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Increasing Productivity and Profitability in Legumes Cultivation: Opportunities, Challenges and Lessons Learnt from Tropical Legumes- II (Phase 1 and 2) project

D Kumara Charyulu[1], D Moses Shyam, Cynthia Bantilan, P Parthasarathy Rao, Uttam Deb and GD Nageswara Rao

International Crops Research Institute for the semi-Arid Tropics (ICRISAT), Patancheru, Hyderabad

ABSTRACT

The Tropical Legumes II (TL-II) project, funded by the BMGF, aims to improve the lives and 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 tropical legumes – chickpea, common bean, cowpea, groundnut, pigeonpea and soybean. It has been implemented in ten target countries that included in WCA, ESA and SA regions in two phases (Phase 1: 2007-08 to 2010-11; Phase-2: 2011-2014). But, the present paper discusses about only three legumes (chickpea, pigeonpea and groundnut) crops and the interventions carried out in India only. Specifically, this initiative has been focusing on proper targeting for development of improved cultivars of food legumes, promotion of their adoption, proactive public sector policies and finally linking these small holders to markets and value chains. A number of studies have been completed in six states (Andhra Pradesh, Maharashtra, Bihar, Karnataka, Odisha and Tamil Nadu) in India and Barind region of Bangladesh during last eight years (2007-2014) of project implementation. The main objective of this paper is to summarize those key findings across crops and also to identify various potential opportunities and challenges for promotion of legumes in the future. These studies have examined and documented the existing situation in legumes cultivation, constraints faced by the farmers, market linkages, potential opportunities for their expansion etc. In close association with crop improvement scientists, Farmers' Participatory Varietal Selection (FPVS) approach was implemented for assessing farmers preferred traits in these crops. These preferred varieties were identified, released formally, multiplied and supplied as seed samples to legume growers in intervention sites. Subsequently, studies were also conducted on monitoring early adoption of newly introduced improved cultivars and their performance in the targeted locations. All those findings emanated from various studies along with lessons learnt during the process are highly valuable to share among NARS partners, researchers, academicians and donors.

Keywords: Legumes in South Asia, Income and Nutritional security, Lessons learnt, TL-II Project

[1] Corresponding author: d.kumaracharyulu@cgiar.org; Scientist, RP-MIP, ICRISAT, Patancheru, Hyderabad.

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1. Introduction

Legumes are integral part of cropping systems and farmers' livelihoods. Besides enriching soil fertility, food legumes also provide substantial income to the farm households and also contribute towards household nutritional security.The Tropical Legumes II (TL II) project, funded by the Bill & Melinda Gates Foundation, aims to improve the lives and livelihoods of smallholder farmers in the drought-prone areas of sub-Saharan Africa (SSA) and South Asia (SA) through improved productivity and production of six major tropical legumes – chickpea, common bean, cowpea, groundnut, pigeonpea and soybean. It is anticipated that productivity would increase by 20% and improved varieties would occupy 30% of all tropical legumes covered in the project.

TL II is jointly implemented by International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), CIAT (International Centre for Tropical Agriculture), IITA (International Institute of Tropical Agriculture) and National Agricultural Research Systems (NARS).The project was implemented in 15 target countries that included Western and Central Africa, Eastern and Southern Africa and South Asia. Since 2007, the project has been implementing in two phases: Phase-1 (2007-2010) and Phase-2 (2011-2014) across the three regions and crops. However, the project has been planned for three phases totalling 10 years[2].

The project approach for improving the productivity and production of tropical legumes includes, among others: 1.Understanding the legumes' environment (through baseline, market and impact studiesand effective monitoring and evaluation systems) and leveraging existing knowledge; 2. Developing farmer-and market-preferred crop varieties and integrated crop management technologies; 3. Establishing sustainable seed production and delivery systems; 4. Capacity building for NARS; and 5. Creating awareness and reaching farmers with available technologies.

2. Target regions and interventions

The project supports applied breeding programs for each of the crop/country combinations and has been highly successful at releasing varieties in nearly all geographies – more than 120 varieties have been released by the project to date (2007-2013). These breeding programs have been considerably strengthened over the past eight years but need further modernizing to take advantage of the advances in molecular breeding sweeping across the discipline.

Table 1 summarizes the major crop-country combinations for targeting the research and project interventions over the last eight years period. However, the present paper confines to South Asia region (India and Bangladesh) and three targeted crops (chickpea, pigeonpea and groundnut) only. The subsequent sections of this paper document the initial impacts on project interventions in South Asia and those legumes. Among several interventions, the

[2] For more details access on http://www.icrisat.org/tropicallegumesII/pdfs/EngagingSmallholders.pdf

present paper focuses and highlights onfour major activities carried out across regions. Overall, the project targeting and scaling-outefforts are summarized and depicted in Fig 1.

Table 1 Country and crop focus under TL II project (phase 1 & 2)

Country	Bean (Common)	Chickpea	Cowpea	Groundnut	Pigeonpea	Soybean
WCA						
Burkina Faso		X		X		
Mali			X	X		
Niger			X	X		
Nigeria			X	X		X
Senegal				X		
Ghana			X	X		
ESA						
Ethiopia	X	X				
Kenya	X	X				X
Malawi	X			X	X	X
Mozambique			X	X		X
Tanzania	X	X	X	X	X	
Uganda	X			X	X	
Zimbabwe	X					
SA						
Bangladesh		X		X		
Bihar (India)		X			X	
Odisha (India)				X	X	
Andhra Pradesh (India)		X			X	
Karnataka (India)		X		X		
Tamil Nadu (India)		X		X		
Maharashtra (India)		X			X	

2.1 Fast-tracking and variety release

Under each crop, large number of participatory varietal selection (PVS) trials was carried out in the targeted countries using released varieties or pre-released advanced lines, in comparison with one or more local check(s), over the three to four seasons. A total of 120 varieties have been released during 2007-2013. All of these are farmers-and market-preferred varieties that have been identified through the PVS trials in those respective countries. Their yield advantages over the checks ranged from 5% to 300%. Some of these varieties have been released in more than one country.

2.2 Seed production and delivery systems[3]

The seed production and delivery system has identified more than two dozen types of seed production models across target countries. Eight, eight and ten seed production systems have been reported for breeder/foundation seed, certified seed and other quality seed production systems in the target countries.

Systems varied from country to country. NARS research centres' are responsible for breeder and foundation seed production across target countries, with few exceptions. It has been observed that there is no much enthusiasm by large seed companies to engage in grain

[3] For more details access on http://www.icrisat.org/tropicallegumesII/pdfs/J401_2013.pdf

legume seed production because of low margin of profit, as farmers could recycle their own saved seed for up to five years. Much attention is therefore paid to strengthening community-based and farmer level seed production systems. Overall, a total of 20-25 seed delivery models have been identified in the 15 target countries. These too varied from country to country.

The availability and access to seeds are crucial factors in the adoption of improved technologies by farmers. TL II project invested significant amounts of time and efforts on this aspect during phase 1 & 2 and will continue to further strengthen it (see Table 2). Considering each crop (and seeding rate in kg per ha) for common bean (100), groundnut (90), chickpea (70), soybean (60), cowpea (20), and pigeonpea (8.5), this amount of seed would be sufficient to plant a minimum of 3.7 million ha. Considering an average of 0.25 ha of the legumes per household, this would mean coverage of more than 14.8 million households under the project directly.

Table 2 Different classes of seed produced and distributed (MT) in target countries

Crop	2007-2011	2011-12	2012-2013	Total
Chickpea	55,756	45329.9	66223.5	167,309
Groundnut	25,968	1367.5	14317.1	41,653
Common bean	9030	8006.8	3928.7	20,966
Soybean	871	621.5	1098.9	2,591
Pigeonpea	698	1593.1	2051.0	4,342
Cowpea	568	370.6	479.9	1,419
Grand total	**92,891**	**57289.4**	**88099.0**	**238,280**

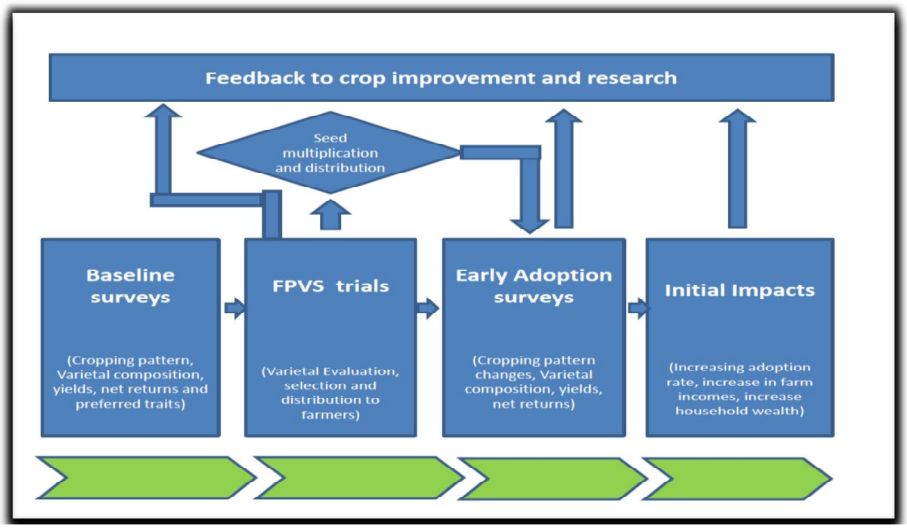
2.3 Capacity building

Good progress has been made in terms of both physical and human capacity building in the NARS of target countries. Laboratory and office equipment has been purchased and submitted to the NARS; irrigation facilities for conducting research on drought tolerance have been installed or upgraded in all countries. Seed storage facilities have been renovated and are in use in the countries which needed these. Additionally, the NARS capacity has been improved significantly at national, regional and overseas universities.

2.4 Creating awareness

Awareness creation has been effected through field days, demonstrations, seed fairs, agricultural shows, dealing with farmers' research groups/farmer field schools, and distribution of small pack seed samples. The project has been able to reach approximately5.0 million farmers during its first and second phases.

Fig 1: Targeting and diffusion interventions under TL II project



3. Impact on adoption, productivity and profitability in South Asia

As mentioned earlier, the present paper confines more to South Asia and three major legumes crops only. Numerous studies have been completed in six states (Andhra Pradesh, Karnataka, Maharashtra, Bihar, Odisha and Tamil Nadu) in India and Barind region of Bangladesh during the eight years of project implementation (2007-2014).These studies have examined and documented the existing situation in legumes cultivation, extent of adoption, constraints faced by the farmers, market linkages, potential opportunities for their expansion etc. Some, studies were also conducted for monitoring early adoption of newly introduced improved cultivars and their performance in the targeted locations. However, the present section highlights the initial impact of those TL II project interventions on extent of adoption, productivity and profitability by crop wise in the targeted sites.

3.1 Chickpea[4]

Chickpea has been targeted in two major states (Andhra Pradesh and Karnataka) of India and Bangladesh. The project interventions have been progressing in India since 2007 whereas they were initiated only from 2012 in Bangladesh. In India, the baseline surveys were carried out during 2007-08 while the early adoption studies completed in 2009-10. FPVS trials were taken-up from 2007 to 2009 in different locations in these two states. Thousands of free seed samples were distributed between 2007 and 2012 in project intervention sites across two study states. A real-time tracking survey was undertaken in 2013 to track the adoption of project introduced cultivars in these locations and to deeply understand the patterns of diffusion among farmers and villages. All these efforts over a period of eight years significantly enhanced the adoption, productivity and profitability of chickpea cultivation in these states. The summary of those findings are furnished below:

3.1.1 Andhra Pradesh

Table 1 & 2 summarizes the extent of adoption of project introduced cultivars in Prakasam and Kurnool districts of Andhra Pradesh respectively. Between 2007-08 and 2009-10, the sample farmers in Prakasam showed more preference towards kabuli types because of price

[4] For more details refer Suhasini et al. (2013)

premiums than desi types. The productivity of JG 11 has improved significantly (50%) in targeted sites. The extent of adoption of JG 11 has increased remarkably (53 to 90%) in Kurnool district between 2007 and 2009. However, the improvement in productivity was around 38 per cent. The traditional old variety 'Annigeri' has been replaced within span of three years.

Table 1: Performance of chickpea in the sample villages of Prakasam district of AP

Varieties	Varietal composition (%)		Yield (kg per ha)	
	BL-2007	EA-2009	BL-2007	EA-2009
Annigeri	24.48	2.62	1072	1420
ICCV-2	9.87	0	1200	-
KAK-2	26.37	78.5	1317	1912
JG-11*	39.28	18.88	1241	1877
JAKI 9218*	0	0	-	-
Overall	100.0	100.0	-	-
* introduced through the TL-II project; BL: Baseline in 2007-08; EA: Early Adoption survey in 2009-10				

Table 2: Performance of chickpea in the sample villages of Kurnool district of AP

Varieties	Varietal composition (%)		Yield (kg per ha)	
	BL-2007	EA-2009	BL-2007	EA-2009
Annigeri	45.35	10.13	1015	1235
ICCV-2	0	0	-	-
KAK-2	1.43	0	1112	-
JG-11*	53.22	89.45	1356	1869
JAKI 9218*	0	0.42	-	1766
Overall	100.0	100.0	-	-
* introduced through the TL-II project; BL: Baseline in 2007-08; EA: Early Adoption survey in 2009-10				

Due to increased yields of chickpea by 2009-10, the weighted average cost of production per quintal decreased (18%) from Rs.1552 to Rs.1275 in the sample villages of Kurnool. The reduction in UCR of was even higher at 23% in Prakasam district (Suhasini et al. 2013). Table 3 clearly visualizes the profitability of chickpea in the state. The net returns per ha was significantly higher in case of Prakasam than Kurnool district. The pooled benefit-cost ratio (BCR) for chickpea cultivation in the state was estimated at 2.39. The increased income as a share of net crop income was around 52% and 66% respectively for Kurnool and Prakasam districts (Suhasini et al. 2013 & also see Box 1).

Table 3 Profitability of chickpea cultivation in Andhra Pradesh, 2009-10 (Rs/ha)

Particulars	Cost of Cultivation		
	Kurnool	Prakasam	Pooled
Labour cost	17485	17760	17622
Material cost	4905	5832	5369
Total cost of cultivation	22390	23592	22991
Cost of production per 100 kg	1232	1245	1238
Grain yield	1818	1895	1857
Gross returns	50904	58745	54825
Net returns	28514	35153	31834
Benefit cost ratio	2.27	2.49	2.39

Box 1: Chickpea impact study in Andhra Pradesh

A comprehensive chickpea technology adoption and impact study was taken-up in Andhra Pradesh with partial support from SPIA during 2012-13. About 810 chickpea growers were tracked across 90 villages in 30 mandals from seven districts of Andhra Pradesh with a structured questionnaire. The study has concluded that the extent of adoption JG 11 was nearly 85% in the state. It is the single dominant variety followed by Vihar and KAK 2. Nearly 98% of cropped area is under chickpea improved cultivars. The farm-level productivity gain was estimated at 37 per cent. The translated unit cost reduction was calculated at $ 144 per ton. The accrued benefits due to adoption of 'short-duration improved chickpea technology' were assessed at US $ 358.9 million. The internal rate of returns (IRR) on research investment was estimated at 28%.

Source: Bantilan et al. (forth coming)

3.1.2 Karnataka

In Karnataka, Annigeri was a long entrenched variety of the region for nearly four decades. It was evolved in Karnataka and became popular quickly and remained the favourite of farmers even in 2006-07, when baseline survey was conducted. Under TLII project, researchers also supplied small quantities of the chickpea seeds of farmer preferred varieties to the sample farmers in adopted and control villages of Dharwad and Gulbarga districts. But there was no much large scale effort to organize the seed production and distribution of preferred varieties by the State Seed Corporation in Karnataka. As a result, these varieties did not enter the seed supply chain in a big way.

Table 4: Performance of chickpea in the sample villages of Dharwad district of Karnataka

Varieties	Varietal composition (%)		Yield (kg per ha)	
	BL-2007	EA-2009	BL-2007	EA-2009
Annigeri	91.5	41	1023.8	1030
Bhima	2.4	2	686.2	1113
Kabuli (KAK 2)	4.9	2	992.9	1019
Local or others	1.2	2	1009.4	-
JG 11*	0	23	-	1314
BGD 103*	0	18	-	1374
JAKI 9218*	0	12	-	1250
MNK-1*	0	0	-	889
Overall	100.0	100.0	-	-

* introduced through the TL-II project;
BL: Baseline in 2007-08; EA: Early Adoption survey in 2009-10

There was remarkable increase in adoption of TL II project introduced cultivars in both the study districts (see Table 4 & 5). More than 50% of Annigeri area has been replaced by JG 11, BGD 103, JAKI 9218 and MNK 1. On an average, the productivity per ha has been increased 25-30% (Suhasini et al. 2013).

Table 5: Performance of chickpea in the sample villages of Gulbarga district of Karnataka

Varieties	Varietal composition (%)		Yield (kg per ha)	
	BL-2007	EA-2009	BL-2007	EA-2009
Annigeri	94.2	42	1148.4	1097
Bhima	0	0	-	-
Kabuli (KAK 2)	1.6	5	1007.8	1175
Local or others	4.2	3	955.1	748
JG 11*	0	22	-	1398
BGD 103*	0	18	-	1405
JAKI 9218*	0	0	-	1333
MNK 1*	0	10	-	1227
Overall	100.0	100.0	-	-

* introduced through the TL-II project;
BL: Baseline in 2007; EA: Early Adoption survey in 2009-10

Table 6 Profitability of chickpea cultivation in Karnataka (Rs/ha)

Costs and Returns	Dharwad		Gulbarga	
	BL-2007	EA-2009	BL-2007	EA-2009
Fixed Cost	3721	4054	3603	4711
Variable Cost	12463	13473	12330	13527
Total Cost	16184	17527	15933	18238
Yield (Kg/ha)	1024	1152	1102	1277
Gross Return	25194	33125	25058	36739
Net Return	9010	15598	9125	18501
Benefit Cost Ratio	1.56	1.89	1.57	2.01

Table 6 summarizes the profitability of chickpea cultivation in Karnataka state. Due to marginal increase in yield per ha and significant increase in costs of cultivation per ha, the benefit-cost ratio improved slightly. Only 4% reduction in the cost of production was noticed in Dharwad while the same fell at 1% for Gulbarga district. The increased income as a share of net crop income was estimated at 29% and 49% respectively for Dharwad and Gulbarga districts (Suhasini et al. 2013).

3.1.3 Real-time tracking surveys

Two massive real-time tracking surveys covering 500 Hh each were initiated in the phase-1 locations i.e., in Andhra Pradesh and Karnataka states respectively for deeper understanding about TL-II project introduced improved cultivars adoption in the targeted sites as well as their further diffusion across seed sample beneficiaries from the project. Based on preliminary field insights, the adoption of chickpea improved cultivars in Prakasam and Kurnool districts of Andhra Pradesh is in its peak (nearly 99%). In case of Karnataka, remarkable diffusion of JG 11 (nearly 60-70%) was observed in both Dharward and Gulbarga districts. The chickpea farmers are significantly benefited through enhanced yields, improved soil fertility, increased household nutrition and fodder availability.

3.2 Groundnut[5]

Groundnut has been targeted in two major states (Karnataka and Tamil Nadu) of India and Bangladesh. The project interventions have been progressing in India since 2007 whereas they were initiated only from 2012 in Bangladesh. In India, the baselines were conducted during 2007-08 while the early adoption studies completed in 2009-10. FPVS trials were

[5] For more details refer Karunakaran et al. (2013)

taken-up from 2007 to 2009 in different locations in these two states. Thousands of free seed samples were distributed between 2007 and 2012 in project intervention sites across two study states. A real-time tracking survey was undertaken only in Tamil Nadu during 2013 to track the adoption of project introduced cultivars and to deeply understand the patterns of diffusion among farmers and villages. However, the tracking study did not undertake in case of Karnataka. Very low penetration of project introduced cultivars was observed in both the targeted states due to various constraints. All these systematic efforts over the project period are summarized below:

3.2.1 Karnataka

Table 7 summarizes the extent of penetration of TL II project introduced groundnut improved cultivars in Karnataka. TMV 2 is a single dominant cultivar occupying more than 90% area in both the study districts. The new cultivars could hardly able to replace TMV 2 in targeted sites. This low adoption was possibly due to the inability of the farmers to access the information about new cultivars and in believing them to be superior (Karunakaran et al. 2013). Even though the productivity of R2001-2 was impressive than TMV 2 in both the locations but its adoption was rather low (4%).

Table 7 Performance of groundnut improved cultivars in the sample villages of Karnataka

Varieties	Raichur				Chitradurga			
	Composition (%)		Yield (kg per ha)		Composition (%)		Yield (kg per ha)	
	BL-2007	EA-2009	BL-2007	EA-2009	BL-2007	EA-2009	BL-2007	EA-2009
TMV-2	100	95.42	1240	1297	100	90.79	782	846
ICGV-91114 *	-	-	-	-	-	7.36	-	1350
R2001-2 *	-	3.26	-	1473	-	1.84	-	1250
ICGV-00350 *	-	1.32	-	1401	-	-	-	-
Pooled	100.0	100.0	-	-	100.0	100.0	-	-
* Project introduced cultivars								

Table 8 Profitability groundnut cultivation in Karnataka (Rs/ha)

Costs and returns	TMV-2	Improved cultivars
Cost of cultivation (Rs/ha)	21600	27120
Grain yield of groundnut (kg/ha)	1072	1391
Gross returns (Rs/ha)	31681	42306
Net returns (Rs/ha)	10081	15186
Benefit cost ratio	1.47	1.66
COP (Rs per 100 kg)	2015	1950

The improved varieties which made a small dent on the sample farms reported better yields than TMV 2. The reduction in the unit cost of production of groundnut was marginal. The fell in UCR was 12.6% and 1% respectively for Raichur and Chitradurga districts. The pooled estimate for entire state was around 7.6%. The increased income as a share of net crop income in baseline was only 5 and 17% respectively for Raichur and Chitradurga (Karunakaran et al. 2013).

3.2.2 Tamil Nadu

Table 9 summarizes the extent of adoption of groundnut improved cultivars in targeted sites of Tamil Nadu between 2007-08 and 2009-10. It is evident from the table that the penetration of TL II introduced cultivars almost negligible. The new cultivars failed to make a dent in the groundnut areas of sample farmers, even though there was a churning between the old varieties (Karunakaran et al. 2013). However, signs of hope were visible as seen in the promising yield of new varieties.

Table 9 Performance of groundnut cultivars in Erode and Thiruvvanamalai districts

Varieties	Erode district				Thiruvvanamalai district			
	Composition (%)		Yield (kg per ha)		Composition (%)		Yield (kg per ha)	
	BL-2007	EA-2009	BL-2007	EA-2009	BL-2007	EA-2009	BL-2007	EA-2009
CO2	50.94	32.71	1255	1286	0	13.77	-	-
JL24	2.83	0	-	0	1.06	0	-	0
TMV1	0.47	0	-	0	-	-	-	-
TMV2	10.38	0	-	0	-	-	-	-
TMV7	1.89	3.74	-	-	42.33	21.02	-	-
VRI2	33.49	62.62	-	-	0	0	-	-
POL 2	-	-	-	-	56.61	64.49	1086	1402
TVG 0004 *	0	0.93	0	2482	0	0	0	0
ICGV00351 *	0	0	0	0	0	0.72	0	1693
Pooled	100.0	100.0	-	-	100.0	100.0	-	-
* project introduced cultivars								

Table 10 Profitability of groundnut cultivation in Tamil Nadu (Rs/ha)

Costs and Returns	Erode		Thiruvannamalai	
	CO-2	TVG0004	POL-2	ICGV00351
Fixed Cost	2600	2750	2550	2618
Variable Cost	14860	17847	14240	16777
Total Cost	17460	20597	16790	19395
Yield (Kg/ha)	1286	2482	1402	1693
Gross Return	42749	54481	43447	48423
Net Return	25289	33884	26657	29028
Benefit Cost Ratio	2.45	2.65	2.59	2.50

Table 10 summarizes profitability of groundnut cultivation in the targeted districts of Tamil Nadu. The improved varieties were grown in small areas only due to the limited seed availability. In Erode, TVG0004 recorded higher yield than CO 2 and reported a high benefit/cost ratio of 2.65. ICGV00351 performed better than that of POL 2 in terms of yield but its BCR ratio was marginally lower.

3.2.3 Real-time tracking survey

The real-time survey has been conducted in the three targeted districts of Tamil Nadu covering approximately 500 sample households during 2012-13. Only 7% of groundnut cropped area was covered with TL project introduced cultivars while the rest occupied with old cultivars. Recurrent droughts coupled with improper seed distribution systems failed to make a dent in the state. Small quantities (5-10 kg) of seeds distributed to sample farmers could not able to influence them significantly.

3.3 Pigeonpea[6]

Pigeonpea has been targeted in two major states (Andhra Pradesh and Maharashtra) of India. The project interventions have been progressing in India since 2007 in Andhra Pradesh whereas they were put-off by 2010-11 in Maharashtra. The baselinesurveys were conducted during 2007-08 while the early adoption studies completed in 2009-10. FPVS trials were taken-up from 2007 to 2009 in different locations in these two states. Thousands of free seed samples were distributed between 2007 and 2010 in project intervention sites across two study states. Partialpenetration of project introduced cultivars was observed in both the targeted states due to some constraints.

3.3.1 Andhra Pradesh

Table 11 furnishes the details of pigeonpea improved cultivars adoption in Andhra Pradesh during 2007-2009. Old cultivars like Abhaya and Maruti lost significant cropped area and it was replaced by project introduced cultivars (LRG 41 and PRG 158). LRG 41 and PRG 158 have showed their superiority in the FPVS trials on par with superior variety 'Asha'.

Table 11 Varietal composition of pigeonpeacultivars in Andhra Pradesh, 2009-10.

Variety	EA, 2009-10		Change in area over baseline (ha)	EA, 2009-10 Yields (kg/ha)	Yield increase (%) over baseline
	Area (ha)	% area			
Asha	128.68	43	-75.89	1250	8.6
Abhaya	-	-	-36.83	-	-
Durga	-	-	-6.48		
LRG 30	8.97	3	6.54	1150	7.4
LRG 41*	59.85	20	57.83	1170	25.8
Maruti	14.96	5	-9.93	1100	15.7
PRG 158*	23.94	8	23.94	1120	NA
Lakshmi	14.96	5	-1.23	1050	8.2
Local (Nallakandi)	47.88	16	10.77	820	9.3
White pigeonpea	-	-	-	-	-
Total	299.24	100	-32.46	-	-
* project introduced cultivars					

Asha and LRG 41 performed very well in study districts of Andhra Pradesh (Table 12). Nearly 20-30% increase in productivity was noticed when moved from local variety to improved cultivars. The net returns per ha increased significantly in case of TL II project introduced cultivars. A reduction (14-20%) in unit cost of production per quintal was estimated in the analysis (Kumara Charyulu et al. 2014).

Table 12 Profitability of pigeonpea cultivation in Andhra Pradesh (Rs/ha)

Particulars	Local cultivar	Asha	LRG 41
Fixed cost (Rs ha^{-1})	3200.50	3250.40	3310.50
Variable cost (Rs ha^{-1})	11525.50	11100.50	11500.50
Total cost of cultivation (Rs ha^{-1})	14726.00	14350.90	14811.00
Cost of production (Rs per 100 kg)	1600.6	1148.07	1384.2
Grain yield (Kg ha^{-1})	920	1250	1070
Gross returns (Rs ha^{-1})	41400	56250	48150
Net returns (Rs ha^{-1})	26674.0	41899.1	33339.0
Benefit-cost ratio	2.81	3.91	3.25

[6] For more details refer Kumara Charyulu et al. (2014)

3.3.2 Maharashtra

Maruti used to be the single dominant variety before the introduction of TL II project. The project introduced new cultivars successfully replaced the old and dominant variety. Nearly 30-40% of 'Maruti' area was replaced by BSMR 736, BSMR 853 and PVK-Tara (see Table 13). Significant pigeonpea cropped area have been shifted towards new cultivars because of farmers' preferred traits between 2007 and 2010. The profitability of pigeonpea cultivation in the state is furnished in Table 14. The average productivity in the targeted sites has increased by 15% than check variety 'maruti'. The benefit-cost ratio has increased marginally from 2.53 (Maruti) to 2.90. This clearly indicates the potential for TL II introduced cultivars in the state.

Table 13: Varietal composition of pigeonpeain Maharashtra

Variety	Early adoption, 2009-10					
	Adopted villages		Change in area over baseline (ha)[1]	Control villages		Change in area over baseline (ha)
	Area (ha)	% area		Area (ha)	% area	
Asha	29.2	13	13.48	18.4	15	15.16
Maruti	105.7	47	-71.0	67.6	55	-20.64
BSMR 736*	56.3	25	56.3	20.8	17	20.8
BSMR 853*	22.5	10	22.5	12.4	10	12.4
PVK Tara*	11.3	5	11.3	3.7	3	3.7
Durga	-	-	-1.22	-	-	0.00
Vipula	-	-	-3.76	-	-	-1.62
Total	225.0	100.0	27.6	122.9	100.0	29.8
* project introduced cultivars						

Table 14 Profitability of pigeonpea cultivation in Maharashtra (Rs/ha)

Particulars	Maruti	BSMR 736	BSMR 853
Fixed cost (Rs ha^{-1})	5300	4950	5200
Variable cost (Rs ha^{-1})	12967	12534	11987
Total cost of cultivation (Rs ha^{-1})	18267	17484	17187
Cost of production (Rs per 100 kg	1773	1561	1482
Grain yield (kg ha^{-1})	1030	1120	1160
Gross returns (Rs ha^{-1})	46350	50400	52200
Net returns (Rs ha^{-1})	28083	32916	35013
Benefit-cost ratio	2.53	2.88	3.03

4. Challenges, opportunities and lessons learnt in South Asia

Section three has summarized the initial impacts of project interventions on three legume crops in the targeted sites between 2007 and 2010. The findings from three real-time tracking surveys (chickpea in AP and KA and Groundnut in TN undertaken during 2012-13) were also summarized by crop. Simultaneously, three baselines were undertaken for three new targeted locations for chickpea (Bihar in India and Bangladesh) and Groundnut (in Odisha, India) crops between 2011 and 2014. Several challenges and opportunities have been identified across crops during the implementation of the project period. The lessons learnt from these studies in the project would not only benefit ICRISAT but also helps several partners, researchers and academicians in South Asia. It is worthwhile to summarize and present by crop in this section.

4.1 Chickpea

Challenges and lessons learnt

The previous sessions have shown clearly the huge penetration of TL II introduced cultivars in the targeted states and their impact on adoption, productivity and profitability on sample households between 2007 and 2014. However, the major challenge in case of chickpea is sustaining the production and productivity in those states beyond project interventions. After attaining the confidence of adoption of improved cultivars, chickpea growers are indiscriminately using various inputs (seeds, fertilizers and pesticides) leading to unsustainable cultivation of chickpea. The per unit output prices have decreased or stabilized over the last three years due to (duty free) imports from Australia and Canada. The farmers are eagerly waiting for 'tall growing cultivars' for their easy mechanical harvesting of chickpea crop. Resistant to terminal moisture stress and heat tolerant traits are most desirable to sustain the crop in future in these states.

Some of the lessons learnt are: 1. Enough care is required in the selection of adopted and control villages in the targeted sites to avoid any potential bias in various studies 2. The FPVS trails have demonstrated potential of new cultivars, hasten-up their formal release and encouraged farmers' to quickly adopt those 3. Besides the physical yields, the prices should also be considered to give the farmers those varieties that can improve their profits 4. Attractive net returns are the best bets for adoption and impact creation rather than physical yields of cultivars 5. Attractive seed subsidies given by respective state governments have motivated the farmers significantly to enhance adoption.

New opportunities

During the phase-2 of the Tropical Legumes (TL-II) Project, two new locations (Bihar in India and Barind region in Bangladesh) were identified for targeting and introduction of new technologies. The baseline surveys in Bihar were completed in Bhagalpur and Banka districts with reference to 2010-11.Subsequently FPVS trials were carried out during 2012-13. The mother trials conducted in different locations have concluded that JG 14, Shubhra and KAK 2 are the most preferred cultivars in Bihar. Deshla Plain and DeshlaRoon were the preferred dominant local cultivars noticed during the baseline survey. Similarly, the chickpea baseline surveys were also implemented in Rajshahi and ChapaiNawabganj districts of Bangladesh in 2010-11. BARI Chola 5 and BARI Chola 9 are the most common cultivars (occupied nearly 85%) observed in the baseline sample households. Among the different BARI Chola varieties, BARI Chola 9 gave the highest productivity in the study locations. Mustard is the most competing crop with chickpea during post-rainy season period. Both these locations and other rice-fallows in India has huge potential for chickpea expansion in the country.

4.2 Groundnut

Challenges and lessons learnt

Section three has visibly highlighted the low adoption of TL II introduced cultivars in both Karnataka and Tamil Nadu states. Enhancing the adoption in Groundnut crop is the biggest challenge in the project. Seed multiplication and distribution is critical in groundnut due to frequent crop failures with recurrent droughts and poor seed multiplication ratio. The existing formal seed systems in the targeted sites are weak. There was severe competition from other

rainy season crops like soybean, cotton and maize etc. Poor marketing and value chain facilities also limiting crop spread in the study states.

The major lessons learnt are: 1. The FPVS trails conducted at several places established that the new varieties outshone the check varieties, but farmers did not always select the varieties with the highest yield potential. For instance, farmers in Raichur were not in favour of R2001-02 and R2001-03 because of their poor pod characteristics and low market acceptance. In Chitradurga, ICGV 91114 preferred over R2001-02 due to positive attributes of short-duration, drought tolerance and good pod characteristics 2. The FPVS trails were conducted for one season in Karnataka while they were carried out for three seasons in Tamil Nadu to reach a logical conclusion 3. The delay in formal release of selected cultivars and their subsequent limited seed multiplication (in seed chains)with respective state agriculture agencies hampered adoption 4. The provision of small quantities (2 kg) of groundnut seed to the farmers by the project staff did not yield the expected benefit, and it is speculated that the small quantities were inadequate in the attempt to encourage the farmers to grow and bulk the seed 5. A community seed systems approach may also be tried to hasten the process of diffusion of the varieties selected by the farmers 6. The government departments should be approached to extend the benefit of subsidy for the new varieties, instead of extending the same repeatedly to the same old and ruling varieties
7. Finally, the adoption pathway in case of groundnut would be much longer than other two legumes crops in the study.

New opportunities

During the phase-2 of the project, groundnut improved cultivars have been targeted additionally in Odisha state of India and in Bangladesh. However, the baseline was conducted only in Odisha state during 2012-13. The study has concluded that more than 90 % of cropped area in the state was covered by local varieties. It indicates huge potential for further penetration of TL II project improved cultivars in this state. The FPVS trails conducted in Bangladesh also clearly showed their superiority over existing check varieties in the country. There are ample opportunities for spread of groundnut but drought and seed availability are the major constraints.

4.3 Pigeonpea

Challenges and lessons learnt

As summarized earlier, the TL II project has partially succeeded in promotion and adoption of new improved cultivars in the targeted sites. Frequent droughts are the major constraints for limited spread and lower productivity of crop in the study states. Most of the farmers' preferred to grow pigeonpea as intercrop rather than sole crop. The major challenge in pigeonpea is development of medium duration cultivars which can escape terminal moisture stress during maturity stage.

The major lessons learnt are: 1. FPVS trails have helped ICRISAT and NARS partners to demonstrate the potential of technology and enhancing their adoption as well 2. Concerted efforts are required for demonstrating the hybrid pigeonpea technology along with seed production and multiplication training programs 3. Timely availability of quality seed of improved cultivars is another constraint limiting adoption 4. Seed village concepts or community seed systems approach can be attempted for further diffusion of varieties selected by the farmers in the FPVS trails.

New opportunities

During the phase-2 of the Tropical Legumes (TL-II) Project, two new locations (Bihar and Odisha) in India were identified for targeting and introduction of new technologies. But, baseline surveys were only taken-up in Bhagalpur and Banka districts of Bihar with reference to 2010-11. Subsequently FPVS trials were carried out during 2012-13. The mother trials conducted in different locations have concluded that Asha, ICP 7035 and ICPH 2740 were most preferred varieties over traditional variety 'Bahar'.There were no systematic efforts in the state of Bihar for crop improvement of pigeonpea by State Agricultural Universities. TL II has provided a way for the small holder farmers to have access to high yielding varieties suitable for their niches.

5. Summary and conclusions

Tropical Legumes II (TL II) seeks to improve the livelihoods of 60 million smallholder farmers (SHF) in 15 countries through enhanced productivity of chickpea, common bean, cowpeas, groundnut, pigeonpea and soybeans. It is expected to enhance productivity by at least 20% through increased adoption covering 30% of legume area, strengthen national breeding programs and generate at least $ 1.3 billion in added value as a result. More, than 258,000 tons improved seed was produced between 2007 and 2013, enough to reach 51.6 million farmers in 5kg pockets. Since 2007, improved varieties disseminated have been adopted on 2,007,889 ha and generated US $ 513 million from direct project funding and nearly $ 2 billion from project and partners investments.

Among the three legumes in South Asia, the FPVS trails paved way to adoption of new varieties preferred by farmers and fast-track release of those varieties. The extent of adoption of project introduced cultivars was highly successful in case of chickpea followed by pigeonpea and groundnut. More robust seed system-models are needed for up-scaling adoption of new varieties, especially for groundnut. All these new cultivars should be encouraged with sizable seed subsidies till they replace the ruling varieties. All the new cultivars showed a minimum (> 15-30%) of enhanced productivity than previous cultivars. The new cultivars have visibly showed the profitability of legume cultivation in different targeted sites. The study also proved that the cultivation of pulses not only increase production but also increases household income and nutritional security. Thus, the viability of SHF increased significantly in South Asia. Huge opportunities are still exists for further penetration of these three legumes in South Asia.

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