STRATEGY PAPER 9

Accelerating Seed Delivery Systems for Priming Indian Farm Productivity Enhancement: A Strategic View Point

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI

May 2018

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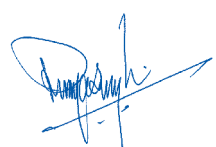
Preface

Seed is the basic and vital input, which makes the largest contribution towards higher productivity. Quality seed of improved varieties is the foundation of agriculture. The production and distribution of high quality seed was initiated systematically on the recommendation of 'Royal Commission on Agriculture' in 1928. Later, the seed production programme was further strengthened with the introduction of high yielding and dwarf varieties of wheat and rice, and hybrids of maize, sorghum and pearl millet in 1960's. The 'National Seed Corporation' was established in 1963 to further strengthen the seed production programme that triggered creation of other Seed Corporations and Seed Certification Agencies.

The seed delivery system in India is represented by both informal and formal systems. The formal seed delivery system comprises of public and private seed sectors that include National and State Seed Corporations, Public Sector Undertakings, National Agricultural Research Education and Extension System including ICAR-Research Institutes and Central and State Agricultural Universities. The private sector is comprised of different Indian and multinational seed companies. Though the Indian Seed Industry has taken a good shape over a period of time, the share of informal seed sector still remains dominant. The issues related to seed delivery system like role of public and private sectors, and farmers to ensure assured supply of quality seeds on affordable prices at appropriate time need urgent attention. In order to deliberate upon these issues, NAAS organized a strategic workshop on "Accelerating the Seed Delivery System" on December 27, 2017 at NAAS, New Delhi involving the stakeholders both from public and private seed sectors. The deliberations focussed on identifying actionable points for accelerating the seed delivery system and have come up with very useful and practical recommendations that will have desirable impact to stengthen seed sector in the years to come.

My heartfelt thanks are due to Prof R.B. Singh, Former President of NAAS for providing the leadership to the group and conducting the proceedings of this workshop. I wish to compliment Dr K.V. Prabhu, Secretary, NAAS and Convener, and Dr D.K. Yadava, Co-convener for organizing this strategy workshop and to all participants for their inputs. Dr V.K. Bhatia and Dr Kusumakar Sharma for their editorial support is duly acknowledged. I am sure that this document will be useful to the Fellowship and other stakeholders.



Panjab Singh
President

Accelerating Seed Delivery Systems for Priming Indian Farm Productivity Enhancement: A Strategic View Point

1. BACKGROUND

The Indian agriculture has made impressive advancements during past century. A major contributor to this is a strong public sector crop breeding research, combined with inputs on production management, plant protection and extension systems. The presence of a viable public seed sector well supported by private sector spread across the country did the primary task of taking the seed to farmers, the founding basic input resource in farm production. However, in terms of productivity, the national averages of different crops are still below the world standards with significant gaps recorded between the yield potential and yields achieved in most of food crops. It is well established universally that quality seed is the pivotal input for sustained growth of agricultural sector and other inputs are contingent upon quality of seed for being optimally effective.

Seeds are genetic powerhouses that are central to food security. Adequate quantity of quality planting material of improved varieties at appropriate time and affordable cost is to be made available to every farmer for bringing about radical changes in the agricultural scenario of our country. Importantly, this remains one of the most vital challenges before the seed industry even today. The seeds of improved varieties, with increased yield and improved performance, are required to overcome crop failure and other adverse effects due to climate uncertainties. Of the total 138 million landholders in India, 85% farmers are either marginal (67%) or small (18%), and access and availability of farm inputs to them remains a matter of serious concern. Current crop yields in smallholder farmers' fields in India are well below their potential. It is imperative that to build a food-secure India and make agriculture remunerative, millions of resource-poor smallholder farmers should raise their agricultural productivity. Use of high quality seeds of improved crop varieties with inbuilt genetic traits resilience to climate change coupled with improved farm practices are the most important determinant in raising the productivity.

In the Global Seed Market, Indian seed industry is one of the most mature and vibrant one. It is built on the foundations of strong public sector commitment to research and development that started in the 1960s under the Green Revolution. India established breeding centers for all major crops, a nationwide trial system and extension support under public sector, which has played a major role in development of landmark varieties of major crops and facilitated their seed availability through its network. In addition to public sector, the private sector currently has significant role both in R&D and marketing with the underlying infrastructure, technical skills, and production capacity; while germplasm has been the result of public investments over many decades. The developments in the seed industry

in India, particularly in the last 30 years, are very significant. A major re-structuring of the seed industry by Government of India through the National Seed Project Phase-I (1977-78), Phase-II (1978-79) and Phase-III (1990-91), was carried out, which strengthened the seed infrastructure that was most needed and relevant around those times. This could be termed as a first turning point in shaping of an organized seed industry. Introduction of New Seed Development Policy (1988-89) was yet another significant milestone in the Indian Seed Industry that transformed the very character of the seed industry. The policy gave access to Indian farmers to the best of seed and planting material available anywhere in the world.

Presently, agriculture is witnessing and experiencing an excellent mix of technological innovations to overcome unprecedented challenges of the kind the country never faced as a consequence of Global Climate Change, a phenomenal progress that has been occurring over a long period of time where both public and private sectors dealing in seeds have contributed enormously. The plant breeders, resource management and protection scientists have got together to work with common goals to breed varieties in major crops which are able to minimize the negative impacts of climate change as well as the environmental degradation.

1.1. Growth of Indian Seed Industry

In the last five decades, the Indian Seed Industry has responded in a vibrant manner with a makeup of players from the public (48.44%) and private (51.56%) sectors participating in the exercise. The public sector in general is dealing with the high volume, low value crops, whereas, private seed sector is more engaged in low volume and high value seed crops. But with the licensing of large number of wheat, rice and maize varieties during last 4-5 years this notion is changing. As a result, India has evolved to become 5th largest seed industry in the world after U.S., China, France and Brazil. The drivers of growth in seed industry are listed as under (Venugopal, 2014):

A. Research and Technology

- Sharing of germplasm and breeder seeds of public-bred varieties
- Minimum restrictions and proper safeguard mechanism for import of germplasm and hybrids/varieties
- Acceptance and commercialization of new seed technology, GM traits, use of biotechnology
- Investments by public/private sector players

B. Regulatory framework

- Enactment of suitable legislations

- Market liberalization to increase availability of high-quality seeds to Indian farmers
- Relaxation of norms for export/import of seed to overseas country

C. Foreign/Multinational investment

- Technical and financial assistance in the early stage of development from foreign aid agencies like USAID, Ford Foundation, Rockefeller Foundations and World Bank to strengthen the breeding, seed production, distribution, processing and quality control infrastructure in public and private sectors
- Entry of multinational corporations into the Indian seed business through equity participation

D. Environment

- Public-private partnership
- Special schemes for upgrading quality of farm saved seed and improving Seed Replacement Rate
- Extension programs for awareness generation and easy accessibility of quality inputs
- Introduction of the Seed Technology subject at Graduate and Post Graduate level

Indian seed market has shown robust Compound Annual Growth Rate (CAGR) of 19 per cent during 2010-14, growing from USD 1 billion in 2010 to USD 2.2 billion in 2014. In value terms, the major growth has come from the increased adoption of Bt Cotton hybrids, single cross corn hybrids and hybrid vegetables. The volume growth has mainly come through increased Seed Replacement Rate in crops like Paddy and Wheat. The overall Indian seed market is expected to grow at 11 per cent annually while Indian vegetable seed market is expected to grow at 14.6 per cent. In 2020, Indian field crop market would cross USD 3 billion mark while vegetable seeds market would reach USD 700 million. (Anonymous, 2015). Seed business can further serve as a catalyst for rural development through income generation and entrepreneurial opportunities besides enhancing the production and productivity.

2. SEED DELIVERY SYSTEM IN INDIA

Seed delivery system in India is represented by both informal and formal systems in the proportion of 55:45, respectively (Fig. 1). Informal seed delivery system is the farmer driven localized seed delivery system, where the farmers obtain, produce, conserve, improve, and distribute seed in an unorganized open market without any regulations.

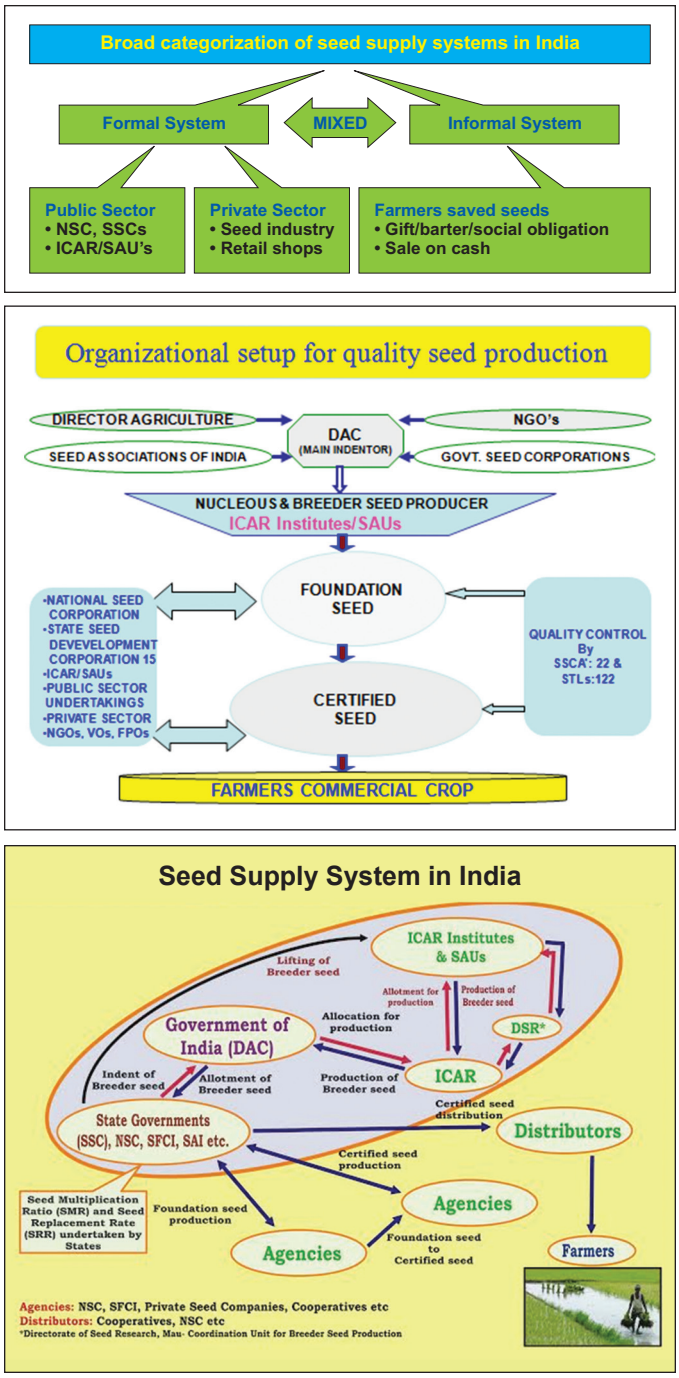


Fig. 1 Seed Production and Supply Systems in India

This system works under no legal norms and is the most important source of seed for most farmers. In a village, there may be a few farmers who are recognized as good seed growers and other farmers may receive some of their seed from them. These farmers are innovative and test the new varieties at their farms to evaluate the potential and promote them. The key characteristics of this system are: (i) Operates at local level, (ii) Deals with small seed quantities, (iii) Wide range of exchange mechanism (iv) No regulatory control and (v) Addresses farmer's immediate needs and operates mainly on "social certification" based on mutual trust. Informal seed sector is the main player in developing economies including India, where despite large investments over the past three decades to build formal seed systems, 90–95% of the world's smallholder farmers still obtain seed from informal sources, largely from other farmers or use their own farm saved seeds.

The formal seed sector of developing countries is controlled either by the state or private industry, which monitors the entire process of seed production from breeding to multiplication, processing, and storage for ensuring high-quality. In the informal sector, on the other hand, seed may be manually cleaned but is otherwise generally left untreated, which exposes the resulting crop to the risk of seed-borne diseases. The repeated use of untested seed by smallholders, can lead to seed degeneration. Knowledge of seeds quality would allow farmers to choose seed that could increase their crop yields significantly. Although smallholders often inspect seed before purchasing it from a neighbouring farmer or from the local market, the health and quality of seed is not always apparent to the naked eyes. Therefore, seed supply from both formal and informal systems suffer from these and other problems caused largely by lack of investments in education, research and quality control programs.

2.1 Strengths of Indian Seed Sector

The formal seed delivery system is represented by public and private seed sector (Fig.1). In India, presently the public sector comprises of one national level corporation viz. National Seed Corporation (NSC), 16 State Seed Corporations (SSCs), 25 Seed Certification Agencies (SCAs), 2 Central and 132 State Seed Testing Laboratories (3 ISTA accredited and 20 have ISTA membership), are providing requisite strength in serving the seed industry and farmers. The research and development in the public sector is dependent on public research under the aegis of the Indian Council of Agricultural Research (ICAR) Institutes and State Agricultural Universities (SAUs)/Central Agricultural Universities (CAUs). SAUs/ CAUs and ICAR Institutes are also engaged in breeder seed production and also in production of foundation and certified/truthfully labelled seed of their varieties (Fig.1).

Besides, seed is also being produced by the farmers under Farmers' Participatory Programme of several Institutes and under Seed Village Programme of the Government of India. 40 SAUs/CAUs and 22 ICAR Institutes across the country are engaged in seed production activities. SAUs are taking up breeder seed production involving their KVKs to bring seed revolution in the country. Private sector has more than 500 players (including

domestic and multinational companies) and the top 10 seed producers account for more than two-third of domestic market. Over the past two decades, private sector seed companies have collected germplasm and also built their R & D capabilities. Some of these have realised the importance of R & D and now spend about 5-10% of their sales proceeds on it. These players have developed many hybrids based on the local needs of the farmers and have been able to gain significant market shares.

Seed Vending Machine: An Innovative System: The National Seed Corporation and a few Agricultural Universities have adopted the vending machine based seed delivery mechanism for making easy access to the availability of vegetable and flowers seed for consumers/ farmers by installing automated seed vending machine facility at village market places.

Public Sector R&D and Seed Production Network: The National Agricultural Research Education and Extension System (NAREES), which serves the agricultural technology and information needs of the country, has created a research network of 108 ICAR Research Institutes, 11 Agricultural Technology Application Research Institutes (ATARIs) and 73 Agricultural Universities (including 3 Central Agricultural Universities and 5 Universities with Agriculture Faculty) spread across the country. DARE/ICAR has also established a network of 690 Krishi Vigyan Kendras (KVKs) across districts in the country aiming at assessment and demonstration of technologies/products developed under NAREES and their dissemination among the farmers and line departments through their district level front line demonstration and training programmes.

The Division of Crop Sciences, Indian Council of Agricultural Research through its one Deemed to be University, 19 Research Institutes, 03 Project Directorates, 03 Bureaux, 02 National Research Centres, 22 All India Coordinated Research Projects (AICRPs) and 10 Network Research Projects, and with active collaboration with SAUs is engaged in the development of improved crop varieties/hybrids, with the main aim of cost-effective production and environment-friendly crop protection technologies to enhance crop productivity and ensure food and nutritional security in the country. The Institutes are located in different parts of the country and developing the area specific technologies. The AICRPs, which are coordinated and funded (75%) by ICAR located in SAUs, have the mandate of developing trait-specific high yielding crop varieties and hybrids, suitable to specific areas/agro-climatic zones. As a result of these efforts, since 1969 till January 2018, 4723 improved field crop varieties have been developed that include 2415 of cereals, 797 of oil seeds, 891 of pulses, 154 of forage crops, 333 of fiber crops, 100 of sugarcane and 33 of other crops. Among these, highest number of varieties have been released in rice (1021), followed by wheat (395) and maize (330). During 2016-17, 1169 varieties are under seed chain and contributing immensely towards high production and productivity in agricultural sector.

Under the ambit of All India Coordinated Research Project on National Seed Project (Crops), breeder seed production programme is being coordinated involving 41 centres, whereas, ICAR Seed Project with 63 centres is aimed at strengthening of infrastructure

pertinent to seed domain of National Agricultural Research System (AICRP NSP (Crops) Annual Progress Report, 2017).

With the implementation of the AICRP NSP (Crops) and ICAR Seed Project, the quantity and quality of breeder seed production has increased (Table 1). The cropwise availability of certified/quality seed is also more than the requirement (Table 2), where public as well as private sector are making collaborative efforts. The share of public & private sector in certified seed production is presently in the ratio of 48.4: 51.6, respectively (Table 3).

Table 1 : Breeder seed indent and production of different field crops during 2007-08 to 2016-17

Year	Indent (q)	Production (q)
2007-08	73687	92060
2008-09	79913	91883
2009-10	91410	115867
2010-11	87215	115696
2011-12	90577	117827
2012-13	98799	95012
2013-14	84789	89266
2014-15	86292	100075
2015-16	122160	127823
2016-17	104046	122616

Table 2 : Crop-wise requirement and availability of certified/quality seed during 2014-15 to 2016-17

(Lakh quintals)

CROP	2014-15		2015-16		2016-17	
	Requirement	Availability	Requirement	Availability	Requirement	Availability
Wheat	112.53	116.86	113.46	117.98	117.55	136.57
Paddy	84.80	92.92	82.86	95.10	87.74	100.48
Maize	10.84	12.25	10.70	12.69	12.47	13.54
Jowar	2.42	2.75	2.95	3.16	2.82	2.89
Bajra	2.42	2.69	2.55	2.84	2.36	2.64
Ragi	0.31	0.36	0.32	0.53	0.34	0.56
Barley	2.23	2.87	2.25	3.17	2.44	2.95
Others	0.03	0.04	0.05	0.06	0.07	0.08
Cereals Total	**215.58**	**230.74**	**215.15**	**235.53**	**225.79**	**259.71**
Gram	16.11	15.72	18.14	14.86	17.65	16.01
Lentil	1.79	1.38	1.30	1.06	1.47	1.15
Peas	1.96	1.57	2.12	1.83	2.67	2.91

Urd	2.68	3.31	2.62	2.71	2.67	2.9
Moong	2.79	3.31	2.87	3.23	2.68	3.27
Arhar	2.64	2.78	2.51	2.72	2.71	2.97
Cowpea	0.36	0.35	0.26	0.29	0.19	0.23
Moth	0.25	0.14	0.21	0.13	0.20	0.21
Others	0.31	0.32	0.45	0.42	1.42	1.63
Pulses Total	**28.88**	**28.87**	**30.49**	**27.24**	**31.66**	**31.28**
Groundnut	28.47	29.99	24.30	23.64	23.48	25.16
Rape/Mustard	2.64	2.70	2.52	2.65	2.49	2.46
Til	0.31	0.37	0.32	0.36	0.28	0.40
Sunflower	0.45	0.46	0.48	0.51	0.39	0.40
Soyabean	34.29	27.33	31.02	23.45	29.00	29.63
Linseed	0.12	0.08	0.08	0.04	0.13	0.10
Castor	0.72	0.85	0.61	0.62	0.58	0.84
Safflower	0.12	0.12	0.10	0.11	0.12	0.13
Niger/Others	0.02	0.02	0.01	0.01	0.02	0.02
Oilseeds Total	**67.13**	**61.93**	**59.45**	**51.39**	**56.49**	**59.14**
Cotton	2.22	2.63	1.95	2.08	2.22	2.35
Jute			0.36	0.14	0.43	0.38
Mesta/Other	0.45	0.61	0.00	0.00		
Fibre crops Total	**2.68**	**3.24**	**2.31**	**2.22**	**2.65**	**2.73**
Potato	27.19	24.85	28.64	26.10	36.53	27.09
Fodder/Others	2.09	2.14	1.05	1.05	0.37	0.34
Total	**29.28**	**26.99**	**29.69**	**27.15**	**36.9**	**27.43**
Grand Total	**343.56**	**351.77**	**337.09**	**343.52**	**353.49**	**380.29**

Table 3 : Requirement and availability of certified/quality seed during 2014-15 to 2016-17 (lakh quintals)

Year	Requirement/Demand	Production		Per cent share
2014-15	343.56	Government	151.09	42.95
		Private	200.68	57.05
		Total	**351.77**	
2015-16	337.09	Government	147.28	42.87
		Private	196.24	57.13
		Total	**343.52**	-
2016-17	353.48	Government	184.21	48.44
		Private	196.07	51.56
		Total	**380.29**	-

Significant Progress in Seed Replacement Rates (SRR) of Different Crops: The impact of Indian seed industry on Indian Agriculture is clearly evident from the steep rise in production and availability of all classes of seed in the country. Over a period of last eight years, it has almost more than doubled. With availability of quality seeds, a very good seed replacement rate in the major crops has been achieved viz. wheat (32.55%), paddy (40.21%), maize (56.58%), sorghum (23.85%), pearl millet (60.40%), chickpea (9.35%), urdbean (34.41%), mungbean (29%), pigeonpea (22.16%), groundnut (22.5%), rapeseed-mustard (78.88%), soybean (52.75%), sunflower (32.47%) and jute (42.11%) in the country during 2012-13 (http://agricoop.nic.in/faq.html). However, the proportion of seed supply by formal seed sector needs to be enhanced for sustainable yield enhancement for national food security.

2.2 Weaknesses of Indian Seed Sector

Non-availability of Reliable Data Source: Authentic data on quality seed is lacking, which needs to be regulated. The Department of Agriculture Cooperation and Farmers' Welfare (DAC&FW), Ministry of Agriculture and Farmers' Welfare should streamline the availability of data through single window, which can make the basis of future seed programmes in the country. The data of quality seed production, availability, seed replacement rate, share of formal and informal sector, share of public private sector etc. is varying from source to source and is a great hinderance in formulating any seed policy. As per various government reports, published papers and information available on the official website of the DAC&FW, the Indian seed sector comprises of formal (public & private) and informal systems (farm-saved; Farmers' Groups/Cooperatives; CSBs; local producers/sellers etc.), the informal sector is contributing 55% with, no provision of quality control of seed. At the same time, 50 to 100% rise in the SRRs are reported in most cereals, oilseeds and pulses during 2005 to 2015 (DAC, 2015 and Hanchinal, 2017).

Governance, Accountability and Penalties: Present seed legislations are not full proof for control of illegal seed business, genuineness of material sold, and other quality issues. Farmers are duped with fake advertisement by selling low quality materials and the government's quality control system is so subjective and weak that accountability is rarely fixed and farmers have to suffer huge losses. The case of herbicide tolerant cotton is latest example which has exposed the quality control and seed business. Likewise, in other crops too, farmers are being cheated by supplying spurious low quality misbranded seeds and no action is taken against the defaulting organization.

Fragmented Seed Sector: Unlike the global trend, the Indian seed industry is highly fragmented with a large number of public sector organizations and more than 500 seed companies without adequate coordination.

Lack of Perfect Seed Rolling Plans: A centralized seed rolling plan based on seed replacement targets, availability of improved varieties/hybrids is not available. This is leading to confounded data on seed replacement, varietal replacement, annual quality seed demand and actual seed availability.

Dominance of Very Old and Obsolete Varieties in Seed Chain: Some very old varieties are still among the top 5 in breeder seed chain, therefore a blanket regulation based on the year of release may not be justified. In the wake of climate change, some varieties released 15-20 years back may not perform well any more. Since these varieties do not show break down of any disease/pest tolerance, they are still in the seed chain. Special efforts are needed to phase out these old varieties by providing suitable superior substitutes.

Wide Varietal Mismatches: Though the total indented breeder seed is produced but still wide mismatches are generally observed, which range between 0-51%, however, on the average it ranges from 24-33% (Table 4). Generally, the seed of newly released varieties are not produced, and therefore older varieties are multiplied to compensate it. This results in varietal mismatches specially related to number of newly released varieties in seed chain *vis-a-vis* their demand. It is a matter of serious concern that leads to dominance of older and obsolete varieties.

Table 4: Varietal mismatch in breeder seed production during 2014-15 to 2016-17

Crops	2014-15		2015-16		2016-17	
	Varieties in seed chain (No's)	Mis-match (%)	Varieties in seed chain (No's)	Mis-match (%)	Varieties in seed chain (No's)	Mis-match (%)
Paddy	219	20.5	248	17.3	310	14.8
Wheat	160	33.8	155	24.5	183	21.9
Chickpea	75	44.0	74	33.8	64	32.8
Pigeon pea	45	20.0	34	5.9	56	0.0
Mung	50	44.0	40	32.5	45	44.4
Urd	39	41.0	35	34.3	41	34.1
Groundnut	49	28.6	41	41.5	43	30.2
Soybean	30	40.0	35	51.4	36	25.0
R&M	51	21.6	50	12.0	48	10.4
Other crops	**453**	**—**	**442**	**—**	**343**	**—**
Total/average	1171	32.60	1154	28.10	1169	23.70

No Systematic Efforts in Seed Production of Vegetable Varieties in Public Sector: Like field crops, a large number of promising varieties/hybrids have been developed in vegetable crops but no systematic seed production procedures have been followed in these crops. Moreover, meagre efforts have been made for commercialization of these materials for their faster dissemination to vegetable growers due to which the private sector is dominating in vegetable seed production and delivery.

Non-lifting and Abuse of Breeder Seed Indents: There are two contradictory facets of breeder seed production programme. On the one hand large breeder seed indents are placed by seed producing agencies, which are many folds higher than actual requirement. On the other hand, the indenters are not lifting the indented quantity. These are two very opposite situations. In one case the confidence of the producing agency is weakened and it becomes a problem for disposal of unlifted seed. In other situation, the breeder seed thus indented and lifted do not reach the seed chain and being marketed directly as foundation/ certified or labelled seed.

Lack of Seed Production Research: Except few of private seed companies, seed production research is altogether lacking in India that leads to poor conversion ratios, high cost of seed produced and sometimes huge losses in the seed production business to the seed organizers of seed producing farmers.

No Seed Quality Control System in NEH Region: After more than 50 years of implementation of seed regulation system in the country, NEH states don't have government seed quality control mechanism in place. The NEH states have the potential of enhancing area and production, but it still remains unexploited to a larger extent due to lack of availability of quality seed.

Poor Coordination Between Central and State Agencies: Agriculture being the state subject, many issues are not given due attention on this plea. Therefore, the coordination between central and state agencies dealing with agriculture in general and seed in particular needs to be strengthened and ascertained for making the system more efficient, accountable and useful. Harmonization of rules and guidelines at national level is required as presently there is huge variation between the states.

No Attention on Seed Production of Biofortified Varieties: Currently, no efforts are being made to produce the seed of biofortified/value added products. Special provision should be made for production of good quality seed of value added varieties of different crops in sufficient quantity. The focus on Taste, Nutritional Value, Supply chain and High Market Value products is totally lacking.

Embargo on Genetically Modified Crops: Except Bt cotton, there has been no headway made in the development and commercial adoption of GM products in field and vegetable crops. Due to the embargo imposed on commercial release of GM varieties of different crops, a situation of insecurity is prevailing among the breeders, biotechnologists and seed technologists. Keeping the global trend of release of more and more GM products and challenge of meeting projected targets of agricultural production in the country, it is very crucial to think over this issue nationally and after complying with all bio-safety issues, research on GM crops should be made as an integral part of the crop improvement programme. Accordingly, field and seed standards of GM varieties need to be defined for facilitating the seed production.

No Seed Banks for Seed Security: There is no provision of seed banks for the seed security of the nation. In case of abnormal season, the seed production declines abruptly and seed crisis is faced leading to higher prices and sale of spurious seeds of varieties not adapted to a particular area. To avoid this type of situation, seed banks need to be established at district/block levels for ensuring seed availabilty for food security of the nation.

2.3 Opportunities

The competitive advantages that Indian agriculture processes are: (a) Favourable agro-climatic zones (b) Large irrigated lands (c) Gap between present and potential productivity and (d) Availability of skilled, educated, technical and scientific manpower. Indian agriculture needs intervention in the areas of policy, technology and market access to leverage the global competitive advantage.

Public Sector Seed Quality Control and Seed Production Network: A huge public sector paraphernalia including NSC, SSCs, SCAs, STLs, SAUs and ICAR Institutes, which are engaged in seed production, maintenance and quality evaluation, is a great resource with the Indian seed industry. NSC has its presence in every nook and corner of the country with 10 regional offices, 76 area offices and 6 state of art seed testing laboratories, besides more than 22000 ha of cultivable land with good soils and state of art infrastructure suitable for quality seed production. It is country's largest network of seed production and delivery through its seed production structures in different parts of the country.

Private Sector: As mentioned above, there are more than 500 seed companies including MNCs, which are engaged in seed business. This is again a big asset to the Indian seed industry.

Large Number of High Yielding Varieties of Different Crops Available for Commercialization: During last five years, more than 1100 varieties of different field crops suitable for various agro-ecological situations of the country were available in public domain and breeder seed chain. The number of varieties in breeder seed chain during past five years were 1217 (2012-13), 1145 (2013-14), 1171 (2014-15), 1154 (2015-16) and 1169 (2016-17).

Public Private Partnership: The very transparent, open and trustworthy PPP is existing in India, which has led to the tremendous progress in seed industry, and it will go further touching new heights. The liberal government policies and a very conducive environment provided to the private seed companies have led to creation of trust that has been replicated rapidly. Howerer, further mutual trust needs to strengthened. This also includes licensing of varieties of crops to private seed companies even to very small entrepreneurs who are actually the beginners at a very nominal fee with easily acceptable terms and conditions. It has led to attracting more than 300 small and big seed companies to get associated with various ICAR Institutes and SAUs, which are proving very helpful in disseminating the good quality seeds of newly released varieties in a very short span of time. To cite an example, IARI has signed non-exclusive agreement with more than 200 seed companies and one NGO for seed production of different IARI released varieties of field and vegetable crops viz. Paddy (PRH-10, Pusa Basmati 1121, Pusa 1460 and PB1509), Wheat (HI 1563, HI 1544, HD 2967, HD 3059, HD 3086 and HD 3090), Mustard (Pusa Mustard 25, Pusa Mustard 26, Pusa Mustard 27 Pusa Mustard 28, Pusa Mustard 29, Pusa Mustard 30, Pusa Double Zero Mustard 31), Maize (PEEHM 5), Cauliflower (Pusa Hybrid 1 and Pusa Kartik Shankar), Carrot (Pusa Rudhira), Cucumber (Pusa Sanjog) and Bitter gourd (gynoecious lines).

Facilitation of Commercialization to Encourage PPP: Business Planning and Development (BPD) unit of IARI initially supported by National Agricultural Innovation Project (NIAP), facilitates Public-Private Partnership (PPP) and extends support to industries and entrepreneurs with technologies, consultancies, project planning and business development. The start-up companies and perspective entrepreneurs can utilize the services of BPD for initiating their agricultural enterprises. They are enrolled as Corporate Members of IARI-BPD and BPD provides them an office space with moderate facilities of sitting, meeting clients, internet and working laboratories. Besides that, mentoring by IARI scientists and back up from laboratories including instrumentation facilities available in different Divisions are also provided. This has helped in developing a large number of partnerships with several private companies for the commercialization of its technologies. IARI has also set up a farmers' producer company BEEJ INDIA for enabling the technologies to reach farmers in the shortest time after their release.

Involving Trained Manpower in Breeder Seed Production as a Seed Campaign: The Dharwad Model can be replicated, which has attained excellent success without involving regular staff and employing agricultural graduates. It will prove to be three pronged strategy for accelerating seed delivery in the country viz., sufficient production of good quality seed, employment to the agriculture graduates and development of seed entrepreneurs by practical training during the seed production programmes to the agriculture graduates.

Enhancing Seed Replacement Rates to Attain the Targets: Quality **s**eed production and availability, based on the present and projected seed multiplication ratio considering the estimated area under different crops, has been calculated. Realistic figures of area and seed replacement rates will help in developing a Rolling Plan for Seed Production and mapping of the Seed Production Zones.

2.4 Factors which may Prevent Accelerated Growth of the Industry

Seed Replacement Rate/Variety Replacement Rate (SRR): Except for a few crops, seed replacement rate in our country is very low which is a very big challenge to the seed industry and Indian agriculture. To overcome this situation, there should be a rolling plan of the government where targets should be fixed to cover the area under quality seeds. Another hurdle is dominance of very old varieties in the seed chain. There are examples in crops where very potential new varieties are available but major share of breeder seed in the crop is of very old varieties, which also needs the policy intervention. Likewise, private seed sector can reach more rapidly to the unreached area, however, the cost of their seed is much higher in comparison to that of public sector seed. There should be some mechanism to have control over the cost of seed of private seed companies so that the small farmer can also procure the seed and it will definitely help in enhancing the SRR. The approach of "Farmer FIRST" will have to be applied in such situations.

Revision of Seed Multiplication Ratio (SMR): The seed multiplication ratios are totally mismatching with the present productivity levels of different improved crop varieties. In most of the crops, the productivity levels have increased many folds and seed multiplication ratios are still based on old low yielding varieties. Revised seed multiplication ratios will help in production of required good quality seed in lesser area with good management. The gap between the current seed multiplication ratio and actual seed multiplication ratio based on productivity of improved varieties is given in Table 5.

Table 5 : Prevailing seed multiplication ratios and actual seed multiplication ratios

Crop	Seed rate (kg/ha)	Seed rate (kg/ ha)(seed net data base)	Avg. seed yield (q/ha)	SMR	SMR (seed net data base)	Per cent difference
Paddy	38.1	30.0	47.3	124	80	55
Wheat	104.9	100.0	39.9	38	20	90
Maize	18.5	20.0	35.8	193	80	142
Barley	93.8	-	29.0	31	NA	NA
Oats	65.6	62.5	10.8	16	15	9
Sorghum	9.5	12.0	19.6	206	100	106
Bajra	5.4	5.0	13.0	242	200	21
Finger millet	9.2	-	19.0	207	NA	NA

Berseem	20.0	20.0	4.0	20	10	100
Chickpea	74.7	75.0	14.8	20	15	32
Mungbean	20.0	15.0	9.8	49	40	22
Urdbean	20.0	12.5	8.0	40	40	0
Field bean	23.0	-	11.1	48	NA	NA
Pea	90.0	100.0	16.0	18	10	78
Soybean	78.7	62.5	15.0	19	16	19
Groundnut	107.0	100-150	21.2	20	8	148
Mustard	4.5	5.0	17.1	380	100	280
Sunflower	5.7	20.0	12.3	215	50	330
Safflower	8.3	12.0	10.3	124	60	107
Sesame	2.6	5.0	7.0	273	250	9
Cotton	10.1	12.5	13.1	129	50	158

Genetically Modified Crops: The research on GM crops should be made as an integral part of the crop improvement programme and after complying with all bio-safety issues, and accordingly their field and seed standards also need to be defined for facilitating the seed production. For making a headway, the Biotechnology Regulatory Authority of India (BRAI) needs to be made operational, by making the regulatory system highly efficient and robust so that release process is not slowed down. Transparent procedures for testing, clearance and monitoring of GM Crops will help in faster approval of potential materials.

Use of Molecular Tools for Varietal Identity and Genetic Purity: Procedures and protocols laid out by ISTA are being followed for varietal identity and genetic purity in all seed testing labs in India. Molecular markers have now become an integral part of almost all the crop improvement programmes. The older methods for varietal purity and identity like Grow-Out-Test and other conventional tests are generally not that effective, time consuming and are influenced by environment. Use of molecular markers for varietal identity and genetic purity can be a very good option and therefore, more efforts are required in this direction.

Organic Seed Production: The International Federation of Organic Agriculture Movements (IFOAM) is the worldwide umbrella organization for the organic agriculture movement. The Government of India has implemented the National Programme for Organic Production (NPOP) for which APEDA is the nodal agency. The

national programme involves the accreditation of Certification Bodies, standards for organic production, promotion of organic farming etc. The NPOP standards for production and accreditation system have been recognized by European Commission and USDA. Increasing demand of organic products has led to the seed production of such crops. Though in a few states like Rajasthan, the State Seed Certification agency has been re-designated to empower it for certification of organic seed production, yet no consensus seed and field standards for organic seed production have been laid out. Hence, if the organic seed production has to be done for producing the organic products as per international standards, the seed production issues of organic seed will have to be addressed on priority. However, there are conflicting views regarding use of organically produced seed for organic production. This needs to be scientifically validated with respect to the residues in inorganically produced seed and carrying forward the residual effect of various chemicals used to the next generation in the production chain.

Alternate Sites for Quality Seed Production: Climate change is coming in the way of achieving the targets of seed production in different crops. Soybean and groundnut seed production has been abruptly affected for last three consecutive years due to one or other weather parameters like dry spells or excess rains. Keeping these situations in view, seed production of these crops have to be taken to some new safer sites to keep the continuity of seed chain and ensure availability of good quality seeds to the farmers. Same situation is arising in wheat where the seed production programme is affected due to late season rains, and high incidence of Karnal bunt resulting in rejection of large quantity of seed lots. Rice seed production in Kalahandi of Odisha is one of the live example to follow.

Seed Bill: Regulatory mechanism for keeping the consistent supply of quality seed will be strengthened once the proposed Seed Bill 2004 is put in place. A long passage of time in implementing this bill is affecting the seed industry. It needs to be implemented for making the quality seed available to the farmers.

Enhancing Conversion Ratio: There was a time when meeting breeder seed demand of various varieties was difficult. But now with the good facilitation through the various seed schemes like ICAR Seed Project, the indented quantity of breeder seed is being produced barring few exceptions. In many crops, it has been observed that the breeder seed indents are too high though only a very small proportion of it can cover the entire area under a particular crop if it is truly converted to foundation and certified classes of seed. Over indenting for breeder seed and using that directly without putting the same in the seed chain puts an extra burden on the breeder seed producing institutions. A control over this practice is required for maintaining the supply of breeder seed of high quality in different crops.

Public Sector Seed Corporation: National Seed Corporation has huge land area and very good infrastructure. The outcome of these giant seed production establishments is very poor. Special attention should be given to further strengthen these public sector institutions to get the maximum out of them. Once it is achieved, the share of public sector

in seed production programme may go much high than the private seed sector. Proper use of 22000 ha land of National Seed Corporation across country will definitely help in enhancing the public sector share in seed production.

Global Seed Trade: Asian and African countries are now new areas for many seed companies for expanding their seed business. Asian countries like Bangladesh, Indonesia, Malaysia, Myanmar, Pakistan and Sri Lanka and African countries mainly Ethiopia, Ghana, Kenya, Nigeria, Sudan, Togo and Tanzania are being selected. Due to limited availability of good quality seeds and adaptability of Indian material in these countries, there is ample scope for the Indian seed companies. Huge investment is being made by large number of Indian companies in these countries for food grain and plantation crops. Getting good quality seed is a major issue for their successful production programme in these countries, which can be meted out from India. Organization for Economic Cooperation and Development schemes are already operational in India and Indian Seed Industry can take advantage of it.

Reaching the Unreached: When we talk of global seed business in Africa and other Asian countries, we should take care of our own states where no attention has been given for ensuring availability of seed of improved varieties. There are seven North Eastern States of our country where no seed corporation and seed certification agency is in existence. The vast areas of rice-fallow lying vacant, can be efficiently utilized under various *rabi* oilseeds and pulses, once the good quality seed of such varieties is taken to these states. Special efforts are required to make the seed production of different varieties of various crops of that region to make the dream of the "Second Green Revolution" a reality in the country. Various voluntary organizations, self help groups and small farmers can be associated in this programme. This will help to improve the condition of small entrepreneurs and also make the good quality seed available to those remote or unreached areas.

Enhancing Participation of Farmers Through Participatory Seed Production and Seed Village Scheme: Farmers participatory seed production programme is in place since 2006 when ICAR Seed Project was implemented. It has helped the public sector institutions in development of trained seed producers later on turning in seed entrepreneurs. More concerted efforts are needed in newer and far off areas to accelerate seed delivery system in three ways viz., faster dissemination of new varieties, availability of seed at farmers' door step, development of seed entrepreneurs and enhanced income of the participating farmers. Likewise, Govt. of India Seed Village Scheme also needs to be expanded to more villages to meet the objective of enhancing quality of farm saved/farmers produced seed to accelerate seed delivery to grass root level.

Climate Smart Seed Production and Storage Facilities: Untimely rains and frequent fluctuations in temperature have made the conventional seed production sites unfit or less remunerative in terms of production of quality seeds. Current season's i.e. *rabi* 2017-18 weather situation has created further panic as all the *rabi* crops have been severely

affected. Abrupt rise and dip of temperatures during the crop season in the conventional seed production areas of various crops is again a serious issue which warns for searching the alternative safe sites for climate smart quality seed production. Likewise, the storage facilities also need to be climate smart for keeping the seed quality intact.

Accreditation of Seed Testing Laboratories: For making the Indian seeds competent globally, the ISTA accreditation of large number of public and private seed testing laboratories needs to be taken up for competing with the global seed markets and enhance the share of Indian seed industry globally.

3. RECOMMENDATIONS ON STRATEGIC CHANGES WITHIN THE EXISTING LEGISLATIVE FRAMEWORK IN INDIA

Keeping in view the regulatory processes and legislative support within the existing Seed Act (1966) and Guidelines operative in that framework, the following strategic reforms and modifications in the system for assuring faster, efficient and affordable seed delivery systems in the country are suggested.

1. All the scientific knowledge generated in seed science and technology should be translated in doubling farmers' income and further efforts should also be focused on this theme to help realize the dream of making new India. *(Action: DAC&FW, NAREES)*.

2. The availability of authentic data on quality seed is a big lacuna which needs to be regulated. Ministry of Agriculture and Farmers' Welfare may consider taking appropriate steps for streamlining the data availability through single window which makes the basis of future seed programmes in the country *(Action: DAC&FW)*.

3. The informal seed sector is still dominating in India. Therefore, efforts should be made to develop a policy enabled complementation of both formal and informal seed sectors for availability of quality seeds *(Action: DAC&FW)*.

4. Establishment of a National Seed Grid to link relevance of varieties with demand generation and timely supply *(Action: DAC&FW)*.

5. Labelling issues need to be refined with details for enabling the farmers to make informed choice on the quality and performance of seeds *(Action: DAC&FW, ICAR)*.

6. Efforts need to be made for strengthening Public Private Participation by breeding trust in sharing the knowledge and material for the growth of seed sector in the country *(Action: DAC&FW, ICAR, Private Sector)*.

7. A well-defined pathway needs to be implemented that may include management, governance and accountability for making the seed sector more strong and vibrant *(Action: DAC&FW)*.

8. Harmonization of rules and guidelines at national level to mitigate huge variation between the states *(Action: DAC&FW)*.

9. Harmonization in licensing to overcome existing discrepancies and complications responsible for slow adoptions *(Action: DAC&FW)*.

10. North Eastern States need special attention and integration in the mainstream of seed production and quality assurance *(Action: DAC&FW, ICAR)*.

11. Human resource development for complete seed value chain and leadership *(Action: DAC&FW, NAREES)*.

12. Private sector needs to be encouraged to take up participatory collaborative research involving cutting edge technologies by coming forward to invest in research and development with public sector R & D institutions *(Action: Private Seed Sector)*.

13. Efforts are needed to replicate the successful models like Dharwad and Jabalpur, where successful quality seed production has been demonstrated by involving farmers through farmers' participatory seed production and establishing farmers' led cooperatives *(Action: NAREES)*.

14. Testing procedure needs to be refined to have neutrality *(Action: ICAR)*.

15. Seed pricing policy needs to be developed *(Action: DAC&FW)*.

16. Clearcut guidelines for benefit sharing need to be developed by encouraging protection of the new varieties with the variety protection authority in appropriate categories to facilitate enhanced usage of formal sector bred new varieties as well as farmer-conserved or bred varieties in the main stream either as adapted variety or as resource for developing new varieties *(Action: DAC&FW, PPV&FRA, ICAR)*.

4. CONCLUSIONS

The Indian seed industry is vibrant and has attained its targets to a larger extent. Keeping the projection of future requirement as an outcome of increasing population, much more needs to be done. Seed being the most vital input and carrier of all agro-technologies, ensuring availability of good quality seeds at appropriate time and affordable prices is the sole responsibility of Indian seed industry. For making of New India with doubled farmers income, science-based decisions need to be implemented. Involvement of social scientists for keeping realistic statistics of seed and impact assessment of varietal technology is need of the hour, which will help in setting the breeding goals, product profiles and targets of seed production. Quality should be central agenda to harvest the gains accruing out of the improved technologies. Public-private sectors need to develop a trust in sharing the information and material to complement each other and converge their energy for betterment of Indian

farming. Private sector is expected to enhance investment in seed sector. Governance and accountability brings quality, which will help in establishing a sound and stable seed delivery system for ensuring farmers prosperity. Though, agriculture is a state subject, there is a need for operational harmonization of various rules and regulations of permitting sale and licensing of technologies in the country. The target of reaching the unreached is expected potentially to lead to increase in area, production and productivity of the deprived areas and north eastern states, which have great potential to adopt the new technologies and expansion of area may be targeted to fill the huge gap between yields from seed of locally available old varieties than that from good quality seed of improved varieties. Breeder seed indents should be on realistic basis and seed chain needs to be followed properly to avoid abusing seed indents. Convergence of public and private seed sectors should lead to enhanced Varietal and Seed Replacement Rates *vis-à-vis* enhanced production. The policy issues like enactment of new seed bill, lifting embargo from commercial cultivation of GM crops and adequate allocation of funds to Seed Sector need to be addressed and brought to the notice of the Government. Development of seed infrastructure including farm power machinery, processing units and smart storage facilities across various zones and establishment of seed banks on zonal level will ensure uninterrupted supply of quality seed to meet the future projections. Human resource development is key to success of any programme, which needs to be addressed. Involvement of unemployed agriculture graduates with seed production will help in seed availability, employment generation and entrepreneurship development. Seed Technology and Seed Production Research need to be strengthened for cutting edge seed research like use of seed tolerants, molecular tools for varietal purity and vigor testing etc. The accreditation of adequate number of seed testing laboratories for quality enhancement, is pertinent to make the Indian Seed Industry globally competent for enhancing its share in International Seed Trade.

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