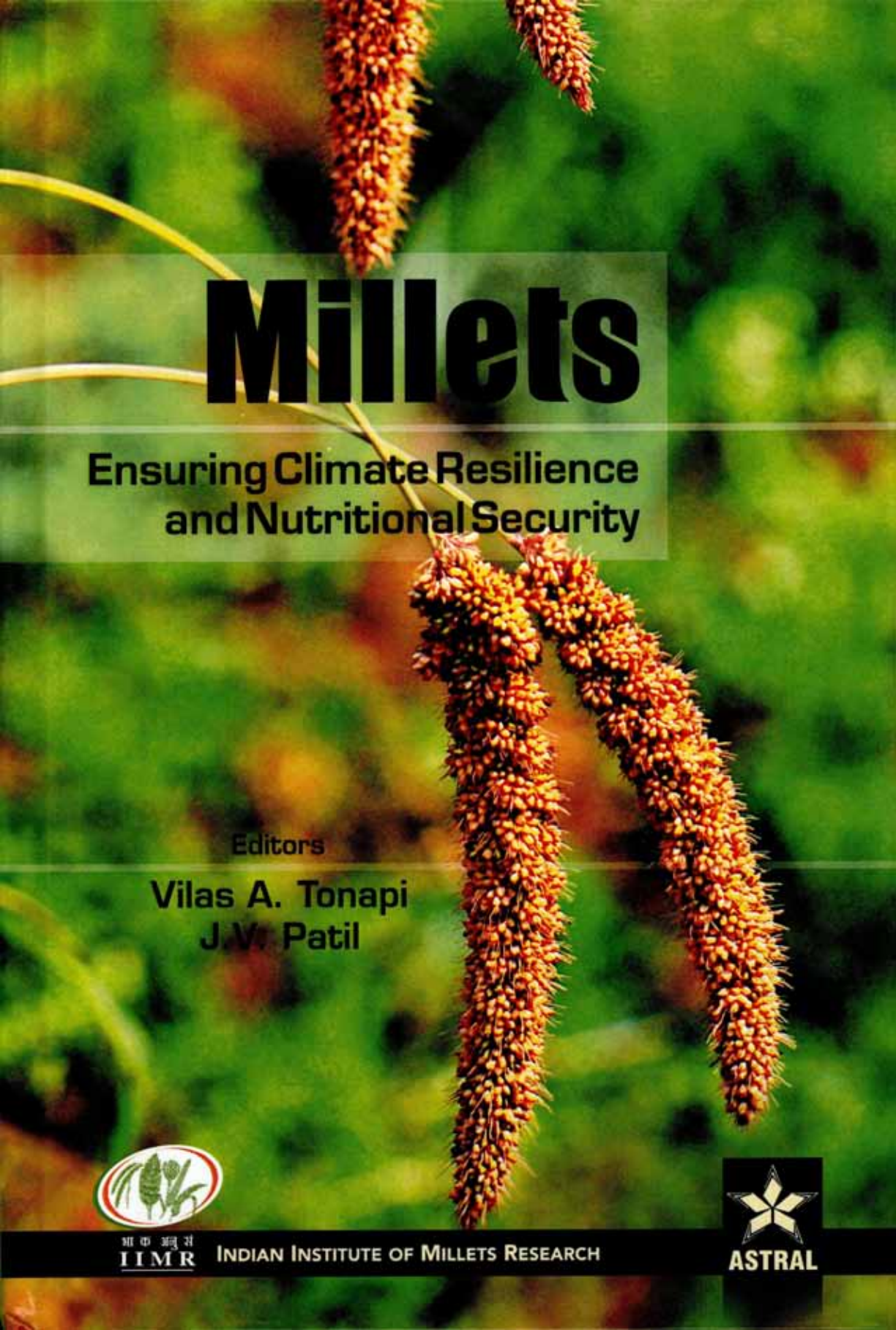
Millets
Ensuring Climate Resilience and Nutritional Security
Editors
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Millets Ensuring Climate Resilience and Nutritional Security

Millets: Ensuring Climate Resilience and Nutritional Security presents the current status of germplasm resource management and genetic improvement of group of climate smart nutri-cereal crops called Millets encompassing Sorghum, Pearl Millet, and Small Millets comprising Finger Millet, Foxtail Millet, Kodo Millet, Proso Millet, Barnyard Millet and Little Millet. The focus is on genetic improvement, agronomy, physiology, biotic and abiotic stresses, pest and disease management, molecular marker-aided approaches for improvement of millets, nutritional and health benefits of millets, utilization pattern, creating demand through value addition, commercialization and marketing of millet products, sustaining viability of informal millet seed systems and Innovative seed delivery models. The emphasis is on improvement of millets elucidating the future road map to enhance scope of millets as "MIRACLE NUTRI-CEREALS" through value chain to ensure food, feed, fodder, biofulel, nutritional and livelihood security, including climate resilience.

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₹ 3995

ISBN: 978-93-5124-644-2

www.astralint.com

Part VII
Seed Systems

Millets: Ensuring Climate Resilience and Nutritional Security (2015)
Editors: **Vilas A. Tonapi and J.V. Patil**
Published by: **DAYA PUBLISHING HOUSE, NEW DELHI**

Pages **607–626**

Chapter 24

Developing Post Rainy Sorghum Seed System in India

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The crops grown under rainfed agriculture are described as farming practices that rely on rainfall for crop production and their seed systems describe, how farmers in these regions are sourcing seed for cultivating these crops. The objective of this chapter is to share information, experiences and some success stories of seed value chain models developed for production and supply of improved varieties to resource poor farmers to enhance production of rainfed crops. Majority of crop varieties grown under rainfed agriculture system are open pollinated varieties or self-pollinated crops especially food crops, cereals and legumes grown in semi-arid tropics of the globe. The importance of rainfed agriculture varies regionally but produces most food for poor communities in developing countries. In sub-Saharan Africa more than 95 per cent of the farmed land is rainfed, while the corresponding figure for Latin America is almost 90 per cent, for South Asia about 60 per cent, for East Asia 65 per cent and for the Near East and North Africa 75 per cent (FAOSTAT, 2005).

The problems in semi-arid tropical (SAT) regions are exacerbated by adverse biophysical growing conditions and the poor socioeconomic infrastructure. The uncertain climatic conditions or otherwise called as climate change effects, makes SAT farmers more vulnerable. The most essential input of crop production is seed and is the cheapest of all inputs in rainfed agriculture. A good quality seed of improved variety can enhance production by 20 per cent and with improved crop production practices can increase yield by 35-40 per cent. The major types of seed constraints in rainfed agriculture are 1) Seed insecurity due to frequent droughts, and natural disaster 2) Poverty and food insecurity leading to seed insecurity 3) Quality seed and new varieties and development of appropriate seed systems.

Availability and accessibility to seed of improved varieties in these areas is a big task. During drought years or and natural calamities subsidized seed or international relief programs meet the requirement of seed supply which nullifies farmers preference and forces to adopt the variety available. But it's a temporary relief for farmers, the year and again the problem of seed security repeats in SAT regions. The SAT is the home to 38 per cent of the developing countries' poor, 75 per cent of whom live in rural areas. Over 45 per cent of the world's hungry and more than 70 per cent of its malnourished children live in the SAT. The institutional mechanisms to multiply the farmers preferred varieties of crops grown in rainfed regions is poorly developed and private seed sector is not showing interest in such crops because of economic reasons. Public sector research and development organizations do develop varieties to enhance production and productivity in these regions but, public sector extension mechanisms are unable to disseminate the technologies available to farmers to meet their requirements fully.

Existing Seed Systems of Post Rainy Sorghum in India

Sorghum is grown both in rainy and post rainy (*Rabi*) seasons in India. The majority of *Rabi* sorghum grain and stover production is concentrated in districts across the states of Maharashtra, Karnataka and Andhra Pradesh (Trivedi, 2008; Rana *et al.*, 1999; Hosmani and Chittapur, 1997; Murty *et al.*, 2007; Pray and Nagarajan, 2009, (Figure 1). Sorghum seed system is very unique in the country with contrasting situations. Hybrids are the cultivar choice in rainy season sorghum and hybrid adoption by farmers is up to 95 per cent in states like Maharashtra though there are wide variations in adoption across the states in India. The public and private sector seed companies developed hybrids, rule the market and seed requirement is predominantly met by the vibrant formal seed system led by private sector seed companies and public sector seed agencies like National Seeds Corporation (NSC) and state seed development corporations in different states and Mahabeej in Maharashtra. In case of postrainy season, open-pollinated varieties are the cultivar choice because of stringent quality considerations and lack of appropriate hybrids and inadequate hybrid seed production and supply chain.

The post rainy sorghum crop accounts for 45 per cent of the total sorghum area under cultivation and 32 per cent of the total sorghum production in India (Sajjanar *et al.*, 2011). Although post rainy (*Rabi*) sorghum is highly valued due for its good grain quality, its yields are lower (750 kg/ha) compared to *Kharif* sorghum

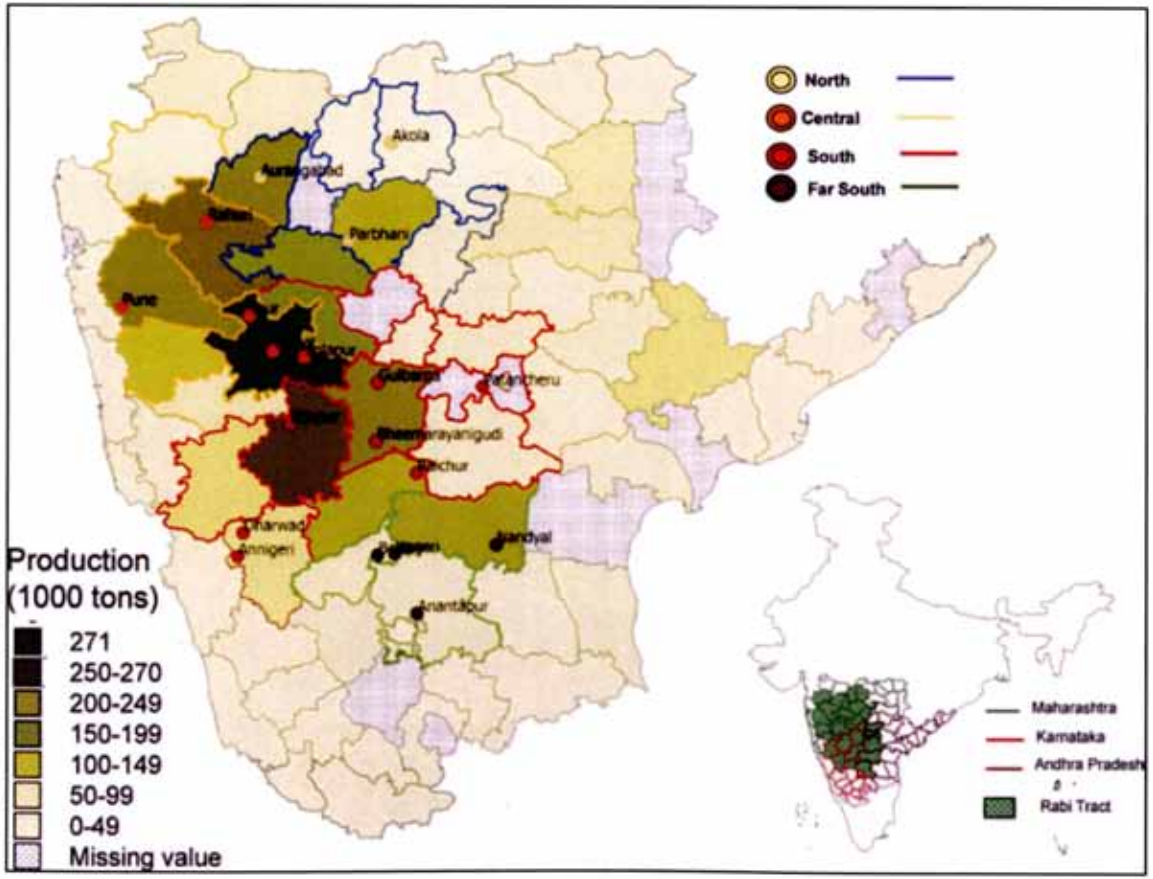

Figure 1: Map of the Sorghum Rabi Production Tract in India with Highlighted Four Major Production Zones – Central, Northern, Southern and Far South. The inset map showsthe location of the Indian states (Maharashtra, Karnataka and Andhra Pradesh) and the major rabi tract.(*Source:* J. Kholová *et al.,* Field Crops Research 141 (2013) 38–46)

(1100 kg/ha) (Anon, 2006).This low productivity rate of post rainy sorghum increase calls for a change in production strategy including breeding, targeting varieties for different soil depths and improved seed systems to make improved variety seed available to small scale farmers in India. The postrainy season sorghum crop was grown on 4.8 million ha (CMIE, 2007) in India (Table 1), Maharashtra has highest area of 3.2 m ha under sorghum, requires 32,000 tons of seed @ 10kg ha^{-1} seed rate. Formal sector is able to meet ~12 per cent of seed requirement and balance ~88 per cent seed supply is from informal sector, mostly from farmers own saved seed.

Table 1: Region-wise Area Under Post Rainy Season Sorghum Cultivation and Seed Sources in India (2011-2012)

Region/state	*Area Under Cultivation (lakh ha)*	*Present Varieties in Cultivation*	*Total Quantity of Seed Requirement (in tons)*	*Seed Supplied by Formal Seed Sector (in tons)*	*Seed Supplied by Informal Seed Sector (in tons)*
Maharashtra	32	M 35-1, Dagadi, Phule Vasudha and Parbhani Moti	32,000	4,000* (12.5 per cent)	28,000** (87.5 per cent)
Karnataka	13	M35-1, Muguti (5-4-1), Annigiri(A-1), DSV-4 and DSV-5	13,000	<10 per cent	>90 per cent
Andhra Pradesh	2	M35-1, Budda Mallelu, Udgir local, Saayi Jonnalu, Dagdi local, CSV216R	2,000	INA	INA
Gujarat	0.1	BP 53, Surat 1, GJ 108, Malvan, Solapuri, Gundari	100	INA	INA
Other states	1	INA	1000	INA	INA
Total	**48.1**		**48,100**		

* Formal sector-supply by private/corporations (Maharashtra state seed Development Corporation/ NSC)

** Informal sector-Farmers own saved seed, local markets, friends, relatives, govt. subsidised seed supply.

INA: Information not available.

High yielding and improved cultivar's seed availability is not a constraint in rainy season sorghum but it is a major issue in postrainy season sorghum in India, and majority of varieties are age old still ruling the major area under cultivation. Most notable local varieties popular among the farmers include M 35-1 (Maldandi), and Dagadi grown by 80-90 per cent of farmers in India. However, M 35-1, a landrace selection from Maldandi cultivated by the farmers is traditionally in these areas for several decades, was selected in 1938, nearly 75 years ago and is still dominating the postrainy season tracts (Maharashtra, Karnataka and Andhra Pradesh) in India (Belum Reddy *et al.*, 2012). Several improved varieties such as Phule Yashoda, Phule Anuradha, Phule Chitra, Phule Revathi, Parbhani Moti and Parbhani Jyothi

developed by SAU have been released in the recent past by the All India Coordinated Sorghum Improvement Project (AICSIP), (Table 2).

Table 2: Sorghum Varieties Released by Agricultural Universities in Maharashtra

Sl.No.	*Variety*	*Year of Release*	*Variety Released by Agriculture University*
1.	M 35-1	1938	MPKV-Rahuri
2.	Parbhani Moti	2002	VNMKV- Parbhani
3.	Phule Vasudha	2007	MPKV-Rahuri
4.	Phule Anuradha	2008	MPKV-Rahuri
5.	Phule Revati	2010	MPKV-Rahuri
6	Phule Yashoda	2009	MPKV-Rahuri
7	Phule Suchitra	2012	MPKV-Rahuri
8.	Parbhani Jyoti	2005	VNMKV Parbhani

The private sector is not forthcoming for multiplying the open pollinated varieties (OPVs) of sorghum for various reasons:

1. There is no proprietary advantages in multiplying public domain varieties
2. In case of postrainy season adapted varieties (or hybrids), the seed produced in postrainy season has to be marketed in next postrainy season which means they need to wait for 8 months to market them and hence the returns on investment are realized late.
3. The margins for private seed companies are low in production and marketing of open pollinated varieties (OPVs) compared to hybrids market, and there are not many improved hybrids with all the farmers preferred traits in post rainy sorghum.
4. It is primarily 10-12 per cent of total seed requirement of Maharashtra state which is fulfilled by the public sector seed agencies and state agricultural universities partially catering to the needs of farmers for sorghum seed supply in postrainy season (Table 3).
5. Major portion (90 per cent) of farmer's seed source is met from farmers own -saved seed (Informal sector).

In India rainy season sorghum is cultivated in around 2.6 m ha which is predominantly grown with hybrids. Considering the high adoption rates of hybrids up to 95 per cent in Maharashtra state, reveals the strength of seed companies, genetic materials adoption in different agro-ecological zones with varied climate and soils. The scenario of hybrid cultivars shows wide variation among states (only 10 per cent adoption in Bihar and Odisha) in adoption of improved cultivars. Similarly, the adoption of Hybrids varies from 2-12 per cent in Eastern and Southern Africa (ESA) and Western and Central Africa (WCA) (Figure 2).

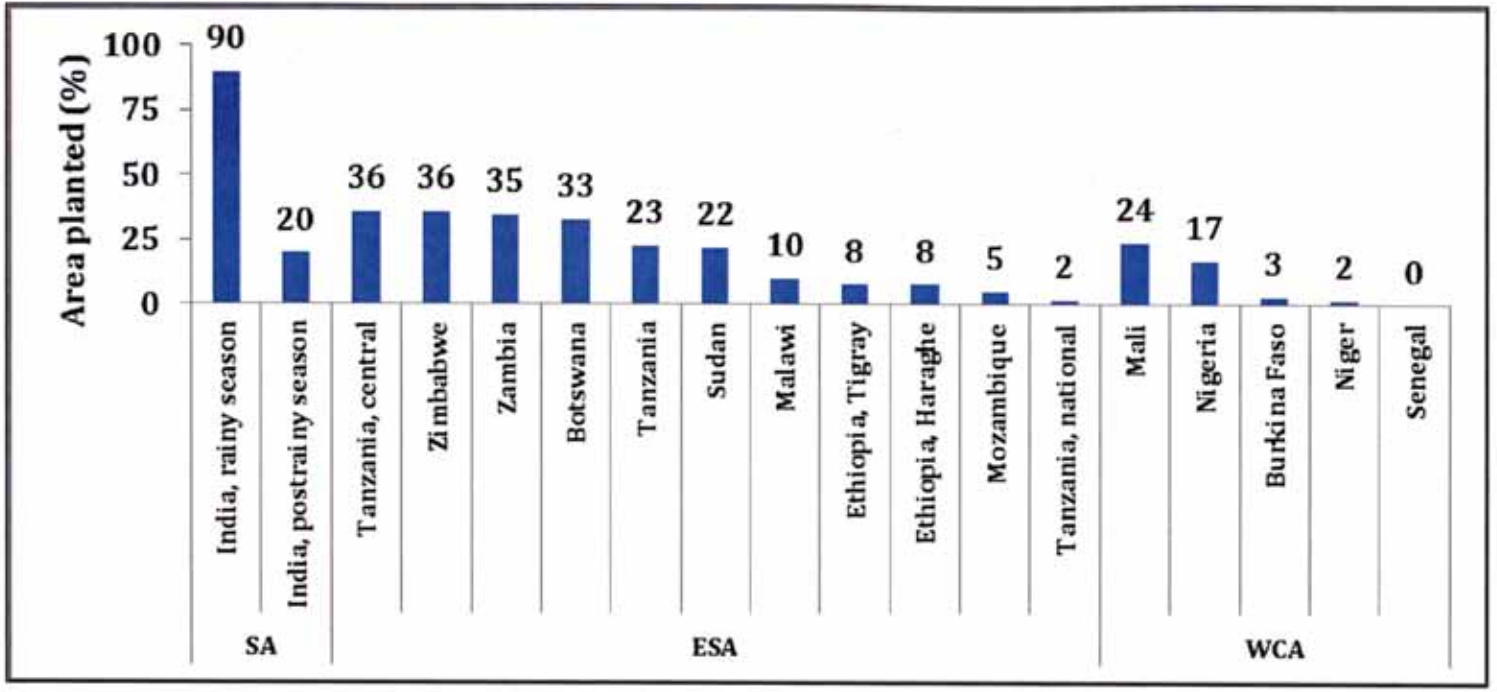

Figure 2: Adoption Levels of Improve Varieties in Sorghum Rainy and Post-rainy Seasons in India and other Countries.

Post-rainy sorghum grain is staple food of Maharashtra state and every farmer grows sorghum for his own food use and stover for livestock. Hence, sorghum is an important crop in crop –livestock cropping system which feeds humans and livestock. The seed required for post rainy sorghum is predominantly produced by the public sector (state seed development corporations and Agriculture Universities) organizations which meets 10-12 per cent of total seed requirement (32000 t) of the state and more over these organizations still produce 80 per cent of their total production that comprises of old varieties (Table 3). Baseline survey report (Pokarkar and Chavan *et al.*, 2014) reveals that 93-98 per cent of the seed sources are from farmers own saved seed and balance component is met by Public and Private sector and other informal seed sources (Table 4). Improved variety seeds are available at seed stores in the market and the takers are very few. The percentage of improved varieties seed sold is 0.6–12 per cent and old local variety constitutes 76 per cent of the total sale of seed (Table 5).

Table 3: Seed Production of Post Rainy Sorghum by State Seed Development Corporation of Maharashtra (Mahabeej) in 2012-13

Sl.No.	*Variety*	*Area under Seed Production (ha)*	*Seed Production (in tons)*
1.	M-35-1*(old local variety)	2336	2564
2.	Parbhani Jyoti	49.60	54
3.	Parbhani Moti	315.20	336
4.	Phule Anuradha	2.00	2
5.	Phule Chitra	30.80	20.6
6.	Phule Revati	77.20	64.7
7.	Phule Vasudha	92.40	76
8.	PKV Kranti	108.20	94.4
	Total	**3011.4**	**3211.7**

* Old variety

Research and development programs of state Agricultural universities (SAU) have developed improved varieties and are available in public domain for several years (Table 2). Due to poor infrastructure and institutional mechanisms to disseminate improved variety seed by state extension department, the yields of the post rainy sorghum is stagnant at 500-700 kg ha^{-1} for last couple of decades. To augment the seed production and dissemination of improved varieties, "seed consortium" model developed by ICRISAT (Figure 3) comprising various partner institutions like Department of Agriculture, Agriculture Universities, Seed certification agency, State and National seed development corporations, Private seed companies, NGOs, SHGs, KVKs which were brought on to one platform with basic objective to enhance availability of improved variety seed at right time and for right price to increase production and productivity of sorghum.

Table 4: Procurement of Seed by the Farmers from different Sources in Maharashtra State during 2013-14.

Seed Source	*Per cent Farmers*					
	Sholapur Dist.	*Pune Dist.*	*Ahmednagar Dist.*	*Beed Dist.*	*Jalna Dist.*	*Parbhani Dist.*
Own saved seed	93.33	98.33	98.33	93.33	95.00	92.5
Borrowed from others	0	0	26.67	1.66	0.00	0.00
Village Market	8.33	3.33	18.33	1.66	0.00	0.00
Local Market at Taluka level	3.33	30.00	15.00	0.00	5.00	5.00
Village Landlords	0	0	1.67	3.03	0.00	2.50
Private seed company*	8.33	3.33	13.33	6.67	8.033	1.25
Govt. Subsidized seed supply**	66.67	0	0	5.0	1.67	1.25
SAU*	0	0	18.33	0.00	0.00	10.00

*: Multiply and supply improved variety seed

**: Multiply and supply 80-90 per cent local variety seed and 10-12 per cent improved variety seed

Source: Baseline Survey Report of SAU, 2014.

Table 5: Post Rainy Sorghum Varieties Seed Sold by Seed Dealers in Maharashtra State during 2013-14

Variety	*Per cent of Total Seed Sale in Project Areas*	
	Marathwada Region (Eastern Maharashtra)	*Western Maharashtra*
M 35-1*(old local variety)	78.66	77.45
Parbhani Moti	11.93	–
Parbhani Jyoti	0.49	–
Phule Anuradha	0.18	0.17
Phule Chitra	0.38	–
Phule Revathi	0.77	–
Phule Vasudha	1.51	–
PKV Kranti	2.87	–
DJ 4005	0.05	–
Deccan Pearl	–	3.11
Kopargaon	–	1.86
Mahabeej	–	0.6
Suvarna	0.06	13.08
Swati	–	0.62
Vimal	3.1	3.11

* Old local variety and rest all improved released varieties

Interventions to Enhance Production

Postrainy sorghum is an important food and fodder crop of India is grown on residual soil moisture and gets affected by terminal moisture stress. Despite good efforts by Indian National agricultural Research services (NARS), the productivity remained low because of poor adoption of improved varieties and crop management technologies by farmers and above all the recurring droughts affecting the grain yields. Further, the market opportunities for grain and fodder are limited restricting it to a subsistence production system.

One of the reasons for the dismal performance of many development projects and programmes is that they are often designed to address problems of target populations as perceived by government officials and other outsiders rather than as perceived by the people themselves. The danger with this approach is that in many cases, considerable amount of resources are expended on trivial problems while priority problems of people are left unattended. The result is that as soon as external funding and assistance are withdrawn, the initiated development activities which are supposed to be continued by the people are not carried beyond the life of the project duration.

To enhance the on-farm productivity and to develop a sustainable integrated postrainy sorghum seed value chain, ICRISAT partnered with Government, Private, Public and people institutions; the project partners are Directorate of Sorghum Research, Hyderabad, Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV) – Parbhani and Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, Krishi Vignana Kendra's (KVKs), State seed development corporation(Mahabeej), National seeds corporation (NSC), Private seed companies, and Farmers associations (FAs), with an aim converge individual resources and knowledge to increase crop productivity and farmers' incomes by reducing the gap between on-station sorghum yields (2.5–3.0 t ha^{-1}) and farmers yields (0.75-0.58 t ha^{-1}) and by adding value to grain and stover and by providing market linkages.

Bill and Melinda Gates Foundation (BMGF) funded the project on "Harnessing the Opportunities for Productivity Enhancement" (HOPE) in Sorghum and Millets implemented in 11 countries including India during 2009-2013 (HOPE.icrisat.org/). Earlier efforts on postrainy sorghum improvement resulted in release of improved varieties with farmers preferred traits. In the absence of suitable seed system to deliver these varieties, farmers' still use old local varieties like Maldandi(M35-1), Dagadi, Zipri, Jut, Dudhmogra, Bondri, Cheetpuri, Shalu, Khadki, Manthi, and Dukrilocal. Concerted efforts by HOPE team in supplying the improved seed, technologies, knowledge, input and credit systems, value addition and market linkages made a remarkable change in the postrainy sorghum value chain in the project areas in Maharashtra, India. The project commenced in 2009, more than 300,000 farmers benefitted directly and indirectly through the project interventions.

Project locations consisting six clusters " Sanpuri (District: Parbhani), Limbaganesh (Dist. Beed) and Wakulni (Dist. Jalna) in Marathwada area (Eastern Maharashtra) and Hivare Bazar (Dist. Ahmednagar), Borkarwadi (Dist. Pune) and Aurad (Dist. South Sholapur) under Western Maharashtra region were selected for

technology dissemination considering the large area under postrainy sorghum in these clusters. Seed of selected (farmers participatory varietal selection) and released varieties such as Parbhani Moti, Parbhani Jyoti, Phule Vasudha, Phule Chitra and Akola Kranti were distributed for cultivation in the project areas and farmers were trained to use improved crop management practices. The fallowing improved crop production technologies were demonstrated across all villages of the project areas.

1. *In-situ moisture conservation*: Opening up of furrows in preceding legume crop at every 3rd or 4th row for improving drainage, moisture and soil conservation which have good effect on the yield of succeeding post rainy season sorghum. Three intercultural operations from 2nd week to 8th week after sowing will help to reduce weeds, loosening the soil for root development; improve soil aeration and moisture conservation.
2. *Plant population geometry and spacing*: Plant population ranging from 1.25 to 1.35 lakhs ha^{-1} is optimum depending on receding soil moisture. Soil types play an important role in deciding on plant population. Wider row spacing of 45cm X 10cm and 10-12 cm depth of sowing must be adopted for better crop yields; a seed rate of 10kg ha^{-1} is recommended for optimum plant population. A seed drill developed for wider row spacing and deep placement of seed and fertilizer should be used for sowing under rainfed cultivation of sorghum.
3. *Seed treatment and fertilizer management*: Seed treatment with Thiamethoxam (70WS) @ 3 g kg^{-1} of seed is a must to manage the shoot fly an important pest on sorghum. Application of basal dose (before sowing) of 40kg Nitrogen and 20kg Phosphorus fertilizer is recommended based on soil analysis reports.

Table 6: Average Yields of Improved Varieties Demonstrated in Project Locations in Maharashtra (2009-2013)

Region	*Grain Yield* (qt. ha^{-1})*	*Fodder Yield (qt. ha^{-1})**	*Percent Increase Over Local Variety*		*No. of Farmers Participated*
			Grain	*Fodder*	
Marathwada region	9.61(6.8)	29.19(23)	41	24	17,143
Western Maharashtra	12.6(9.2)	29.0(22)	36	33	16,100

* One qt. =100kg

In the first five years of project implementation, the project directly covered 33,000 farmers and the impact of the interventions reached more than 300,000 farmers in Maharashtra state. The implementation of technologies led to significant increase in grain productivity by 39 per cent and stover productivity by 29 per cent (Table 6) in project villages. The early adoption results indicated that the HOPE interventions enhanced technology adoption rates, reduced the yield gaps (by 30 per cent), increased the productivity and gave higher returns to farmers (36-41 per cent). They also indicated that for every single farmer covered by HOPE project directly, 5-6 non-

HOPE farmers benefitted. Dissemination of technologies (improved variety seeds) through secondary channels like farmer to farmer, relatives, friends and gifts to their kith and kin spurred the production (http://www.cgiar.org/consortium-news/hope-leads-to-increased-sorghum-yields/).

With these interventions farmers got convinced and are showing more inclination for growing improved varieties. To mitigate the deficiency of seed production and supply, an innovative seed system model (Figure 1) developed and for its implementation and monitoring a 'Seed Consortium' was formed during 2013 involving Department of Agriculture, Indian NARS, public and private sector seed agencies, seed certification agency, KVKs, SHGs, NGOs, and farmers became the stakeholders of the consortium with respective roles and responsibilities in production and distribution of seed.

Implementation of Seed System Model

i) Main Objective

To improve farmers accessibility and availability of seed of improved varieties at affordable price at right time for enhancing yield, income and household seed and food security

Specific Objectives

1. Conduct regional survey to understand the existing seed system
2. Develop appropriate seed system model through participation of Private-Public-People -partnership to improve accessibility and availability of improved varieties seed to small-scale farmers.
3. Identifying the varieties suitable for different agroecological regions through farmers participatory selection.
4. Harnessing the farmers knowledge and preferences in improving the seed system and research.
5. Improve the cultivar replacement rate (CRR) and seed replacement rate (SRR) to enhance the production.

ii) Approach

The proposed conceptual and organizational approach, strategies and partners, the linkages and support from formal sector institutions were planned and developed a seed consortium model that includes private, public sector seed companies, State Agriculture Universities(SAU), Krishi Vignana Kendras (KVKs), Self-help groups(SHGs), Non-Government organizations (NGOs), and farmers.

iii) The Model

Based on the findings of baseline survey on existing seed systems of post rainy sorghum in Maharashtra, a model (seed consortium) was developed to multiply improved varieties and distribute to farmers was implemented (Figure 3).

In this model, we envisaged a decentralized seed production and centralized seed procurement and distribution in initial years but eventually shifted to

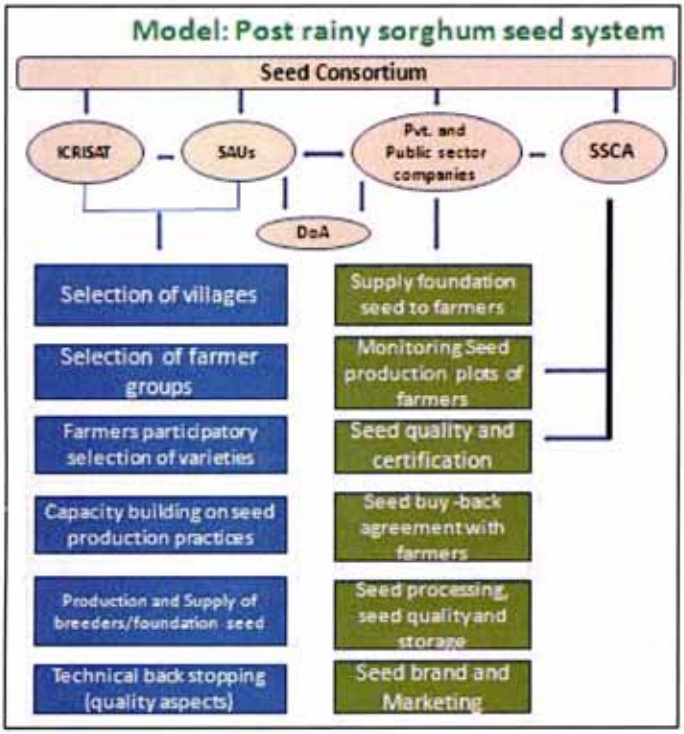

Figure 3: Seed Consortium Model.

decentralized seed production and distribution. The public sector research and development institutions (ICAR, SAUs and ICRISAT) and private sector seed companies engaged in partnership research to develop improved products and the private sector seed companies and public sector seed agencies played a critical role in seed production, procurement and dissemination of these improved products to farmers. This is akin to the rainy season hybrid seed production and distribution model in the country, which is one of the most successful examples in the developing world for having a strong seed system. Thus we have a sustainable commercial model to replicate to strengthen the postrainy sorghum value chain.

The seed consortium developed a work plan to produce 29,000 tons of improved varieties seed to meet the requirement of 2.9 m ha in Maharashtra in 4 years. The early adoption studies on improved varieties by the farmers conducted by ICRISAT, revealed that secondary dissemination of seed is very active in the region, each farmer on an average is sharing seed with 2 to 6 other farmers across the districts in the state. The trends of secondary dissemination of seed by the farmers will able to meet the seed requirements of farmers in Maharashtra, covering 3.2 m ha by the end of 4 year project duration.

iv) Roles and Responsibilities of Consortium Members

For establishing a seed consortium, ICRISAT and Partners worked for developing integrated postrainy sorghum value chain by harnessing the power of

genetics, crop management, value addition and markets under the HOPE project. Based on the strength of achievements under HOPE project for postrainy sorghum productivity enhancement, a 'Seed Consortium' was formed during 2013 under the chairmanship of commissioner of Agriculture, Maharashtra state involving private and public sector partners to sustain HOPE interventions. Under the Consortium, an innovative seed system model developed and delineated responsibilities to partners for achieving seed production targets fixed during the meeting (Table 7).

Table 7: Seed Production Targets of the Project

Year	*Seed Production Area (Ha)*	*Seed Production (tons)**	*Expected Area covered with Improved Varieties (Lakh Ha)*
1st year (2013-14)	500	1000	1.0
2nd year (2014-15)	2000	4000	4.0
3rd year (2015-16)	4000	8000	8.0
4th year (2016-17)	8000	16000	16.0

*: Indicative seed yield 2.0 tons ha^{-1}

1. *State Agricultural Universities*: Two agricultural universities MPKV and VNMKV are the members of the consortium and have developed new varieties. The selected released varieties Phule Vasudha, Phule Chitra, Phule Revathi, Parbhani Mothi were multiplied on research farm and supplied Breeder/and Foundation seed to public sector seed company (Mahabeej) for production of certified seed. the cost of foundation seed production is borne by the project. The universities and Mahabeej scientists jointly selected villages and farmers for seed production. The Govt. of Maharashtra is encouraging farmers by paying an incentive of Rs. 500/- per quintal (100kg) of seed produced by the farmers under seed village scheme (Anon. 2009).
2. *Public sector seed company (Mahabeej)*: Mahabeej has agreed on the work plan (Table 7) and also agreed in principle to reduce gradually production of local variety M35-1 (Maldandi) to promote improved released varieties. They have entered into buy-back agreement with farmers with a prefixed minimum price of seed procurement and agreed to pay 20 per cent more over the grain price in the market at the time of procurement. The seed harvesting and transportation to processing plant is the responsibility of farmers and processing, grading, branding and marketing is Mahabeej responsibility.
3. *NGOs, KVKs*: These organizations agreed to promote farmers in growing seed in addition to village seed programme to meet the target area under seed production. However, the organizations has a programme of seed development which was merged with our programme and they are benefited by access to foundation seed supply, training programmes for farmers and other crop production incentives and market linkages through consortium.

4. *State seed certification agency*: Mahabeej has taken responsibility to register farmers name and area for seed certification. The main objective of seed certification agency is to monitor genetic purity of the variety and certify the quality and quantity of seed produced by the farmers. The expenses incurred for monitoring the seed crop and issuing the certificate for seed produced by the farmer was borne by the project.
5. *Department of Agriculture*: Agriculture Department was established in 1883. Work started with the aim of helping the rural community to achieve higher productivity in agriculture. Development of hybrid varieties of different crops since 1965-66 laid down the foundation of Green Revolution. Introduction of intensive agriculture, comprising of large scale use of improved seed, fertilizers, pesticides and available water helped to increase in agriculture production. Later on, considering the need for providing guidance to the farmers for proper and judicious use of these inputs, Training and Visit Scheme was launched. Valuable contribution of this scheme through effective implementation of programmes like Crop Demonstrations, Field Visits, Corner meetings, Workshops, Fairs, Exhibitions etc. aimed at transfer of technology from Agriculture Universities to farmers fields increase agricultural production.

Agriculture department considers farmer as the focal point and the whole department is organized in such a fashion that a single mechanism is working to facilitate the farmer for adoption of advanced technology and sustainable use of available resources. There are several government schemes for the farmer's producer group like National Food Security Mission, National Horticulture Mission, Seed production scheme, Exposure visit, ATMA project scheme. Again there are many schemes crop wise for all the farmers from Maharashtra.

v) Capacity Building

Seed producing farmers were trained on seed production technique, isolation distance, sowing practices, other agronomic practices to be followed for the sorghum crop. Training was organized during flower initiation stage of the seed crop. The seed growing farmers were trained to identify off types, rogues and its removal from the seed plots and to maintain the quality of seed production and other agronomic practices, plant protection measures and harvesting methods. Further training was organized after harvest and at the time of seed processing to impart knowledge on seed cleaning, seed grading, seed treating, seed storage, seed packaging aspects, and how to draw the representative seed sample, for seed testing/local seed testing method to assess the seed germination and quality.

Training programmes were conducted on-station (University) and on- farm (in the villages) by technical staff of universities jointly with seed certification officials. Mahabeej staff joined the programmes to announce their buy-back agreement and assurance of seed procurement to develop confidence levels in seed producers. During seed production period university technical staff visited the farmers' fields and wave technical advice to farmers on crop production. Most of these villages were earlier

adopted under HOPE project. Hence, almost all farmers in the villages are well-versed with improved crop production technologies giving fillip to the seed production programme.

vi) Seed Production

The first seed consortium meeting was conducted at Pune in April 2013, under the chairman ship of commissioner of Agriculture. The members of department of agriculture, Vice chancellor, Director of Research, Advisor to Dryland Agriculture Mission, Seed certification agency director, General Manager- Mahabeej and Private seed company's representatives participated in the meeting.

There was consensus among the consortium partners to develop robust seed system for post rainy sorghum in Maharashtra and the commissioner of Agriculture extended all support under seed village program for the benefit of seed growing farmers (Anon, 2009).

Table 8: Seed Production during 2013

Partners	*Target Seed Production Area (ha)*	*Seed Production Area in ha*	*Quantity of Seed Produced in tonns*
MPKV (Eastern Maharashtra)*	250	243	263
VNMKV (Western Maharashtra)**	250	198(98)	166
Total	500	341	429

* MPKV area Average yield -10.18 q/ha

**VMMKV area average yield- 17 q/ha from 98 ha

During year 1 (2013-14) of project implementation we could grow seed crop on 341 ha and produce 429 tons of seed (Table 8). We could not achieve target area and yield for various administrative and adverse climatic conditions. Due to short time in implementing the project, MKV could not reach the targets due to unfavorable climatic conditions (heavy rains and high speed winds) during harvesting period. All the seed produced in both the regions was procured by the Mahabeej as per buy-back agreement signed with the farmers.

Table 9: Seed Production during 2014

Partners	*Target Seed Production Area (ha)*	*Certified Seed Production Area Sown (ha)*	*Quantity of Seed Produced (tons)**
MPKV (Eastern Maharashtra)	1000	2000	2400
VNMKV (Western Maharashtra)	1000	210	315
Total	2000	2210	2715

* Expected yield.

During second year (2014), the targets of area were doubled over year1 (Table 9). Foundation seed production area was damaged during year 1 in western Maharashtra

so they did not have sufficient seed to meet the target area of 1000 ha in year 2. To reduce the deficit of other partner, eastern Maharashtra partners increased their seed production area by 2000 ha to meet the target area of the year.

Farmers in Maharashtra acquired post rainy sorghum seed through various modes (Table 4) in varying proportions depending up on the variety, rate of seed replacement, social networks, and market integration. Sorghum is grown in rainy season purely under rainfed conditions and in post rainy seasons it is grown on receding soil moisture condition. On the contrary the seed system operating in rainy season in Maharashtra is 95 per cent formal and acquisition varies from place to place, hybrids are main choice of farmers. Whereas, 93 per cent of seed sourced informally during post rainy season. This indicates that the seed sowing by farmers vary greatly during seasons and across ecoregions. The proportion of seed is sourced by the farmers varies with in the system and among the regions of the state (Table 4). Majority of farmers in Maharashtra save their own seed and use it for sourcing next year, this practice is likely to alter the sourcing the seed from other two mode (purchasing and sharing). Farmers living in the vicinity of SAU procured improved varieties seed from SAU sales counter and mostly they are big farmers and are aware of varieties and sources of seed and by virtue of their location and accessibility to seed source.

It is not uncommon that the innovative farmers use seed (cultivars) from formal and informal sectors (relatives, neighbours, own-saved seed) and grow all on same piece of land leading to contamination due to lack of isolation. Farmers select the variety and save the seed for next season sowings seed is shared with their friends and relatives. Varietal purity and identity thus become blurred. With this sort of farmers practice, the purity of the good old variety M 35-1(Maldandi) released during 1938 is questionable. Still farmers prefer this variety and covers 80 per cent share in post rainy sorghum cultivation.

The components of formal and informal seed systems of post rainy sorghum operating in India and the flow of the genetic material from one system to other is depicted in Figure 4.

The replacement of old varieties with new varieties is the major task for govt. extension department to make availability of new variety seed in time on regular basis to the farmers. Usually, the seed production by State Seed Development Corporation (largest seed producing agency of post rainy sorghum) produces improved varieties seed only 2 per cent of total seed production (Table 3), because there is no uptake of improved varieties seed by the farmers; the social reason for not preferring new varieties is that the people prefer the taste of the roti they make from old variety and animals like the fodder of old variety.

Cultivar replacement indicates how effectively seeds of new cultivars are adopted by the farmers and produced and supplied by the seed agencies. The factors which determine the rate of replacement are how government popularizes the cultivar, superiority of new cultivar to the existing ones which they intend to replace. The higher and quicker replacement depends on superiority of the cultivar base yield, price of seed, and seed quality of farmers saved seed. The resuls indicate that farmers

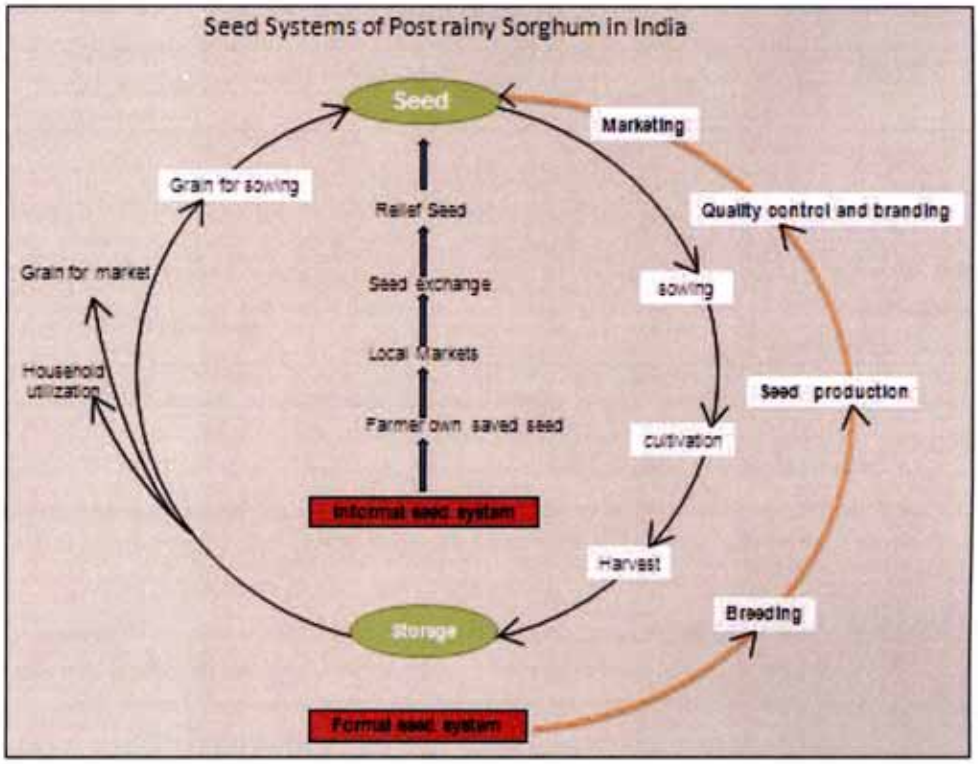

Figure 4: Flow of Genetic Material from Formal and Informal Systems in Post Rainy Sorghum in India.

did not adopt improved varieties released by AICSIP over a period of 7 years (Table 2) inspite of higher yields of grain and fodder (Table 6) for the reasons mentioned above. Assessing varietal or cultivar replacement rate (CRR) is not very easy and many indices of varietal replacement have been proposed (Brennan, J.P. and Byerlee, D.1989; Byerlee, D. and Heisey, P.W. 1990), but these indices can be obtained from statistics on breeder or certified seed production data and field surveys on adoption of new varieties (Witcombe *et al.*, 1998).

The project partners of state agricultural universities (MPKV and VNMKV) are committed to produce breeder and foundation seed (Table 10) and supply to Mahabeej for production of certified seed under seed village program of Govt. of India (Anon, 2009). With available foundation seed, Mahabeej will be able to take up seed production on 5000 ha in 2015, inturn will be able to produce 7500 t (average seed production 1.5 t/ha) of certified seed, which will be sufficient for sowing 7,50,000 ha area with improved varieties to cover 23 per cent of total area of post rainy sorghum area in Maharashtra.

Table 10: Seed Production Programme of Agricultural Universities-2014

Varieties	*Seed Production*		
	Nucleus (Kg)	*Breeder (Kg)*	*Foundation (Kg)*
Phule Revathi	50	1000	14,800
Phule Vasudha	50	1000	14,800
Phule Suchitra	50	1000	14,800
Phule Anuradha	25	500	4800
Parbhani Moti	10	11880	2430
Parbhani Jyoti	10	2160	1080
Total	**195**	**17540**	**52710**

Way Forward

Some important issues that could provide way forward for sustainable seed value chain to meet the demand of improved varieties of Post rainy sorghum in India are:

1. Varietal Denotification

i) A review of existing list of released and notified varieties do reveal that old varieties still find place in package of practices

ii) Continued production of seed of old varieties by state corporations is rather counter productive

iii) Denotifying old and obsolete varieties irrespective of whether they are from public or private sector to allow the seed multiplication of the new improved cultivars.

2. Cultivar Replacement Rate (CRR)

i) State must ensure production of Breeder/Foundation seed of rainfed crops and multiplication and replacement of seed to increase CRR progressively.

ii) CRR will happen through technology upgradation and extension work and govt. policies.

iii) For achieving the desired levels of CRR, adequate quantities of seed of improved varieties has to be produced and made available to farmers.

iv) Varietal replacement rate is a continuous process, the new varieties released from time to time should flow into seed chain to improve income and profitability.

3. Seed Mission

Developing and implementing rainfed agriculture seed mission -with a built in mechanism of supporting the cost of seed production for five years through Public – Private–Partnership with effective coordination and convergence mechanisms will help to increase productivity.

4. Advocacy

By increasing access to high yielding varieties/hybrids on priority basis to enhance adaptation rate will bridge the productivity gap and increase production.

5. Selection of Cultivars

Appointing a joint committee comprising of Indian council of agricultural Research (ICAR), State agriculture Universities (SAUs), public and private seed sector representatives and farmer groups to select rainfed crop varieties /hybrids suitable for different agro-ecological areas.

6. Seed Production

Promoting contract seed production by advance indenting of the seed of specific improved cultivars by both Public and Private Sector Seed Companies including KVKs, and community based organizations with technical support and capacity building for production of quality seed will strengthen the seed system.

7. Policy and Funding Support Framework

i) An enabling policy environment does help in production and dissemination of improved variety seed of rainfed crops.

ii) Provision of funds and support for seed multiplication and dissemination activities at least for 5 years.

iii) Strengthening extension services for creating awareness and demonstration of rainfed agricultural technologies.

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