Indian Journal of Agricultural Sciences **86** (5): 563–79, May 2016/Review Article
https://doi.org/10.56093/ijas.v86i5.58233

Research Review Articles

Seed production of field crops in India: Quality assurance, status, impact and way forward

J S CHAUHAN[1], S RAJENDRA PRASAD[2], SATINDER PAL[3], P R CHOUDHURY[4] and K UDAYA BHASKAR[5]

Indian Council of Agricultural Research, Krishi Bhawan, New Delhi 110 001

Received: 22 July 2015; Accepted: 2 March 2016

ABSTRACT

Of the several factors vital for enhancing production and productivity of the crops, seed is a critical input for long-term sustained growth of agriculture. A robust seed system is the first and foremost step towards food security of the country and acts as driver of growth in agriculture. From a predominantly public sector in the 1960's, the Indian seed sector has evolved gradually into a multi-faceted industry with involvement of large number of private firms and increasing emphasis on research and development activities. The present paper reviews the evolution of seed sector in India, quality assurance regulations, international seed testing and certification, development of varieties and their induction in the seed chain, present status of breeder, foundation and quality/certified seed production. The paper also discusses the varietal scenario in the seed chain during 2014-15, demand and availability of seed and contributions of public and private seed sector. On quality seed front, production of 3.52 MT (2014-15), more than requirement was made possible due to synergistic efforts of public and private sectors in Indian seed domain. Analysis of Indian seed production scenario revealed that seed production has shown compound growth rate of 16-17 %, which is an encouraging positive sign and Indian seed industry is vibrant and strong enough to make its presence felt in global seed domain and India is poised for up-scaling its current position, 6th with US $ 2 billion, in international seed market valued at US $ 45 billion. Indian seed sector managed this growth due to proactive policy support and seed markets such as Bt cotton, hybrids of vegetables, rice and maize especially, single cross hybrids. An attempt has also been made in the present study to analyze the impact of quality seed on Indian agriculture, potential for seed export, way forward and strategies for meeting the emerging challenges in the seed sector for enhancing seed replacement rate, varietal replacement rate and making quality seed available to the farmers at affordable prices for up-scaling and sustaining high yield in field crops.

Key words: ISTA, OECD, Quality assurance, Seed chain, Seed production, Seed sector, Varietal scenario

Despite the declining contribution of agriculture to gross domestic product as it stood only 13.9% during 2013-14 (Anonymous 2015a) as compared to industry (26.1%) and services (59.9%), India is predominantly an agriculture-based country as evident from the fact that nearly 65% population is directly or indirectly dependent on agriculture. Globally, India accounts for 2.4% of land; 4% water; 18% of population (Anonymous 2015a; Kumar and Bharat 2014) and ranked 2nd after USA on the basis of arable land (11.3%). There is substantial increase in net sown and gross cropped area which rose from 118.8 to 140.8 m ha and 131.9 to 195.2 m ha during 2011-12, respectively, since 1950 (Anonymous 2015a). The net sown and gross cropped area increased by 18.5% and 48.0%, respectively, largely because of increased cropping intensity made possible by the development of photo-insensitive and early maturing varieties.

Considering the annual population growth rate (1.31%) during 2012, the demand for foodgrains will be 298 MT and 330.0 MT by 2020 and 2030 with an increase of 12.2% and 24.2%, respectively, over the present production (2013-14) to feed around 1.30 billion and 1.52 billion people, respectively (Table 1). To achieve these targets against formidable challenges of diminishing land and water resources, increasing biotic and abiotic stresses, loss of bio-diversity and global competitiveness is a daunting task. This can only be possible by bridging the existing yield gaps through improved productivity and by integrated natural resource management as well as raising the crop productivity.

Of the several factors vital for enhancing production and productivity of the crops, seed (living product that must be grown, harvested, and processed appropriately to

[1]Assistant Director General (Seed) (e mail: adgseedicar@gmail.com), [3]Chief Technical Officer (Seed) (e mail: toseed9@gmail.com), [4] Principal Scientist (Seed) (e mail: prc71@rediffmail.com), ICAR, New Delhi; [2]Project Director (e mail: pddsrmau@gmail.com), [5]Scientist (e mail: udaya9252@gmail.com), Indian Institute of Seed Science, Mau, UP

Table 1 Current (2013-14) production and future targets for food grains, oilseeds and commercial crops

Crop	Production (MT)*	Target (MT)		Change (%) over that of 2013-14	
	2013-14	2020	2030	2020	2030
Cereals	245.8	273.7	298.0	11.4	21.2
Pulses	19.8	24.3	32.0	22.7	61.6
Total food grains	265.6	298.0	330.0	12.2	24.2
Oilseeds	32.7	53.4	81.8	63.3	150.2
Cotton	6.6	6.8	7.3	3.2	10.6
Sugarcane	345.6	355.0	385.0	2.7	11.4
Jute and Mesta	2.1	1. 8	3.0	-13.6	46.3

*MT : Million tonnes

maximize its viability and subsequent crop productivity) is a critical input for long-term sustained growth of agriculture. Quality seed implies that seed is genetically pure with acceptable standards of germination, moisture content and free from weed seeds, seed-borne diseases, insects or other inert matter. Quality seed is the key input for realizing potential productivity by ensuring good germination, rapid emergence and vigorous growth thereby good crop stand alone contributes about 15-20 % to the crop productivity. The seed sector plays a major role in the dissemination of latest agricultural technologies to farmers through high quality seeds of high yielding varieties as exemplified by consistent increase and record production of food grains, oilseeds and other crops. Seed security is prerequisite for food security and in past few years, a significant stride in this aspect through effective implementation of ICAR Seed Project and AICRP-NSP (Crops) was made. It brought out the fact that the increase in quality seed availability has a huge bearing on food grain production (Chauhan *et al.* 2013). The present paper discusses the evolution of seed sector, seed quality regulatory frame work, seed chain, varietal scenario, seed production and its impact on agriculture in India and way forward to match the emerging challenges .

SEED SECTOR IN INDIA

A robust seed system is the first and foremost step towards food security of the country and acts as driver of growth in agriculture. Indian seed sector comprises public sector institutions as well as private seed companies. Public seed sector includes various organizations, viz. National Agriculture Research System (NARS) comprising 60 ICAR Research Institutes, 6 Bureaux, 15 National Research Centres, 19 Project Directorates, 78 All India Coordinated and Network Projects and eight Agricultural Technology Application Research Institutes, 60 State Agricultural Universities (SAUs), 6 Central Agricultural Universities and 5 Deemed Universities having Faculty of Agriculture, 641 Krishi Vigyan Kendras (KVKs), National Seed Corporation (NSC), New Delhi; 15 State Seed Corporation (SSC) and 24 State Seed Certification Agencies (SCA) with one SCA with ISTA accredited laboratory (Chauhan *et al.* 2014, Datta *et al.* 2013, National Seed Corporation Limited, www.indiaseeds.com, 15.06.2015). Private seed sector is also playing equally important role in seed production but usually of high value, low volume crops such as vegetables and also hybrid corn, cotton, pearl millet, sunflower, etc. (Hanchinal 2012). Private seed sector experienced rapid growth under liberalized government policy which resulted in establishment of around 500 seed companies across the country (Agrawal 2012a).

From a pre-dominantly public sector in the 1960's, the Indian seed sector has evolved gradually into a multi-faceted industry with involvement of large number of private firms and increasing emphasis on research and development activities (Fig 1). Initially, Indian seed sector consisted primarily of two national organizations, NSC, established in 1963 and States Farms Corporation of India Limited (SFCI) formed in 1969 under Ministry of Agriculture, Government of India. The NSC is mandated to undertake production of foundation and certified seeds. Presently, it has 10 regional and 66 area offices spread all over the country.

It is undertaking production of certified seeds of nearly 600 varieties of 60 crops through its 8,000 registered seed growers in different agro-climatic conditions (National Seed Corporation Limited, www.indiaseeds.com, 15.01.2015). Quality control of seeds is the main objective of the corporation which ensures supply of quality seed to farmers. It has also established five quality control laboratories, one each at New Delhi, Secunderabad, Bhopal, Kolkata and Pune. In the seed production, emphasis is given for production of major oil seeds, pulses and hybrids including vegetables. It also undertakes supply of seedlings/saplings of fruits crops including tissue cultured crops and provides technical support to SSCs and seed producing agencies for production of quality seeds and also involves in exporting of seeds to South Asian Association for Regional Cooperation (SAARC) and African countries. It was the main organization for the production and marketing of seeds assisted by the foreign aids such as the Rockefeller Foundation and United States Agency for International Development (USAID) for quality control and training in seed production. The mandate of SFCI was production of breeder, foundation, and certified seeds of high yielding varieties. With the possession of 12 large farms located in 8 different states, the SFCI continued to be the largest seed-producing agency in the country, till it was merged with NSC in 2014.

In the 1970's and 1980's, the SSCs were formed on the model of the Tarai Seed Development Corporation, Govind Ballabh Pant University of Agriculture and Technology, Pant Nagar, Uttar Pradesh. The SSCs largely took over the role of the NSC in states. The NARS has the responsibility of producing the breeder seed, which forms the backbone of the quality seed programme to facilitate seed sector. The World Bank assisted considerably for strengthening the Indian seed programme by launching National Seed Project (NSP) I in 1977-78 and subsequently NSP II and III in the following year. The Indian Council of Agricultural Research

(ICAR), being apex organization to undertake, promote and coordinate agricultural research, education and extension in the country, initiated major efforts in the seed research and development endeavour by launching All India Coordinated Research Project – National Seed Project [AICRP-NSP] (Crops) in 1979-80, with 14 centres on Seed Technology Research with an equal number of Breeder Seed Production centres, a landmark in the evolving seed industry in India (Anonymous 2011, 2014a). Another related Coordinated Project called 'Seed Borne Diseases' with eight centres was also launched in 1980, which was later on merged with NSP in 1991 for better resource utilization and also to avoid the overlapping. World Bank financed this project in a big way during three phases (1975-1995) to meet the shortage of nucleus and breeder seed in the country (Indian Seed Sector, http://seednet.gov.in, 15.06.2015). During the NSP III, started in 1989-90, besides supporting NARS, world bank provided support to Department of Agriculture & Corporation (DoAC), SSCs, SCAs and Private Seed Industry to a great extent in production, processing and in providing quality seeds to the entrepreneurs. Its thrust was to upgrade the efficiency and infrastructure of the public seed sector. To further strengthen the efforts, ICAR has upgraded the Project Coordinator's Unit of NSP (Crops) to a full-fledged directorate – Directorate of Seed Research in 2004 at Kushmaur in Mau district of Uttar Pradesh to undertake basic, applied, strategic and anticipatory research and also to coordinate major national network projects on quality seed production and seed technology research (Anonymous 2014a). In 2016, th ICAR upgraded Directorate of Seed Research, Mau to Indian Institute of Seed Science.

The AICRP-NSP (Crops) has 39 and 24 collaborating centres for breeder seed production and seed technology research, respectively. Realizing the spectacular gains of AICRP–NSP (Crops) and need of strengthening seed production infrastructure in the country, ICAR launched a mega seed project 'Seed Production in Agricultural Crops and Fisheries' in 2005-06 during X five year plan for field crops, horticulture and fisheries. The project has resulted in enhanced supply of seeds including planting material and fish seeds. Further, looking into the achievement of the project during X plan, the project was continued in XI plan (2007-12) and has ushered in significant positive impact in enhancing the quality seeds to help seed and food security. It also facilitated in the emergence of new seed hubs in many centres. Significant achievements of ICAR Seed Project was clearly reflected in terms of sustained and progressive increase in quality seed production (20.9 lakh quintals during XI plan) and supply with improved seed production technologies across the country resulting in augmenting seed replacement rate (0.4 to 0.8 % per annum in major crops). With respect to infrastructure development, state of art machinery, modern processing plants, fully equipped seed testing labs, precision irrigation facilities, tissue culture labs, protected cultivation structures, etc. were established. This project also has helped in human resource development, technology dissemination through farmers' participatory seed production and seed village programme, employment generation and ultimately socio-economic upliftment of farmers (Anonymous, 2014a). The project has also made a significant dent in establishing strong linkages among NARS partners and other organizations like DoAC, NSC and SFCI, private seed companies in popularizing new varieties/hybrids, application of new technologies and marketing of the seed. The project made spectacular achievements in qualitative and quantitative enhancement in the availability of quality seed (Fig 2) which increased from 4.77 lakh q in 2006-07 to 5.55 lakh q in 2013-14, an increase of 16.1%, thereby paving the way for seed as well as varietal replacement, the important means for ensuring food security. Nevertheless, the seed production during 2014-15 (4.8 lakh q) decreased by 13.9% over that of 2013-14 (5.55 lakh q) due to vagaries of monsoon and it was only 0.6% higher over that of 2006-07 (4.77 lakh q).

In a bid to derive continued benefits, ICAR Seed Project is also continuing in the XII plan to achieve technological breakthroughs in the field of seed science to meet the demands of global seed market and at the same time for assurance of uninterrupted availability of quality seeds to the farmers. It is focusing at core areas of seed quality improvement thereby enabling quality seed to gain its rightful place in national and international seed domains and also will facilitate collaboration with seed industry to reduce the time gap for product development and its commercialization.

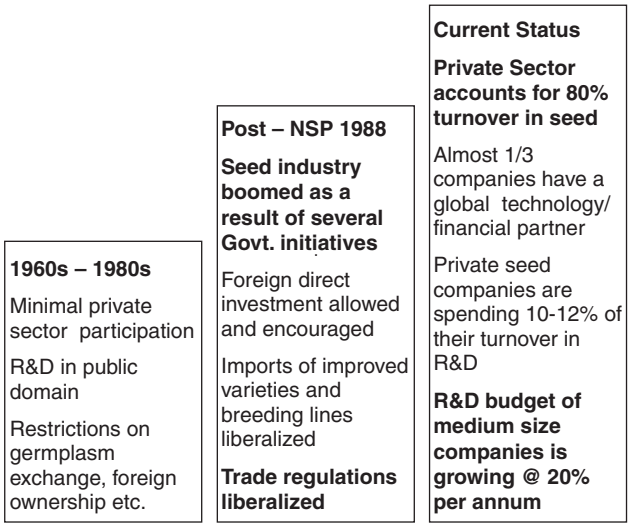

Fig 1 Evolution of seed sector in India

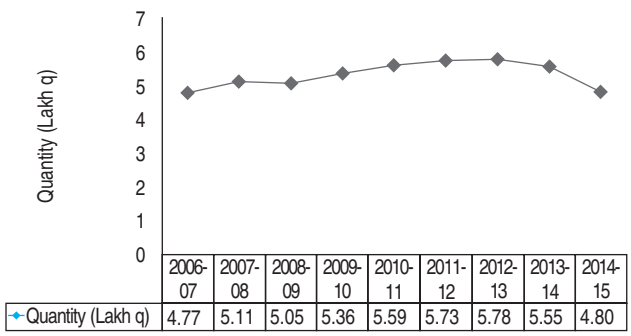

Fig 2 Seed production under ICAR-mega seed project

Establishment of seed quality assurance laboratory will facilitate validation of information and technologies in seed domain, viz. production, processing, storage and packing, quality control and seed health. During XII plan, ICAR seed project comprised 62 cooperating centres under field crops component, 51 under horticultural crops and 35 under fisheries component, and five quality assurance laboratories (Anonymous, 2014a). Private seed firms slowly emerged throughout the 60's and the 70's, with a number of them benefiting from NSC's technical assistance. Many of these firms have developed their own breeding programmes and released inbreds/improved cultivars. Apart from hybrids, the private sector is also largely involved in the commercialization of low volume, high value crops such as vegetable seeds. Of the about 500 companies, 24 have links with multinationals (Agrawal 2012a, Merrman 1997).

Presently, Indian seed industry is one of the mature and vibrant domain in the world seed market. During the past 5 years, the Indian seed industry has been growing at rate of 12% compared to global growth of 6-7% (Indian Seed Industry, www.nuziveeduseeds.com, 15.06.2015). 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. World seed market in terms of value is about US$ 45 billion and Indian seed market is 6th largest after USA, China, France, Brazil and Canada. Indian seed market is growing at rapid rate and in terms of value it stood at US$ 2 billion. During 2012, India imported seeds of vegetables, flowers and field crops worth US$ 84 million of the total global import trade of US$ 9,749 million. Similarly, India exported seeds of vegetables, flowers and field crops worth US $ 67 million against global export of US $ 10 543 million (International Seed Federation, www.worldseed.org/isf/seed_statistics.html, 15.06.2015).

QUALITY ASSURANCE: POLICY AND REGULATORY ISSUES

The Seed Act, 1966, the Seed Rules, 1968 and the Seeds (Control) Order, 1983 are the legal instruments to regulate the quality of seeds available in the market. The responsibility for seed law enforcement is vested with the state governments. The Seed Act/Rules are applicable to notified seeds (notification of kind/varieties of seeds under Section 5 of the Act). The first set of varieties was notified through S.O.4045 dated September 29, 1969 and came in to force on October 1, 1969. Minimum limits for germination, physical and genetic purity of varieties/hybrids for crops have been prescribed. Labeling of seed is compulsory as per the Seed Act. State governments have power to appoint Seed Analysts and Seed Inspectors. Seed Inspectors are vested with adequate powers for quality control, viz. to draw the sample; enter and search; examine records, register and document; seize the stock and issue 'Stop Sale' order in case the commodities under reference contravene provisions of law. Inspectors are authorized to take punitive action/ launch proceedings against dealers found to be selling sub-standard seeds (Trivedi and Gunasekaran 2014). The seed in respect of which the contravention has been committed can be forfeited under Section 20 of the Seed Act. Penalties are provided under Section 19 of the Act. Provision exists for seed certification of notified kind/varieties to ensure genetic identity and purity. The Certification Regulations include the Indian Minimum Seed Standards and Seed Certifications procedures. Export or import of seed of any notified kind or variety is subject to conditions such as conforming to the minimum limits of germination and physical purity, etc. Exemption under Section 24 from the provisions of the Act covers farmers' seeds.

Besides the provisions of Seed Act 1966 and Seed Rules 1968, the Seeds (Control) Order 1983 is applicable to both notified and non-notified seeds. The business of selling, exporting and importing seeds can be carried out only under a license issued by the state government. A dealer's license is liable to be suspended/cancelled for contravention. Seed dealers are required to maintain books and accounts and display the stock position and its price. The dealers can also be directed to distribute seeds in specified manner in public interest. The seed was brought under the ambit of Essential commodities Act, 1955 (Trivedi and Gunasekaran 2014).

The New Policy on Seed Development (NPSD) of 1988 heralded a new era of private enterprise. The focus of the policy was to achieve the food production targets, enhance the seed replacement rate of various crops and create conducive environment for growth of the competitive and localized seed industry by permitting import of useful germplasm. Vegetable, flower and ornamental seeds could be imported freely under Open General License (Trivedi 2013). Seeds of oilseeds, pulses, fodder and coarse cereals like maize, sorghum and other millet could be imported for two years by companies which had technical and financial collaboration agreements for production of seed with companies abroad. Initially, a small quantity of seeds will be imported and tested in ICAR's multi-location trials. The bulk import was also allowed subject to the provision that the foreign supplier agreed to supply parental line seed or breeder seeds to the Indian company within two years of the date of first commercial consignment. Import of items on the restricted list is allowed on case-to-case basis on the basis of recommendations of the Department of Agriculture and Cooperation, under import permit issued by Plant Protection Advisor, Government of India. Export-Import (EXIM) policy targets boosting export of seed with a view to raise India's share to global seed export from the present level of < 1% to 10% by the year 2020. The New policy on Seed Development (1988) was further modified in 2011 to allow the import of wheat and rice.

New Industrial Policy (1991) opened doors for the foreign investors in the Indian seed industry. Since then, a number of multinational companies have entered in the seed market. The National Seed Policy (2002) envisioned establishing and strengthening of Seeds Export Promotion Zones and customized production of seed for export. A data

bank was also aimed for provision of information on international market for Indian varieties in different countries along with establishment of seed testing/certification facilities in conformity with international requirements (Trivedi 2012, 2013).

The export of seeds and planting materials is further liberalized under the Export and Import Policy (2009-14). Under the new EXIM policy, seed of all crops are allowed for free export except (i) Breeder or foundation seeds or seeds of wild plants; (ii) Seeds or planting material of onion, berseem, cashew, nux vomica, rubber, pepper cuttings, sandalwood, saffron, neem, forestry species, red sanders, russa grass, tufts and seeds of tufts. The export of these seeds (i & ii) is restricted and is only allowed on case-to-case basis under license issued by Director General of Foreign Trade on the basis of the recommendations of Department of Agriculture and Cooperation, Government of India.

Recently, Central Seed Committee, Ministry of Agriculture, Government of India also recognized the testing, evaluation and release mechanism of rice varieties of Bangladesh and Nepal and accordingly notified Binadhan 8, Binadhan 10, Binadhan 11 and Binadhan 12 from Bangladesh for cultivation in West Bengal, Tripura and Asom through S.O. 921(E) dated April 1, 2015 (Anonymous 2015b). Similarly, two varieties (Sukhadhan 5 and Sukhadhan 6) of Nepal were also notified for cultivation in Uttar Pradesh and Bihar. However, these six varieties were notified for the whole of India for the purpose of the Seed Act, 1966.

OECD varietal certification

The Organization for Economic Cooperation and Development (OECD), established in 1958 with its headquarters in Paris also provides an international framework for the certification of agriculture seed moving in international trade. The main objective of the OECD Seed Schemes is for the varietal certification of seed to encourage the use of "quality-guaranteed" seed in participating countries. Since October 2008, India is a member of the OECD Council. Including India, 58 countries from Europe, North and South America, the Middle-East, Asia and Oceania participate in the OECD Seed Schemes (Trivedi, 2012; Anonymous 2015f; www.oecd.org). A total of 109 varieties of 20 crops from India have been enlisted in the OECD list of varieties.

ISTA accreditation

International Seed Testing Association (ISTA) was founded in 1924, with the aim to develop and publish standard procedures to upgrade accuracy and reproducibility in the seed testing results throughout the world and is linked with the history of seed testing with member laboratories in over 70 countries worldwide (Masilamani and Murugesan, 2012). ISTA is engaged in the development of standardized seed testing procedures in the form of International Rules for Seed Testing. ISTA rules are being used in our country also for seed testing purposes. In India, the first Central Seed Testing Laboratory (CSTL) was established at IARI, New Delhi in 1960. Section 4(2) of the Seed Act, 1966 empowers the state government to establish one or more State Seed Testing Laboratories in the State. Presently, there are 124 state and 2 central laboratories in the country (Anonymous, 2014b; agricoop.nic.in). The central laboratories include National Seed Research and Training Centre at Varanasi and the laboratory at Central Institute for Cotton Research, Nagpur (for GM cotton only). Of these, one public (Seed Testing Laboratory, Department of Seed and Organic Certification Agency, Tamil Nadu) and five private seed testing laboratories (Bejo Sheetal Seeds Pvt Ltd, Jalna ; Indo-American Hybrid Seeds, India, Pvt Ltd, Bangalore; Maharashtra Hybrid Seeds Company Ltd, Jalna; Nuziveedu Seeds, Hyderabad and Namdhari Seeds Pvt Ltd, Bengaluru) have been accredited by ISTA. Further, 18 are ISTA member laboratories from India. The ISTA certification would facilitate seed trade from India in international market.

SEED PRODUCTION

Timely availability of certified quality seeds of high yielding varieties is still a major concern. Concerted and coordinated efforts are imperative in ensuring timely availability of seeds as well as increasing the seed replacement rate. Certain norms are followed for the production of pure seeds and seeds are multiplied through a well defined seed chain, viz. nucleus, breeder, foundation and certified/truthful labeled seed (Trivedi and Gunasekaran, 2013). The whole process of quality seed production of notified varieties is regulated by the provisions of Seed Act, 1966. The bags of different classes of seed are identified with specific coloured tags (Table 2).

VARIETAL IMPROVEMENT

Table 2 Colour of tags used for different classes of seeds

Class	Colour of tag
Basic or nucleus seed (Stage I and Stage II)	Tag is not used: Quality assurance given by the concerned breeder
Breeder seed (Stage I and Stage II)	Golden yellow (No. 356 IS: 5-1978)
Foundation seed (Stage I and Stage II)	White
Certified seed (Stage I and Stage II)	Azure Blue (ISI No. 104)
Truthful labeled seed	Opal green

Genetic yield enhancement had been the principal technological intervention supported by the NARS. Since early 60s, the NARS has been continuously developing new varieties suitable for different agro-climatic regions and changing production conditions. Presently, 42 agri-horticulture ICAR institutes and all the SAU's are engaged in development of new varieties/hybrids of different crops and production of breeder/basic seed (Chauhan *et al*. 2013, Anonymous 2014c). This ensured continued variety

improvement, developing 4 307 varieties of field crops till 2015. Further, 98 varieties of tobacco were also developed but they were not notified as the crop is not covered under Seed Act 1966. During 2015, 81 varieties comprising cereals (49), oilseeds (16), pulses (8), forages (4), fibres (3) and sugarcane (1) were notified. Of the 4 307 varieties notified until 2015, 250 varieties have been de-notified, thus bringing the total number of varieties released and notified to 4 057 (Table 3). Of these, NARS has released 706 and 658 varieties

Table 3 Varieties of field crops notified during 1969-2015 in India

Crop	Number of varieties
Cereals (2062)	
Rice	860
Wheat	350
Triticale	3
Barley	87
Sorghum*	185
Maize*	266
Pearl millet*	156
Small millets (155)	
Finger millet	68
Foxtail millet	19
Little millet	17
Barnyard millet	15
Kodo millet	21
Proso millet	15
Pulses (793)	
Chick pea/Gram	171
Pigeonpea	106
Mung bean	130
Urd bean/Blackgram	85
Lentil	48
Moth bean	6
Horsegram	21
Rajmash/French bean	31
Field pea	74
Cowpea	80
Lathyras	4
Guar/Cluster bean*	37
Oilseeds (700)	
Soybean	99
Groundnut	169
Rapeseed-mustard (161)	
Black mustard	01
Ethiopian mustard	04
Indian mustard (Raya)	99
Toria	20
Yellow sarson	15
Brown sarson	05
Gobhi sarson	11
Taramira/Rocket salad	06
Sunflower	53
Safflower	31
Linseed	54
Sesame	79
Niger	17
Castor	37
Commercial crops (355) [Fibre crops : 274; Sugar crops : 81 and Tobacco : 94]	
Cotton	228
Jute	33
Mesta	10
Sunhemp	3
Sugarcane	79
Sugar beet	2
Tobacco	98**
Forage crops and grasses (114)	
Berseem	16
Oat*	22
Lucerne	12
Rice bean	8
Bajra Napier (Hybrid)	8
Napier grass/Elephant grass	4
Guinea grass	11
Setaria grass	4
Sudan grass	2
Anjan grass	5
Dhaincha	2
Dinanath grass	4
Birdwood grass	1
Dharaf grass	1
Marvel grass	3
Tall rescue grass	3
Sen grass	1
Teosinte	1
Golden thimothy grass	1
Indian clover	1
Persian clover	1
White clover/Shaftal	1
Red clover	1
Stylosanthes	1
Potential crops (33)	
Grain amaranthus	7
Rice bean	8
Job's tear (Coix aquatic)	2
Buck wheat	7
Chinopodium/Bathua	1
Winged bean	1
Faba bean	1
Adzuki bean	1
Kalingada	1
Tumba	1
Jojoba	1
Kankoda	1
Jatropha	1
Total	4057

*Includes forage, vegetables and grain varieties; ** Tobacco varieties released but not notified as it is not covered under Seed Act 1966.

of field crops during X and XI plan, respectively. During the first four years of XII plan, 390 varieties were released and notified. The largest number of varieties (188) was released during the year 2006. These varieties are input-responsive, high yielding and show tolerance to major biotic and abiotic stresses.

Of the total 1686 varieties notified during 2002-2015, 48.0% were notified by Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops for more than one state and the rest were for a particular state. Recently (2011-15), 450 varieties comprising 272 of cereals; 68 of oilseeds; 59 of pulses; 17 of fibres; 18 of forages and 16 of sugarcane were notified.

Induction of varieties into seed chain

The public sector seed companies/state governments forecast seed demand for various crops at least three years in advance. Breeder seed is produced on the basis of indents from private as well as public sector organizations placed with Department of Agriculture Cooperation (DoAC), Government of India, New Delhi which in turn consolidates the indents and forward them to the ICAR. The production of breeder seed is demand driven and produced by different crop based Institutes of ICAR, State Agricultural Universities (SAUs) and NSC. The breeder seed is supplied to indenting organizations by the NARS on the basis of allocation by DoAC for further multiplication to foundation and certified seeds which are made available to farmers (Fig 3). Crop Science Division of the ICAR coordinates the breeder seed production of field crops in the country with the cooperation of DoAC. Production of foundation and certified/quality seed is primarily the responsibility of the State and National Seed Cooperation, SAUs although ICAR institutes also produce limited quantity of certified/truthfully labeled seeds. Each institute fixes the price of foundation/certified/ truthfully labeled seeds keeping in view the prevailing market price, cost of production and interest of farmers. The price of breeder seed is fixed by the Council in consultation with Joint Secretary (Seed), DoAC, Government of India, New Delhi.

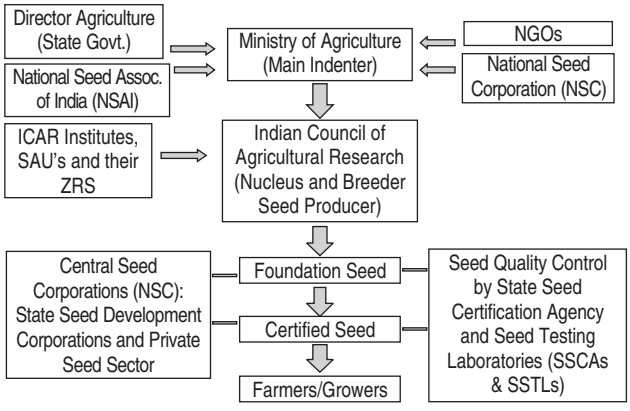

Fig 3 Seed chain for the production of quality seed

Varietal scenario in the seed chain

Since the quality seed production commences with the production of breeder seed, it would be interesting to know the trend of inclusion of recently released varieties in the seed production chain. The present study analyses the seed indents for production of breeder seed for the year 2014-15 (Anonymous 2015b; http://seednet.gov.in, 15.06.2015) to present the varietal scenario of major crops. The analysis revealed that in wheat out of 165 varieties, top 5 varieties (HD 2967, GW 322, DWR 17, GW 366 and PBW 550) account for 24.3% of the total breeder seed and were released during the last 5 years (Table 4). Of the 241 varieties of rice indented for breeder seed production, the 5 top leading varieties [Cottondora Sannalu (MTU-1010), MTU-7029, Vijetha (MTU-1001), Sahbhagi Dhan and IR-64] comprising 30.4% of the indent were released prior to the year 2000 except Sahbhagi Dhan, which was released in 2011 (Table 4). In maize, out of the 36 varieties/hybrids in seed chain, 5 varieties and hybrids [JAWAHAR MAKKA-216 (Composite), HQPM-1 (Hybrid), HQPM-4 (Hybrid), Pratap Hybrid Maize-1 and HM 10 ((Hybrid)] comprised 53.5% of the total breeder seed. Of these top varieties/hybrids, HQPM 4 and HM 10 were released in 2010 and 2008, respectively, and the rest were released prior to 2002. Of the 26 varieties/ hybrids of sorghum indented, the top 5 varieties, viz. SM-35-1, Prabhani Moti, SPSSV6, CSV-23 and CSV-20 comprised 62.7% of the total indent and were released during the last 10 years except SM 35-1 which was released in 1984 (Table 4). Of the 16 varieties/hybrids of pearl millet, 5 top leading varieties (MP 124, HHB 67 Improved, MBC 2, FBC 16, and RHB 173) comprising 71.2% of the total indents were released during the last 10 years except MP124 which was released in 1988.

In pulses, of the 54 varieties of mungbean, leading 5 varieties [SML 668, IPM 02-3, GM-4, HUM16 and IPM 02-14] accounted for 60.7% of the indent and all were released during the last 10 years. In urd, out of 47 varieties in the seed chain, top 5 indented varieties [Pant Urd-31, TAU-1, IPU 02-43, IPU-94-1, Azad Urd-3] comprised 47.8% of the total indent. In pigeonpea, of the 48 varieties, BSMR-736, MARUTI, TS 3R, Vaishali and Bahar were the leading varieties and accounted for 43.7% of the total indent. Except TS 3R, which was released in 2011, all were released prior to 2002 (Table 5). In chickpea, 75 varieties were in the seed chain (Table 5) and indent for top 5 varieties (JAKI-9218, Gangaur, JG 11, JG 63 and JG 130) comprised 38.9% and were released during 2002-2008 except JG-11, released in 1999. Of the 40 lentil varieties, the top 5 varieties [Pant Lentil-8, Narendra Masoor 1, Malviya Vishwanath (HUL 57), Mallika and Sheri DPL 62] comprised 47.9% of the total indent (Table 5). Of the 27 varieties of field pea, the top 5 varieties [Azad (P-1), DDR 23, Prakash(IPFD 1-10), KPMR-522 (JAY) and Vikas (IPFD-99-33)] comprised 57.0% of the total indent.

In oilseeds, of the 56 varieties of groundnut, the leading 5 varieties [Kadiri-6, ICGV-91114, GPBD-4 (Vikas), TAG 24, Kadiri-9] accounted for 74.0% of the breeder seed

Table 4 Year-wise distribution of varieties of cereals in seed chain (2014-15) and their contribution to breeder seed production of the crop

Crop	2009-13	2004-08	1999-03	1994-98	Up to 1993	Total varieties	Indent (q)
Wheat	46 (28.2%)*	44 (34.4%)	24 (15.3%)	20 (9.5%)	31 (12.8%)	165	20929.9
Rice	42 (12.3%)	87 (26.9%)	30 (18.6%)	20 (11.6%)	62 (30.5%)	241(V-229, H-12)	4837.5
Maize	5 (13.5%)	16 (35.1%)	4 (23.7%)	1 (3.8%)	9 (23.9%)	35(C-17; H-18)	60.3
Sorghum	10 (30.8%)	6 (20.1%)	2 (0.4%)	2 (4.2%)	6 (44.6%)	26(V-21; H-5)	51.9
Pearl millet	5 (29.4%)	4 (33.3%)	2 (1.3%)	0 (0.0%)	5 (35.9%)	16(V-9; H-7)	8.3

V: Variety; C: Composite and H: hybrid and * within parenthesis is the contribution to the crop indent.

Table 5 Year-wise distribution of varieties of pulses in seed chain (2014-15) and their contribution to breeder seed production of the crop

Crop	2009-13	2004-08	1999-03	1994-98	Up to 1993	Total varieties	Indent (q)
Mung bean	12 (20.6%)*	17 (47.2%)	14 (25.1%)	6 (3.3%)	5 (3.8%)	54	802.7
Urd bean	8 (15.9%)	13 (39.2%)	10 (18.9%)	5 (5.1%)	11 (20.9%)	47	520.8
Pigeonpea	7 (16.5%)	15 (18.8%)	5 (10.7%)	6 (17.4%)	15 (36.5%)	48	392.7
Chickpea	15 (12.3%)	33 (43.9%)	13 (22.0%)	8 (11.8%)	6 (9.9%)	75	8284.4
Lentil	11 (30.5%)	8 (19.9%)	4 (4.5%)	6 (23.6%)	11 (21.5%)	40	380.5
Field pea	5 (9.6%)	9 (29.5%)	6 (22.7%)	1 (1.7%)	6 (36.5%)	27	718.7

* Within parenthesis is the contribution to the crop indent.

Table 6 Year-wise distribution of varieties of oilseeds in seed chain (2014-15) and their contribution to breeder seed production of the crop

Crop	2009-13	2004-08	1999-03	1994-98	Up to 1993	Total varieties	Indent (q)
Soybean	5 (1.7%)*	9 (41.0%)	6 (29.1%)	5 (27.8%)	2 (0.3%)	27	18139.0
Groundnut	17 (14.8%)	19 (68.8%)	4 (0.3%)	3 (0.7%)	13 (15.4%)	56	12487.0
Rapeseed- mustard	19 (8.6%)	9 (5.7%)	5 (2.9%)	5 (7.9%)	22 (74.5%)	60	78.3
Sesame	6 (14.5%)	6 (35.6%)	7 (22.2%)	3 (19.9%)	7 (7.8%)	29	25.7
Linseed	5 (22.9%)	9 (55.9%)	6 (14.9%)	2 (2.6%)	1 (3.6%)	23	41.5

* Within parenthesis is the contribution to the crop indent.

indent. Except TAG 24, released in 1992, all were released during the last 10 years. In soybean, of the 27 varieties, 14 were released during the last 10 years (Table 6). The top 5 varieties [JS 95-60, JS-335, JS 93-05, JS 97-52, Samrudhi (MAUS-71)] comprised 96.1% of the breeder seed indent and all were released during the last 10 years except JS 335 which was released in 1994. In rapeseed-mustard, of the 60 varieties (Table 6), top 5 varieties, viz. M 27, TS 36, Pusa Bold, Binoy (B 9) and Laxmi, comprised 59.7% of the indent and all were released prior to 2000. In sesame, of the 29 varieties, 5 varieties, viz. Gujarat Til 2, Jawahar Til PKDS 11, Gujarat Til 10, JTS 8 and JT 55 (TKG 55) comprised 58.6% of the total breeder seed indent. Except Gujarat Til 10 and Jawahar Til PKDS 11 which were released in 2005 and 2006, respectively, the rest were released prior to 10 years.

TRENDS IN SEED PRODUCTION

Breeder seed

Production of breeder seed is essential for the effective seed chain. Analysis of indent and production of breeder seed from 2007-08 to 2014-15, showed an inconsistent trend and indent increased from 59 530 q during 2007-08 to 94 220 q during 2011-12 with the exception of the year 2010-11 and thereafter decreased to 62 215 q in 2014-15, thus registering an increase of 58.3% till 2011-12 but this increase was only 4.5% during 2014-15 (Chauhan *et al.* 2014a, b). Since 2011-12, there has been a continuous decline in the indents for breeder seeds until 2014-15. The reduction in indent was 13.8%, 25.8% and 34.0%, respectively, during 2012-13, 2013-14 and 2014-15.

Indent for cereal crops increased from 25 903 q in 2007-08 to 36 831 q in 2011-12 showing an increase of 42.2% and then decreased to 25,178 q in 2014-15 (Table 7), showing a decrease of 31.6%. In the year 2007-08, indent for cereal crops was 43.5% of the total indent. It increased for the next two years and then decreased up to 37.0% in 2013-14 but again rose to 40.5% in 2014-15. Breeder seed indent of oilseed crops was 37.9% of the total indent placed during 2007-08. It showed a consistent increase for the next four years except 2010-11 and was 46.9% during 2012-13 (Anonymous 2015c) but decreased for the next two years and was 41.3% during 2014-15. For pulse crops, indent was

Table 7 Breeder seed indent and production of different crops during 2007-08 to 2014-15

Crop	2007-08		2008-09		2009-10		2010-11		2011-12		2012-13		2013-14		2014-15*	
	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P
Cereals																
Wheat	21461	26204	23349	28983	32330	35049	29692	38469	28860	35745	20542	27502	20050	24250	19604	24192
Paddy	2491	3923	3028	4333	3880	5387	4604	6095	5772	6828	5267	11455	4745	10586	4328	7757
Sorghum	22	98	40	375	55	221	36	167	113	158	115	375	83	305	55	250
Maize	100	146	131	246	179	243	178	232	211	173	99	109	60	89	45	48
Barley	1811	2317	2081	3078	2496	3053	1778	2900	1842	1906	1029	698	843	1820	1112	1141
Pearl millet	16	40	17	36	8	8	10	28	15	32	17	67	11	28	11	36
Small millet	3	32	4	18	5	24	22	42	18	47	37	109	44	116	23	50
Total	25903	32759	28650	37068	38954	43985	36294	47814	36831	44889	27106	40315	25836	37194	25178	33474
Oilseeds																
Groundnut	8044	8757	9216	7544	22897	16407	11423	15092	18115	20076	13075	12014	11027	12996	10546	10459
Soybean	14216	16739	17184	13803	11625	12517	22293	18327	22973	20853	24688	20718	19509	8660	14919	8960
Sunflower	53	55	17	80	14	36	9	36	32	48	5	16	3	15	2	11
Niger	8	16	18	13	6	17	16	10	11	15	10	15	8	10	9	5
Castor	45	114	25	34	17	88	24	202	11	28	9	15	4	15	5	9
Sesame	17	59	29	34	3	9	28	49	42	67	32	41	26	59	23	23
Rapeseed–mustard	112	141	90	177	76	138	75	150	49	151	108	212	95	213	127	414
Linseed	49	79	43	85	38	68	49	97	145	157	96	139	41	99	61	116
Safflower	34	78	38	82	10	138	20	51	27	53	28	65	21	331	28	33
Total	22578	26038	26660	21852	34685	29417	33937	34015	41404	41446	38051	33235	30734	22398	25720	20030
Pulses																
Gram/Chickpea	7581	8328	8926	9736	9381	8850	9889	10787	9915	11141	9944	10452	9433	8768	7434	7695
Lentil	303	416	416	414	347	516	431	433	644	718	622	916	470	692	296	312
Field pea	636	601	1,125	1,211	178	1,304	332	997	838	959	774	863	588	636	529	637
Urd bean	333	380	396	342	501	617	508	805	846	1,031	799	606	518	533	485	461
Mung bean	568	787	823	971	798	1,169	1,059	1,073	1,244	1,343	1168	703	799	732	1,053	1,277
Pigeonpea	291	456	326	638	276	499	475	975	537	1,317	646	787	391	674	488	670
Rajmash	20	36	6	17	2	5										
Cowpea	48	96	49	92	66	82	30	28	54	42	55	37	39	53	39	15
Moth bean	168	135	195	163	151	113	221	262	213	95	140	63	95	40	95	36
Horse gram					1	2			12	11	7	3	8	-	8	4
Total	9948	11235	12268	13585	11700	13155	12944	15360	14303	16656	14155	14430	12341	12128	10427	11107

Contd.

Table 7 (*Concluded*)

Crop	2007-08		2008-09		2009-10		2010-11		2011-12		2012-13		2013-14		2014-15	
	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P
Forages																
Cowpea	11	20	11	21	8	17	9	16	43	12	29	14	20	10	0.4	0.5
Maize	106	91	74	75	54	72	63	93	75	77	99	109	89	138	132	147
Sorghum	36	19	27	26	55	221	23	29	34	53	33	74	34	19	39	44
Teosnite	4	4	9	5	4	4	5	10								
Guar	422	841	450	842	480	389	248	520	277	575	289	431	344	206	342**	283**
Bajra	3	5	3	4	1	2	2	9	6	6	5	9	3	6	0.3	0.6
Rice bean	2	2	2	2	3	3			3	3	3	2	3	4		
Oat	255	339	314	422	224	371	202	305	1,082	890	1,278	611	402	398	283	216
Berseem	73	72	75	126	45	60	69	50	94	84	87	77	35	37	41	41
Lucerene	19	11	21	20	8	8	6	6	13	7	7	7	6	5	4	2
Gobhi sarson							0	1	1	2	0	2	0.32	0.43		
Total	931	1402	1543	1544	882	1145	627	1039	1627	1708	1832	1336	936	823	842	734
Fibre crops																
Jute	11	14	8	34	6	8	8	13	13	15	11	14	17	19	16	16
Sunhemp									10	11						
Cotton	162	177	47	80	37	102	44	58	32	59	40	107	26	36	32	54
Total	172	190	55	115	42	110	52	71	55	85	51	121	43	55	48	70
Grand Total	59530	71623	69176	74162	86264	87812	83880	98419	94220	104784	81193	89437	69890	72598	62215	65415

I: Indent and P: Production;*Provisional estimates till October 2015; **Includes forage, vegetables and grain varieties. Source: Anonymous (2015c).

16.7% of the total indent during 2007-08 and slightly increased (17.7%) for the next year and then remained 13.5-15.4% for the next two years. During 2012-13 and 2013-14, it was around 17% of the total indent and then decreased to 16.8% during 2014-15.

The breeder seed indent for forage and fibre crops was about 1-2% of the total indent. Further, analysis within different group of crops revealed that the predominant crops were wheat (79.1%), paddy (16.2%) and barley (4.2%) in cereals accounting for 99.5% of the indent (Table 7). Groundnut and soybean contributed 99% to the total indent for the oilseed crops. Chickpea (73.9%), mung bean (9.1%) and field pea (5.6%) are the major pulse crops accounting for 88.6% of the indent for pulses (Table 7).

Total indent for breeder seed production from 2007-08 to 2014-15 was 6.06 lakh q while the production was 6.64 lakh q. The trend of breeder seed indent and production followed similar trend as expected. The highest production reached upto 104 784 q during 2011-12 (Anonymous 2015c) thereafter showed a continuous decline and was 65 415 q during 2014-15. The increase during 2011-12 was to the extent of 46.3% as compared to that of 2007-08 and decline was 14.6 %, 30.7% and 37.6%, respectively, during 2012-13, 2013-14 and 2014-15 over that of 2011-12. During this period (2007-08 to 2014-15), the contribution of cereals to the total production varied from 42.8% to 51.2%; oilseeds accounted for 29.5% to 39.6%. The pulses contributed 15.0%-18.3% (Table 7). The share of forage and fibre crops to total breeder seed production was only 1.2% to 2.3%. The seed production for cereals declined since 2009-10 and their contribution to total breeder seed production was only 42.8% during 2011-12 as compared to 50% during 2008-09. Oilseeds registered a low but consistent rise from 29.5% (2008-09) to 38.7% (2013-14) and pulses showed consistent decline of low magnitude from 18.3% (2008-09) to 17.0% (2014-15) in their contribution to total breeder seed production (Table 7). Wheat (36.6%-80.3%), paddy (5.5%-28.4%) and barley (1.7%-8.3%) contributed maximum to the total production of breeder seed for the cereal crops. Similarly, in oil seeds, groundnut and soybean are the predominant crops with contribution of 33.6%-55.8% and 42.6%-65.2%, respectively. In pulses, chickpea is the main crop with contribution of 67.2% during 2009-10 and 73.1% during 2013-14. Mung bean is the next highest contributing crop to breeder seed production of pulses (5-11%). The pigeonpea, field pea, urd bean and lentil each contributed around 5% to the total breeder seed production of pulses during 2014-15. Cereals, oilseeds, pulses, forage and fibre crops contributed 51.2%, 30.6%, 17.0%, 1.1% and 0.1%, respectively, to the total production during 2014-15.

Foundation and certified/quality seeds

To make seed production chain effective, it is imperative that breeder seed should be multiplied to foundation and certified seeds. The foundation seed production showed consistent increase during XI plan varying from 852 540 to 2 227 000 q.

A total of 7.0 lakh tonnes of foundation seed was produced during XI plan. The increase in foundation seed production during 2011-12 was 161.2% over that of the year 2007-08. During the first three years of the XII plan, 4.94 lakh tonnes of foundation seed was produced which is 66.9% higher than that of the corresponding period of XI plan (Anonymous 2015g).

Total quality seed availability/production during 2007-08 to 2011-12 was 13.99 MT, showing an increase of about 82.5% over a period of five years. Similarly, there was an increase of 136.9% during the first three years of XII plan as compared to that of corresponding period of XI plan (Table 8). The seed production by the private sector increased from 0.83 million tonnes during 2007-08 to 2.06 MT during 2014-15 (Anonymous 2015d, Selvaraj 2013) showing an increase of 148.2% during the last eight years. The contribution of public sector reached up to 61.1% in the year 2009-10 but declined thereafter and during 2014-15, it was only 41.2% (Table 8). During the same period, the contribution of private sector consistently increased from 42.6% (2007-08) to 58.8% (2014-15). Private seed sector dominates in quality seed production of hybrids of maize, pearl millet, sorghum, sunflower and cotton and up to 90% of vegetable seed comes from this sector only.

Availability of quality seeds varied from 1.94 (2007-08) to 3.52 MT (2014-15), registering an increase of 81.4%. However, the highest increase of 82.4 % in availability of quality seeds was observed during 2011-12 (3.54 MT) over that of 2007-08 (Selvraj 2013 and personal communication). The availability of quality/certified seeds was always higher than the required quantity (Table 8). During the last eight years, availability of certified/quality seed showed a

Table 8 Certified/Quality seed production/availability by public and private sector and their contributions

Year	Quantity (MT)		Difference (%) between	Quantity of seed (MT) produced by	
	Availability	Demand	availability and demand	Public sector	Private sector
2007-08	1.94	1.80	7.7	1.12 (57.4%)*	0.83 (42.6%)*
2008-09	2.50	2.07	20.8	1.51 (60.2%)	1.00 (39.8%)
2009-10	2.80	2.49	12.4	1.71 (61.1%)	1.09 (38.9%)
2010-11	3.22	2.90	11.0	1.66 (51.6%)	1.56 (48.4%)
2011-12	3.54	3.30	7.3	1.81 (51.1%)	1.73 (48.9%)
2012-13	3.29	3.15	4.4	1.61 (49.1%)	1.67 (50.9%)
2013-14	3.47	3.35	3.7	1.68 (48.4%)	1.79 (51.6%)
2014-15	3.52	3.44	2.3	1.51 (41.2%)	2.06 (58.8%)

*Share in percentage to total seed availability.

consistent increase until 2014-15 (81.4% over the first year of XI plan). But about 6% decline in seed demand was recorded during the year 2012-13 as compared to that of 2011-12. However, it again increased. The requirement for quality seed consistently increased from 1.8 (2007-08) to 3.44 MT (2014-15) showing an enhancement of about 91.1%.

DISTRIBUTION OF QUALITY SEEDS

It is the certified/quality seeds made available to the farmers/growers that could raise crop productivity by enhancing seed replacement rate. The cereals, oilseeds and pulses together comprised the bulk of the quality seed distributed (87-95%) from 2007-08 to 2013-14 (Table 9). During the last seven years, the contribution of cereals to the total quality seed ranged from 59.5% (2009-10) to 69% (2007-08). Pulses contributed 6.7% (2008-09) – 9.2% (2013-14). The contribution of oilseeds during this period was consistent varying from 18.2% (2010-11) to 20.3% (2011-12). The quality seed of cereals, distributed to the stakeholders from 2007-08 to 2013-14 showed an upward trend and increased from 123.8 lakh q (2007-08) to 204.37 lakh q (2012-13) with an increase of 65% (Anonymous 2015a). A decrease of 11.7% in seed supply, however, was observed during 2013-14 over that of 2012-13 (Table 6). Quality seed of wheat increased consistently and was maximum during 2012-13 (116.47 lakh q) with an increase 84.1% over that of 2007-08. But, in paddy, maximum dissemination of quality seeds was during 2011-12 (74.41 lakh q) showing an increase of 52.1% over that of 2007-08 and remained almost stagnant for the next two years. In maize, quality seed distribution has increased consistently and reached maximum during 2013-14 (Table 9).

In pulses, the quantity of quality seeds distributed, increased consistently and reached 27.80 lakh q during 2013-14 from 12.57 lakh q in 2007-08, a quantum jump of 121.2%. Chickpea alone contributed significantly to this jump as its distribution increased from 6.73 lakh q to 17.48 lakh q (Table 9) with an increase of 159.7%. For lentil and pea, highest distribution was observed during 2013-14, while in case of urd, moong, arhar, cowpea, etc. maximum dissemination of quality seeds to stakeholders was during 2012-13.

Quality seed of oilseeds showed an increase of 77.9% from 2007-08 (34.33 lakh q) to 2013-14 (61.09 lakh q). However, the highest distribution ever was attained during 2011-12 (Table 9). Soybean contributed the highest, where maximum distribution was during 2013-14 (38.94 lakh q) with an increase of 135.7% over that of 2007-08 (16.52 lakh q) followed by groundnut, the highest being 23.16 lakh q during 2012-13 with an increase of 60.5%. In case of fibre crops, the quantity registered an upward trend till 2011-12 since 2007-08 (2.63 lakh q) with an increase of 17.5% but showed declining trend thereafter (Table 9). For potato and others, an increasingly upward trend was obtained since 2007-08 and reached to maximum of 24.63 lakh q in potato, a huge increase of 360.4% and 1.97 lakh q in other crops (pulses) during 2013-14, an increase of 432.4%.

IMPACT

Increased seed replacement rate

The availability of quality/certified seeds was always higher than the required quantity due to coordinated efforts of public as well as private seed sector (Chauhan *et al.* 2014b). The private sector contributes nearly 58.8% of the commercial seed requirement for the country today. In the recent years, partly as a consequence of the reforms due to government policies, many joint ventures between foreign and Indian firms have entered the seed market. Private sector research is also fast expanding, with huge investments in research. During the last eight years, availability of certified/quality seed showed a consistent increase of 81.4% over that of 2007-08. The requirement for quality seed consistently increased from 1.80 (2007-08) to 3.44 MT (2014-15) showing an enhancement of about 91.1%. The increase seed availability resulted into high seed replacement rates (SRR) in major cereals, oilseed and pulse crops. The SRR during XI plan period increased from 25.2 to 32.6% (wheat); 25.9 to 40.4% (paddy); 44.2 to 56.6% (maize); 48.5 to 60.4% (pearl millet); 21.8 to 30.3% (moong/greengram); 23.9 to 34.4% (urdbean/blackgram) and 14.3 to 22.5% (groundnut); 33.4 to 52.8% (soybean) in 2011 as compared to that of 2007. During first two years of XII plan (2012-13 and 2013-14), the Seed Replacement Rate (SRR) of all the major cereal, oilseed and pulse crops increased substantially except rapeseed-mustard and soybean. The SRR during 2013-14 was 34.9%, 57.6%, 31.4%, 49.6%, 46.3%, 25.4%, 51.3% and 37.5% for wheat, paddy, chickpea, mungbean, pigeonpea, groundnut, rapeseed-mustard and soybean, respectively.

Increased production and productivity

Indian Agriculture has made an impressive progress in recent times. The food production was lowest (218.1 MT) during 2009-10 as this year was affected by drought. Since then, food production showed a gradual and consistent increase until 2011-12 (259.3 MT) with reduction of 0.8% during 2012-13 and again rose to record high during 2013-14 (Anonymous 2015a). The area under food crops showed a declining trend for last three years and reduced by 5.1% during 2012-13 as compared to that of 2010-11 but again increased by 12.9 % during 2013-14. Nevertheless, yield (kg/ha) increased by 10.0% from 1909 (2008-09) to 2101 (2013-14). Similarly, area and production of cereals showed variable trends ranging from 96.9 (2012-13) to 100.8 m ha (2013-14) and 219.9 (2008-09) to 245.5 MT (2013-14), respectively. Overall, production registered an increase of 11.6% during the period with an increase of 2.8% during 2013-14 over that of 2012-13. Nevertheless, the yield/ha was highest (1 379 kg) in the year 2011-12 with a range of 1 168-1 379 kg. During 2013-14, it showed marginal dip over the highest ever achieved so far. Pulses showed an enhancement by 14.2% in acreage from 2008-09 to 2013-14 but the highest (26.4 m ha) was recorded during 2010-11 but with an all time high of 28.5 MT in 2013-14 registering

Table 9 Crop-wise distribution of certified/quality seeds (lakh quintals)*

Crop	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Cereals							
Wheat	63.25	74.83	90.66	97.83	97.61	116.47	93.75
Paddy	48.93	58.18	60.95	69.34	74.41	72.14	72.45
Maize	5.80	7.94	7.74	8.94	9.35	9.07	11.20
Jowar	2.38	2.41	2.24	2.16	1.99	2.29	2.06
Bajra	1.90	2.20	1.74	2.31	2.27	2.14	2.20
Ragi	0.27	0.25	0.05	0.26	0.26	0.29	0.29
Barley	1.27	1.62	1.77	1.79	3.80	1.97	1.08
Total	123.80	147.43	165.15	182.62	189.96	204.37	183.03
Pulses							
Gram/Chickpea	6.73	8.6	12.32	12.50	13.16	14.83	17.48
Lentil	0.56	0.59	0.55	0.74	0.66	0.70	1.28
Peas	1.10	1.29	2.07	1.47	1.36	1.79	3.17
Urd bean	1.40	1.37	1.61	1.96	2.31	2.33	1.64
Mung bean	1.34	1.23	1.29	1.76	2.00	2.13	1.95
Pigeonpea	1.18	1.09	1.37	1.52	1.92	1.80	1.73
Cowpea	0.10	0.16	0.20	0.33	0.32	0.45	0.24
Others	0.16	0.15	0.28	0.56	0.53	0.48	0.31
Total (Pulses)	12.57	14.48	19.69	20.83	22.26	24.51	27.80
Oilseeds							
Groundnut	14.43	15.90	18.86	21.79	20.02	23.16	19.39
Rapeseed-mustard	1.71	1.63	2.09	2.07	2.56	1.88	1.63
Sesame	0.22	0.18	0.18	0.20	0.23	0.20	0.18
Sunflower	0.92	0.80	0.76	0.55	0.29	0.35	0.32
Soybean	16.52	20.89	28.44	25.55	37.60	32.08	38.94
Linseed	0.02	0.01	0.01	0.04	0.02	0.02	0.05
Castor	0.42	0.42	0.29	0.31	0.67	0.68	0.51
Safflower	0.08	0.09	0.07	0.08	0.09	0.04	0.06
Others	0.01		0.01	0.01	0.01		0.01
Total	34.33	39.92	50.71	50.61	61.49	58.41	61.09
Fibers							
Cotton	1.89	2.27	2.36	2.33	2.53	2.50	2.28
Jute	0.24	0.28	0.27	0.27	0.32	0.30	0.30
Mesta/Others	0.50	0.03	0.02	0.04	0.24	0.15	0.29
Total	2.63	2.58	2.65	2.64	3.09	2.95	2.87
Others	5.72	11.40	18.91	20.63	18.32	23.20	26.60
Grand total	179.05	215.81	257.11	277.34	294.85	313.44	301.39

*Anonymous (2015a).

an overall increase of 9.9%. Except for the year 2011-12, pulses production consistently increased from 14.6 (2008-09) to 19.3 MT (2013-14) showing an appreciable enhancement of 32.3% with an yield/ha increase of 15.9%.

Production of oilseeds did not show a consistent trend and was quite variable during 2008-09 to 2013-14. The highest production (32.9 MT) was obtained during 2013-14 while in the drought affected year (2009-10) it was 24.9 MT. The overall increase during this period was 18.6%. The yield (kg/ha) ranged from 958 (2009-10) to 1 193 kg/ha (2010-11), an increase of 19.7%. The cropped area under oilseeds varied between 26 m ha (2009-10) to 28.5 m ha (2013-14), an increase of 9.6%. In case of cotton, the area, production and yield increased consistently by 24.2%, 64.2% and 32.0%, respectively, during 2008-09 to 2013-14. Likewise, jute and mesta production and yield enhanced by 11.7% and 18.3%, respectively, from 2008-09 to 2013-14 but with a marginal decrease of 5.6% in acreage. As a consequence of increase of rice productivity and production, export of basmati rice also increased to a great extent from 2 MT in 2009-10 to 3.8 MT worth ₹ 33 000 crores in 2013-14.

WAY FORWARD

A systematic, strong and vibrant seed production system is essential for food security of the country and also acts as a driver of growth in agriculture. Enabling the resource poor farmers with quality seed and its production technology is

still an imminent challenge that needs to be focused upon. It is a matter of serious concern that the gap between demand and availability has been narrowed down up to 2.3%. There was a consistent and appreciable decline in the indents for breeder seed production since 2011-12, especially in wheat. Analysis of recent data of SRR in comparison with expected availability of certified/quality seed considering full conversion factor revealed that quality seed availability with the present rate of basic seed production is more than sufficient for all the crops except wheat, maize, groundnut and chickpea; even >100 % SRR for rice, sorghum, pearl millet, mung bean and rapeseed-mustard (Table 10). Main reasons for low to moderate SRR in these crops are due to problems in seed multiplication chain and outreach activities.

Further, assuming absolute conversion of the indented breeder seed for the year 2014-15 and the cropped area under cereals, pulses and oilseeds remained similar to that of the year 2013-14, the expected area under certified seed was assessed for the year 2017-18. The analysis revealed, on the basis of ideal SRR of 33% for self-pollinated crops (chickpea, rice, wheat and pulses); 50% SRR for open pollinated crops (rapeseed-mustard and pigeon pea) and 100% in case of crops (castor, sunflower and maize), where mostly hybrids are sown; for wheat, chickpea, groundnut, lentil, field pea, sunflower and maize there would be shortage of quality seed (Table 11). In cotton, mostly the area is under Bt hybrids and, therefore, coverage of less sowing area with quality seeds due to low indent of breeder seed is not of much consequence. Similarly, in maize and sunflower, the hybrids cover major area. But in case of soybean, wheat, groundnut, and lentil, the problem of less indent of breeder seed is of serious concern as the quality seed may cover only much less than the recommended SRR. Since SRR has a strong positive relationship with the crop productivity, hence to achieve desired productivity levels and for attaining sustained food security, anomalies viz. skewed SRR and low varietal replacement rates (VRR) should be addressed appropriately. Therefore, there is need for strengthening the quality seed production programme and induction of recently released varieties in to the seed chain through concerted efforts involving plant breeders/sponsoring organizations and state departments of agriculture. Analysis of breeder seed requirement for gross cropped area revealed that requirement of breeder seed shall be 2.66 lakh quintals even at hypothetical 100% SRR with an assumption that absolute conversion prevails and scenario of gross cropped area remains the same.

Further, a realistic assessment for the breeder seed requirement has been worked out considering the present level of SRR, assuming annual increment of 2% in SRR and the highest cropped area in the country. Although, desired SRR was achieved during 2012-13 for most of the crop except sorghum, chickpea, pigeon pea, mung bean and groundnut, yet it is desirable to increase it further by utilizing quality seed. For paddy, mung bean, pigeon pea, urd bean, rapeseed-mustard, sorghum, pearl millet the production of breeder seed was higher than the projected demand even for 2019-20 (Table 12).

As 60% of farmers use farm saved seeds, technological intervention for upgradation of such seed requires immediate attention. An effective strategy to make available quality seed of improved varieties/hybrids at appropriate time and affordable price could be possible by suitable model deployment such as participatory seed production involving farmers, seed village scheme, community seed banks, also enabling partnership with private sector; self help groups, non-government organizations and community based organizations. In seed domain, capacity building with focus on skill intensification, technology dissemination needs to be further strengthened. This would require organized communities, institutional technical backstopping and continued interaction between various institutions,

Table 10 Quantity of certified/quality seed of field crops available, actual cropped area and expected SRR during 2011-12.

Crop	SMR*	Breeder seed indent	Seed quantity (q)		Seed rate	Area under certified/quality seed during 2011-12 (m ha)		SRR** (%) during 2011-12	
		(2008-09) (q)	Foundation seed	Certified seed	(kg/ha)	Actual	Expected	Actual	Expected
Rice	100	3028	302800	30280000	40	44.0	75.7	40.4	172.0
Wheat	20	23349	466980	9339600	100	29.9	9.3	32.6	31.2
Sorghum	160	40	6400	1024000	15	6.3	6.8	23.9	108.4
Pearl millet	200	17	3400	680000	5	8.8	13.6	60.4	154.5
Maize	80	131	10480	838400	20	8.8	4.2	56.6	47.6
Pigeonpea	40	326	13040	521600	20	4.0	2.6	22.2	65.1
Chickpea	15	8926	133890	2008350	80	8.3	2.5	19.4	30.1
Mung bean	30	823	24690	740700	20	3.4	3.7	30.3	108.8
Urd bean	30	396	11880	356400	20	3.1	1.8	34.4	58.1
Groundnut	10	9216	92160	921600	100	5.3	0.9	22.5	17.5
Rapeseed-mustard	200	90	18000	3600000	5	5.9	72.0	78.9	1220.3
Soybean	15	17184	257760	3866400	75	10.1	5.2	52.8	51.0
Sunflower	50	17	850	42500	10	0.7	0.4	32.5	60.7

*SMR-Seed Multiplication Ratio; **SRR-Seed Replacement Rate

Table 11 Expected quantity of certified/quality seed of field crops likely to be available with absolute conversion factor during 2017-18 and area covered

Crop	SMR	Breeder seed indent (q)	Seed quantity (q)		Seed rate (kg/ha)	Actual area during 2013-14 (m ha)	Expected area cropped with quality seed during 2017-18 (m ha)	Expected SRR (%)
			Foundation seed	Certified seed				
Rice	100	4286	428600	42860000	40	44.0	107.2	243.5
Wheat	20	20897	417940	8358800	100	31.2	8.4	26.8
Sorghum	160	67	10720	1715200	15	5.8	11.4	197.1
Pearl millet	200	11	2200	440000	5	7.9	8.8	111.4
Maize	80	44	3520	281600	20	9.3	1.4	15.1
Pigeonpea	40	292	11680	467200	20	3.9	2.3	59.0
Gram/Chickpea	15	7614	114210	1713150	80	10.2	2.1	20.6
Mung bean	30	934	28020	840600	20	3.4	4.2	123.6
Urd bean	30	426	12780	383400	20	3.1	1.9	61.3
Field pea	15	580	8700	130500	80	0.96	0.16	16.7
Lentil	15	263	3945	59175	40	1.3	0.15	11.5
Groundnut	10	11434	114340	1143400	100	5.5	1.1	20.8
Rapeseed-mustard	200	132	26400	5280000	5	6.7	105.6	1576.1
Soybean	15	15326	229890	3448350	75	12.2	4.6	37.7
Sunflower	50	2	100	5000	10	0.7	0.01	7.1
Sesame	200	25	5000	1000000	5	0.17	20.0	1764.7

Table 12 Projected demand for breeder seed of major crops for the year 2019-20

Crop	Highest ever cropped area (m ha)	SRR (%) (2012-13)	Breeder seed (2012-13)		2019-20	
			Requirement (q)	Production (q)	Targeted SRR (%)	Requirement of breeder seed to be produced during 2016-17 (q)
Paddy	45.5	38.5	700.7	19374.9	50.5	919.1
Wheat	30.6	36.5	27922.5	30516.7	48.5	37102.5
Maize	9.1	58.3	165.8	483.7	70.3	199.9
Pearl millet	9.6	65.1	7.8	71.8	77.1	9.3
Sorghum	8.3	30.2	14.7	368.9	42.2	20.5
Gram/Chickpea	9.6	19.4	6621.9	5975.4	31.4	10717.9
Pigeonpea	3.7	22.2	103.4	720.1	34.2	159.3
Mung bean	3.7	30.3	141.2	676.9	42.3	347.8
Urd bean	3.2	37.0	147.5	746.8	49.0	348.4
Soybean	12.0	52.8	21120.0	9606.8	64.8	25920.0
Sunflower	1.9	43.6	33.1	20.6	55.6	42.5
Groundnut	6.3	22.5	14157.0	16003.5	34.5	21707.4
Rapeseed-mustard	7.3	78.9	7.2	110.6	90.9	8.3

policymakers and stakeholders to strengthen local seed systems to enhance seed productivity and availability thereby enabling food security (Chauhan *et al*. 2014b). Village-based seed banks may serve as an alternative to help farmers become self-reliant. Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India launched a National Mission on Agricultural Extension and Technology including sub-mission on seed and planting material during XII plan (Anonymous 2014d) with an aim to restructure and strengthen agricultural extension to enable delivery of appropriate technology and improved agronomic practices to the farmers. The sub-mission envisions covering entire gamut of seed chain from nucleus seed to supply to farmers and also to the major stakeholders in the seed chain. It provides support for infrastructure to create enabling environment for development of seed sector. The sub-mission also focuses on issue of protection of plant varieties, rights of farmers and plant breeders.

OPPORTUNITIES AND STRATEGIES

Export of seeds

Agrinnovate India Limited (AgIn), a company registered under the Companies Act, 1956 (No.1 of 1956) was

established in 2011 and is owned by Government of India in Department of Agricultural Research and Education (DARE). It aims to promote the commercialization of technologies developed by ICAR and also forging partnerships both within and outside the country for the public benefit. It is also open to facilitate the commercialization of technologies developed by other organizations in NARS.

The technological assets include a number of high yielding and climate resilient crop varieties, packages of improved crops and post-harvest technology having immense potential for commercialization. The company has formulated guidelines for commercializations of technologies which invokes a consultative process with ICAR institutes and provide Standard Operating Procedure for technology acquisition, evaluation and valuation, prospecting clients, policy for benefit (http://agriinnovateindia.co.in, 16.06.2015). Ensuring global competitiveness of Indian seed sector by harmonizing national and international seed laws and implementing international seed standards for seed quality assurance, sampling and testing is foremost.

India is a dominant player in the South Asian Association for Regional Cooperation (SAARC) seed market, since India's total seed export to SAARC constitutes over 93% of its total seed trade (Singh 2013). It is an avenue for increasing seed trade in India as these countries have mutual advantages of trade due to low transaction cost, scope for quicker delivery, similar agro-climatic conditions and food habits (Agrawal 2012b). Nine important seeds that are directly or indirectly related to food security and livelihood in the region include vegetables; fruits, oil, maize, wheat, rice, barley, grain sorghum and buckwheat have much bigger potential and opportunity for seed trade. The Council is also contemplating to establish Agricultural Seed Production-cum-Demonstration Centres in 8 African nations with a view to promote and ensure better-quality improved seeds and disease free planting materials of major crops for enhancing productivity and food security over there. It also has vast potential for the export of seeds from India and/or customizes seed production for Indian market (Anonymous, 2015e; http://agriinnovateindia.co.in, 16.06.2015).

In conclusion, a systematic, strong and vibrant seed production system is essential for food security of the country and also driver of growth in agriculture. Consistent decline over the years in the indented quantity of breeder seed, narrowing down of surplus availability of quality seed with the government agencies and procurement of seed on tender basis by the states are serious issues that will have long term repercussion on the availability of quality seed and *inter alia* on food production in near future. Timely availability of quality seed to the farming community can be ensured if the states place their indents for breeder seed three years in advance so that ICAR and SAUs are able to meet the demand by the next year and subsequently, states have the requisite time to multiply the same to the foundation and certified seed in the second and third year, respectively. Therefore, all the stakeholders such as DAC, ICAR, SAUs, NSC, State Agriculture Department, State Seed Certification Agencies and private sector should look into this matter on priority and take appropriate measures for placing timely demand of adequate quantity of breeder seed besides ensuring full conversion of breeder seed to foundation and certified seed. Awareness amongst the farmers and other stakeholders about the new varieties developed by the NARS also needs to be promoted for their induction in the seed chain. Technological breakthroughs in field of seed science are essential to meet the demands of global seed market. Inherent strengths of India are being the 2nd largest arable land with 46 soil types across 15 agro-climatic zones favour seed production of diverse crops. Besides this, increasing demand for quality seed, enabling policy support from government such as tax exemption, credit on soft terms, duty free import of equipments and integrated approach towards seed security through nationwide seed science research are the growth drivers for a vibrant seed sector having vast untapped potential to raise India from 6th to 3rd position in global seed trade.

REFERENCES

Agrawal P K. 2012a. Indian Seed Industry: Today and its potential in next five years. (*In*) *National Seed Congress on Welfare and economic prosperity of the Indian farmers through seeds*, Raipur, Chhattisgarh. 21-23 Dec. 2012, p 60–9.

Agrawal P K. 2012b. Future growth drivers for the Indian seed industry. Seed Testing International. *ISTA News Bulletin* **144**: 4-9.

Anonymous. 2011. *Vision 2030*. Directorate of Seed Research, Kushmaur, Mau, Uttar Pradesh.

Anonymous. 2014a. *EFC to the XII Plan* (2012-2017). ICAR, Krishi Bhavan, New Delhi, p 171.

Anonymous. 2014b. Report of Technical Audit. Seed Division, Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, New Delhi.

Anonymous. 2014c. Statutory Order (S.O.) No. 1919 (E) dated 31.7.2014. The Gazette of India. (http://seednet.gov.in/SeedGO/Index).

Anonymous. 2014d. Sub-mission on Seeds and Planting Material under National Mission on Agricultural Extension and Technology-Operational Guidelines 2014. Department of Agriculture and Co-operation, Ministry of Agriculture, Govt. of India, New Delhi, P 56.

Anonymous. 2015a. Agricultural Statistics at a Glance 2014. Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, New Delhi, p 452.

Anonymous. 2015b. http://seednet.gov.in, 15.06.2015

Anonymous. 2015c. Breeder seed review report 2013-14. 18thBreeder Seed Review Meeting. ICAR Research Complex for NEH Region, Umiam, Meghalaya, p 85.

Anonymous. 2015d. Component details of the Central Sector Scheme 'Development and strengthening of infrastructure facilities for production and distribution of quality seeds'. (agricoop.nic.in / image default /seed / programs and schemes seed.doc), 15.06.2015

Anonymous. 2015e. Agrinnovate India. http://agrinnovateindia.co.in, 16.06.2015

Anonymous. 2015f. http://www.oecd/tad/code/oecdseedschemesrulesandregulations.html, 15.06.2015.

Anonymous. 2015g. National Mission on Agricultural Extension and Technology (NMAET). (*In*) *Annual Report 2014-15,*

Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, New Delhi, pp 178+iv.

Chauhan J S**,** Rajendra Prasad S and Pal Satinder. 2013. Quality seed and productivity enhancement in major crops in India. (*In*) *Current Trends in Plant Biology Research*. Proceedings of National Conference on Plant Physiology. JAU, Junagadh, Gujarat. 13-15 Dec., 2013, pp 160–8.

Chauhan J S**,** Pal Satinder and Rajendra Prasad S. 2014a. Recent trends in breeder seed production of selected food and oilseed crops. (*In*) *7th National Seed Congress, 'Quality Seeds for Successful Agriculture'*, Bhopal, Madhya Pradesh, 25-27, September 2014, pp 103–5.

Chauhan J S, Rajendra Prasad S and Pal Satinder. 2014b. An overview of seed trade and seed research in India. Paper presented in 7th National Seed Congress, 'Quality Seeds for Successful Agriculture', Bhopal, Madhya Pradesh, 25-27, September 2014.

Datta S K, Chauhan J S and Rajendra Prasad S. 2013. Indian seed sector – emerging issues. Paper presented in FAI Annual Seminar-Fertilizer Sector at Crossroads, New Delhi, 11-13, Dec. 2013, p 104.

Hanchinal R R. 2012. An overview of developments in Indian seed sector and future challenges. (*In*) *National Seed Congress on Welfare and economic prosperity of the Indian farmers through seeds*, Raipur, Chhattisgarh, 21-23, Dec. 2012, pp 1–12.

Indian Seed Industry. (www.nuziveeduseeds.com), 15.06.2015

Indian Seed Sector. (http://seednet.gov.in/material/IndianSeed Sector.htm), 15.06.2015

International Seed Federation. (http://www.worldseed.org/isf/seedstatistics.html), 15.06.2015

Kumar S V and Bharat G K. 2014. Perspectives on a water resource policy for India. Discussion Paper. The Energy and Resources Institute (TERI), New Delhi.

Masilamani P and Murugesan P. 2012. ISTA accreditation and strength and weakness of Indian seed testing system. (*In*) *National Seed Congress on Welfare and Economic Prosperity of the Indian Farmers through Seeds*, Raipur, Chhattisgarh, 21-23, Dec. 2012, pp 45–59.

Meerman Jacob. 1997. Reforming agriculture: the World Bank goes to market. A World Bank operations evaluation study. The World Bank. Washington DC, p 179.

National Seeds Corporation Limited (www.indiaseeds.com), 15.06.2015.

Selvaraj S. 2013. Preparation of state seed rolling plan and strategy to tie up seed production with different seed agencies. (*In*) *6th National Seed Congress on Advancement in agriculture through quality seeds,* Lucknow, 12-14, Sept. 2013, pp 37–48.

Singh, Nitesh Kumar. 2013. Potential for Trade in Seeds between India and Other SAARC Countries. CUTS International, Jaipur, India, p 47.

Trivedi R K. 2012. Seed quality regulation and OECD varietal certification for export of seeds. (*In*) *National Seed Congress on Welfare and Economic Prosperity of the Indian Farmers through Seeds*, Raipur, Chhattisgarh, 21-23, Dec. 2012, pp 30–50.

Trivedi R K. 2013. Policy initiatives to facilitate export and import of seeds. (*In*) *6th National Seed Congress on Advancement in agriculture through quality seeds*, Lucknow, 12-14, Sept. 2013, pp 73–6.

Trivedi R K and Gunasekaran M. 2013. Indian minimum seed certification standards. The Central Seed Certification Board, Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, p 569.

Trivedi R K and Gunasekaran M. 2014. Compendium on seed legislations. Seeds Division, Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, New Delhi, p 148.