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OPTIMISING SEED REPLACEMENT RATES IN JHARKHAND: PRESENT SCENARIO, CHALLENGES AND OPPORTUNITIES

R.P. Singh[1] and S. Singh[2]

Farm saved seed (FSS) is commonly used to raise the next crop in predominantly rainfed Jharkhand. Though the organized seed sector is able to produce seed in large quantities, presently, in Jharkhand, the supply chain is unable to cope with the huge demand for seed (approximately 75 percent of the planting material used in the state is farm saved seed). Due to predominance of rainfed agriculture, poor infrastructure, monocropping, undulated topography, inadequate seed availability including seed cost and poor technology adaptation etc., the seed replacement rates of cereals, pulses and oilseeds, except rice, in the state are poor. This paper attempts to analyse the seed requirement of different crops in Jharkhand state. It discusses the constraints and strategies to enhance seed replacement rates (SRRs) including the impact of SRR on crop productivity. Due to improved varietal replacement rates (VRRs) and SRRs in Jharkhand state, the average productivity increased by 27.9 percent in rice, wheat (13.9%), pulses (18.3%), and in oilseed by 29.6 percent during 2007-08 to 2014-15, over the base year 2006-07. This signifies the critical role of both VRRs and SRRs in enhancing production, which should contribute to improving food security in Jharkhand.

Introduction

The majority of Jharkhand's population is dependent on agriculture. In spite of rich natural resources the state has poor agricultural growth and output. According to the 55th round of the National Sample Survey Organization (NSSO), 10.5 percent of households in Jharkhand face seasonal food insecurity and 2.5 percent of households face chronic food shortage. Furthermore, 64 percent of households face food shortage for two to three months while as many as 28 percent of households face the same for four to five months (Singh, 2012). Jharkhand has sufficient rainfall but deficient water availability for irrigation, and ideal land topography for traditional fruits and tuber crops. But due to improper exploitation of natural resources (land, water, sunshine, biodiversity in crops and varieties etc.), insufficient infrastructure and market facilities, and poor technology adaption, mono-cropping cultivation has traditionally been the hallmark of Jharkhand agriculture.

Farmers need a genetically diverse portfolio of improved crop seeds varieties suited to a range of agro-ecosystems, farming practices, to improve their resilience to climatic change. Crop

[1] Directorate of Seed & Farms, Birsa Agricultural University, Ranchi-834006, Jharkhand, dsfbau@rediffmail.com
[2] Directorate of Seed & Farms, Birsa Agricultural University, Ranchi-834006, Jharkhand, dsfbau@rediffmail.com

improvement and seed improvement are like two wheels of the same cart, having to co-exist with uninterrupted complimentary, playing supplementary roles and having to move with the same force and speed (Pattanaik, 2013). However, timely delivery to farmers of the seed of high-yielding varieties (HYVs) or hybrids requires big improvements in the system that connects plant germplasm collections, plant breeding and seed production and delivery (Ghosh, 2013).

Crop seed is one of the most crucial elements in the livelihoods of farming communities. The potential benefits to farmers from increasing the use of quality seeds of a diverse range of crop varieties are widely acknowledged. Though the seed is critical, its cost in farmers' total price of inputs is low as compared to other input factors such as fertilizers, bio- fertilizers, insecticide, fungicides and herbicides including bio- pesticides, land preparation, irrigation and post-harvest management etc. With a small increase in seed expenses, the yield enhancement could be increased significantly. In India and other parts of the world, the so-called green revolution was due to higher-quality seed of semi-dwarf varieties of major cereal crops, particularly wheat and rice. In the first decade of the new millennium, the success of improved Bt-cotton productivity in India is an example of what technology can deliver and could be a lesson for other crops. The new seed biotechnology Bt cotton increased production from 158,00,000 bales (170 kg of packed lint constitutes one bale) in 2000-01 to 345,00,000 bales in 2011-12, and during the same period the productivity of lint increased from 190 kg/ha to 491 kg/ha which is phenomenal (more than 2.5 times in a decadal span) (Kranthi, Venugopalan, & Yadav, 2012). Seed replacement rate (SRR) is defined as the percentage of area sown with certified/quality seeds out of the total cultivated area under a crop in a season (Singh and Chand, 2011). Seed is the carrier of technology and the medium for translating scientif-ic achievements to the field. Often, Indian farmers do not distinguish be-tween grain and seed (Chand, 2007). Concerted efforts are essential in ensuring timely availability of seeds as well as increasing the SRR.

It is estimated that the direct contribution of quality seed alone to the total production is about 15-20 percent, depending upon the crop and it can be further raised up to 40-50 percent with effective management using other inputs (Singh, 2013; Natrajan, Jacob, & Mandal, 2009). Extremely low seed replacement rate (SRR) remains one of the hindrances to introducing high yielding varieties. In the present paper an attempt is made to realize the crop productivity, the seed requirement of popular crops, and the status of SRRs in comparison to standard SRRs among different crops grown in Jharkhand. Constraints including strategies to enhance SRR, opportunities for increasing VRRs and SRRs, and finally the impact of SRR on crop production and productivity.

Comparison of productivity among major food crops in Jharkhand and India

Out of its total geographical area of 79,71,000 hectares, Jharkhand has a cultivable land area of 38,00,000 hectare, and a net sown area of only 25,75,000 (32.3 percent). Only one-fourth of the net sown area is utilized during the *rabi* season (Ministry of Agriculture, 2015). The state falls under Agro-Climatic Zone VII (Eastern Plateau and Hilly region), which is further divided into three subzones (NITI Aayog, 2015). The state receives annual rainfall of 1200-1600 mm and the climate ranges from dry semi humid to humid semi arid types. In the state approximately 70 percent of the cultivable area during post summer season (*kharif* season) is covered by rice and most of this area remains fallow during the *rabi* season. Despite good rainfall, the cropped area and cropping intensity are low. The level of technology adaptation including quality seed is also poor leading to lower productivity (NITI Aayog, 2015).

Major food crop productivity in Jharkhand and India

The average productivity of major food crops in Jharkhand is far below the national average, which indicates the backwardness of the agriculture practices in the state. Table 1 shows the comparative performance with regard to major food crops productivity in Jharkhand and India. In Jharkhand, the increased production and productivity of rice is very important for food security reasons. The overall productivity of rice in Jharkhand was less than the national average throughout the first decade of the new millennium, although the latest three years of data shows that productivity of rice has increased (Table 1). The wheat and maize productivity of the Jharkhand state is quite low as compared to the all India level. In pulses the productivity of the state is high but in the case of oilseeds it is drastically low if one compares it with the national average. The productivity of different crops in Jharkhand agriculture suffered due to severe drought conditions during 2009-2015, except in 2011 in which normal rainfall was observed (Ministry of Agriculture, 2015).

Table - 1. Comparative Productivity (kg/ha) Performance in Major Crops Cultivated in Jharkhand and India

Year	Rice		Wheat		Maize		Pulses		Oilseed	
	Jhar[1]	India	Jhar[1]	India	Jhar[1]	India	Jhar[1]	India	Jhar[1]	India
2001-02	1797	2079	1764	2762	1496	2000	783	607	661	913
2002-03	1497	1744	1734	2610	1708	1681	613	543	634	691
2003-04	1694	2078	1719	2713	1600	2041	556	635	352	1064
2004-05	1495	1984	1614	2602	1457	1907	653	577	564	885
2005-06	1150	2102	1340	2619	1266	1938	427	598	548	1004
2006-07	1832	2131	1528	2708	1504	1912	727	612	497	916
2007-08	2023	2202	1500	2802	1500	2335	749	625	554	1115
2008-09	2035	2178	1541	2907	1407	2414	764	659	561	1006
2009-10	1505	2125	1550	2839	1332	2024	733	630	475	958
2010-11	1451	2239	1500	2988	1235	2540	656	691	487	1193
2011-12	3197	2393	1908	3177	1446	2476	817	699	679	1135
2012-13	2833	2462	1944	3118	1812	2552	1169	786	783	1169
2013-14	2694	2419	2007	3059	1851	2602	993	770	706	1149

Source: Kharif Workshop-2014, Department of Agriculture and Cane Development, Government of Jharkhand (document in hard copy only, with no further reference); Government of India, (2012, 2013, 2014)

The major constraints to good crop production are related to hydrology (moisture stress); soil and nutrients, availability of high quality seed of improved varieties; insect, disease and weed problems; difficulties in crop establishment; and unawareness of specific technologies [integrated pest management (IPM); integrated nutrient management (INM); integrated disease management (IDM) etc.]. Moreover, seed replacement rates (SRRs) and varietal replacement rates (VRRs) in Jharkhand are very low. To enhance agricultural production, productivity and sustainability by mitigating challenges emerging due to climate change and degradation of the agricultural resource base, the adoption and replacement of new HYVs are associated with seed replacement, since it is impossible to change varieties without changing seed.

Seed replacement rates (SRRs)

Quality seed is most critical for enhancing agriculture production. In India in general and in Jharkhand in particular, farm saved seed (FSS) is the most prominent source of seed to raise crops year after year. Farmers are familiar with the seed they themselves grow and know that the variety is adapted to local conditions and preferences. In India more than 70 percent seed usage, particularly for food crops, is through FSS which leads to low SRRs. Use of FSS is the time tested household tradition ingrained in the farming practices (Ayyappan and Kochhar 2010). In spite of the availability of quality seed of superior genotypes from the organized seed industry, the age old tradition continues (Pattanaik, 2013). However, the yield potential cannot be realised if due care is not taken regarding varietal and physical purity, seed health and vigour. Seed viability and seed vigour are the two important traits that signifi-cantly influence crop performance. The use of quality seed solves this problem because the term 'quality' is maintained in the seed as per seed certification standards and the certified seed is supposed to have all the quality parameters as per norms.

The adoption and replacement of new HYVs are always associated with seed replacement, since it is impossible to replace varieties (VRR) without changing seed. Unlike modern varieties (MVs)/HYVs adoption and replacement, seed replacement has nothing to do with gaining access to new genetic material contained in seed (Morris, Risopoulos, & Beck, 1999). SRRs and VRRs are twin perennial bottlenecks which ail the Indian seed sector. SRRs have a strong positive correlation with productivity, hence to meet desired productivity levels skewed SRRs and VRRs should be tackled (Bhaskar et al., 2014). Nevertheless, through SRR the genetic gains of new cultivars can be realized in terms of having higher yield.

To increase the adoption and diffusion of improved varieties to enhance production and productivity, strong back-up of seed multiplication and distribution system is needed. The Planning Commission, Government of India in its mid-term appraisal of the 10^{th} Five Year Plan (2002-07) with respect to seed has concluded that despite the public and private sector institutional framework for seed production, availability of good quality seeds continues to be a problem for farmers (National Seed Plan, 2005). As is well known, SRR has a strong positive correlation with the productivity and production of crops. The need for achieving optimal seed replacement rates should be one of the focus areas besides putting in place mechanisms for supplying quality and appropriate seed varieties taking into account the native agro-ecosystems and the pest profile of the region (Planning Commission, 2011a).

Rolling seed plan and seed requirement of Jharkhand

The seed requirement of different crops grown in Jharkhand state is estimated through an effective seed roll plan which in turn can be calculated by having knowledge of (i) area under the respective crop, (ii) seed rate/hectare and (iii) seed multiplication rate (SMR). The seed roll plan is always dynamic and keeps on changing depending on the earlier mentioned factors which are variable in nature. The outcome of an earlier study, which demonstrated that to achieve food production targets the existing SRR needs to be increased at the rate of 33 percent for self-pollinated crops, 50 percent for cross-pollinated crops and 100 percent for hybrids (Planning Commission, 2011a), was used in the calculations. The rolling seed plan of the state, which presents the current status of SRR of major crops grown in Jharkhand, was prepared by the authors (R. P. Singh and S. Singh) and submitted to the Department of Agriculture and Sugarcane Development, Government of Jharkhand for its implementation (Table 2).

Table - 2. Seed Requirement of Different Categories of Crops Grown in Jharkhand

S.N.	Crop	Area (ha)	Seed rate (kg/ha)	SMR	Certified Seed requirement (q) to cover entire area	Certified Seed requirement as per standard SRR & area required to produce the desired quantity of CS	
						Seed (q)	Area (ha)
Kharif crops							
1	Rice	16,92,000.00	50.00	50.00	8,46,000.00	2,79,180.00	11,167.20
2	Maize	2,50,000.00	20.00	50.00	50,000.00	25,000.00	1,666.67
3	Fingermillet	30,000.00	7.00	60.00	2,100.00	700.00	100.00
4	Pigeonpea	1,04,000.00	20.00	15.00	20,800.00	6,864.00	1,144.00
5	Blackgram	84,000.00	20.00	20.00	16,800.00	5,544.00	1,386.00
6	Greengram	16,000.00	20.00	20.00	3,200.00	1,056.00	264.00
7	Groundnut	22,000.00	100.00	6.00	22,000.00	7,260.00	907.50
8	Til	3,120.00	8.00	50.00	250.00	83.00	20.75
9	Soybean	5,000.00	75.00	15.00	3,750.00	1,238.00	123.80
10	Sunflower	2,000.00	15.00	15.00	300.00	150.00	37.50
11	Niger	15,000.00	5.00	100.00	750.00	375.00	93.75
12	Horsegram	31,900.00	25.00	30.00	7,975.00	2,632.00	438.67
	Sub total	22,55,020.00	-	-	9,73,925.00	3,30,082.00	17,349.84
Rabi crops							
13	Wheat	1,20,000.00	100.00	20.00	1,20,000.00	39,600.00	2,640.00
14	Lentil	32,000.00	25.00	30.00	8,000.00	2,640.00	528.00
15	Pea	35,000.00	75.00	10.00	26,250.00	8,663.00	866.30
16	Linseed	38,000.00	30.00	30.00	11,400.00	3,762.00	752.40
17	Gram	1,50,000.00	75.00	10.00	1,12,500.00	37,125.00	5,303.57
18	Rapeseed & mustard	1,30,000.00	7.00	80.00	9,100.00	3,003.00	600.60
	Sub total	5,05,000.00			2,87,250.00	94,793.00	10,690.87
	Grand total	27,60,020.00			12,61,175.00	4,24,875.00	28,040.71

Source: Calculated by authors
Note: ha – hectare, q – quintal, CS – Certified seed

The total seed requirement (in quintal) of the state and area requirement (in hectare) to produce the different categories of certified seed (CS), foundation seed (FS) and breeder seed (BS) of crops grown in Jharkhand are listed in Table 3.

Table - 3. Seed and Area Requirement to Produce Different Categories of Seed Crops (CS, FS & BS) Grown in Jharkhand

S.N.	Crop	CS requirement based upon standard SRR & area requirement to produce the desired quantity of CS		FS requirement based upon determined SRR & area requirement to produce the desired quantity of FS		BS requirement based upon determined SRR & area requirement to produce the desired quantity of BS		Requirement of seed of all category (CS+FS+BS) and area requirement to produce the desired quantity of seed	
		Seed (q)	Area (ha)	Seed (q)	Area (ha)	Seed (q)	Area (ha)	Seed (q)	Area (ha)
Kharif crops									
1	Rice	2,79,180.00	11,167.20	5,583.60	223.34	111.67	4.47	2,84,875.30	11,395.01
2	Maize	25,000.00	16,66.67	500.00	33.33	10.00	0.67	25,510.00	1,700.67
3	Ragi	700.00	100.00	11.67	1.67	0.19	0.03	711.86	101.69
4	Tur	6,864.00	1,144.00	457.60	76.27	30.51	5.08	7,352.11	1,225.35
5	Urd	5,544.00	1,386.00	277.20	69.30	13.86	3.47	5,835.06	1,458.77
6	Moong	1,056.00	264.00	52.80	13.20	2.64	0.66	1,111.44	277.86
7	Ground-nut	7,260.00	907.50	1,210.00	151.25	201.67	25.21	8,671.67	1,083.96
8	Til	83.00	20.75	1.66	0.42	0.03	0.01	84.69	21.17
9	Soybean	1,238.00	123.80	82.53	8.25	5.50	0.55	1,326.03	132.60
10	Sun-flower	150.00	37.50	10.00	2.50	0.67	0.17	160.67	40.17
11	Niger	375.00	93.75	3.75	0.94	0.04	0.01	378.79	94.70
12	Kulthi	2,632.00	438.67	87.73	14.62	2.92	0.49	2,722.65	453.78
	Sub total*	3,30,082.00	17,350.00	8,279.00	595.00	380.00	41.00	3,38,740.00	17,986.00
Rabi									
13	Wheat	39,600.00	2,640.00	1,980.00	132.00	99.00	6.60	41,679.00	2,778.60
14	Lentil	2,640.00	528.00	88.00	17.60	2.93	0.59	2,730.93	546.22
15	Pea	8,663.00	866.30	866.30	86.63	86.63	8.66	9,615.93	961.59
16	Linseed	3,762.00	752.40	125.40	25.08	4.18	0.84	3,891.58	778.32
17	Gram	37,125.00	5,303.57	3,712.50	530.36	371.25	53.04	41,208.75	5,886.96
18	R&M	3,003.00	600.60	37.54	7.51	0.47	0.09	3,041.01	608.20
	Sub total*	94,793.00	10,691.00	6,810.00	799.00	564.00	70.00	1,02,167.00	11,560.00
	Grand total*	**4,24,875.00**	**28,041.00**	**15,088.00**	**1,394.00**	**944.00**	**111.00**	**4,40,908.00**	**29,546.00**

* Subtotals and totals rounded to 0 d.p.
Note: ha – hectare, q – quintal, BS – Breeder seed, FS – Foundation seed, CS – Certified seed

Challenges

There are several reasons for poor seed replacement in field crops in Jharkhand, including high cost of seed, large storage losses, inefficient conversion of breeder seed to certified seed, and lesser participation of the private seed sector. In spite of several constraints the seed replacement rate has increased tremendously, which though relative and region specific, has a direct bearing on the total production of the country (Singh, 2013). A poor SRR among crops grown in Jharkhand, particularly in oilseed and pulses, has been observed. Furthermore, due to lack of awareness about the potential of quality seed, the non-availability of good quality seed, and relatively high price of seed also affect SRRs. To a greater extent, this also explains the large gap between attain-able levels of productivity achieved in front line demonstration plots and the actual productivity at farm levels (Singh and Chand, 2011). The various factors which are responsible for low SRRs in Jharkhand are mentioned below:

1. Recycling of seed: With respect to recycling of seeds, Pixley and Bänzinger (2001) reported that if second-generation ('recycled') seed of both open pollinated varieties (OPVs) and hybrids are used, then OPVs/HYVs are higher yielding than hybrids. So, regarding grain yield the following formula applies: hybrid > OPV > recycled OPV > recycled hybrid. In marginal areas where yield levels are low, if the price of hybrid seed is high compared to the grain price and if fertilizer application is constrained, consequently it is more profitable for resource-poor farmers to use OPVs or recycled OPVs than to purchase new hybrid seeds annually. Recycling of hybrid seed is a non-recommendable economic alternative (Schroeder et al., 2013). In some areas, farmers indicated that they often are forced to recycle hybrid seed because the input supply system is unreliable and replacement seed is unavailable. But even when replacement seed is available, many farmers choose not to purchase first filial generation (F_1) seed because they do not expect the investment to be profitable. Generally, farmers relate the profitability issue in extremely sophisticated terms, relating the cost of purchasing F_1 seed to the expected incremental benefits associated with its use. The incremental benefits stem mostly from the expected yield difference between F_1 seed and advanced-generation seed (which may have suffered a loss in genetic purity and/or a loss of viability), although another important factor is the risk of weather-induced crop failure. Jharkhand state is characteristically a rainfed state and its distribution of rainfall is erratic both spatially and temporally, with late onset of monsoon, and thus farmers prefer farm saved seed particularly in oilseed and pulses which are grown under marginal conditions.

2. High seed cost: The cost of good quality seeds, especially hybrid seeds are very high and farmers at times are unable to purchase the seed at high cost. Considering small and marginal farmers who will be affected by the high cost of hybrid seeds, the seed producing companies should set the price of quality seed at a reasonable level. Supply of seed to small and marginal farmers should be at subsidized rates using government support. However, Heisey and Brennan (1989) found that the price of seed purchased by farmers for sowing is a less important factor when base yields are high, and increases in the price of seed for sowing by farmers could even encourage higher replacement by stimulating seed production and its marketing (Witcombe, Packwood, Raj, & Virk, 1998).

3. High seed rate per unit area and cost of transportation: The availability of quality seed of improved varieties and hybrids is grossly inadequate and is a major constraint to enhanced production. Study findings of several researchers (Gadwal, 2003; Patil, Hanchinal, Nadaf, Biradar, & Motagi, 2004; Hanchinal, Nadaf, & Vijayakumar, 2009) clearly demonstrate that with high-volume low-value seeds, such as wheat, groundnut, soybean and chickpea, 80 percent of the cropping area is sown with farm saved seed of old and obsolete varieties under rain-fed and marginal conditions. Cost of transportation for some of the seeds e.g. potato and sugarcane seeds, is high because the seed production centres are located far away from the areas where production takes place. Localized seed production centres may be created to avoid the high cost of transportation.

4. Non availability of quality seed of new varieties: In Eastern India, rainfed upland rice covers approximately 4 million hectares. Although the upland varieties of rice are clearly marketable, efforts to involve the private sector in India in their seed production have not been successful because of the unprofitable nature of low yielding upland rice compared with irrigated transplanted rice (Witcombe et al., 2009). It is evident from the data that a huge gap exists between the number of varieties released and the number of varieties brought under Seed Production Programme. This is another big challenge facing the Seed Sector, which needs to be bridged. This would happen only when varieties which are released have distinct advantages over existing popular varieties (Gautam, 2013).

5. Inefficient seed conversion ratio: Production of certified seed by following an efficient chain of breeder seed - foundation seed - certified seed, is still a major concern throughout India including Jharkhand. The Planning Commission, Government of India, while reviewing the availability of inputs used in agriculture, particularly seed, observed a huge gap between what is supplied to seed producers as breeders' seed and their converting it to the certified seed that goes to farmers (Singh, 2013). This is wastage of time, land and other resources as well as a wasteful diversion of research field for seed production that is non-productive to national needs. "The extent of wastage of the efforts put by breeders in producing the nucleus seed and seed scientists in converting it to breeders' seed in India is phenomenal and can be even termed "national wastage". For example, the breeders' seed indents for rice and wheat if converted to foundation level 1 and certified seed would meet several times the need of the total seed requirements [in the total area covered under the respective crop] ... This obviously indicates a huge gap between what is supplied to seed producers as breeders' seed and their converting it to certified seed that goes to farmers" (Planning Commission, 2011c, p. 52). The most challenging task is to correct the conversion ratio (the seed multiplication ratio) in different categories of seed. The conversion ratio can be increased by improving seed multiplication rates (SMRs) and ultimately through good agronomic practices (GAPs).

6. Poor seed multiplication ratios (SMRs) and lack of exit plan: In Jharkhand, pulses and oilseed crops are grown under rain-fed and marginal conditions, viz. chickpea, groundnut and soybean in particular. They tend to have higher seed rates and low SMRs, leading to higher seed prices and relatively higher seeding costs. This leads to poor SRRs and VRRs, leaving farmers to go for farm saved seed. Re-sowing and/or gap filling further increase the requirement of quality seed in these areas (Singh, 2013). Moreover, the purchase of seed in major oilseed crops like groundnut and soybean for consumption as food commodities are also common, as the prices of the certified seed are lower than the commercial grain, which are generally in short supply at national level (Paroda, 2013; Singh, 2013). The SMR varies in different regions, particularly the rainfed ones. The improvement in SMR will help efficient conversion of breeder seed into other classes, easing pressure to produce more breeder seed (Sandhu, 2013). There is an absolute lack of 'exit plan' for a variety once its replacement is available, as a consequence of which even three decade old varieties continue to be indented, even though each acre of their cultivation deprives the farmer financially as well as in productivity of his land (Planning Commission, 2011c). Improvement to enhance productivity is required. SRR can be enhanced by increasing the quality seed availability and by educating farmers and state government officials.

Strategies to improve seed replacement rates (SRRs)

Rainfed areas are vulnerable to high climatic risks so seed systems have to be responsive towards meeting shortage on account of risk management. Wastage of seeds due to prolonged dry monsoon spells immediately after sowing is a common occurrence in Jharkhand (NITI Aayog, 2015; Singh, 2013). In such a situation maintaining seed diversity and assured seed supply is important from the point of view of reducing rainfall risks. There has to be an assured availability of a second batch of seeds for repeat sowing, if the first sowing fails. In cases of prolonged dry spells, the local seed systems must be capable of providing seeds of contingency or alternative crops. Fodder seeds are always a scarce resource which local seed systems could produce and supply (Planning Commission, 2011b; Singh, 2013). The state is dependent on outside agencies for seed as there is no strong organized system of seed production. Maintaining a strong local seed system with linkage to research and development (R&D) systems in universities or other institutes is necessary (NITI Aayog, 2015).

Other strategies to improve SRR are mentioned below.

1. Extension activities: Front line demonstrations (FLDs) of new varieties should be planned to demonstrate their high yield potential. This will enhance requirement for quality seed of new varieties ultimately resulting in increased production (Planning Commission, 2011c). The National Food Security Mission (NFSM) has focused on districts in which the productivity of wheat and rice is below the state average. The Mission is being implemented in 480 districts of 18 states, comprising 142 districts in 15 states for rice; 142 districts in 9 states for wheat, and 468 districts in 16 states for pulses. Some of the districts have a common overlap for two or more crops. The dissemination of new varieties among self-pollinated crops could easily be done through front line demonstrations (FLDs) by ensuring seed supply to farmers from successful FLDs. Therefore, front line demonstrations need to be conducted with utmost care in order to increase the adoption and diffusion, including SRRs.

2. Introduction of new climate resilient varieties: Climate change is a reality and its impact includes increase in the frequency of extreme events viz., droughts, flood, cyclones etc. An ideal solution to mitigate the challenge of climate change is the production and distribution of the seed of climate resilient crops/varieties. Nevertheless, to achieve food and nutritional security, the varietal and seed replacement rate can be enhanced through multiplying the seed of newly developed varieties of drought and/or heat tolerant crops such as coarse cereals (finger millet, pearl millet, sorghum, barley), pulses (pigeonpea, chickpea, horsegram, mothbean etc.) and oilseed (niger, sesamum, toria and linseed etc.) in rainfed conditions. Tsusaka and Keijiro (2013) report that the improved traits (drought/ heat/salinity/ submergence tolerance) of recent modern varieties (MVs) have contributed to alleviating, not aggravating, the influence of climatic conditions. This sharply contrasts with commonly accepted wisdom that MVs, particularly in the early stage of the Green

Revolution, were typically resource-demanding technologies and were higher-yielding only under favourable production environments. In rice a few climate resilient varieties have been developed through international collaboration and have been inducted into the active seed chain.

3. Emphasis on farmer-managed seed systems: The widespread attention to the formation of formal seed supply systems in developing countries has resulted in a virtual denial of the existence of local seed supply systems. These consist of farmer selection, on-farm seed production and local diffusion (Singh, 2013). These activities are equivalent to breeding, production and marketing in the formal system. The crop diversity developed and maintained by farming communities play a big role in adapting agriculture to climate change and variability. And history shows that farmer-bred seeds can be adopted and dispersed rather quickly. In India, the 'waterproofing' trait has been transferred into a popular rice variety *swarna*. The trait for flood-tolerance was derived from a farmers' variety, *dhullaputia* identified as the world's most flood-tolerant rice variety over 50 years ago in Odisha. The variety *swarna* is very popular in Jharkhand state and is planted in low land topography. Long term strategies for improving rainfed farming must include, among others, measures to strengthen the capacity of local seed systems (ICRISAT, 2010; Singh, 2013).

4. Strengthening seed systems: Seed systems are an important area for enhancing resiliency. Resilience emerges as a property of germplasm, institutions, and interactive information systems, which allow for strategic response to change (McGuire & Sperling, 2013). An effective seed system denotes the activities from selection and breeding to marketing, and the use of seeds by farmers for growing crops. It has close linkages with other systems, particularly research and extension (Venkatesan, 1994). The increase in seed production in India came through two important events. First, the implementation of the New Seed Development Policy (1988) through which flow of germplasm from other countries became easy and number of hybrids released and seed production thereof increased significantly (Singh, 2013). The introduction of this policy in 1988 had a positive effect on investments by the private sector (Paroda, 2013). The second factor which helped tremendously to increase the seed replacement rate in major crops was the implementation at the state level of the Central Sector Seed Scheme by the Ministry of Agriculture, and the implementation at the institutional level of the Mega Seed Project by the Indian Council of Agricultural Research in 2005-06. After the implementation of these schemes the availability and production of quality seed increased several times (Singh, 2013). Due to this, the state of Jharkhand benefited, whereas earlier at the time of separation from Bihar, the infrastructural facilities related to seed production, processing, and storage were totally absent. Before separation, Jharkhand (then southern Bihar) was considered an industrial corridor, and so emphasis was given to agriculture only in the northern region (present-day Bihar).

5. Public-Private Partnership (PPP): The importance of the formal sector is often overestimated. At present, the public seed agencies owing to their social responsibility are engaged mostly in production and supply of high volume-low value seed; whereas, the private seed agencies concentrate on production of low volume-high value seed (Singh, 2013). The time lag between the release and farm level adoption of the new varieties needs to be reduced (ibid.). This can be made possible by the promotion of seed cooperatives/seed growers associations, involvement of NGOs, and the establishment of close coordination with input agencies like Krishak Bharati Cooperative Limited (KRIBHCO), Indian Farmers Fertiliser Cooperative Limited (IFFCO), National Fertilizer Ltd. (NFL), National Bank for Agriculture and Rural Development (NABARD) and other agro-input agencies, to reduce the yield gap and quick popularization of new varieties/hybrids. The availability of quality seeds can also be increased by Public-Private Partnership (PPP) in the seed industry, which can exploit the strengths that exist in these two sectors. While the public system has competent scientific manpower and is equipped for both basic strategic and applied research, the private sector relatively lags behind the vast modern infrastructure facilities and large manpower. However, the private sector has expertise in high tech research like the development of genetically modified varieties and seed production. The climatic conditions of Jharkhand state are ideally suited for quality seed production during winter crops and could be an ideal state for private sector to exploit the opportunities. Moreover, the easily availability of labour and proximity to West Bengal, Bihar, Odisha and Chhattisgarh advocate its candidature for the quality seed production, processing, storage and marketing required for the private sector to operate.

Opportunities and ways forward

Cereals: The National Commission on Farmers indicated that there is a large knowledge gap between yields in research stations and actual yields in farmers' fields. To meet the rice production target of 120-125 million tonnes by 2025, it is necessary to increase the productivity levels of the rainfed rice growing Eastern Region substantially, without adversely affecting the natural resource base. Moreover, the Eastern Region constitutes about 60 percent of India's area under rice but contributes just about 50 percent of total production; and thus shows poor productivity (<2 tonnes/ha). In certain areas, non-availability of suitable HYVs and quality seeds also contributes to the problem (Mohapatra, 2014). In the case of rainfed rice, which contributes 55 percent of the total area under rice, the average yield is about 1 tonne/ha, and the extent of adoption of high-yielding varieties is 32 percent and the achievable yield about 2500 kg/ha (Venkateswarlu and Prasad, 2012). In Jharkhand, the area under rainfed upland rice varies from 0.4-0.5 million ha and the productivity is below 1 tonne/ha. Drought tolerant short duration varieties are needed for the upland situation in Jharkhand, and their induction into the seed chain is very important.

Similarly, the wheat crop has tremendous yield potential and exploitation of this potential would be possible through stepping up the yield level in the North Eastern Plain Zone (NEPZ) (9 million ha) to around 3 tonnes/ha from the present level of 2.25 tonnes/ha (Dastagiri, Prasad Gajula, & Patil, 2014). As the wheat crop is sown to capitalize the residual moisture in low land topography after rice, it suffers productivity loss due to moisture stress and terminal heat stress. Induction of heat and drought tolerant varieties adapted to late sown conditions into the seed chain of the state would be beneficial. In maize, the adoption of single cross maize hybrids (SCHs) bred by both the public and private sector doubled maize production and productivity in the last decade. In Jharkhand, the area under hybrid maize is increasing with the private seed sector dominating the scene.

Pulses and oilseeds: Utilization of the vast area under rice fallow is possible, to a larger extent, by a shift to direct seeded rice (DSR) with shorter duration (early maturing) varieties in drought prone shallow lowland, and replacement of long duration high yielding hybrids with shorter duration in medium lands. This will open up opportunities to grow other crops like short duration oilseeds (Toria, Mustard, Linseed), pulses (Gram, Lentil and Pea) with residual moistures or with minimal supplemental irrigation (NITI Aayog, 2015). Large-scale on-farm trials conducted by several State Agricultural Universities in the eastern states of India have clearly shown that short-duration varieties of chickpea and lentil can be successfully grown after rice harvest, and with reasonably high yield levels of 1 to 2.5 tonne/ha (Gowda, Srinivasan, Gaur, & Saxena, 2013).

With regards to Jharkhand agriculture, the NITI Aayog (2015) suggests that about 1 million ha of rice fallow area needs diversification, particularly through pulse cultivation and at least 0.1 million ha additional area of rice fallow should be brought under pulse production every year. Nevertheless, 0.1 million ha additional area of rice fallow should be brought under oilseeds production every year to increase the cropping intensity to 150 percent in rainfed areas and 175-200 percent in irrigated areas over the next three years (NITI Aayog, 2015). To attain the targeted goals, efficient seed chain management system is required. This can only be met through involving all stakeholders in seed multiplication, storage, processing, marketing and distribution, and by setting up a State Seed Corporation, as established in 2016 by the Government of Jharkhand. The newly established Jharkhand State Seed Corporation plans to support backward and forward linkages by involving all the stakeholders including the Department of Agriculture and Sugarcane Development, Jharkhand State Seed Corporation (JSSCL), Jharkhand State Seed Certification Agency (JSSCA), the State Agricultural University, Krishi Vigyan Kendras (KVKs), Seed Villages, Self Help Groups, Non Governmental Organizations etc., as depicted in Figure 1.

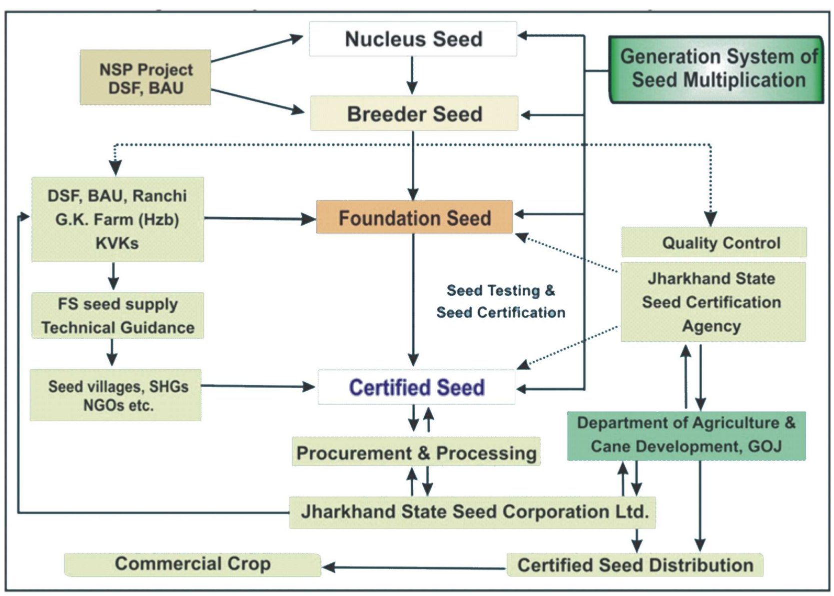

Figure - 1. Role of stakeholders in quality seed production, certification and distribution in Jharkhand

Impact of varietal and seed replacement rates (VRRs & SRRs) in Jharkhand

As per the National Seed Policy, 2002 emphasis was placed to increase the seed replacement rate (SRR) among different crops. The year-wise progressive status of seed replacement rate among different field crops in Jharkhand is given in Table 4. Since an emphasis was made to increase SRRs in field crops, the state government adopted measures to strengthen seed chain management by establishing seed villages. In addition, through various central government central sector seed schemes and also through National Food Security Mission (NFSM), *Rashtriya Krishi Vikas Yojana* (RKVY), Bringing Green Revolution to Eastern India (BGREI), and Accelerated Pulses Production Programme (A3P) for pulses etc., structural reforms took place. In order to increase varietal replacement rates (VRRs), under NFSM emphasis was placed upon only providing the seed of newly released varieties (<10 years old) for their adoption and diffusion among farming communities. The rice crop received the highest attention and the SRR has been achieved, because it excluded the area under hybrid rice which is quite significant (approximately ~25 percent). The case of maize is more or less the same. In wheat the SRR is increasing steadily, even though it has not reached the standard level of 33 percent. In pulses and oilseeds the SRR is erratic except in chickpea (gram) where it is extremely low (<5 percent) and requires immediate attention, because chickpea is very important for food and nutritional security. For other crops, consistent and persistent efforts are needed to improve SRRs.

Table - 4. Progressive status of seed replacement rate among different field crops in Jharkhand

Crop	Norms	2007 -08	2008 -09	2009 -10	2010 -11	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16
Rice*	33	7.6	14.6	23.4	25.1	17.1	22.4	15.65	15.41	28.29
Maize*	50	2.0	7.6	19.2	14.3	7.3	13.6	1.15	13.65	16.67
Wheat	33	-	-	-	27.6	31.9	41.2	8.34	22.26	28.57
Lentil	33	-	-	-	13.9	6.9	6.3	4.50	2.77	34.29
Gram	33	-	-	-	2.4	1.3	2.9	0.73	2.48	3.17
Arhar	50	-	-	-	11.7	23.6	21.6	3.26	6.70	25.00
Mung	33	-	-	-	-	21.2	19.0	7.03	0.00	25.00
Urd	33	-	-	-	-	6.9	5.1	2.96	10.01	20.00
Pea	33	-	-	-	17.4	9.4	10.2	-	-	-
Horsegram	33	-	-	-	23.7	7.6	8.8	0.00	0.00	80.00
R/mustard	50	-	-	-	72.1	20.5	34.4	2.43	15.59	40.82
Niger	50	-	-	-	-	-	39.3	0.00	0.00	72.73

Source: Zonal seed review meeting for Kharif 2010 (North-East Zone, dated 11.2.2010), MOA-GOI. Zonal seed review meeting for Rabi 2011-12 (North-East Zone, dated 12.9.2011), Rabi 2012-13 (dated 14.9.12), MOA-GOI, Department of Agriculture and Cane Development, Government of Jharkhand 2015-16 (seednet.gov.in).
* Seed replacement rate of OPVs only excluding hybrids.

Year wise productivity of different crops in Jharkhand over the past decade

Due to increased varietal and seed replacement rates, the productivity of all crops increased significantly in Jharkhand, due to proper planning and execution by including new climate resilient varieties in the seed chain. The average productivity of rice increased (27.9 percent) from 1832 kg/ha (2006-07) to 2344 kg/ha (2014-15). Over the same period, wheat productivity increased by 13.9 percent, pulses productivity by 18.3 percent, and in oilseed the average productivity increased by nearly 30 percent. After that, the productivity increased due to the launching of many schemes like Rashtriya Krishi Vikas Yojana (RKVY), National Food Security Mission (NFSM), Bringing Green Revolution to Eastern India (BGREI), Accelerated Pulse Production Programme (A3P) etc. The productivity of major food crops has increased due to the emphasis placed by these schemes on the introduction of new varieties and increased seed replacement rates. The Government of Jharkhand received the Krishi Karman Award in pulse production and productivity for two consecutive years, i.e. 2011-12 and 2012-13. In 2013-14 the Jharkhand state was selected for the same award in the field of coarse cereal production. The effect of increased varietal and seed replacement rate on productivity in Jharkhand is given in Table 5.

Table - 5. Impact of VRRs and SRRs on crop productivity (kg/ha) in Jharkhand (Crop wise comparative average productivity from 2007-08 to 2014-15 over base year of 2006-07)

Year	Rice	Wheat	Pulses	Oilseed crops
2006-07 (Base year)	1832	1528	727	497
2007-08	2023	1500	749	554
2008-09	2035	1541	764	561
2009-10	1505	1550	733	475
2010-11	1557	1500	656	475
2011-12	3197	1908	817	679
2012-13	2833	1944	1169	783
2013-14	2694	2007	993	636
2014-15	2909	1975	1000	990
Mean (2007-08 to 2014-15)	2344	1741	860	644
Average increase (percentage) in productivity during 2007-08 to 2014-15 over base year 2006-07	27.9	13.9	18.3	29.6

Source: Kharif Workshop-2016, Department of Agriculture, Animal Husbandry & Cooperative, Government of Jharkhand (document in hard copy only, with no further reference).

Conclusion

According to Kumara Charyulu et al. (2014, p. 21), "Seed, the vehicle for delivering the benefits of technology, is the most important basic input, influencing the growth and sustainability in agriculture". Quality seeds have the potential to produce healthy plants which is the key to food production and food security. Furthermore, seed is a potential commodity for overall agricultural development and entrepreneurship as well as an important component of agricultural biodiversity. From the present study it has been established that seed is a critical input factor to increase production and productivity. The identified constraints to increasing VRRs and SRRs needs to be tackled on a priority basis with consistent and persistent efforts. Maintaining a strong local seed system with linkages to R&D systems in universities or other institutes is necessary. The most challenging task is to correct the conversion ratio (the seed multiplication ratio) in different categories of seed (Singh, 2013). The conversion ratio can be increased by improving seed multiplication rates (SMRs) and ultimately through good agronomic practices (GAPs). The adverse effect of climate change on seed production and supply can be minimized by various approaches to seed chain management, i.e. breeding, seed production, seed certification and seed marketing. Regarding seed production, adjustment of crop calendars for quality seed production, strengthening of seed systems including farmers managed ones, seed processing and seed storage all need to be strengthened (ibid.).

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