2011	IITA	IT98K-573-1-1	91,152	241	Yes	750	Grain yield, early maturity, *Striga* resistant

- Poor agronomic practices and lack of appropriate machinery for expanding planted area
- Poorly developed markets, high cost of transportation of produce to the markets, weak farmer organizations, poorly motivated extension staff, and fluctuations in producer prices are among the major institutional and organizational constraints.

Planned Phase 2 activities and their contributions to national efforts

In TL-II Phase 2, we plan to bring about a major impact through improved cowpea technologies that would be implemented especially in the important cowpea production environments or agroecologies. At the end of this project it is expected that productivity of cowpea should reach at least >1.5 t ha^{-1} and the national productivity should increase from 0.6 in 2012 to 1 t ha^{-1} by 2014.

Expected outcomes from Phase 2 cowpea improvement for production and productivity

Cowpea farmers and farm practitioners will obtain higher income. The national cowpea production will increase to more than 3.3 million tons with productivity of 1 t ha^{-1}. There would be a reduction in the deficit resulting from higher demand than supply, which should save the country some foreign exchange.

Agroecologies for cowpea cultivation in Nigeria

Cowpea is grown mainly in the Northern Guinea Savanna, Sudan Savanna and Sahelian Savanna. Some cultivation is also noticeable in Southern Guinea Savanna and Derived Savanna. Data from 2006 (National Bureau of Statistics, Nigeria) were used to produce the maps in Figures 5 and 6. There are several states with cowpea occupying more than 200,000 ha and there are states with average productivity level greater than 1 t ha^{-1}.

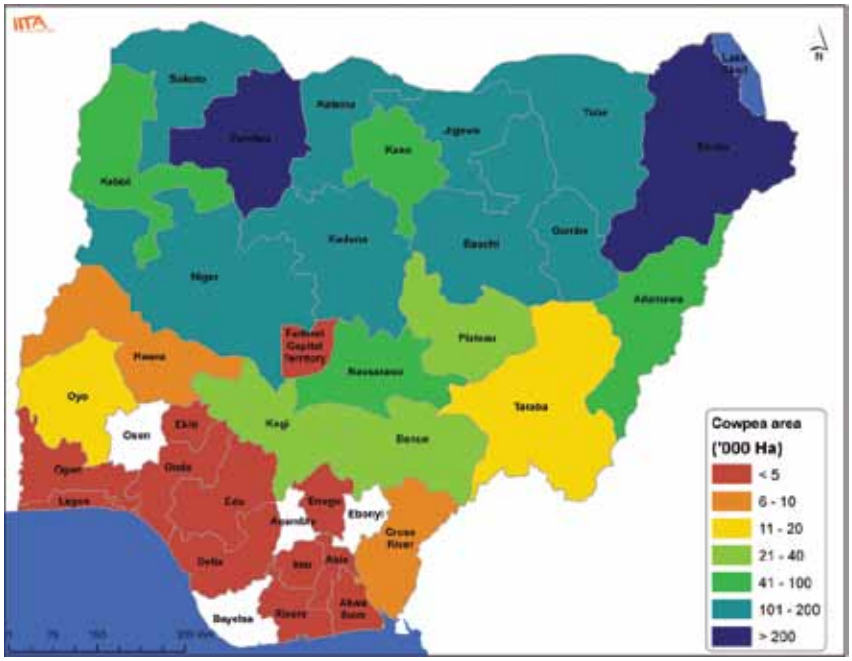

Figure 5. Cowpea production areas in Nigeria.

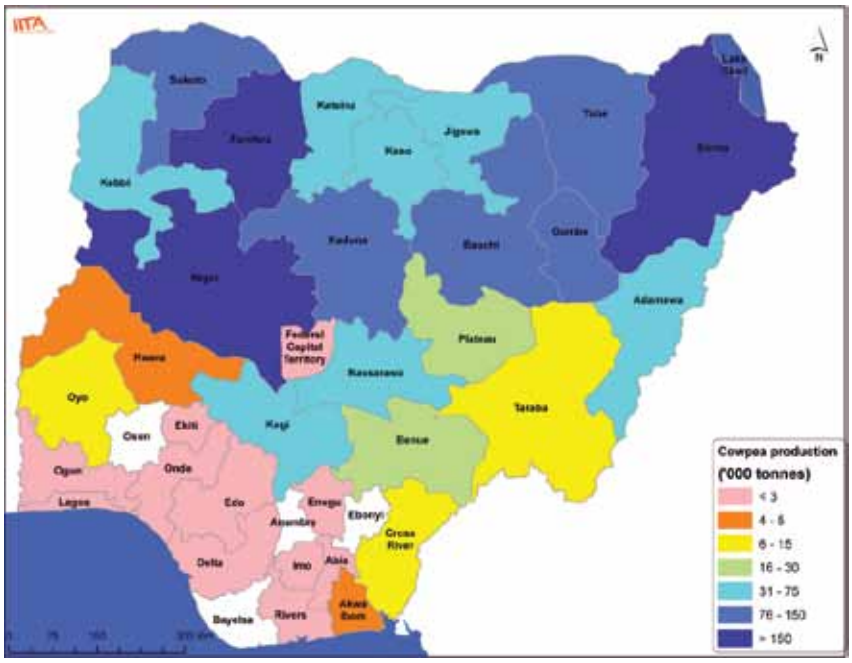

Figure 6. Cowpea yield distribution in different states of Nigeria.

Seed systems for a legumes green revolution in Nigeria

Cowpea is the most important food legume in Nigeria providing a cheap source of protein, as well as income for millions of resource-poor families. A number of dual-purpose cowpea varieties have been developed with yield potential of 1.5 to 2.5 t ha^{-1} grain and 2.5 to 4 t ha^{-1} fodder. Despite progress made in the development of improved cowpea varieties for marginal areas, the adoption of improved seeds by farmers for growing cowpea is slow in Nigeria with less than 10% of area under new varieties. The low uptake is due to constraints in both the supply and demand for seeds. Consequently, most of the seeds being planted are derived from previous years' harvest from farmers' fields. In general, farmers seek seed from off-farm sources to replace seed that has been recycled over too many years, to change the crop variety, or to supplement stock that has been unexpectedly depleted. Cowpea is almost unique to Nigeria and Niger, as the two countries account for 87% of the world's cowpea production. Cowpea's seeding rate is high but its multiplication rate is low, and it takes many years to recover the seed stock through recycling once it is depleted. Such stock depletion is therefore an important factor that explains the demand for cowpea seed. The low multiplication rate due to lower yields makes cowpea unattractive to established seed companies to trade in cowpea seeds. They prefer the highly profitable hybrid maize seed sector. Cowpea area and projected yield are given below.

Area: 3,646,116 ha

Seed rate (mean): 20 kg ha^{-1}

National demand: 72,922 tons (2012–14)

Capacity to deliver 20% area: 729,223 ha ≃14,600 tons

Target of productivity: 1.5 t ha^{-1} at intervention sites and 1 t ha^{-1} at national level

Total production target: >4,010,000 tons

Nigerian seed system strategy (2012–14)

The overall strategy is to improve farmers' access to quality seed and enhance widespread adoption of improved cowpea varieties in Nigeria through the development and promotion of community seed production and promotion of local market for seed through linkage with private seed companies. Over the years IITA has made efforts to encourage formal seed sector particularly in Nigeria to produce and market certified seed of cowpea. The national seed council and national agricultural research systems (NARS) were encouraged to produce foundation seed for use by certified seed producers. However, most seed companies primarily produce hybrid maize seed because of its high value and high multiplication rate. Cowpea foundation seed production by the NARS is very low because of poor funding by the government. The Nigerian Government has however, liberalized foundation seed production, which makes it possible for research institutions to produce foundation seed and supply to seed companies. Because of increasing demand for cowpea seeds, a number of seed companies have shown interest in certified seed production with Premier Seed Co now marketing cowpea seeds. To promote new crop varieties among farmers, IITA has initiated community-based seed production schemes in collaboration with extension institutions in the country. Through this scheme, several tons of seed of new cowpea varieties have been produced and sold to farmers in local communities in northern Nigeria. Some of the community seed producers have grown into seed cooperatives.

Opportunities, constraints, partnership and seed production plan

The target is to cover 20% of each important cowpea agroecology in Nigeria with improved seed.

Opportunities

- Well developed informal seed system experience
- Good market setup for cowpea in general and cowpea seed in particular
- Policy environment that enhances innovative seed system
- Availability of suitable varieties in major cowpea growing areas
- Sufficient land mass suitable for cowpea (millions of ha)
- High consumption level/culture in the country

Constraints

- Seed production and marketing is only picking up gradually
- Low capacity of national seed council to certify seed
- Insect pests from field to the store
- Poor seed distribution systems (lack of seed dealers in communities)

Partners and their role

- Federal Ministry of Agriculture and Rural Development, and Agricultural Research Council of Nigeria: Policy formulation and supervision of commodity-based agricultural research institutions.
- Institute for Agricultural Research (IAR), Ahmadu Bello University (ABU), University of Agriculture, Makurdi, Bayero University, Kano (BUK): Responsible for the improvement of cowpea; provide laboratory and other technical services to agricultural organizations, farmers, agro-based industries and others needing these services; research into the total farming systems and problems of production of all agricultural crops grown in the northern parts of the country; maintain strong Agricultural Extension Liaison with Federal and state Ministries of Agriculture and Agro-based industries, Agricultural Development Projects (ADPs) and other end-users of research results in the zones. They also produce foundation seed for seed companies.
- IITA: Technology development, backstopping in training, technical skills in priority areas, development of joint projects and production of breeder and foundation seeds.
- NGOs such as SG 2000 and CRS: Carry out technology dissemination activities especially in rural areas.
- State extension organizations (ADPs) in the cowpea production regions: Provide guidance to farmers (through demonstrations, training, field days, radio programs) to produce cowpea profitably.
- Seed companies (Jirkur Seed Coop, Premier Seed Co, Maina Seed Co, Project Seed Co and Dalgreen Seed Co) in the Nigeria savannas: Produce and market certified seeds.
- National Seed Council, Nigeria: Ensures seed quality through capacity building of seed companies and seed certification.

Seed production plan

Cowpea seed production plan is given in Tables 2 and 3. The seed will be produced mainly by community seed producers and three seed companies that are now actively involved in cowpea seed production. IITA and the IAR, Zaria will supply foundation seed to the various seed companies.

Table 2. Cowpea seed production in Nigeria from 2012 to 2014.

			Breeder seed in 2012		Foundation seed in 2013		Certified seed for use in 2014	
Agroecological demand (ha)	Variety demand	Yield (kg ha^{-1})	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
Sudan Savanna 1260806	IT97K-499-35	1100	0.38	0.42	20.84	22.92	1146.19	1260.81
	IT98K-573-2-1	1100	0.38	0.42	20.84	22.92	1146.19	1260.81
	IT98K-573-1-1	1100	0.38	0.42	20.84	22.92	1146.19	1260.81
	IT89KD-288	1100	0.38	0.42	20.84	22.92	1146.19	1260.81
Northern Guinea Savanna 387014	IT97K-499-35	1100	0.12	0.13	6.40	7.04	351.83	387.01
	IT98K-573-1-1	1100	0.12	0.13	6.40	7.04	351.83	387.01
	IT98K-573-2-1	1100	0.12	0.13	6.40	7.04	351.83	387.01
	IT89KD-288	1100	0.12	0.13	6.40	7.04	351.83	387.01
Sahel Savanna 354910	IT97K-499-35	1100	0.11	0.12	5.87	6.45	322.73	355.00
	IT98K-573-1-1	1100	0.11	0.12	5.87	6.45	322.73	355.00
	IT98K-573-2-1	1100	0.11	0.12	5.87	6.45	322.73	355.00
	IT89KD-288	1100	0.11	0.12	5.87	6.45	322.73	355.00
Southern Guinea Savanna 213125	IT97K-499-35	1100	0.06	0.07	3.52	3.88	193.75	213.13
	IT98K-573-1-1	1100	0.06	0.07	3.52	3.88	193.75	213.13
	IT98K-573-2-1	1100	0.06	0.07	3.52	3.88	193.75	213.13
	IT89KD-288	1100	0.06	0.07	3.52	3.88	193.75	213.13
Derived Savanna 189405	IT97K-499-35	1100	0.06	0.06	3.13	3.45	172.27	189.50
	IT98K-573-1-1	1100	0.06	0.06	3.13	3.45	172.27	189.50
	IT98K-573-2-1	1100	0.06	0.06	3.13	3.45	172.27	189.50
	IT89KD-288	1100	0.06	0.06	3.13	3.45	172.27	189.50
Total			2.89	3.18	159.04	174.94	8747.07	9621.78

Table 3. Certified seed production (t) plan over three years.

Variety	2012	2013	2014
IT97K-499-35	900	1750	2405.45
IT98K-573-1-1	900	1750	2405.45
IT98K-573-2-1	900	1750	2405.45
IT89KD-288	900	1750	2405.45
Total	3600	7000	9621.78

Vision of success for cowpea in Nigeria

Highest productivity of cowpea of >1 t ha^{-1} will be attained at national and global levels that attribute to the wealth of producer farmers with significant contribution to food security at farmers' home level. The overall increased production will satisfy the national demand thereby contributing significantly to the GDP with potential for exports and/or agro-processing.

Soybean

Mohammed Ishaq, Hesham Agrama and Alpha Kamara

Introduction

Soybean cultivation in Nigeria has increased in the last two decades in the savannas because it is a major cash crop widely used in food and feed (Source: Brader 1998, Sanginga et al. 2002). Soybean also constitutes an important component of the smallholder cropping systems and has considerable potential for arresting decline in soil fertility. Over the years scientists at the International Institute of Topical Agriculture (IITA) and the National Cereals Research Institute (NCRI) have developed a range of soybean varieties that store well and nodulate freely with native rhizobia strains (Okogun et al. 2004). Farmers in the areas have adopted the new varieties developed. The expansion of soybean production in Nigeria in the past decade was primarily driven by growth in the poultry and livestock sector and the need for feed. However, the existing varieties have low yield potential and are also not resistant to drought and some biotic diseases. While average grain yield of soybean in Nigeria is 1 t ha^{-1} (Source: FAO 2010), average yield is 2.7 t ha^{-1} in USA and 2.8 t ha^{-1} in Argentina (Source: Masuda and Goldsmith 2009). The huge differences in grain yield and total production of soybean may be due to several reasons. The use of low-yielding varieties and poor agronomic practices are largely responsible for the low grain yield in Nigeria. In addition, farmers do not have access to seeds of improved high-yielding varieties because the existing seed companies have not been able to meet farmers' demand for improved seeds in the main producing areas due to lack of seed dealers in communities.

Nigeria seed system strategy (2012–14)

The TL-II project has facilitated an innovation platform in Nigeria to enhance legume seed production including soybean seed production in the various agroecological regions of Nigeria. The platform consists of Institute for Agricultural Research (IAR), NCRI, State Agricultural Development Programs (State ADPs), agro-processors, major seed companies (Premier Seed Co, Maina Seed, Project Seed, Jirku Seed Association, Alheri Seed), and the University of Agriculture, Makurdi. The Agricultural Research Institute evaluates and adapts high-yielding varieties and produces foundation seed of selected varieties after their release. The State ADPs, seed companies, as well as the University of Agriculture, Makurdi are involved in large-scale demonstration and dissemination of the improved varieties across the different ecologies. They also strengthen community seed schemes to produce and market seeds of improved soybean varieties. Soybean seed production target is given below.

Area: 348,233 ha

Seed rate (mean): 50 kg ha^{-1}

National demand: 6964.50 tons (2012–14)

Capacity to deliver 10% area: 34823 ha $\simeq$ 696 tons

Target of productivity: 1.85 t ha^{-1} at intervention sites and 1 t ha^{-1} at national level

Total production target: 9398 tons

Opportunities, constraints, partnership and seed production plan

The target is to cover 20% of each important soybean agroecology in Nigeria with improved seed.

Opportunities

- High demand for soybean for feed and industrial processing
- Good market access for soybean
- Availability of suitable varieties in major soybean growing areas
- Favorable ecology (drylands) for soybean production

Constraints

- Low yield due to biotic and abiotic constraints
- Limited seed production and marketing opportunities
- Low capacity of national seed certification laboratory
- Poor seed distribution systems (lack of seed dealers in communities)

Partners and their role

- NCRI, Badegi: Responsible for the improvement of soybean in Nigeria; provides laboratory and other technical services to agricultural organizations, farmers, agro-based industries and others needing these services
- IITA: Technology development, backstopping in training, technical skills in priority areas, development of joint projects and production of foundation seed
- State Departments of Ministry of Agriculture in the various ecologies and the University of Agriculture, Makurdi: Conduct field demonstration, farmer training and varietal dissemination
- Seed companies (Premier Seed Co, Maina Seed, Project Seed, Jirku Seed Association, Alheri Seed): Produce and market certified seeds

Seed production plan

Soybean seed production plan in presented in Tables 1 and 2. The quantity of seed will be produced mainly by Premier Seed Co, Project Seed, Maina Seed, Alheri Seed, Jirku Seed Association and other small-scale seed companies and community seed producers supported by the project. IAR and NCRI will produce foundation seed. The State ADPs will work with University of Agriculture, Makurdi to facilitate seed dissemination and marketing activities.

Table 1. Soybean seed production plan for Nigeria.

Agroecology	Variety demand	Yield potential (kg ha^{-1})	Breeder seed in 2012		Foundation seed in 2013		Certified seed in 2013	
			Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Production (t)
Derived Savanna	TGX 1987-62F	1.7	1	0.5	9.4	16	322	549
	TGX 1987-10F	1.7	1	0.5	9.4	16	322	549
Southern Guinea Savanna	TGX 1987-62F	1.7			4.1	7	142	241
	TGX 1987-10F	1.7	2	1	4.1	7	142	241
Sudan Savanna	TGX 1987-62F	1.7	1	0.5	2.9	5	109	186.29
	TGX 1987-10F	1.7	0.5	0.2	2.9	5	109	186.29
Northern Guinea Savanna	TGX 1987-62F	1.7	0.6	0.3	2.9	5	102	174.48
	TGX 1987-10F	1.7	0.5	0.25	2.9	5	102	174.48
	TGX 1904 -6F	2.5	0.5	0.25	2.1	3.5	102	174.48
Arid/Sahel	TGX 1835-10E	1.7			0.3	0.5	5.8	10
	TGX 1835-10E	2.5	2	1	0.1	0.2	5.8	10

Table 2. Certified seed production (t) plan over three years.

Ecology	Variety	2012	2013	2014
Derived Savanna	TGX 1987-62F	549	549	549
	TGX 1987-10F	549	549	549
Southern Guinea Savanna	TGX 1987-62F	241	241	241
	TGX 1987-10F	241	241	241
Sudan Savanna	TGX 1987-62F	186.30	186.30	186.30
	TGX 1987-10F	186.30	186.30	186.30
Northern Guinea Savanna	TGX 1987-62F	174.49	174.49	174.49
	TGX 1987-10F	174.49	174.49	174.49
	TGX 1904-6F	174.49	174.49	174.49
Arid/Sahel	TGX 1835-10F	10	10	10
	TGX 1904-6F	10	10	10

Senegal

Groundnut

Issa Faye, Bonny Ntare and Jupiter Ndjeunga

Introduction

Groundnut is the major cash and food crop in Senegal representing up to 60% of the cultivated area and 70% of rural labor force. The groundnut sector contributes up to 6.5% of GDP. The crop is produced under rainfed conditions mainly in the northern, central and southern groundnut basins. There is potential for irrigation in the Senegal River basin. Average area and production are presented in Table 1. The trends in these parameters are presented in Figure 1.

Table 1. Average area and production of groundnut in Senegal[1].

Parameter	Value
Average area (ha)	912,894
Average production (t)	781,889
Average yield (current) (kg ha^{-1})	816
Average yield (2015) (kg ha^{-1})	1200
Expected growth of production (%)	3
Proportion of production sold (%)	75

1. Source: FAOSTAT 2007–11.

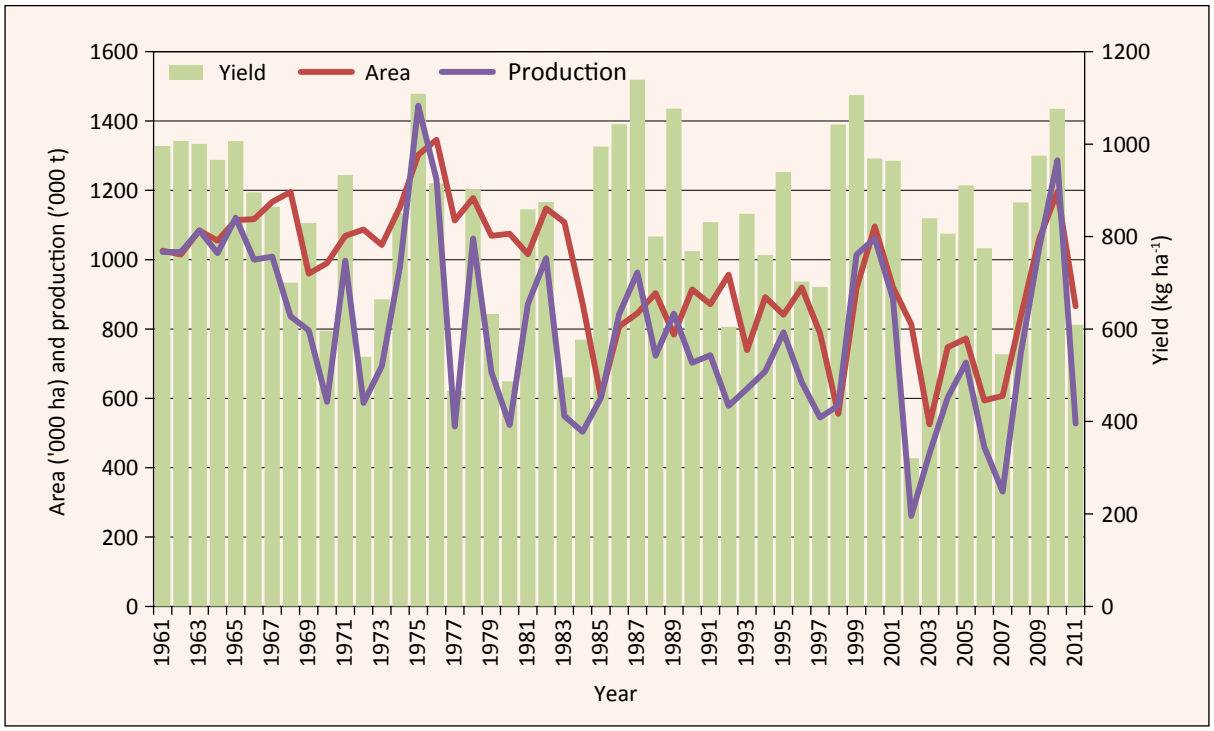

Figure 1. Trends in groundnut area, production and yield during 1961 to 2011 in Senegal.

Dominant varieties

The dominant groundnut varieties include: Fleur 11, 55-437, 28-206, 69-101, GH119-20, Hâtive de Séfa and 73-33**.**

New releases in 2009 include: Four extra-early maturing varieties (55-33, SRV1-19, 78-936 and 73-9-11); one early leaf spot resistant variety (PC79-79) and one confectionery variety (H75-0) with higher resistance to *Aspergillus flavus* than the old variety GH119-20.

Agroecologies

Senegal is divided into three major agroecological zones, viz, the Sahaelian, Sudan Savanna and Forest zones. For groundnut, Senegal is divided into three groundnut basins (north, central and south). The bulk of the crop is produced in the central groundnut basin (Fig. 2).

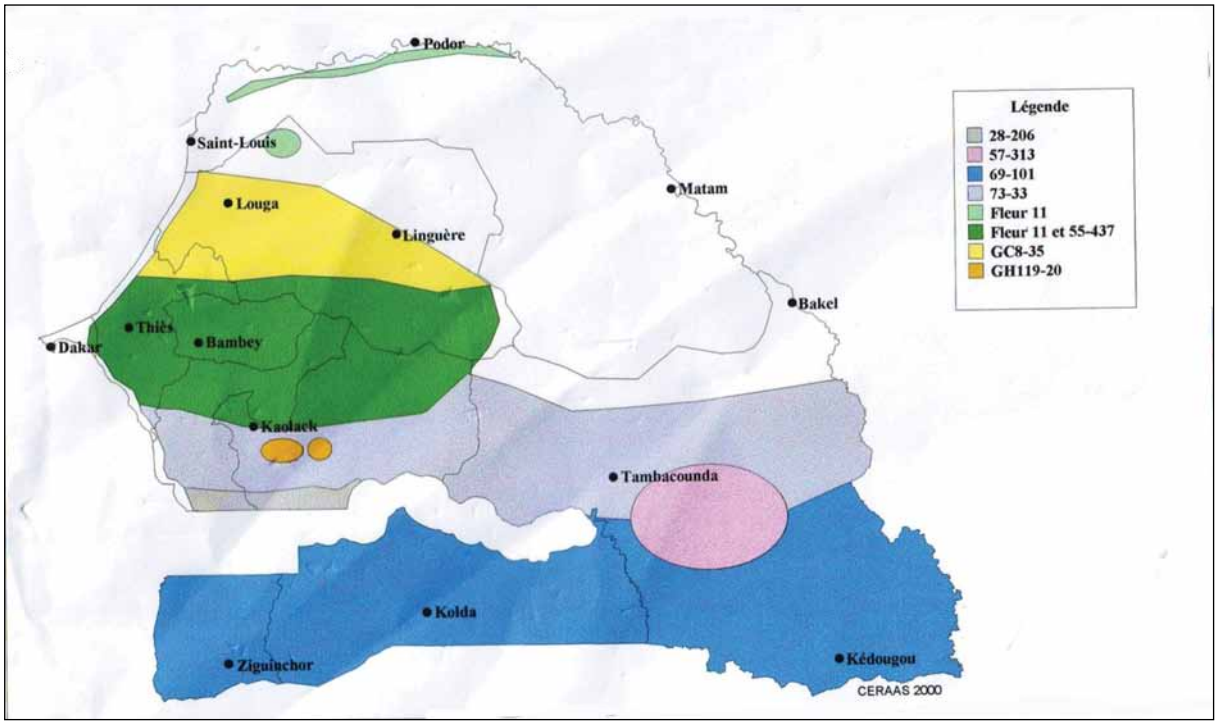

Figure 2. Distribution of groundnut varieties grown in Senegal.

Seed system

Biotic and abiotic constraints

- Foliar diseases (cercospora leaf spots)
- *Aspergillus flavus* causing aflatoxin contamination
- Drought
- Low soil fertility

Socioeconomic constraints

- Lack of availability and access to seed of new improved varieties
- Poor access to agricultural equipment to expand production area
- Difficulties in accessing fertilizers and insecticides
- Labor constraints for weeding and harvesting
- Poorly developed market and volatile prices
- Poor access to credit and input delivery system
- Poor road infrastructure to transport produce to markets
- Poorly developed processing industry
- Lack of coordination of actors along the groundnut value chain

Organizational constraints

- Weakness in information and knowledge sharing and policy support through modern communication pathways
- Weakness in institutions and institutional arrangements that will deliver quality seed at affordable prices to the small-scale farmers
- A weak link between research and extension
- Uncertainty in the quality and timely availability of fertilizers, fungicides and pesticides
- Difficulty in accessing credit by farmers
- Poor organization of farmers
- Lack of policies to reduce fluctuations in market price and gaps between the farm-gate price and price paid by the consumers

Strategic partners

The strategic partners and their role in the seed system are presented in Table 2.

Capacity building needs (staff, infrastructure)

- Trained researchers in plant breeding, entomology, pathology and agronomy
- Enhanced capacity in marker-assisted breeding
- A modern glasshouse
- An efficient irrigation system for precision phenotyping

Special cultural/gender considerations

Women are involved in the groundnut sector in both production and processing. Usually they have their own fields and in some parts of the country they are fully in charge of all field operations. Women

Table 2. Strategic partners and their role.

Strategic partner	Role
ISRA	Develop and promote new groundnut varieties and supply breeder and foundation seed of demanded varieties
ICRISAT	Collaborating in a joint project which aims to increase groundnut yield in marginal environments of sub-Saharan countries by providing different germplasm tolerant to drought and diseases and confectionery types
CIRAD	Assisting in developing locally adapted varieties by using molecular-assisted backcross (MABC) techniques between two amphidiploids and some of the released varieties
Association de Producteur de base (ASPRODEB)	Fosters stronger linkages between public and private sectors and facilitates business between the market players, empowering farmer groups to be better organized with more effective leadership at the local and national levels to achieve more coordinated production and marketing
EMBRAPA (Brazil)	Collaborating with ISRA through a Generation Challenge Program funded project
SONACOS	Responsible for industrial processing and commercialization of groundnut
NGOs (World Vision)	Seed production and technology transfer

are involved in the processing and commercialization of peanut butter, oil-cake, roasted peanut, etc and sold in the local markets.

The following require attention:

At production level: Provide more resources to women such as credit, land, extension services, tools/equipment, knowledge/skills and access to markets

At the consumption level: Information on the nutritional value of groundnut as food, provision of resources for processing and finance for investment, improvement in quality products.

Processing and storage requirements and market opportunities

Storing groundnut requires some caution because of storage pests (bruchids) and aflatoxin contamination. Thus installing appropriate storage facilities and local processing centers in some key villages is essential. Value addition by developing marketable groundnut-based products will promote their consumption at the household level. Market development for these products will enhance rural incomes. There are processing opportunities for groundnut for oil extraction and production of oil-cake for animal feed. Considering the adverse effects of aflatoxin contamination on human health, policy makers need to be sensitized to impose food safety regulations.

Key policies (recently implemented/needed)

- The groundnut sector has been liberalized and the main parastatal (SONACOS) responsible for the commercialization of groundnut privatized.
- The Agricultural Orientation Act is aimed at improving institutional framework of the farm sector to increase exports and improve product quality.
- The Institute for Food Research is facilitating development of recipes to include legumes in making bread which will be fed to school children to improve their nutritional status.
- Support for input (fertilizers, chemicals) is needed.

Key issues for competitiveness (ie, reducing production costs, increase market value)

- Distribution of small oil crushing machines in selected villages to allow farmers to add value to their harvest thus improving income. The products could be sold to the industries which will process them into final products (refined oil, packaging, etc).
- Subsidize inputs (seeds, fertilizers, pesticides and small equipment for field operations) to enable most farmers to have access
- Promotion of a wide range of productive varieties and crop management options to increase productivity
- Development of sustainable seed production and delivery schemes to increase access and availability of seed of preferred varieties
- Promote the adoption of best-bet pre- and postharvesting techniques to minimize aflatoxin contamination in groundnut. Aflatoxin reduction in groundnut will improve access to international markets
- Increased awareness of the dangers of aflatoxin contamination to improve health of rural and urban groundnut consumers

Mechanization as it relates to timely planting/harvesting and processing

All production operations (land preparation, planting, weeding, and harvesting) are done manually by using hand tools that severely limit the area planted. Thirty-three percent own a plow, less than 1% own a seeder and 52% own oxen. Groundnut production is a labor intensive enterprise. In this case the returns to investment in small mechanization in the form of simple animal traction may be high. Access to suitable machinery for various small-scale field operations is essential to increase productivity and profitability of groundnut.

Monitoring and evaluation

- Groundnut production, area cultivated and yield are monitored every year through surveys of households
- A good monitoring system is needed to be put in place at the national level
- Annual sub-regional review meetings of stakeholders
- Monitoring tours and visits to experimental sites will be encouraged among scientists
- Annual progress reports of the project
- Institutional work planning and review meetings

Perspectives for Phase 2

Since Senegal did not participate in Phase 1 it is envisaged that the groundnut programs will be enhanced with the genetic resources from ICRISAT to select appropriate varieties for local adaptation. Others include:

- Large-scale dissemination and adoption of improved technologies (varieties and productivity enhancing agronomic practices) through on-farm participatory trials

- Training extension agents in technology transfer
- Facilitating interaction among the various stakeholders to exploit synergies and comparative advantages
- Scientists and technicians are expected to gain skills in the use of new tools of molecular breeding methodologies and data management

The seed production strategy

Seed production has over the years been the responsibility of the national program (ISRA for breeder seed, National Seed Services for foundation seed and ONCAD for certified seed). Control and certification was the responsibility of seed service. With this scheme, seed capital was totally reconstituted. The advantages of this scheme were:

- A close follow-up by different actors: extension organizations (SRDR), ONCAD, Seed Service, ISRA, Department of Agriculture, different inspections of agriculture and Department of Crop Protection. These met annually to analyze the situation of the past year (quantities available at each level) and estimate the needs for the new crop season. This enhanced production planning by knowing beforehand the seed requirement of each region.
- Training of farmers was assured by ONCAD, which had agents in the field to conduct the training.
- Precise national seed needs by region were published in a document presented at annual seed meetings.
- This state controlled scheme has regressively been liberalized with the sector and emergence of the private sector. Hence the creation of the national Union of Interprofessional Seed Producers (UNIS) and final state disengagement from seed sector control. The private sector has however over time been weakened by the entry of other nonprofessional operators.

The current strategy is to produce adequate quantities of breeder and foundation seeds to meet the needs of certified seed. The seed roadmap is presented in Table 3.

Table 3. Groundnut seed roadmap for Senegal.

Ecology	Demand (ha)	Varieties	Available (t)			Goal	Breeder seed needs (t)			Foundation seed needs (t)			Certified seed needs (t)		
			Breeder seed	Foundation seed	Certified seed	20% adoption (t)	Year 1 2012	Year 2 2013	Year 3 2014	Year 1 2012	Year 2 2013	Year 3 2014	Year 1 2012	Year 2 2013	Year 3 2014
River zone	4000	Fleur 11 57-313 Hâtive de Séfa	1	0	0	8000	10	100	800	0	500	0	0	0	8000
North Peanut basin (Louga)	116400	55-33	1	3	1	465.5	0.5	0	0	0	5	10	0	40	400
		78-936	1	2	1	465.5	0.5	0	0	0	5	10	0	40	400
		SRV1-19	1	2	2	465.5	0.5	0	0	0	5	10	0	40	400
		73-9-11	1	3	2	465.5	0.5	0	0	0	5	10	0	40	400
Central North Peanut Basin (Fatick)	100,000	55-437	0.5	2	4	800	1	0	0	0	10	20	0	80	800
		Fleur 11	0.5	4	5	800	1	0	0	0	10	20	0	80	800
Kaolack (Central South Peanut basin)	260000	73-33	0.15	1	2	690	1	0	0	0	8	15	0	60	690
		Hâtive de Séfa	0.20	2	1	690	0.7	2	0	0	8	15	0	60	690
		GH119-20	0.15	0.5	2	690	0.5	1	0	0	8	15	0	60	690
		H75-0	0.4	0.5	1	690	1	2	0	0	8	15	0	60	690
		28-206	0.2	2.5	1	690	0.5	2	0	0	8	15	0	60	690
		PC79-79	0.3	2.0	2	690	0.5	2	0	0	8	15	0	60	690
High Casamance and Eastern Senegal zone	10000	73-33, 57-313	1	0	0	5000	10	100	800	0	500	0	0	0	5000

Grain Legumes Strategies for South Asia

Bangladesh

Groundnut

Md Manjurul Kadir, Rawshan Ali, P Janila, SN Nigam, HD Upadhyaya, P Parthasarathy Rao, CG Goodrich, Uttam Kumar Deb and CL Laxmipathi Gowda

Economic importance of groundnut

Groundnut is the third most important oilseed crop in Bangladesh grown in an area of 90,000 ha in 2010 with a production of 129,000 tons (Source: DAE 2012). However, the FAOSTAT data shows only an area of 33,500 ha and a much lower production. It is mainly consumed as roasted nut (*badam*) or as confectionery item. Limited amount of it is also used for extraction of edible oil used for cooking purpose and oil-cake is used as cattle feed. During 2000/01 to 2009/10, groundnut production increased at the rate of 5% per annum. High growth in groundnut production occurred as a result of steady increase in groundnut yield at the rate of 3.9% and increase in groundnut area at the rate of 1.1% per annum. The average yield in 2010 was 1591 kg ha^{-1}, an increase of 43% compared to the yield in 2001 (Source: FAOSTAT 2011). Groundnut is mainly cultivated in Char areas (riverbed or areas adjacent to river with sandy-loam soil type) that generally remain inundated with water during rainy season (June to September). Consequently, more than 90% of groundnut cultivation is in postrainy season.

The major groundnut growing districts in the country are Dhaka, Mymensingh (Dhaka Division), Comilla, Chittagong, Rangamati (Chittagong division), Sylhet (Sylhet Division), Jessore, Rajshahi (Khulna division) and Rangpur (Rangpur division). During 2007/08 to 2009/10, top five groundnut growing districts (Noakhali, Faridpur, Dinajpur, Dhaka and Chittagong) accounted for 58% of groundnut production and 60% of groundnut area in Bangladesh. The annual groundnut seed requirement is about 8958 tons; however, only 87 tons of seed is supplied by public sector agencies (BARI, BADC and DAE). Private sector is not engaged in groundnut seed production. Groundnut production has to be increased to meet the domestic demand and there is scope for area expansion by increasing cultivation in Char area.

Seed production target

Area: 33,591 in 2010 (Source: FAOSTAT 2012)

National production: 34,600 tons in 2000 and 53,461 tons in 2010 (FAOSTAT 2012)

Average yield: 1591 kg ha^{-1} in 2010

Proportion of production sold commercially: 90%

National demand: 225,000 tons (2015–17) as per the projection of IMPACT model

Expected growth in demand: 1.08% annually as per the IMPACT model projection

Target yield by 2015: 1.9 t ha^{-1}

Agroecology

The major groundnut growing districts fall in four agroecological zones:

Zone 3: Tista Meander Floodplain

Zone 7: Active Brahmaputra-Jamuna Floodplain

Zone 12: Low Ganges Floodplain

Zone 18: Young Meghna Estuarine Floodplain

These are characterized by Char areas, where soil is sand to sandy-loam. The Char areas have poor water-holding capacity and also very poor nutritional status. Most of the areas consist of riverbed and riverine region. Groundnut is the principal crop of Char land where other crops cannot survive due to moisture stress and it also prevents soil erosion as the Char lands are highly prone to soil erosion. Moreover, the Char areas are increasing as the river water is declining during winter and consequently new islands erupt in the riverbeds. In every 3–5 years, the Char area increases by 36,000 ha in the country and needs to be brought under crop production.

Dominant varieties

Dhaka 1 is the oldest (released in 1976) and dominant variety grown all over the country although several improved groundnut varieties were released in the country for cultivation in different regions. Other groundnut varieties released in Bangladesh are Dhaka 2 (1976), DG 2 (1979), DM 1 (Tridana) (1987), Jingbadam (1988), ICGS (E) 55 (1995), BARI Chinabadam 5 (1998), BARI Chinabadam 6 (1998), BARI Chinabadam 1 (2000), BARI Chinabadam 2 (2000), BARI Chinabadam 3 (2000) and BARI Chinabadam 8 (2006) (Source: Ministry of Agriculture, Bangladesh).

Key constraints

Lack of quality seed production and supply of cultivars of appropriate duration (mainly short-duration) and consequently cultivation of obsolete variety Dhaka 1 in large areas is one of the important constraints. Others include abiotic constraints like mid- and end-of-season drought, salinity, floods, excess moisture and humidity, extreme temperature, soil factors like erosion and poor fertility status coupled with low input use. Biotic constraints are foliar diseases (late leaf spot and rust), root rot, viral diseases, nematodes and insect pests. Socioeconomic constraints are lack of awareness on production technology among the farmer and trained manpower, lack of support price and marketing, and lack of storage facilities.

Strategic partners

The strategic partners and their role in the seed system are given in Table 1.

Capacity building needs (staff, infrastructure)

Training in groundnut breeding methodologies, seed production and molecular breeding (MAS and bioinformatics) is needed for national partners and women scientists need to be included in such training programs. Basic infrastructure facilitates to support seed production activities, phenotyping facilities for foliar diseases screening, and glasshouse facility for crossing programs are needed at Oilseeds Research Center, BARI, Gazipur.

Table 1. Strategic partners and their role.

Strategic partner	Role
ICRISAT	Project implementation, monitoring, coordination and reporting, NARES capacity enhancement [scientists, technicians, Department of Agriculture (DoA) and NGO staff and farmers]; generation and supply of genetic and breeding resources to NARES, preparation and distribution of farmer-friendly generic literature on farmer-preferred varieties (FPVs), integrated crop management (ICM) and basic seed production
Bangladesh Agricultural Research Institute (BARI)	Evaluation of FPVs in national testing system; facilitation of release of FPVs at national level; organization of breeder seed production for formal seed sector
Bangladesh Agricultural Development Corporation (BADC), BARI, Department of Agriculture Extension (DAE) and various NGOs involved in seed production and allied activities	Production and marketing of certified/truthfully labeled seed of FPVs
Farmers	Conduct of farmer participatory varietal selection (FPVS) trials and evaluation of varieties as per their preference, participation in formal and informal seed production and marketing

Special cultural/gender considerations

- Women are engaged in preparation and sale of groundnut-based food items for cash income to meet family needs. This activity helps to improve livelihoods of poor rural women in poverty-stricken Char areas. Large numbers of poor people employ themselves for selling roasted nut at places of mass gathering.
- Promotion of groundnut cultivation will enhance employment opportunities particularly for rural women by engaging them in local markets like selling roasted/slated groundnut and other local preparations.
- Increase in production would also increase the drudgery of women and hence there is need for varieties suitable for mechanical harvesting. Similar interventions are required at various stages of production, like weeding and harvesting that reduce drudgery for women, offering more time to pursue productive activities.
- In terms of seed storage options, women are in the forefront of adaptive research and they often make the hard decision of what to use for seed, and what to use as food to feed their children. This may be important especially for decentralized seed enterprises. Seed production and delivery approaches and tools that capture priorities from both male and female participants as well as giving them equal opportunities for participation, will be emphasized. A gender considerate skills and knowledge enhancement in areas of seed systems will facilitate an equitable participation of men and women.
- Participation and employment opportunities to women will be increased through their involvement in hand-sorting to remove *Aspergillus flavus* infected kernels.
- It is also proposed that the participatory monitoring and evaluation system will be guided by a performance measurement framework that integrates local and gender specific indicators for monitoring project outcomes.

Processing and storage requirements and market opportunities

Majority of the groundnut produced is used for food purposes in domestic markets. Demand for groundnut for food uses is expected to rise with increase in income and population. The groundnut export markets are yet to be opened-up in the country.

- Bangladesh imports groundnut oil and shelled groundnut on a regular basis. In 2008, Bangladesh imported 27 tons of groundnut oil spending US$ 100,000 (Source: FAOSTAT 2011). Bangladesh Bureau of Statistics (BBS) reported sudden jump in groundnut oil import in 2008–09 – that was the time when all edible oil prices experienced rapid increase all over the world. This implies one important fact that groundnut oil is well accepted by the Bangladeshi consumers, if available at a competitive price.
- Due to lack of knowledge and shortage of storage facility, farmers sell groundnut in the local markets at a cheap rate just after harvesting. Consequently groundnut farmers are deprived from actual price but the middlemen are benefited. Hence good storage facilities are needed.

Policies needed

The following policies are needed in the seed system:

Introduction of new varieties through farmer-participatory varietal selection (FPVS) and its recognition in formal release of a variety at state level, recognition of truthfully labeled seed produced through informal seed systems, market-price determination based on aflatoxin content, easy access to credit for small-scale farmers, enhanced subsidy on agricultural machinery required for groundnut cultivation including sprinklers for irrigation, and quality seed supply.

Key issues for competitiveness (ie, reducing production costs, increase market value)

- Quality seed production and supply of new improved varieties
- Cultivation of short-duration, drought tolerant and disease resistant high-yielding genotypes
- Cultivation of varieties with special confectionery traits will increase the market value of the produce
- Adoption of ICM practices that include use of inputs like fertilizers to increase net returns
- Suitable machinery for various small-scale field operations in groundnut to reduce the cost including portable sprinkler irrigation sets

Mechanization as it relates to timely planting/harvesting and processing

Farmers still use indigenous equipment for sowing and other operations up to harvest. But in some areas where road communication is developed, small-scale machinery like power tillers are used. Specially designed seeder-cum-fertilizer applicator may enhance timely planting. Portable sprinkler irrigation will help to increase the yield of groundnut in Bangladesh. Other farm machinery include groundnut digger suitable for dryland conditions, seed drill, thresher and decorticators at affordable or subsidized price. Technologies/equipment for tasks that women do to reduce drudgery are also needed.

Environmental/sustainability issues

No negative environmental/sustainability issues are associated with groundnut cultivation. Being an energy rich crop (high oil content), it harvests more carbondioxide (CO_2) from the environment for the same level of economic yield than non-oil crops. Groundnut ensures systems sustainability by supporting livestock. Groundnut haulms provide nutritious fodder thus improving livestock productivity. It ensures sustainability of rainfed cropping system by fixing biological nitrogen. Diseases and insect pest tolerant varieties require minimum pesticide use.

Monitoring and evaluation

It includes annual in-country review and planning meeting, visits to partner locations during the cropping season, farmer–scientist interaction meeting to assess impact, gender disaggregated focus group discussion with all value chain stakeholders to gauge preliminary impacts/constraints of the project, and conducting workshop with partners to share findings of reports, field-level interactions, etc.

Seed production plan

Groundnut seed roadmap for Bangladesh is presented in Table 2.

Table 2. Groundnut seed roadmap for Bangladesh[1].

Ecology[2]	Demand (ha)	Variety characteristics: Productivity traits	Variety characteristics: Market traits	Promising varieties	Seed available in 2012 (breeder and foundation seed) (t)	Seed production (t): Breeder seed	Seed production (t): Foundation and Certified seed	Seed to reach 20% adoption (t)	Seed production goal (t) for Year 3	Key partners
Zone 3, 7, 12 and 18 characterized by Char areas with sand and sandy loams	90,000	Drought tolerant, short duration, foliar fungal disease tolerant	Medium bold seed	BARI Chinabadam 4 BARI Chinabadam 8	11 6	42	340	2700	2700	Production: Breeder seed by BARI; foundation and certified seeds by BADC, BARI, DAE, NGOs Distribution: BADC, DAE, NGOs

1. Seeding rate: 150 kg pods per ha.
2. Zone 3 = Tista Meander Floodplain; Zone 7 = Active Brahmaputra-Jamuna Floodplain; Zone 12 = Low Ganges Floodplain; and Zone 18 = Young Meghna Estuarine Floodplain.

Chickpea

Abid Hossain, Md Jahangir Alam, Uttam Kumar Deb, Pooran Gaur and CL Laxmipathi Gowda

Introduction

Chickpea is one of the important food legumes of Bangladesh. The area and production of chickpea has declined because of high emphasis on enhancing area and production of staple cereals like rice, wheat, maize and other short-duration oilseed crops. There is increasing concern about the sustainability of high input, cereal-dominated cropping systems in Bangladesh. Crop diversification with legumes can help in improving soil fertility and system productivity. Chickpea is one of the most important pulse crops in Bangladesh considering consumers' choice and consumption. It has been traditionally cultivated in Bangladesh under rainfed condition.

In the early 1980s, area of chickpea was about 113,000 ha and production 87,000 tons. Major chickpea producing districts are: Faridpur, Madaripur, Chapainawabgonj, Jessore, Jhenaidah, Magura, Narail, Patuakhali, Rajshahi and Natore. These districts cover 69% of chickpea area and 70% of chickpea production in the country. Most of these areas belong to the Agroecological Zones 11 and 12. The soils of these areas are moderately drained heavy structured clay-loam. The top five chickpea producing districts (Rajshahi, Faridpur, Barisal, Jessore and Jhenaidah) account for about 50% of area and production of chickpea in the country. Average yield of chickpea in Bangladesh is about 1200 kg ha^{-1}. The domestic demand of chickpea exceeds the local supply and the deficit is met through import. Bangladesh imported on an average 80,000 to 100,000 tons (valued at US$ 40 million to 55 million) chickpea per year during 2007 to 2012. Bangladesh imports chickpea mainly from Canada and Australia. However, there are good opportunities to expand area and production substantially with adoption of improved varieties and crop management practices. Chickpea area and production in Bangladesh are given below.

Average area: 7,000 ha (DAE 2012)

Average production: 9,000 tons (DAE 2012)

Average yield: 1200 kg ha^{-1} (DAE 2012)

Proportion of production sold commercially: 10–75%

Dominant varieties

Bangladesh Agricultural Research Institute (BARI), Joydebpur and Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh have released 16 chickpea varieties for cultivation in different regions of the country. BARI Cholla 5 (released in 1996), BARI Cholla 3 (released in 1993), BARI Cholla 9 (released in 2011) and local varieties are popular among farmers. BARI Cholla 8 is the only kabuli variety (released during 1998) which was popular at the initial time, but due to susceptibility to *Helicoverpa* pod borer and botrytis gray mold (BGM) it lost its importance. ICRISAT has been working in close collaboration with BARI and the breeding material supplied by it has led to release of six cultivars.

Potential for chickpea cultivation in Bangladesh

Cropping system in Bangladesh is mainly rice based where chickpea is grown in the postrainy season, mainly in two cropping systems: rice/jute (April–August)–fallow (August–October)–chickpea (November–April); and rice (July–December)–chickpea (December–April)–fallow (April–June). The

period from November to April is considered optimal for chickpea; thus about 60–65% of chickpea is grown during this period. In the second cropping pattern, chickpea sowing is delayed until rice harvest. However, mid-November is considered to be the optimum time for sowing chickpea in Bangladesh, except in the Barind tract. Some chickpea genotypes have capacity to tolerate drought and in that case sowing time can be delayed. However, late sowing caused drastic reduction in yield and net profit compared with timely sowing. BINA Cholla-4 can be sown up to early December under rainfed condition for better yield but the seed size is small. BARI Cholla-9 has also the late sowing potentiality.

Chickpea has proven to be very suitable to grow after rice in the Barind region of Bangladesh. About 800,000 ha land of the high Barind tract in Northwestern Bangladesh can be brought under chickpea cultivation. Relatively less humid climate in the Barind area is not favorable for *Helicoverpa* pod borer infestation and BGM infection which are major problems of chickpea cultivation in Bangladesh. On-farm trials have shown that yield of chickpea can be increased through the use of seed priming technique. The seed priming process involves soaking the seeds overnight (for about 8 h), surface drying them and then sowing the following day. Seed priming was evaluated in many locations (farmer-managed trials) in the high Barind tract over four years (1998–2002). Seed priming raised yields by 22 to 48% (from 1.1 to 1.6 t ha^{-1}) and reduced the risk of crop failure by half. The major constraint to adoption in the Barind area of Bangladesh is non-availability of quality seed and lack of knowledge of improved crop production technology. Pod borer infestation and BGM infection is relatively low in the Barind area due to less humid climate, so there is a scope to bring 0.8 million ha land of the high Barind tract in Northwestern Bangladesh under chickpea cultivation.

Preferred traits and qualities of chickpea

In Bangladesh chickpeas are consumed in various forms and are subjected to primary processing, ie, dehulling, splitting, grinding, parching and roasting. Consumers of chickpea are sensitive to quality characteristics depending on the use. Kabuli chickpeas are mostly consumed as dried whole seed cooked separately or combined with other ingredients. Kabuli chickpeas are differentiated on the basis of seed color (beige or cream) and larger seed size. Large seed is preferred and fetches higher price. The other preferred qualities are cream color, uniform size and thin seed coat. Desi chickpeas are consumed in different forms – fresh green seed, dried whole seed, roasted and puffed, roasted and split (*phutdna dhal*), splits (*dhal*) and flour (*besan*). Splits and flour are the most common forms of consumption (70–75%) followed by whole seed (15–20%). Green immature chickpea is used as vegetable. Large seed, light brown or golden yellow color, thin seed coat and good water absorption capacity are the preferred qualities. Desi type chickpea is more preferred by the Bangladeshi consumers than kabuli type due to its red-brown seed coat.

Target yield and beneficiaries

Target yield by 2016: 1600 kg ha^{-1} in project locations Rajshahi, Chapainawabgonj (33% increase)

Target beneficiaries by 2016: >100,000 (This will be achieved by coordinated approach among research stations, DAE, BADC and NGO partners)

Key constraints to production

- Abiotic: Drought, temperature extremes, poor soil fertility and boron deficiency
- Biotic: Fusarium wilt, BGM, collar rot, dry root rot, pod borer and pulse beetles

- Socioeconomic: Low profit and high risk, limited inputs, lack of cash and credit, lack of storage system and knowledge of advanced storage technique, and lack of support price and marketing

Strategic partners

Bangladesh Agricultural Research Council (BARC), BARI and BINA are the major organizations for agricultural research and management, while Bangladesh Agricultural Development Corporation (BADC), Department of Agricultural Extension (DAE) and NGOs are involved in transfer of technology and developmental activities. Further details on role of partners are given in Table 1.

Table 1. Role of strategic partners in research and development of chickpea in Bangladesh.

Partner	Role
ICRISAT	Project implementation, monitoring, coordination and reporting; NARS capacity enhancement [scientists, technicians, Department of Agriculture Extension (DAE) and NGO staff and farmers]; generation and supply of genetic and breeding resources to NARS; preparation and distribution of farmer-friendly generic literature on farmer-preferred varieties (FPVs); integrated crop management (ICM) and basic seed production
Bangladesh Agricultural Research Institute (BARI)	Evaluation of FPVs in national testing system; facilitation of release of FPVs at national level; organization of breeder seed production for formal seed sector
BADC, BARI, DAE and NGOs	Production and marketing of certified/truthfully labeled seed of FPVs, dissemination of technologies and allied activities
Farmers	Conduct farmer participatory variety selection (FPVS) trials, evaluation of varieties of their preference and participation in formal and informal seed production and marketing

Major initiatives

The Government earlier launched a Crop Diversification Program (CDP) with the assistance of CIDA. BARI established a Pulses Research Centre (PRC) located at Ishurdi that focuses on pulses research.

NARS capacity building needs

The chickpea improvement program is very weak in Bangladesh. It needs to be strengthened with trained staff and by development of basic infrastructure facilities.

Special cultural/gender considerations

Women farmers play an important role in Bangladesh agriculture, including production and processing of food legumes. Participation of women farmers in various activities needs to be ensured. Women remain conservative due to the prevalent social system and are not engaged in field work. However, after harvesting, most of the work is carried out by household women.

Possible interventions to increase production and productivity

- Increased productivity through adoption of improved varieties and crop production practices.
- Increasing area through utilization of fallow lands and introduction of chickpea in new cropping systems.
- Inclusion of early chickpea variety in between transplanted aman–boro cropping pattern.

Institutional and technical innovations

Some innovations required are:

Strengthening research for chickpea improvement and development of improved crop production practices; strengthening seed production and delivery systems; and strengthening of extension services to enhance awareness of farmers for improved cultivars and production technologies.

Processing and storage requirements and market opportunities

Seed processing and storage facilities need to be strengthened at the research stations. Knowledge empowerment of women farmers is needed in safe storage of seeds and grains. Due to lack of knowledge and shortage of storage facility, farmers sell chickpea in the local markets at a lower price just after harvesting. Consequently, chickpea farmers lose their valuable seeds and are deprived of good price. Hence, knowledge about seed storage needs to be provided to the farmers.

Key policies (recently implemented/needed) to promote legumes in the country

Policy support from Government is needed for encouraging crop diversification, increasing cropping intensity and seed production and marketing of pulses.

Key issues for competitiveness (ie, reducing production costs, increase market value)

Some key issues are the development of improved cultural practices and promotion of high-yielding and moisture stress tolerant cultivars preferred by the market and which can be afforded by the farmers. Chickpea must fit in the rice–rice and rice–fallow cropping system so that farmers can get an additional crop. The present level of profitability of alternative postrainy season (*rabi*) crops is high and thus farmers may not grow chickpea replacing other postrainy season crops. Bangladesh needs early-maturing, large-seeded desi chickpea varieties having erect plant type, BGM and pod borer tolerance. There is a need for appropriate value addition activities and quality seed production and supply of improved high-yielding varieties.

Some new areas for research intensification

- Disease and pest monitoring and management research in addition to identification of resistant sources.
- On-farm research to identify new cropping pattern involving pulses.
- Identification of potential areas and limiting factors for pulses and find their solution.
- Identification of innovative and beneficial farmers' practices on pulses and validate them.
- Identification of breeder seed production so that BADC and private seed companies/NGOs can multiply the seed of new varieties to meet the demand.

Special cultural/gender considerations

Women farmers play an important role in Bangladesh agriculture, mostly in postharvest processing of food legumes. The active participation of women farmers in various activities has to be ensured. In terms of seed storage options, women are in the forefront of adaptive research and they often make the hard decision of what to use for seed, and what to use as food to feed their family. Seed production and delivery approaches and tools that capture priorities from both male and female participants as well as giving them equal opportunities for participation will be emphasized. A gender considerate skills and knowledge enhancement in areas of seed systems will facilitate equitable participation of men and women.

Environmental/sustainability issues

Being a high protein rich crop, chickpea harvests more carbondioxide (CO_2) from the environment for the same level of economic yield than non-legume crops. Chickpea cultivation ensures sustainability of rainfed cropping system by fixing biological nitrogen. Disease and insect pest tolerant varieties require minimum pesticide use. No negative environmental/sustainability issues are associated with chickpea cultivation.

Monitoring and evaluation

- Annual in-country review and planning meeting
- Monitoring visits during the cropping season
- Farmer–scientist interaction meeting to assess impact
- Workshop with partners to share findings

Seed production plan

Chickpea seed production plan for Bangladesh is given in Table 2.

Table 2. Seed roadmap for chickpea in Bangladesh[1].

Ecology	Demand (ha)	Variety characteristics: Productivity (t ha^{-1})	Variety characteristics: Type	Promising varieties	Seed currently available (Breeder + Foundation) (t)	Production: Breeder seed (t)	Production: Foundation + Certified seed (t)	Seed to reach 30% adoption (t)	Seed production goal (t): 2012	Seed production goal (t): 2013	Seed production goal (t): 2014	Key partners (seed production and distribution)
Rainfed	4,480	2	Desi	BARI Cholla 5	15.00	0.94	93.14	94.08	18.82	28.22	47.04	BARI, BINA, BU, BADC, DAE and NGOs
Rainfed	350	2	Desi	BARI Cholla 9	1.30	0.07	7.28	7.35	1.47	2.21	3.68	
Rainfed	70	2	Desi	BARI Cholla 3	0.06	0.02	1.45	1.47	0.29	0.44	0.74	
Rainfed	1,400	2	Desi	BINA Cholla 4	3.30	0.29	29.11	29.40	5.88	8.82	14.70	
Rainfed	700	2	Desi	BU Cholla 1	1.85	0.15	14.55	14.70	2.94	4.41	7.35	

1. Seeding rate 70 to 120 kg ha^{-1} (depending on seed size).

India

Groundnut

K Ganesamurthy, HL Nadaf, KP Vishwanatha, P Venkataramana, Somasekhar, M Vaithiyalingan, GS Shekar, Damodara Parida, Manoj Kumar, Ravi Gopal Singh, N Manivannan, P Janila, SN Nigam, HD Upadhyaya, P Parthasarathy Rao, D Kumara Charyulu, CG Goodrich and CL Laxmipathi Gowda

Economic importance of groundnut in India

Groundnut is the major oilseed, food and feed crop in India grown in an area of 4.93 million ha during 2010 with a production of 5.64 million tons and an average yield of 1140 kg ha^{-1} (Source: FAOSTAT 2012). It contributes about 15% to the edible oil basket of the country. India remains a major importer of edible oils. The South Asian region has more than 7 million ha (31% of world total) under groundnut; nearly 83% of this is in India. The country has lost 1.62 million ha of groundnut area to other crops like soybean, maize and Bt cotton during the period 2000 to 2010. Nevertheless, non-traditional area under groundnut is expanding and falls largely in Agroecological Zone 4.

Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra are major states (in Agroecological Zones 2, 3 and 5) that account for 90% of total groundnut production in India. About 85% of the total area under groundnut in the country is sown in the rainy season (Jun/Jul– Oct/Nov) and the remaining 15% is sown during postrainy season (Oct/Nov–Feb/Mar; Jan/Feb–May/Jun), either with irrigation or under residual soil moisture along the riverbanks in rice fallows. Being a rainfed crop, the yield variability across growing regions as well as years is high. Groundnut is grown as a sole crop (mostly in the postrainy season) or in intercropping system with pigeonpea, castor, cotton, etc (mostly in the rainy season). In India, 80% of the total produce is crushed for extraction of oil, 11% as seed, 8% for food uses and 1% is exported. India ranks fifth in export of groundnut with shell and 12th in export of shelled groundnut (FAOSTAT 2012). The oil-cake and haulms are used as cattle feed. Groundnut production and demand in the country are given below.

National production: 6.3 million tons in 2002 and 5.64 million tons in 2010

National demand: 6.4 million tons (2002) as there are no imports of groundnut

Expected growth in demand: 2.41% (2000–15)

The estimated production during 2015–17 is 8.3 million tons, while the estimated demand is 9 million tons as per projections of IMPACT model. The expected demand/production growth rate is 1.86% (2000–15).

Agroecology

The 3-year average of 2005–07 district level data has been used to derive the zonal data. In the district data, break up of rainy and postrainy seasons is not available, so the data reported is for all groundnuts.

Zone 1

This zone includes Rajasthan, Haryana, Punjab and Uttar Pradesh for rainy season and Punjab, Rajasthan and Uttar Pradesh for spring season.

Area: 0.4 million ha (2005–07)

Average production: 0.53 million tons (2005–07)

Proportion of production sold commercially: 85%

Dominant varieties: M 522, Pratap Mungphali 2 (ICGV 92195), RG 382 and HNG 10 in rainy season and SG 99 (ICGV 89280), SG 84 (ICGS 1), Avtar (ICGV 93468) and Dh 86 in spring season

Key constraints: In rainy season, drought, low input usage, insect pests and foliar diseases are important, while high temperature is a major constraint in spring season. Lack of quality seed production and supply of improved varieties are constraints in both the seasons. The average yield in this zone (1.25 t ha^{-1}) is close to national average; however, the average yield in spring season (>2 t ha^{-1}) is higher than in rainy season.

Target yield by 2015: 1.5 t ha^{-1} in rainy season and 2.5 t ha^{-1} in spring season

Zone 2

This zone includes Gujarat and Southern Rajasthan for rainy season and Gujarat, Maharashtra and Chhattisgarh for summer season.

Area: 1.89 million ha (2005–07)

Average production: 2.84 million tons (2005–07)

Proportion of production sold commercially: 85%

Dominant varieties: GG 6, Girnar 2, AK 159, TAG 24 and GG 20 in rainy season and ICGS 76 and TG 37 A in summer season

Key constraints: In rainy season, erratic distribution of rainfall leading to drought/waterlogging, foliar diseases, soilborne diseases like stem rot, and insect pests are important, while in summer season, high temperature and insect pests are important. Although there is variety replacement, quality seed production and supply still remains a constraint. Farm mechanization can help in reducing production costs.

The average yield in this zone (1.5 t ha^{-1}) is higher than the national average.

Target yield by 2015: 1.8 t ha^{-1} in rainy season and 2.2 t ha^{-1} in summer season

Zone 3

This zones includes Northern Maharashtra and Madhya Pradesh for rainy season, Karnataka and Southern Maharashtra for summer season and Andhra Pradesh, Tamil Nadu and Kerala for postrainy season

Area: 0.37 million ha (2005–07)

Average production: 0.36 million tons (2005–07)

Proportion of production sold commercially: 85%

Dominant varieties: TG 37 A, J 11, AK 159 and TPG 41 in rainy season and TMV 2 and JL 24 in postrainy season

Key constraints: In rainy season, drought, low input use, foliar diseases and insect pests are important, while in postrainy season bud necrosis in Andhra Pradesh and Tamil Nadu and rust and leaf spots in

Tamil Nadu are important. Lack of quality seed production and supply of improved varieties and lack of farm mechanization and adoption of integrated crop management (ICM) practices are constraints in both the seasons.

The average yield in this zone is less than 1 t ha^{-1}, lower than national average, but in this zone too postrainy season yields are far better than rainy season yields.

Target yield by 2015: 1.2 t ha^{-1} in rainy season and 2 t ha^{-1} in postrainy season

Zone 4

This zone includes Jharkhand, West Bengal, Orissa and North Eastern Region for rainy season and West Bengal, Jharkhand and Northeastern states for postrainy/summer non-traditional areas.

Area: 0.33 million ha (2005–07)

Average production: 0.48 million tons (2005–07)

Dominant varieties: AK 12-24, Smruti (OG 52-1), ICGS 44, ICGV 91114, ICGS 76, TG 37 A, TAG 24, Kaushal

Key constraints: Low soil fertility and micronutrient deficiencies and lack of quality seed production and supply of improved varieties are common. Erratic distribution of rainfall leading to drought/water stagnation, insect pests and foliar diseases are constraints in rainy season, while in summer season high temperature and insect pests are key constraints.

The average yield of the zone (1.45 t ha^{-1}) is higher than national average.

Target yield by 2015: 1.5 t ha^{-1} in rainy and 1.9 t ha^{-1} in postrainy season

Zone 5

This zone includes Southern Maharashtra, Andhra Pradesh, Karnataka, Kerala and Tamil Nadu for rainy season

Area: 3.31 million ha (2005–07)

Average production: 3.35 million tons (2005–07)

Proportion of production sold commercially: 85%

Dominant varieties: JL 24, TMV 2, TAG 24, Vikas (GPBD 4), Prutha (Dh 86, Kadiri 6, ICGV 91114, VRI 2, Narayani (TCGS 29), TG 37 A, TMV (Gn) 13

Key constraints: Drought, eroded soils with poor soil fertility, cultivation of obsolete varieties, low input use, lack of quality seed production and supply of improved varieties, foliar fungal diseases, aflatoxin contamination, seed and seedling diseases, bud and stem necrosis, and insect pests like leaf miner and *Spodoptera* are important. Labor intensive cultivation and lack of mechanization is another important constraint. The average yield in the zone is about 1 t ha^{-1}, but within this zone the average yield is less than 1 t ha^{-1} in Andhra Pradesh and Karnataka, while it is higher in Tamil Nadu. In large areas of Andhra Pradesh and Karnataka, TMV 2, an obsolete variety with poor performance, is still under cultivation. In Karnataka, groundnut area has decreased from 908,000 ha in 2007–08 to 659,000 ha in 2010–11 as groundnut is less competitive than crops like maize and Bt cotton and the productivity remained low at 900 kg ha^{-1}.

Target yield by 2015: 1.4 t ha^{-1}

Strategic partners

The strategic partners and their role in the seed system are given in Table 1.

Table 1. Strategic partners and their role.

Strategic partner	Role
ICRISAT	Project implementation, monitoring, coordination and reporting, NARES capacity enhancement [scientists, technicians, Department of Agriculture (DoA) and NGO staff and farmers]; generation and supply of genetic resources and breeding materials to NARES; preparation and distribution of farmer-friendly generic literature on farmer-preferred varieties (FPVs); integrated crop management (ICM) and basic seed production
All India Coordinated Research Project on Groundnut (AICRP-G), ICAR	Evaluation of FPVs in national testing system; facilitation of release of FPVs at national level; organization of breeder seed production for formal seed sector
State Agricultural Universities (TNAU, Coimbatore in Tamil Nadu; UAS-Bengaluru, UAS-Dharwad and UAS-Raichur in Karnataka; BAU, Sabour in Bihar and OUAT, Bhubaneswar in Odisha)	Development of new varieties with farmer- and market-preferred traits using conventional and molecular breeding tools; conducting farmer participatory variety selection (FPVS) trials; evaluation of FPVs in the state testing system; facilitation of release of FPVs at state level; organization of breeder and foundation seed production for formal and informal seed sector; training of farmers and staff of DoA and NGOs in seed production and ICM; preparation and distribution of farmer-friendly literature in vernacular languages on FPVs, ICM and seed production
State Farm Corporation of India (SFCI), State Seeds Development Corporations, State Departments of Agriculture, Oilseeds Growers' Federations, ABI, various NGOs operating in different states	Production and marketing of certified/truthfully labeled seed of FPVs
Farmers	Conducting FPVS trials; evaluation of FPVS; participation in formal and informal seed production and marketing

Capacity building needs (staff, infrastructure)

Training in groundnut breeding methodologies, seed production and molecular breeding (MAS and bioinformatics) is needed for national partners in which women scientists are to be included and the number to be increased along the years. Basic infrastructure to facilitate seed production activities and phenotyping in new states (Bihar and Odisha) is needed and in old locations (Tamil Nadu and Karnataka) further strengthening of the existing facilities for phenotyping and facilities for integration of MAS in breeding programs are needed.

Special cultural/gender considerations

- Promotion of groundnut cultivation will enhance employment opportunities particularly for rural women by engaging them in local markets like selling roasted/slated groundnut and other local preparations.
- Increase in groundnut production would also increase the drudgery of women and hence there is a need for varieties suitable for mechanical harvesting. Similar interventions are required at various stages of production, like weeding and harvesting that reduce drudgery for women, offering more time to pursue productive activities.

- Trading for confectionery varieties also increases participation and employment opportunities to women through their involvement in hand-sorting to remove *Aspergillus flavus* infected kernels and hand-picked kernels for bold size (for export purpose).
- In terms of seed storage options, women are in the forefront of adaptive research and they often make the hard decision of what to use for seed, and what to use as food to feed their children. This may be important especially for decentralized seed enterprises. Seed production and delivery approaches and tools that capture priorities from both male and female participants as well as giving them equal opportunities for participation, will be emphasized. A gender considerate skills and knowledge enhancement program in areas of seed systems will facilitate an equitable participation of men and women.
- Women are often engaged in livestock rearing and are involved in sale of milk to chilling units and local markets. The earning from this is the only regular income to a farm family used to meet family food and other requirements. Groundnut haulms supplement cereal fodder with proteins and minerals and enhance livestock productivity and thus increase women's earning from livestock.
- The participatory monitoring and evaluation system will be guided by a performance measurement framework that integrates local and gender disaggregated data and gender specific indicators for monitoring project outcomes.

Processing and storage requirements and market opportunities

- Majority of groundnut produced is crushed for oil and meets 15% of edible oil requirement of the country. Oil-cake, by-product obtained after oil extraction, is used as animal feed. The utilization pattern indicates that 80% of the total produce is used for oil extraction, 11% as seed, 8% for direct food uses and 1% is exported. The food uses are showing an increasing trend in the country. The exports are not taking-off from the country due to stringent regime on permissible levels of aflatoxin on imports in developed countries.
- Dried pods after harvest are sold in the market and the farmers generally do not store the produce except for seed purpose. When not appropriately stored, storage pests cause serious losses. Due to lack of seed storage facilities at village level farmers end up buying seed from market, Department of Agriculture or public seed agencies that escalates the cost of production. Moreover, variety replacement is also lagging despite release of several improved varieties for cultivation as seed of obsolete varieties is supplied by these agencies. Improper storage of produce by traders/exporters/farmers can also result in aflatoxin contamination that has trade implications.
- Due to the price premium for groundnut oil in the domestic market, oil extraction remains the dominant market for groundnut. However, the groundnut marketing chain comprises numerous market intermediaries who get the lion share of the profit. With growing demand for edible groundnut, mainly for exports, a price premium is attached in the groundnut confectionery trade. Thus many traders in Mahabubnagar district of Andhra Pradesh and neighboring districts now prefer selling their decorticated produce to the Maharashtra market/traders. This has resulted in increase of the prices at the farmers' end. On the other hand, the oil millers have not been able to buy high quality produce since the prevailing prices are well above the parity prices for breaking even. Consequently, oil millers are shifting towards trading for confectionery markets or to crushing of other crops like sunflower and soybean and most of the local oil milling units were shut down in the last four years. Thus an increase in market opportunities for confectionery trade is observed in recent years. Driven by rapid increase in demand for animal products, India's demand for oil-cake meal as feed too has increased considerably and is likely to increase further. Limiting and monitoring aflatoxin contamination levels in export consignments can fillip export markets.

Key policies

Policies recently implemented

- India provides price support to major oilseeds in the form of a Minimum Support Price (MSP). The MSP for groundnut has been increased steadily since 2004–05 when it was ₹ 15,000 to ₹ 27,00 per ton. However, MSP was not really operational since market prices were higher than MSP.
- Import duties for oilseeds have been lifted in order to increase domestic availability. The current duty difference between crude and refined oils stands at 7.5%, which provides some measure of protection to domestic refiners against competition from imported refined oils. Imports of edible oils to India increased from 1.3 million tons in 1997/98 to 8.8 million tons in 2010, constituting nearly 40% of its total consumption.
- Export of edible oils was banned in 2007 and the ban was extended till 2010 –11. The export ban has particularly affected groundnut oil since India exports around 30,000 tons of groundnut oil annually.
- Under the small-scale industry reservation policy, expelling of groundnut, rapeseed, sesame and safflower oils is restricted to units with investment of ₹ 0.5 million to ₹ 7.5 million (US$ 10,000 to 170,000), effectively restricting their processing capacities to units much smaller by international standards. Firms that manufacture oilseed processing equipment are subject to the same-scale limits, restricting use of modern technology.
- Restrictions on inter-state movement of agricultural products however, have been lifted recently. The legalization of future trading was allowed for soybean and groundnut products, palm and rapeseed in 2003/04.

Policies needed

- Recognition of farmer-participatory varietal selection and evaluation in formal release of a variety at state level
- Innovative seed systems to increase the uptake and dissemination of improved varieties
- Enhancement in MSP of groundnut
- De-reservation of groundnut oil extraction to small-scale industries (which use obsolete technologies)
- Market-price determination based on oil content, aflatoxin contamination and confectionery value
- In case of delayed onset of monsoon, buy-back seed of improved varieties from farmers by the state governments to avoid distress sale of seed as commodity in the market
- Enhanced subsidy on agricultural machinery required for groundnut cultivation
- Enforcement of quality checking and certification at various stages of groundnut marketing chain to facilitate exports to EU and other developed countries with stringent aflatoxin screening mechanisms
- Easy access to credit for small-scale farmers, particularly women farmers
- Farm machinery made available at affordable and subsidized prices

Key issues for competitiveness (ie, reducing production costs, increase market value)

The key issues for enhancing competitiveness of groundnut vis-à-vis other oilseed crops are:

- Enhancing groundnut productivity to lower the cost of per unit production (through integrated use of FPVs and ICM)
- Quality seed production and supply of improved varieties
- Mechanization in groundnut cultivation to reduce labor cost
- Promotion of dual-purpose groundnut varieties for systems sustainability through enhanced livestock productivity
- Promoting aflatoxin-free groundnut production (cultivation of aflatoxin tolerant varieties and adoption of management practices)
- Monitoring aflatoxin contamination levels in groundnut produce/products
- Promoting groundnut cultivation in non-traditional areas that have an opportunity and potential (for instance, spring–summer groundnut cultivation in Uttar Pradesh, India)
- Promotion of groundnut and its products for health and nutrition
- Agronomy needs to be defined appropriately for area expansion in non-traditional areas like Bihar state and paddy fallow areas of command and coastal regions in Karnataka
- Promoting contract farming by involving groundnut processing industries and farmers in Tamil Nadu
- Storage infrastructure development
- Promotion of seed supply chain between seasons in Odisha wherein seed for postrainy season is produced in the preceding rainy season and vise-versa

Mechanization as it relates to timely planting/harvesting and processing

Groundnut cultivation is labor intensive, but with labor being non-available and/or expensive for agricultural operations, moving toward farm mechanization is urgently needed to reduce the production cost of groundnut. Moreover, it also reduces drudgery to women often engaged in laborious activities such as, sowing, weeding, harvesting, stripping and shelling. Suitable women friendly machinery for various small-scale field operations in groundnut for tasks performed by women is needed. Groundnut digger suitable for dryland conditions and other available farm machinery (seed drill, thresher and decorticators) need to be made available to the farmers at subsidized prices. The possibility of training women in use of farm machinery can also be explored.

Environmental/sustainability issues

No negative environmental/sustainability issues are associated with groundnut cultivation. Being an energy rich crop (high oil content), it harvests more carbondioxide (CO_2) from the environment for the same level of economic yield than non-oil crops. Groundnut ensures systems sustainability by supporting livestock. Groundnut haulms provide nutritious fodder thus improving livestock productivity. It ensures sustainability of rainfed cropping system by fixing biological nitrogen. Diseases and insect pest tolerant varieties require minimum pesticide use.

Monitoring and evaluation

It includes annual in-country review and planning meeting, visits to partner locations during the cropping season, farmer–scientist interaction meeting to assess impact, gender disaggregated focus group discussion with all value chain stakeholders to gauge preliminary impacts/constraints of the project and will include gender sensitive indicators and gender disaggregated data, and conducting workshop with partners to share findings of reports, field-level interactions, etc.

Seed production plan

Groundnut seed production plan for India is given in Table 2.

Table 2. Groundnut seed roadmap for India[1].

Ecology	Demand (ha)	Variety characteristics: Productivity traits	Variety characteristics: Market traits	Promising varieties	Seed available in 2012 (Breeder/ foundation) (t)	Seed production (t): Breeder seed (BS)	Seed production (t): Foundation seed (FS) + Certified seed (CS)	Seed to reach 20% adoption (t)	Seed production goal (t) Year 3	Key partners
Zone 5 (Karnataka)	680,000	Drought tolerant, foliar fungal disease resistant, short duration, high yield	High oil content, medium bold seed	ICGV 91114 Chintamani 2 ICGV 00350 R 2001-2 GPBD 5 GPBD 4[2]	10.0 (BS) 0.5 (BS) 0 0.95 (BS) 1.5 (BS) 80.0 (BS)	320	2550 FS	20,400	20,400	Production: BS by UAS-D, UAS-R, UAS-B; FS and CS by UAS-B, UAS-R, UAS-D, State Seed Corp., SFCI, State Department of Agriculture (DOA), Oilseed Growers Fed, Agribusiness Incubator (ABI), NGOs Distribution: State Seed Corp., SFCI, State DOA, Oilseed Growers Fed, NGOs
Zone 5 (Tamil Nadu)	320,000	High pod and haulm yield, drought and foliar fungal disease tolerant	High oil content, medium bold seed	ICGV 87846 ICGV 00351 TMV 7[2] TMV 13[2] VRI 2[2] VRI 3[2] Co G 4[2]	0 0 245.8 41.5 329.6 56.4 28.7	150	1200 FS	9, 600	9, 600	Production: BS by TNAU; FS and CS by State Seed Corp., SFCI, State DOA, Oilseed Growers Fed, Agribusiness Incubator (ABI), NGOs Distribution: State Seed Corp., SFCI, State DOA, Oilseed Growers Fed, NGOs
Zone 4 (Odisha, for both rainy and postrainy seasons)[4]	243, 000	High pod yield, drought and foliar fungal disease tolerant	High oil content	ICGV 91114 [3] TAG 24[2] Smruthi[2]	20.0 (BS) 15.0 (BS)	7	90	4, 860	730	Production: BS by OUAT; FS and CS by State Seed Corp., SFCI, State DOA, Oilseed Growers Fed, NGOs Distribution: State Seed Corp., SFCI, State DOA, Oilseed Growers Fed, NGOs
Bihar[5]	1650	High pod yield, drought and heat tolerant	Medium bold seed, high oil content	Yet to be identified although R 20 is popular locally	0	1	7	50	50	Production: BS by BAU; FS and CS by BAU, State Seed Corp., DOA Distribution: BAU, State Seed Corp.

1. Seed rate 150 kg pods per ha.
2. Improved variety released before inception of TL-II project.
3. FPV identified in a previous project supported by IFAD and released for cultivation as Devi.
4. More than 65% groundnut cultivated is in postrainy season.
5. Non-traditional area with potential for spring and rainy season cultivation similar to Zone 4.

Chickpea

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Introduction

Chickpea is the most important pulse crop of India contributing to 40% of the country's pulse production. India is the largest producer (67% of the world production) and consumer of chickpea in the world. During 2007–09, annual average import of chickpea by India was 227,400 tons (valued at US$ 121.8 million) and export was 128,000 tons (valued at US$ 107.6 million). Chickpea is grown mainly in six states namely Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, Karnataka and Andhra Pradesh, and together they account for more than 90% of the crop's area.

Chickpea is an important source of protein for millions of people who are vegetarian because of choice or economic reasons. The per capita availability of chickpea is 12 g per day (32 g per day for all pulses). Expansion of irrigation and wheat cultivation in northern India led to large shift in chickpea area from northern states (cooler long-season environments) to central and southern states (warmer short-season environments). Chickpea has higher levels of drought and heat tolerance as compared to several other cool season food legumes. It is largely grown under rainfed conditions; only one-third of the chickpea area is irrigated. It plays an important role in preventing soil degradation and improving soil fertility and enhancing system productivity.

Chickpea production and demand in India are given below.

National production: 6.76 million tons (average of 2007/08 to 2009/10)

National demand: 8 million tons

Area: 7.87 million ha (average of 2007/08 to 2009/10)

Average yield: 857 kg ha^{-1}

Proportion of production sold commercially: 20–50% by marginal to small farmers; 50 to 90% by medium to large farmers

Production target by 2015: 30% increase in production in the target regions

Agroecology

North Hill Zone (NHZ)

It includes western Himalayan regions of Jammu and Kashmir, Himachal Pradesh, Uttaranchal (except Tarai area), Sikkim and hills of West Bengal and Northeast states. The chickpea area (<5,000 ha) is negligible in this zone.

North West Plain Zone (NWPZ)

It includes Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), Western Uttar Pradesh (except Jhansi division) and Tarai region of Uttaranchal. The major chickpea growing state in this zone is Rajasthan (0.88 million ha). Chickpea area in other states (Punjab, Haryana and Uttar Pradesh) has been largely replaced by wheat. Chickpea area in this zone is 0.98 million ha.

North East Plain Zone (NEPZ)

It includes Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal, Orissa, Assam, Sikkim and the northeastern states. There is vast area of rice fallows in this zone that offers opportunity for expansion of chickpea area. Chickpea area in this zone is 0.29 million ha.

Central Zone (CZ)

It includes Madhya Pradesh, Maharashtra, Chhattisgarh, Gujarat, Jhansi division of Uttar Pradesh and Kota and Udaipur divisions of Rajasthan. This is the largest chickpea growing zone with an area of 5.28 million ha.

South Zone (SZ)

It includes Andhra Pradesh, Karnataka, Tamil Nadu and Kerala. Chickpea area is rapidly increasing in this zone and is currently 1.62 million ha.

Potential for expansion

Chickpea area and production in India are given in Table 1. The additional area will mainly come from expansion of chickpea area in rice fallows, other fallow lands mainly in NEPZ and SZ, and increasing awareness of crop diversification in all zones.

Table 1. Area and production of chickpea in 2009/10[1].

				Potential for expansion by 2020		
Zone	Area (million ha)	Production (million t)	Yield (kg ha^{-1})	Area (million ha)	Production (million t)	Yield (kg ha^{-1})
NWPZ	0.98	0.63	643	1.4	1.12	800
NEPZ	0.29	0.24	833	0.6	0.54	900
CZ	5.28	5.17	979	5.5	6.05	1100
SZ	1.62	1.42	877	2.0	2.4	1200
All India	8.17	7.46	913	9.5	10.11	1100

1. Source: Agricultural statistics at a glance 2011, Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India (http://eands.dacnet.nic.in/latest_2006.htm).

Dominant chickpea varieties

The dominant varieties of chickpea are given in Table 2.

Table 2. Dominant chickpea in different agroecological zones of India.

Zone	Dominant varieties
NWPZ	Avrodhi, C 235, KPG 59, Radhey, RSG 888, Pratap Chana 1
NEPZ	JG 16, DCP 92-3
CZ	JG 74, JG 315, JG 130, JG 11, KAK 2, Vijay, Vardan, Vishal, Samrat,
SZ	JG 11, KAK 2, JAKI 9218, Vihar, Annigeri

Key constraints

Abiotic and biotic constraints

The abiotic and biotic constraints to chickpea production in India are given in Table 3.

Table 3. Abiotic and biotic constraints to chickpea production in different agroecological zones of India[1].

Constraint	NWPZ	NEPZ	CZ	SZ
Abiotic				
Terminal drought	***	***	***	***
High temperatures at reproductive stage	**	***	***	***
Low temperatures at reproductive stage	***	**		
Soil salinity	**			
Poor soils		**		
Biotic				
Fusarium wilt	***	***	***	***
Pod borer (*Helicoverpa armigera*)	***	***	***	***
Dry root rot	*	**	***	***
Collar rot	**	**	**	**
Ascochyta blight	**			
Botrytis gray mold	**			
Nematodes		**		
Weeds	**	**	*	*

1. Degree of severity: * = Low; ** = Medium; and *** = High.

Socioeconomic constraints

Farmers generally give high priority to staple cereals and vegetables as compared to food legumes. Chickpea is generally grown rainfed and largely on marginal lands. Use of low inputs by farmers, poor adoption of improved cultivars and production technologies are other reasons of low productivity of chickpea.

Organizational constraints

- Inadequate availability of quality seed
- Uncertainty in the quality and timely availability of fertilizers, fungicides and pesticides
- Difficulty in accessing credits by farmers
- Lack of policies to reduce fluctuations in market price and gaps between the farm-gate price and price paid by the consumers

Strategies for TL-II target states

Andhra Pradesh

Chickpea is the most important pulse crop of Andhra Pradesh occupying an area of 614,000 ha with a production of 708,000 tons and a productivity of 1298 kg ha^{-1}. There was dramatic increase in chickpea area in Andhra Pradesh since 1997/98 (147,000 ha with production of 59,000 tons and 398 kg ha^{-1}) and the area touched 647,000 ha during 2009/10. The typical growing environment of Andhra Pradesh is characterized by short growing season and mild winter. The most important chickpea growing districts in Andhra Pradesh are Kurnool, Prakasam, Kadapa and Ananthapur. The realized productivity in Andhra Pradesh is the highest in India. This could be achieved through the adoption of improved cultivars and production technologies and mechanization of agricultural operations. The most important varieties grown by the farmers are JG 11, JAKI 9218, KAK 2 and Vihar. The current major constraints to chickpea production include frequent dry spells, dry root rot, *Helicoverpa* pod borer and *Spodoptera exigua.*

Suggested strategies for increasing chickpea production

- Promotion of varieties with higher and stable yields under drought situations.
- Development of tall and upright growing varieties which can be harvested mechanically.
- Management of *Helicoverpa* pod borer by improving host-plant resistance and integrated pest management (IPM) technologies.
- Promotion of kabuli varieties like Vihar and extra-large-seeded kabuli varieties like MNK 1 which help farmers to realize higher net returns.
- Creating awareness among farmers about improved varieties and increasing the efficiency of seed systems for promoting the adoption of improved varieties.
- Promoting the spread of improved varieties and production technologies by involving public agencies, NGOs, women self-help groups (SHGs) and farmer groups.
- Promotion of improved cultivars and production technologies in Guntur, Adilabad, Medak, Rangareddy and other potential districts.
- Promotion of chickpea under rice fallows.
- Study of value chain to realize profitable price for the farmers.

Karnataka

The area under chickpea is steadily increasing in Karnataka since 2007/08. During postrainy season 2010 the area under chickpea was 960,000 ha with a production of 640,000 tons. The average productivity is 723 kg ha^{-1}. The districts of north Karnataka occupy 85% of area and contribute to approximately 90% of the production of chickpea in the state. The popular varieties of the region are JG 11, JAKI 9218, BGD 103, MNK 1 and the local variety Annigeri.

Suggested strategies for increasing chickpea production

- Development of extra-early genotypes for cultivation in shallow and poor soils.
- Development of varieties tolerant to terminal drought and heat stresses.
- Development of varieties responsive to high management practices.

- Development of tall, semi-erect and non-lodging varieties suitable for mechanical harvesting.
- Expansion of chickpea area under rice fallows.
- Popularization of new and improved varieties identified in different ecological niches.
- Strengthening of informal seed system by establishing seed banks at community level by involving progressive farmer groups, NGOs and women SHGs.

Odisha

Chickpea is an important postrainy season pulse crop of the state occupying an area of 45,000 ha in the cropping system of rice–chickpea. Though chickpea is grown in about 30 districts, large areas are in remote and tribal dominated districts like Kalahandi, Mayurbhanj, Keonjhar, Nawapara and Nawarangpur. The productivity of the state is 748 kg ha^{-1} (2009/10). The trend analysis for five years (2005/06 to 2009/10) indicates that there is an increase in area by 5% from 2005/06 to 2008/09 and record growth during 2009/10 (20%) over its previous year. Similarly, the productivity has increased by 1% from 2005/06 to 2008/09 with a record growth of 13% during 2009/10 over the previous year.

The current major constraints to chickpea production include non-availability of quality seeds, small and marginal farmers with scattered landholdings, lack of knowledge on improved package of practices, poor market linkages and lack of life saving irrigation facilities during stress periods.

Suggested strategies for increasing chickpea production

- Generate awareness among the farmers by different activities [farmer participatory variety selection (FPVS) trials, demonstrations, field days, farmers' fairs, etc] on improved cultivars and production technologies.
- Strengthening of formal and informal seed systems with emphasis on seed production at the village level.
- Development of proper sowing technologies for rainfed conditions with emphasis on biotic stresses.
- Development of heat tolerant varieties suitable for different agroclimatic zones of the state.
- Development of high-yielding farmer- and consumer-preferred varieties.
- Capacity building of the tribal farmers.
- Supportive policies for price and marketing.

Bihar

Chickpea is an important pulse crop of Bihar, cultivated on an area of 65,000 ha with a total production of 77,000 tons and productivity of 1182 kg ha^{-1}. Chickpea area is mainly concentrated in South Gangetic Plains, which has sandy loam to clay loam soils and an average annual rainfall of 1100 mm. The top 10 chickpea growing districts of Bihar are Patna, Aurangabad, Bhojpur, Bhabhua, Rohtas, Nalanda, Banka, Gaya, Lakhisarai and Bhagalpur. All these districts are under South Gangetic Plains. The most common cropping systems in this zone include rice/maize (rainy season)–wheat/maize (postrainy season)–onion/mungbean (summer) in the irrigated conditions and rice/maize (rainy season)–chickpea/lentil/groundnut/pigeonpea/oilseeds (postrainy season) in the rainfed conditions.

The constraints to chickpea production include drought and heat stresses, pod borer, low and unstable yields as compared to wheat in irrigated conditions, lack of suitable technologies for good crop establishment in rice fallows, and inadequate availability of quality seed.

Suggested strategies for increasing chickpea production

- Development of drought and heat tolerant cultivars.
- Development of high input responsive cultivars.
- Incorporation of resistance to biotic stresses.
- Development of extra-large-seeded kabuli varieties.
- Refinement of crop production practices for growing chickpea in rice fallows.
- Enhancing adoption of improved cultivars and production technologies.
- Ensuring availability of quality seed at the local level.
- Bringing additional area under chickpea cultivation by promotion of short-duration, heat tolerant varieties under rice fallows and new niches.

Key partners

The key partners along the value chain and their role are given below.

- ICRISAT: Generation and supply of improved germplasm to NARS partners; development and application of molecular tools in crop improvement; development and promotion of integrated crop management (ICM) technologies; capacity enhancement of NARS; international networking in research and development; facilitating NARS in dissemination of improved cultivars and production technologies.
- Indian Council of Agricultural Research (ICAR) and its institutes, such as Indian Institute of Pulses Research (IIPR), Indian Agricultural Research Institute (IARI), and All India Coordinated Research Project (AICRP) on Chickpea: Development of regionally adapted cultivars and production technologies; coordinating research and evaluation of cultivars and technologies in India; transfer of technology.
- State Agricultural Universities: Development of regionally adapted cultivars and production technologies; transfer of technology.
- State Agriculture Departments and NGOs: Transfer of technology
- National and State Seed Corporations: Seed production

Capacity building needs

Training of NARS partners is needed on hybridization, selection, and novel breeding methods, such as marker-assisted backcrossing (MABC) and marker-assisted recurrent selection (MARS) and use of electronic field books, pedigree and data management system. Attention will be given to include women scientists/staff.

Special cultural/gender considerations

Women farmers play an important role in chickpea cultivation in India. Efforts will be made to ensure involvement of women farmers in participatory varietal selection (PVS), field days, farmers' fairs and various training programs. Roles of men and women in cultivation, processing and marketing will be identified. Constraints faced by and needs of women in relation to the tasks/roles they perform will be considered. Training programs will be tailored to cater the needs of women.

Processing and storage requirements and market opportunities

Seed processing and storage facilities are needed to be strengthened for farmers or farmers' groups/ societies involved in seed production. Attention will be given to women's groups.

Over 60% of chickpea is consumed as splits (dal) and flour (*besan*). Consequently the processing of chickpea is an important step in the marketing chain. The marketing channel for chickpea and its processed products is marked by a few important bottlenecks.

- A majority of the harvested produce is sold to the village traders owing to prior input-credit contracts. The market price that the farmers get in this situation is typically lower than the price in the market yard. Grading facilities are typically absent or not implemented depriving the farmers of a fair price.
- There are additional links in the value chain between chickpea farmers and dal processors that further erode the farmer's share in the consumers' rupee. Dal processors prefer to buy whole grain in bulk in order to cut down on their transaction costs. However, since a lot of the chickpea farmers are small-scale farmers with small marketable surpluses, a commission agent who collects all the grains from the farmers, and sells it to the dal millers in bulk quantity becomes an important actor in the value chain.

Key policies

Policies recently implemented

The Ministry of Agriculture, Government of India (GOI) made efforts on enhancing production of pulses in India through Integrated Scheme of Oilseeds, Pulses, Oil palm and Maize (ISOPOM). Under this scheme, new technologies, timely supply of inputs, extension support, remunerative price, marketing infrastructure and postharvest technologies were provided for increasing pulses production including chickpeas. In 2008, the Project was implemented in 437 districts in 14 states spread across the country.

In 2007, under the nationally sponsored National Food Security Mission, sustainable production for pulses (chickpeas) were being targeted in 168 districts in 14 major pulse producing states as part of a special project called the Accelerated Pulse Production Program (A3P). The program includes quality seed production, integrated nutrient management, IPM, distribution of sprinkler sets, strengthening infrastructure, and training and extension services.

The GOI announces Minimum Support Price (MSP) for several crops including pulses as a floor price for procurement by government agencies. In a bid to improve acreage under pulses, the MSP for chickpea has been hiked steadily over the years with a big push in 2010/11 when the MSP increased by 20% over 2009/10 from ₹17,600 to 21,000 per ton. Despite this, by and large during the last several years the MSP for pulses (chickpea) has remained lower than the market prices.

Pulses imports were placed under Open General License (OGL) in 1979, allowing any public or private sector player to import into India without approval or restriction. With the elimination of import duties since 2000, imports of pulses to India have risen from 350,000 tons in 2000/01 to 1.7 million tons in 2005/06. In 2009/10 India imported 3.6 million tons of pulses of which chickpeas constituted around 10%.

In 2008 the GOI had launched the sale of subsidized pulses in Fair Price Shops (FPS) after a steep rise in prices caused consumer distress. The scheme required state governments to import pulses through state-run agencies and sell them through FPS and state cooperative dairies. The Government gave a fixed subsidy of ₹10 per kg, which enabled eligible consumers to buy pulses at a price lower than those prevailing in the market.

Policies needed

The following policies are needed: for recognition of FPVS data for release of varieties; to support seed production of legumes by informal seed systems; to promote inclusion of legumes for crop diversification in cereal dominated cropping systems (eg, rice–wheat in northern India); for better targeted food subsidy that increases access to chickpea through sale in FPS to below poverty line (BPL) families thus enhancing their nutritional security.

Key issues for competitiveness

- Varieties with higher and stable yields for increased production
- Varieties suitable for mechanical harvesting for reducing production cost
- Varieties with market-preferred seed traits (size, shape and color) to ensure higher market value
- IPM for management of pod borer to reduce use of pesticides
- Increasing the availability of quality seed at the local level and at affordable price

Mechanization needs

- Promote tall and erect varieties which can be harvested mechanically
- Organize marginal and small farmers in farmers' groups/societies/communities and provide them tractors, cultivators, seed drills, harvesters and other farm equipment at community level
- Develop pod shellers to meet the potential need of green immature seeds in supermarkets
- Develop/identify women friendly equipment and herbicide tolerant cultivars to decrease drudgery (eg, hand weeding)
- Explore avenues where possible to train women on use of other equipment

Environmental/sustainability issues

- Promote IPM practices which are eco-friendly and affordable by the farmers
- Enhance crop diversification for ensuring sustainability of the cropping system

Possible interventions to increase production and productivity

These are: development of improved germplasm with enhanced resistance/tolerance to abiotic and biotic stresses, phenology and plant type required for existing and evolving cropping systems, and seed quality preferred by the enhancement market using conventional and modern breeding approaches; and enhancement of adoption of improved varieties and improved management practices by conducting PVS trials, through various activities for knowledge empowerment of farmers and by strengthening informal and formal seed systems.

Institutional and technical innovations required

- Establishing linkages between informal and formal seed systems.

- Evaluation of improved lines developed through MABC and MARS for developing drought tolerant varieties.

Monitoring and evaluation

These will include annual in-country review and planning meeting, monitoring visits during the cropping season and farmer–scientist interaction meeting to assess impact. Gender disaggregated data and gender sensitive indicators will be included.

Seed production plan

Chickpea seed production plan is given in Table 4.

Table 4. Chickpea seed roadmap for India[1].

Ecology	Demand (ha)	Variety characteristics: Productivity (t ha^{-1})	Variety characteristics: Type	Promising varieties	Seed currently available (Breeder + Foundation) (t)	Seed production (t): Breeder seed	Seed production (t): Foundation + Certified seed	Seed to reach 30% adoption (t)	Seed production goal (t): Year 1 (2012)	Seed production goal (t): Year 2 (2013)	Seed production goal (t): Year 3 (2014)	Key partners (Seed production and distribution)
Rainfed	960,000	2.5	Desi	JG 11	3000	201.6	19958.4	20160.0	4032.0	6048.0	10080.0	RARS-Nandyal, ARS-Gulbarga, UAS-Raichur, UAS-Dharwad, BAU-Sabour, NSC, SFCI, APSSDC and KSSC
Rainfed	400,000	2.5	Desi	JAKI 9218	1540	94.1	9313.9	9408.0	1881.6	2520.0	4200.0	
Rainfed	160,000	2.0	Kabuli	KAK 2	800	48.0	4752.0	4800.0	960.0	1440.0	2400.0	
Rainfed	48,000	1.5	Kabuli	MNK 1	68	5.8	570.2	576.0	115.2	302.4	504.0	
Rainfed	30,000	2.0	Desi	BGD 103	15	3.4	332.6	336.0	67.2	324.0	540.0	
Rainfed	15,000	2.0	Desi	Pusa 256	2.8	31.5	283.5	315.0	63.0	94.5	157.5	BAU-Sabour, NSC, SFCI and BSSC
Rainfed	10,000	2.0	Desi	Pusa 362	2.2	21.0	189.0	210.0	42.0	63.0	105.0	BAU-Sabour, NSC, SFCI and BSSC
Rainfed	12,000	2.0	Desi	Pant G 186	2	25.2	226.8	252.0	50.4	75.6	126.0	BAU-Sabour, NSC, SFCI and BSSC

1. Seeding rate 70 to 120 kg ha^{-1} (depending on seed size).

Pigeonpea

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Economic importance of pigeonpea in India

India is the largest producer of pigeonpea in the world and contributes around 80% of the world's total production. In 2009/10, pigeonpea consumption for urban areas was 0.26 kg per month while it was 0.16 kg per month in rural areas. Production in India is not sufficient to support the domestic needs and resulted in the rising prices to nearly 250% in the last couple of years and the need to import about 500,000 tons of pigeonpea yearly from Myanmar and Southeastern Africa.

Pigeonpea is mainly consumed as dry split seed (dhal) and to a lesser extent as green vegetable in certain areas. It is an excellent source of protein (20–22%), supplementing energy rich cereal diets in a mainly vegetarian population. Pigeonpea is a multi-purpose crop that fits very well in the context of sustainable agriculture. In addition to food, it is used as fodder, feed, fuel, functional utility (for making baskets, huts, fences, etc), fertilizer (fixes atmospheric nitrogen and releases phosphorus), forest use (re-forestation, lac production), and even for pharmaceutical purposes.

Pigeonpea is often planted in marginal environments and under rainfed (96%) conditions. It is drought tolerant; its root system allows optimum utilization of soil moisture and nutrients. Pigeonpea is known to improve the soil structure and fertility, and consequently, ensures better growth of the succeeding crops. It is estimated that pigeonpea has a beneficial effect on subsequent crops equivalent to about 40 kg N ha^{-1}. The traditional pigeonpea cultivars are medium to long duration, with maturity ranging from 150 to 280 days, and are typically grown as an intercrop with relatively shorter duration crops including sorghum, maize, millets, cotton, groundnut, soybean, etc.

Development of high-yielding disease resistant varieties has helped in increasing pigeonpea area and thereby production from 1.7 million tons in 1950/51 to over 3.19 million tons in 2009/10. However, productivity has remained at around 700 kg ha^{-1} and increase in productivity is yet to be witnessed. Recently, attempts have been made to increase pigeonpea productivity through breeding high-yielding disease resistant varieties and hybrids.

Seed production target

National production: 2.63 million tons (average of 2007/09)

National demand: 3.13 million tons

Area: 3.55 million ha (average of 2007/09)

Proportion of production sold commercially: 60–75%

Average yield: 742.48 kg ha^{-1}

National projected demand for 2020: 5 million tons

Expected growth of production: 2%

Target average yield for 2015: Andhra Pradesh and Odisha – 1,000 kg ha^{-1}; Bihar – 1,300 kg ha^{-1}

Agroecology

Data on pigeonpea production is given in Table 1.

North Hill Zone (NHZ)

This includes western Himalayan regions of Jammu and Kashmir, Himachal Pradesh, Uttaranchal (except Tarai area), Sikkim and hills of West Bengal and North East States. The pigeonpea area is negligible (<5,000 ha) in this zone.

North West Plain Zone (NWPZ)

This includes Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), Western Uttar Pradesh (except Jhansi division), and Tarai region of Uttaranchal.

North East Plain Zone (NEPZ)

This includes Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal, Odisha, Assam, Sikkim and plains of far eastern states.

Central Zone (CZ)

This includes Madhya Pradesh, Maharashtra, Chhattisgarh, Gujarat, Jhansi division of Uttar Pradesh and Kota and Udaipur divisions of Rajasthan.

South Zone (SZ)

This includes Andhra Pradesh, Karnataka, Tamil Nadu and Kerala.

Table 1. Area and production of pigeonpea in different agroecological zones of India during 2005 to 2007[1].

Zone	State/District	Area ('000 ha)	Production ('000 t)	Yield (kg ha^{-1})
NEPZ		480	440	917
	Bihar	35	40	1125
	Bhagalpur	0.8	1.375	1758
	Banka	0.6	1.071	1859
	Odisha	133	111	841
	Dhenkanal	3.07	2.69	875
	Angul	9.65	8.59	890
	Naupada	5.5	4.12	750
CZ		1800	1400	778
SZ		1100	650	591
	Andhra Pradesh	450	207	460
	Ranga Reddy	35	35	1000
	Mahaboobnagar	80	36	450
NWPZ		160	160	1000
All India		3540	2700	750

1. Source: DES (Directorate of Economics and Statistics), Department of Agriculture and Cooperation, Ministry of Agriculture, various years. Government of India, New Delhi.

Dominant varieties by ecology

NEPZ: UPAS 120 (early maturity); Bihar – Bahar, Bada, Pusa-9, Patam; Odisha – Kandula

CZ: Asha, Maruti, Laksmi, BSMR-736, LRG-30, PRG-100, BDN-2, PRG 158 (medium maturity)

SZ: Asha, Maruti, Laksmi, BSMR-736, LRG-30, PRG-100, BDN-2, PRG 158 (medium maturity); Andhra Pradesh – Asha, Maruti, Laksmi, LRG 30, LRG 41, PRG 100, PRG 158

NWPZ: Manak

Key constraints

Abiotic and biotic constraints

The abiotic and biotic constraints to pigeonpea production are given in Tables 2 and 3.

Table 2. Abiotic and biotic constraints to pigeonpea production in different agroecological zones in India[1].

Constraint	NWPZ	NEPZ	CZ	SZ
Abiotic				
Terminal drought	**	**	***	***
Soil salinity	**	*		
Waterlogging	**	**		
Biotic				
Fusarium wilt		***	***	***
Sterility mosaic		***	***	***
Pod borers (*Helicoverpa* and *Maruca*)	***	***	***	***
Dry root rot			*	*
Pod fly/pod bugs	**	***	*	*
Nematodes			*	*
Phytophthora blight	**	**	*	*
Storage pests	**	**	**	**
Alternaria leaf spot		**		
Weeds	**	**	**	**

1. Degree of severity: * = Low; ** = Medium; and *** = High.

Socioeconomic constraints

India continues to struggle with the problem of poverty that is largely dependent on low productivity of rainfed agriculture. Constraints to pigeonpea production are not solely biophysical, but also influenced by various socioeconomic factors such as efficient markets and their links with producers, availability of quality seeds, timely availability of inputs, small farm holdings, value addition, credit and availability of labor.

Organizational constraints

Land shortage and land tenure (government owned) restricts private investment in land management (such as soil and water conservation), leading to land degradation. Some organizational constraints are listed.

Table 3. Abiotic and biotic constraints to pigeonpea production in three states of India[1].

	NEPZ		SZ
Constraint	Bihar	Odisha	Andhra Pradesh
Abiotic			
Terminal drought	*	***	***
Waterlogging	*		
Biotic			
Fusarium wilt	***	***	***
Sterility mosaic	***	***	***
Pod borers (*Helicoverpa* and *Maruca*)	***	***	***
Dry root rot		*	*
Pod fly/pod bugs	***	*	*
Nematodes		*	*
Phytophthora blight	**	*	*
Storage pests	**	**	**
Alternaria leaf spot	**		
Weeds	**	**	**

1. Degree of severity: * = Low; ** = Medium; and *** = High.

- High poverty level
  - Poor investment in labor and inputs such as quality seed, fertilizers and insecticides
  - Difficulty to access medium- and long-term credit and poor loan recovery
- Marketing in domestic and international markets
  - Limited volume of domestic production and huge domestic demand
  - Lack of value addition facilities
  - Lack of infrastructure facilities (ie, postharvest facilities, improved farm to market roads)
  - Lack of market information and grading facilities
  - High commission of brokers and middlemen
  - High transportation cost

Key partners along the value chain (across zones)

Partners from the public and private sector play key roles in research and development efforts (Table 4). They cooperate in joint evaluation and selection programs, promotion, production and distribution of breeder and certified seeds of promising varieties and hybrids. They also contribute knowledge and skills to educate and train farmers, technicians, scientists and students in theoretical and practical aspects of breeding, genetics, seed systems, etc. They also assist in monitoring, evaluation and impact assessment of the technologies developed and shared (CMS hybrid system, new varieties, improved seed systems).

Table 4. Key partners and their role in the seed system.

Partner	Role
ICAR (Indian Council of Agricultural Research), State Agricultural Universities	Variety development, evaluation and release; production of breeder and foundation seeds
ICRISAT	Provide improved germplasm/breeding populations; capacity building through training; research on effective methods for technology dissemination
NSC (National Seed Corporation) and SSC (State Seed Corporations)	Seed systems support; production of certified seed and distribution of quality seed
Department of Agriculture	Seed systems support and distribution of quality seeds and technology transfer
NGO/CSO initiatives	Production and distribution of quality seeds and technology transfer
Private sector (market intermediaries and emerging small-scale seed enterprises and processors)	Processing and commercialization of seed and products
Farmers	End-users of technologies in terms of high-yielding varieties, management practices

Capacity building needs

- Training programs for NARS in pigeonpea breeding, genetics, seed production, integrated pest management (IPM) and crop production technologies. Attention will be given to include women.
- Create farmer friendly literature.
- Promotion of hybrid technology.
- Improvement of seed system at farmers' level. Women's seed systems and networks will be targeted.
- Training in data management to include women.
- Modernization of field equipment and identifying friendly technology for women to reduce drudgery in milling and harvesting.

Processing and storage requirements and market opportunities

For pigeonpea, the traditional private marketing channel is the most prevalent. Typically, the farmers sell grain directly to the traders in the agriculture produce market yards or to village traders who are also popular. Imported pigeonpea is channeled through agencies, such as the State Trading Corporation (STC), Minerals and Metals Trading Corporation (MMTC) and Project and Equipment Corporation (PEC), to private wholesalers or processors. Importers who are licensed to import pulses sell the consignment directly to secondary wholesalers or processors through middlemen. The major portion of the processed pulses from processors goes to secondary wholesalers, and is then sold to consumers through retailers. The processing and storage requirements and market opportunities are:

- At present processing and storage at village level are lacking and it needs to be established with the help of NARS/NGOs.
- Enhance yield levels through hybrids.
- Availability of varieties with farmer and market preferred traits such as color, uniformity of grain size, recovery rate, cooking time, taste, storability, etc.

- Diversification of crop to non-traditional areas both under limited as well as high input conditions. This can be achieved through development of varieties and hybrids belonging to short-, medium- and long-duration groups.
- Linkages with markets are essential.

Key policies (recently implemented/needed)

In order to improve pulses production, the Government of India (GoI) launched a program called the Integrated Scheme of Oilseeds, Pulses, Oil palm, and Maize (ISOPOM). Under this scheme, new technologies, timely supply of inputs, extension support, remunerative price, marketing infrastructure and postharvest technologies were provided for increasing pulses (pigeonpea) production. In 2008, the Project was implemented in 437 districts in 14 states spread across the country. In 2007, under the nationally sponsored National Food Security Mission, sustainable production for pulses was being targeted in 168 districts in 14 major pulse producing states as part of a special project called A3P (Accelerated Pulse Production Program). The program includes quality seed production, integrated nutrient management, IPM, distribution of sprinkler sets, strengthening infrastructure, and training and extension services.

The GoI announces Minimum Support Price (MSP) for several crops including pulses as a floor price for procurement by government agencies. In a bid to improve acreage under pigeonpea, its MSP has been hiked steadily over the years with a big push in 2010/11 when the MSP was increased to ₹30,000 per ton, ie, 30% increase over 2009/10 prices. Despite this, by and large during the last several years the MSP for pigeonpea has remained lower than its market prices.

Pulses imports were placed under Open General License (OGL) in 1979, allowing any public or private sector player to import into India without approval or restriction. With the elimination of import duties since 2000, imports of pulses to India have raised from 350,000 tons in 2000/01 to 3.6 million tons in 2009/10. Pigeonpea imports constitute about 10–15% of total pulse imports.

In 2008 the GOI had launched the sale of subsidized pulses in Fair Price Shops (FPS) after a steep rise in prices caused consumer distress. The scheme required state governments to import pulses through state-run agencies like STC, PEC, MMTC and NAFED and sell them through FPS and state cooperative dairies. The Government gave a fixed subsidy of ₹10 per kg, which enabled eligible consumers to buy pulses at a price lower than those prevailing in the market. The scheme was discontinued from March 2012 after a report from the Comptroller and Auditor General's office pointed out that importing agencies suffered a loss of ₹1,201 crore on import and sale of pulses between 2006 and 2011 without succeeding in price stabilization in the market.

Key issues for competitiveness

- Introduction of integrated pest and disease management to reduce input costs; efficient and effective seed system; organized marketing to demand good prices; widespread introduction of farmer- and market-preferred varieties; product delivery as per domestic, regional and international market demands to fetch high prices.
- The lack of competitiveness of pigeonpea relative to competing crops or companion crops in the intercropping system is an important constraint, especially under irrigated conditions. Joshi et al. (2000) estimated that if pigeonpea were to replace rice, farmers would have to sacrifice 49% profit and 76% rice production. However, under rainfed conditions, pigeonpea can grow on low moisture with minimal or no fertilizer application. Therefore promoting pigeonpea in rainfed growing domains would increase production.

- Increased adoption of high-yielding varieties that are suited to the agroecologies where pigeonpea is grown with special reference to drought tolerance to reduce the unit cost of production.
- Better management practices (pre- and postharvest) to reduce pest and disease incidence.
- Improvement in efficiency of seed system to ensure that high-yielding varieties of pigeonpea are available and of good quality.
- Stringent seed certification requirements and accompanying bureaucratic hassles discourage farmers' participation in the formal seed system.

Mechanization as it relates to timely planting/harvesting and processing

Indian farmers use mechanical as well as traditional plow for land preparation; it depends on the landholding of farmers. Transportation is done using bullock carts, while threshing is done manually. Sometimes harvested produce is placed on the main road for vehicles to pass over it – but this is detrimental to the quality of the grain. The majority of Indian farmers still use bullocks for sowing because of lack of affordable tractor-drawn implements for small-scale farmers. To enhance commercialization of pigeonpea, it is important to introduce pre- and postharvest machineries such as irrigation pumps, light tractors, planters, tractor-mounted sprayers, harvesters and threshers.

Gender considerations

Women represent 80% of the workforce involved in agriculture in India. Men tend to move into higher income jobs and thus women have the responsibility of handling farm labor from planting to harvesting. Feminization of agriculture in India is a reality. Despite this, women only receive 2–10% of extension support (Source: FAO). Women have been traditionally discriminated in terms of access to inputs such as land, credit and agricultural technologies. Thus efforts, both political and socioeconomical are needed to empower women in India.

Grain legumes (pigeonpea included) are 'pro-gender crops'. Women and children (the most vulnerable groups nutritionally) will be the primary clients of nutritionally improved legumes. Women play a critical role in any nutrition education component, both for their own health, and their role as 'care givers' and homemakers.

In terms of seed storage options, women are in the forefront of adaptive research and they often make the hard decision of what to use for seed, and what to use as food to feed their children. This may be important especially for decentralized seed enterprises. Seed production and delivery approaches and tools that capture priorities, from both male and female participants, as well as giving them equal opportunities for participation, will be emphasized.

Women are also more involved in small-scale processing and food preparation for home use or local sale, so the introduction of simple processing technologies can directly benefit them and the households. It is expected that the increased and focused participation of women in the value chain could increase their involvement in higher level economic activities like marketing, managing end-product enterprises and decision-making.

It is also proposed that the participatory monitoring and evaluation system in each center be guided by a performance measurement framework that integrates local and gender specific indicators for monitoring project outcomes.

Environmental/sustainability issues

- To overcome the problem of early season drought, the varieties should have flexible adaptation.
- Crop protection options to suit variable climatic conditions.
- Quality seeds are of primary importance and high priority should be given by public/private sector.
- Losses due to drought and waterlogging are significant in some areas; therefore research has to be initiated in these areas.
- Awareness program should be strengthened.
- Capacity building for diffusion of improved crop production technologies is needed to improve livelihood through increased yields from the crop.

Monitoring and evaluation

- Monitoring visits during the cropping season
- Farmer–scientist interactions during project monitoring
- Annual in-country review and planning meetings
- Regional planning and reporting workshops
- Early adoption and diffusion studies
- Gender disaggregated focus group discussions
- Feeding the yearly monitoring and evaluation findings back into the research cycle

Strategies for the target states

Andhra Pradesh

- The productivity of pigeonpea has been static and low over decades.
- Enhance production and productivity through promotion of hybrids and improved seed systems.
- Expansion in non-traditional areas.

Bihar and Odisha

- Identification of varieties for different agroecologies
- Identification of variety/hybrid for new ecological niches (rice bunds, rice fallows)
- Relevant backup research for enhancement of productivity, quality and adaptation
- Refinement and genetic improvement of local variety *Patam*
- Developing a weed management module for rainy and postrainy seasons

Seed production plan

Pigeonpea seed production plan is given in Table 5.

Table 5. Seed roadmap for pigeonpea in India[1].

Ecology	Demand (ha)	Variety characteristics: Yield (t ha^{-1})	Variety characteristics: Special traits	Promising varieties	Seed currently available (Breeder + Foundation) (kg)	Seed production: Breeder seed (kg)	Seed production: Foundation + Certified seed (t)	Seed to reach 30% adoption (t)	Seed production goal (t): Year 1 (2012)	Seed production goal (t): Year 2 (2013)	Seed production goal (t): Year 3 (2014)	Key partners (Seed production and distribution)
Rainfed North Eastern Plain Zone (Odisha and Bihar)	170,000	2.5	Drought tolerant, early and medium duration and disease resistant	Asha, Maruti, Kamica, ICPL 88039, ICPH 2671	50	200	10	510	300	400	550	ICRISAT, SAUs, SSDC, Farmer seed growers, NGOs, private seed companies
Rainfed Southern Zone (Andhra Pradesh)	500,000	2.5 to 3	Drought tolerant, early and medium duration and disease resistant	Asha, Maruti, PRG 158, ICPH 2740	200	600	30	1500	1100	1300	1500	

1. Seeding rate: 10 kg ha^{-1}.

Partners

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The **International Crops Research Institute for the Semi-Arid Tropics** (ICRISAT) is a non-profit, non-political organization that conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners throughout the world. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid tropics have over 2 billion people, of whom 644 million are the poorest of the poor. ICRISAT innovations help the dryland poor move from poverty to prosperity by harnessing markets while managing risks – a strategy called Inclusive Market-Oriented Development (IMOD).

ICRISAT is headquartered in Patancheru near Hyderabad, Andhra Pradesh, India, with two regional hubs and five country offices in sub-Saharan Africa. It is a member of the CGIAR Consortium. CGIAR is a global research partnership for a food secure future.

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