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# Current Status, Challenges and Future Prospects of Vegetable Seed system in India

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**ABSTRACT**

Vegetable production in India has increased manifolds due to gradual increase in productivity and area under vegetable cultivation over the years, which maintains its $2^{nd}$ ranking in global vegetable production after China. This has led to availability of 357 grams/person/day of vegetables in the country. India has first rank in pea and okra production, while it ranks $2^{nd}$ in tomato, cauliflower, potato, onion and brinjal production. Vegetables are important constituents of agriculture for attaining food and nutritional security. It also has ability to generate on-farm and off-farm employment. An increase in availability, affordability and consumption of nutrient dense vegetables is one of the ways to prevent malnutrition. India is bestowed with huge diversity of vegetables and is the largest contributors (59.20%) of the total horticultural produce in the country in 2017-18. Area under vegetable cultivation is continuously increasing, mainly due to higher productivity, shorter maturity cycle, high value and greater income leading to improved livelihoods. Production of vegetables is touching new records every year, making it the most favoured agricultural commodity by the farmers. Production during 2017-18 was recorded 184 million tons from 10.3 million hectares, whereas it was less than 20 million tons during independence. This manifold increase needs to be sustained to meet the demand of 1.5 billion people by 2030. Seed is the first and foremost important commodity for successful vegetable cultivation. Indian vegetable seed industry is growing enormously. Since independence, government policies liberalized and encouraged seed trade in India. Several private seed firms with multinational base are actively involved in vegetable seed production in India. Vegetable seed industry has positive influence on Indian economy in terms of income and employment generation and earning foreign exchange in international market. There are few constraints like high cost of seed production, technical problems and stringent laws set break to the vegetable seed industry in India.

**KEYWORDS**

India, Vegetable, Seeds, Vegetable Production, Seed Production

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## INTRODUCTION

### Vegetables and Vegetable Seed Scenario in India

India is blessed with diverse agro-climatic zones with distinct seasons, making it possible to grow wide range of vegetables. Vegetables are good source of nutrients, dietary fiber, phyto-chemicals and vitamins. Vegetables with shorter duration, higher productivity have resulted in greater economic returns to farmers. Vegetables are reported to be rich source of carbohydrates (sweet potato, potato, onion, garlic and fenugreek), proteins (leguminous vegetables, leafy vegetables and garlic), Vitamin-A (tomato, carrot, drumstick, leafy vegetables), Vitamin-B (garlic, tomato and peas), Vitamin-C (drumstick leaves, Cole crops, leafy vegetables, green-chillies and leaves of radish), and minerals (leafy vegetables, drumstick pods). Vegetables can be grown year round in India. Most of the vegetables have medicinal properties and are very good source of micronutrients that are useful to persons suffering with several chronic health problems especially heart diseases and diabetes. In addition, it can also contribute for improving soil health and as feed to livestock. Per capita availability of vegetables in India is 357 gm/person/day, which helps in fighting malnutrition. It can also be grown in backyard of the house as a kitchen garden. Apart from nutritional benefits, the production of vegetables improves the economy of a country as these are very good source of income and employment. The contribution of vegetables remains highest 58.70 to 59.20 % in horticulture crop productions over the last five years (Table 1 ).

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**Table 1:** Production share of various Horticulture Crops in the past five years

| **Crops** | **2013-14** | **2014-15** | **2015-16** | **2016-17** | **2017-18** |
|---|---|---|---|---|---|
| Fruits | 32.10 | 30.80 | 31.50 | 30.90 | 31.20 |
| Vegetables | 58.70 | 60.30 | 59.10 | 59.30 | 59.20 |
| Flowers & Aromatics | 1.00 | 1.10 | 1.10 | 1.10 | 1.20 |
| Plantation Crops | 5.90 | 5.50 | 5.80 | 6.00 | 5.80 |
| Spices | 2.10 | 2.20 | 2.40 | 2.70 | 2.60 |
| **Total Horticulture** | **100** | **100** | **100** | **100** | **100** |

**Table 2:** Vegetable seed system in India

| **Crops** | **2015-16** | | **2016-17** | | **2017-18** | |
|---|---|---|---|---|---|---|
| | **Area (in '000 ha )** | **Production (in '000 MT)** | **Area (in '000 ha )** | **Production (in '000 MT)** | **Area (in '000 ha )** | **Production (in '000 MT)** |
| Beans | 232 | 2334 | 198 | 2012 | 228 | 2277 |
| Bitter gourd | 93 | 1046 | 95 | 1030 | 97 | 1137 |
| Bottle gourd | 149 | 2458 | 153 | 2529 | 157 | 2683 |
| Brinjal | 663 | 12515 | 733 | 12510 | 730 | 12801 |
| Cabbage | 394 | 8806 | 395 | 8807 | 399 | 9037 |
| Capsicum | 46 | 288 | 24 | 306 | 24 | 326 |
| Carrot | 82 | 1338 | 86 | 1350 | 97 | 1648 |
| Cauliflower | 426 | 8090 | 454 | 8557 | 453 | 8668 |
| Cucumber | 71 | 1202 | 74 | 1142 | 82 | 1260 |
| Chillies (Green) | 292 | 2955 | 316 | 3634 | 309 | 3592 |
| Elephant Foot Yam | 28 | 733 | 29 | 748 | 30 | 774 |
| Mushroom | 170 | 436 | 182 | 441 | 198 | 487 |
| Okra/Lady finger | 511 | 5849 | 507 | 6003 | 509 | 6095 |
| Onion | 1320 | 20931 | 1306 | 22427 | 1285 | 23262 |
| Pointed gourd | 18 | 264 | 18 | 268 | 20 | 310 |
| Peas | 498 | 4811 | 530 | 5345 | 540 | 5422 |
| Potato | 2117 | 43417 | 2179 | 48605 | 2142 | 51310 |
| Radish | 199 | 2844 | 203 | 2898 | 209 | 3061 |
| Pumpkin | 68 | 1509 | 74 | 1664 | 78 | 1714 |
| Sweet Potato | 126 | 1454 | 128 | 1460 | 131 | 1500 |
| Tapioca | 204 | 4344 | 199 | 4171 | 173 | 4950 |
| Tomato | 774 | 18732 | 797 | 20708 | 789 | 19759 |
| Others | 1625 | 22707 | 1558 | 21557 | 1580 | 22320 |
| **Total Vegetables** | **10106** | **169064** | **10238** | **178172** | **10259** | **184394** |

India has witnessed increase in vegetable production over the last few years (Table 2). Significant progress has been made in area expansion, production and productivity of vegetables (Table 3). Over the last decade, the area under horticulture grew by 2.6% per annum and annual production increased by 4.8%. The production of vegetables has increased from 88.62 Million tons to 184.40 Million Tons since 2001-02 to 2017-18. The leading vegetable producing states in India in 2017-18 are depicted in Table 2 and Figure 1.

In India, the area under cultivation of vegetables is 10.23 million hectares with production of 184.39 million metric tons in 2017-18. Our demand for vegetables will be 225 million tons by 2025, and 350 million tons by 2050. In order to ensure food and nutritional security, there is an urgent need to augment the production of vegetables in India. India's diverse climate ensures availability of all varieties of fresh vegetables. It ranks second in vegetables production in the world, after China. India has first rank in pea (*Pisum sativum*) and okra (*Abelmoscus esculentus*), while it ranks $2^{nd}$ in tomato (*Solanum lycopersicum*), cauliflower (*Brassica oleracea*), potato (*Solanum tuberosum*), onion (*Allium cepa*) and brinjal (*Solanum melongena*) production (Kumar *et al*, 2017).

The need for diversification of horticulture sector was acknowledged by the Government of India in mid-eighties by focusing its attention on investment in this sector. Presently horticulture has established its credibility in improving income through increased productivity, generating employment and in enhancing export earnings. As a result, and consequently horticulture moved from subsistence/rural confines to commercial venture. The Department of Agriculture and Co-operation (DAC) of the Ministry of Agriculture is the nodal department for over viewing horticulture development in the country. It implements different programmes through Departments of Horticulture/Agriculture in all the States and provides the leadership to coordinate activities for the promotion of horticulture (Anonymous, 2018) and (APEDA, 2013).

**Table 3:** Area, Production and Productivity of Vegetable Crops from 1991-92 to 2017-18 in India

| Year | Area (in '000 ha) | Production (in '000 MT) | Productivity (MT/ha) |
|---|---|---|---|
| **1991-92** | 5593 | 58532 | 10.47 |
| **2001-02** | 6156 | 88622 | 14.40 |
| **2002-03** | 6092 | 84815 | 13.92 |
| **2003-04** | 6082 | 88334 | 14.52 |
| **2004-05** | 6744 | 101246 | 15.01 |
| **2005-06** | 7213 | 111399 | 15.44 |
| **2006-07** | 7581 | 114993 | 15.17 |
| **2007-08** | 7848 | 128449 | 16.37 |
| **2008-09** | 7981 | 129077 | 16.17 |
| **2009-10** | 7985 | 133738 | 16.75 |
| **2010-11** | 8495 | 146554 | 17.25 |
| **2011-12** | 8989 | 156325 | 17.39 |
| **2012-13** | 9205 | 162187 | 17.62 |
| **2013-14** | 9396 | 162897 | 17.34 |
| **2014-15** | 9542 | 169478 | 17.76 |
| **2015-16** | 10106 | 169064 | 16.73 |
| **2016-17** | 10238 | 178172 | 17.40 |
| **2017-18** | 10259 | 184394 | 17.97 |

**Table 4:** Production Share of Leading Vegetable Producing States in 2017-18

| S. No. | STATES/UTs | Production (in '000 MT) | % Share |
|---|---|---|---|
| 1 | Uttar Pradesh | 28316.45 | 15.4 |
| 2 | West Bengal | 27695.29 | 15.03 |
| 3 | Madhya Pradesh | 17545.48 | 9.52 |
| 4 | Bihar | 15863.21 | 8.61 |
| 5 | Gujarat | 12254.29 | 6.65 |
| 6 | Maharashtra | 12306.96 | 6.63 |
| 7 | Odisha | 8766.82 | 4.76 |
| 8 | Karnataka | 8394.15 | 4.55 |
| 9 | Haryana | 7151.66 | 3.88 |
| 10 | Chhattisgarh | 7003.25 | 3.8 |
| 11 | Others | 39096.96 | 21.21 |
| **TOTAL** | | **184394.51** | **100** |

Seed is a key component among all inputs for sustainable crop production. It is estimated that quality of seed accounts for

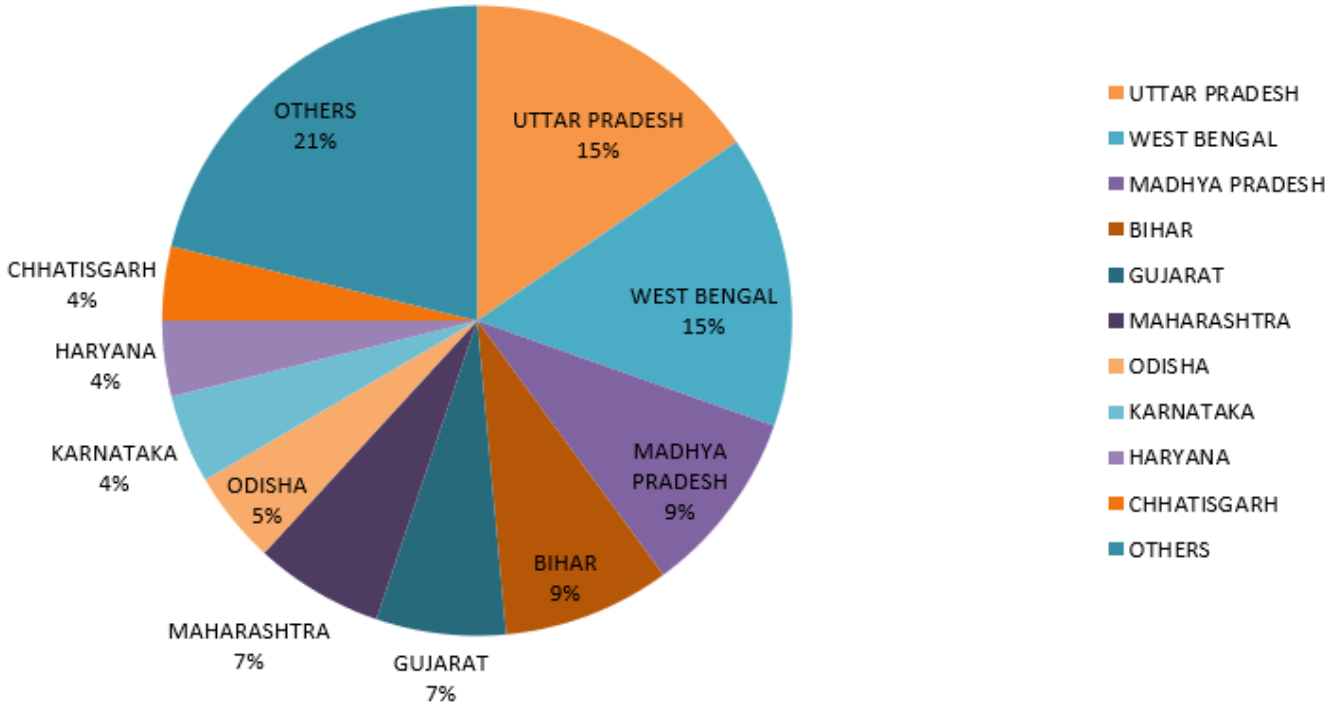


**Fig. 1:** Production & Share of LeadingVegetable Producing States: Graph for 2017-18

20-25% of productivity. The importance of quality seed has been realized by mankind long ago. The need for a good viable seed for prosperity of human race is mentioned in Rigveda of ancient India. It is mentioned in the Primeval Manusmriti as **"Subeejam Sukshetre Jayate Sampadyate"** which literally means **"A good seed in a good field will win and prosper"**. Although there have been few private seed industries dealing with production of vegetable seeds, the growing of crops especially for seeds in an organized fashion to maintain quality in terms of genetic and physical purity is realized for the first time during green revolution period with the establishment of National Seeds Corporation (NSC) in 1963 (Anonymous, 2013; Poonia, 2013). The National Seeds Corporation (NSC) was setup by aiming development of seed industry in India. The principle responsibilities of NSC are establishing an adequate system of quality control inspection for scientific processing, storing and marketing of seeds. Currently there are about 850 seed companies (mostly seed producers) operating in India as of 2014, of which about 50 have capacity in crop breeding research. National Seeds Corporation (NSC) also undertakes the responsibility of multiplication of seed of pre released varieties and production of foundation seed of released varieties. The Seed Replacement Rate (SRR) in vegetable crops has gone from 20 percent in eighties to >90 percent. At present the total Indian traded seed market is Rs. 20,000 crores. Out of this total vegetable seed market including Open Pollinated varieties is Rs. 4000 crores. Out of 110 hybrids released in All India Coordinated Research Project of ICAR Sixty percent are from Private Sector. Indian seed Industry is currently occupying the $5^{th}$position in the world. During the past 5 years the Indian Seed Industry has been growing at a Compound Annual Growth Rate (CAGR) of 12% compared to global growth of 6.7%. Coupled with increasing domestic demand and demand for quality seeds in various foreign countries, mainly the South East Asian countries, seed industry in India is witnessing new paradigms of growth and development. The use of hybrid seeds has silently but consistently witnessed growth along with several other driving factors like increasing middle class and increasing disposable income, growth in the food processing sector, increasing seed replacement ratio and other allied factors. Creating awareness among the farmers related to the benefits of using certified/quality seeds has led to an increase in the demand for seeds over the past few years. This has resulted in an increasing willingness among the farmers to pay higher price for quality seeds. When compared to the global seed production India´s share is very less. India is way behind countries like USA and China in terms of total seed market size. Few mile stone events in seed policy by Government of India are below:

i. The Seeds Act, 1966.
ii. The Seeds Rules, 1968.
iii. National Seeds Project.
iv. New Policy on Seed Development, 1988.
v. Protection of Plant Varieties and Farmers Right Act, 2001.
vi. National Seeds Policy, 2002.
vii. Seed Bill (2004).

**Commercially important vegetable seeds in India :** The Indian public sector seed industry used to dominate over the private sector from the very beginning. Leading category of

seeds in the market in terms of quantity and value had been mostly open-pollinated varieties (OPVs) which are followed by public hybrids and private hybrids (Gadwal, 2003). The situation is quite reversed currently. Seeds of the private hybrids constitute a significant portion of the total vegetable seed market. This is due to the advent of private seed companies with the liberalization of seed trade in 1988. Currently, the public sector is mostly confined to produce certified seeds in high volume, low value segment of high yielding varieties of cereals, pulses and cotton with a limited share in the high value hybrid sectors of cotton and cereals (Mazumdar, 2012). In vegetables most of the public sector varieties and hybrids are replaced by private sector varieties and hybrids, seed production of which is solely done by the particular manufacturers. Corporate seed firms are mainly concentrating on vegetables like tomato, cabbage, brinjal, chilli, okra and cucurbits where the seed production of OPVs and hybrids is comparatively easy and more profitable. Plausible explanation for the moribund state of public sector could be the incapability to generate huge funds on research and development (R&D) compared to private seed companies, and lack of proper advertisement and market for public sector bred varieties and hybrids. Private seed corporations spend 10-12 % of their turnover in R&D. Medium sized seed companies annual investment in R&D is growing 20 % annually (Gadwal, 2003).

**Current demand and supply of vegetable seeds in India**: There is no regular assessment done to assess the demand and supply of vegetable seeds in the country as most of the certified/quality seed of the vegetables is sown by the farmers comes from the private seed sector. But, in case of field crops, a well-developed mechanism exists where every State of the country prepares a Seed Rolling Plan (SRP) based on Seed Replacement Rate (SRR) which is generally kept 33% in case of self-pollinated crops, 50% in case of cross-pollinated crops and 100% in case of hybrids. The Seed Rolling Plan is prepared by State according to the crops sown in different seasons, area under crops and Seed Replacement Rate (SRR). Accordingly, a tentative seed requirement is calculated by different states and provided for compilation to Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, GoI. According to the Seed Rolling Plan targets for seed production is assigned to different seed producing agencies working in the state to meet the requirement of seed. Based on targets the requirement of breeder seed is assessed and indents is place to Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, GoI for compilation and onward submission to Indian Council of Agricultural Research (ICAR) for production of breeder seed. Agriculture being a State subject, the role of the State Government is critical in the production, availability and distribution of seeds. The Government of India supplements the efforts of the State Governments by coordinating seed requirement and availability among the states through Zonal Seed Review Meetings (ZSRM) held before every crop season, weekly video conference and National Campaign meeting of Zaid, Kharif and Rabi seasons. National Seeds Corporation, State Seeds Corporations (SSCs), other National and State level agencies engaged in seed production play an important role in production and availability of certified seeds to the farmers.

**Current vegetable seed production and distribution system in India**

There are two types of seed systems, i.e., informal and formal, prevalent in India (Figure 2). Formal seed system involves a chain of activities leading to clear products. Formal system generally consists of public sector research institutions, public and private sector agencies producing and marketing seeds, and agencies responsible for seed certification and quality control. The guiding principles in the formal system are maintenance of varietal identity, genetic purity and production of seed with optimal physical, physiological and sanitary quality (Reddy *et al*, 2007).

In case of informal system, also known as village or farmer or local seed system, farmers themselves produce, disseminate and access seed directly from their own harvest, through exchange among friends, neighbours and relatives or through local grain markets. The varieties disseminated may be landrace or mixed races and likely to be heterogeneous mixture of different varieties. Both seed systems have their own limitations that need to be addressed through innovative approaches. Before seed sector liberalization in 1988, crop breeding research was primarily done by the institutes of the Indian Council of Agricultural Research (ICAR), such as the Indian Agricultural Research Institute (IARI), and State Agricultural Universities for formal seed sector. Formal seed production was done by the National Seeds Corporation, State Seed Corporations, and a handful of private companies. Informal seed production of open-pollinated varieties by farmers, farmer associations and local companies was the main source of seed supply. Seed sector reform allowed unrestricted import of vegetable seed (subject to tariffs and phytosanitary regulations) and allowed foreign and large domestic companies to enter seed production (Pray *et al*, 2001). The reform led to rapid expansion of private seed production for crops in which hybrid seed production was possible, such as cotton, pearl millet, sorghum, maize and many vegetables (Morris *et al*, 1998; Kolady *et al*, 2012) and slower but steady growth in private seed production of other crops such as rice and wheat (Tripp and Pal, 2001; Spielman *et al*, 2013). For vegetables, the reform led to rapid growth in private sector research and development (R&D). Intellectual property rights protection for new plant varieties introduced in 2001, further boosted private crop breeding research (Kolady *et al*, 2012). Currently there are about 850 seed companies (mostly seed producers) operating in India in 2014, of which about 50 have capacity in crop breeding research (Reddy *et al*, 2014).

Indian seed industry has been growing awfully in quantity and value over the past fifty years. Both public and private sector corporations/companies are actively involved in quality seed production. The public sector component comprises

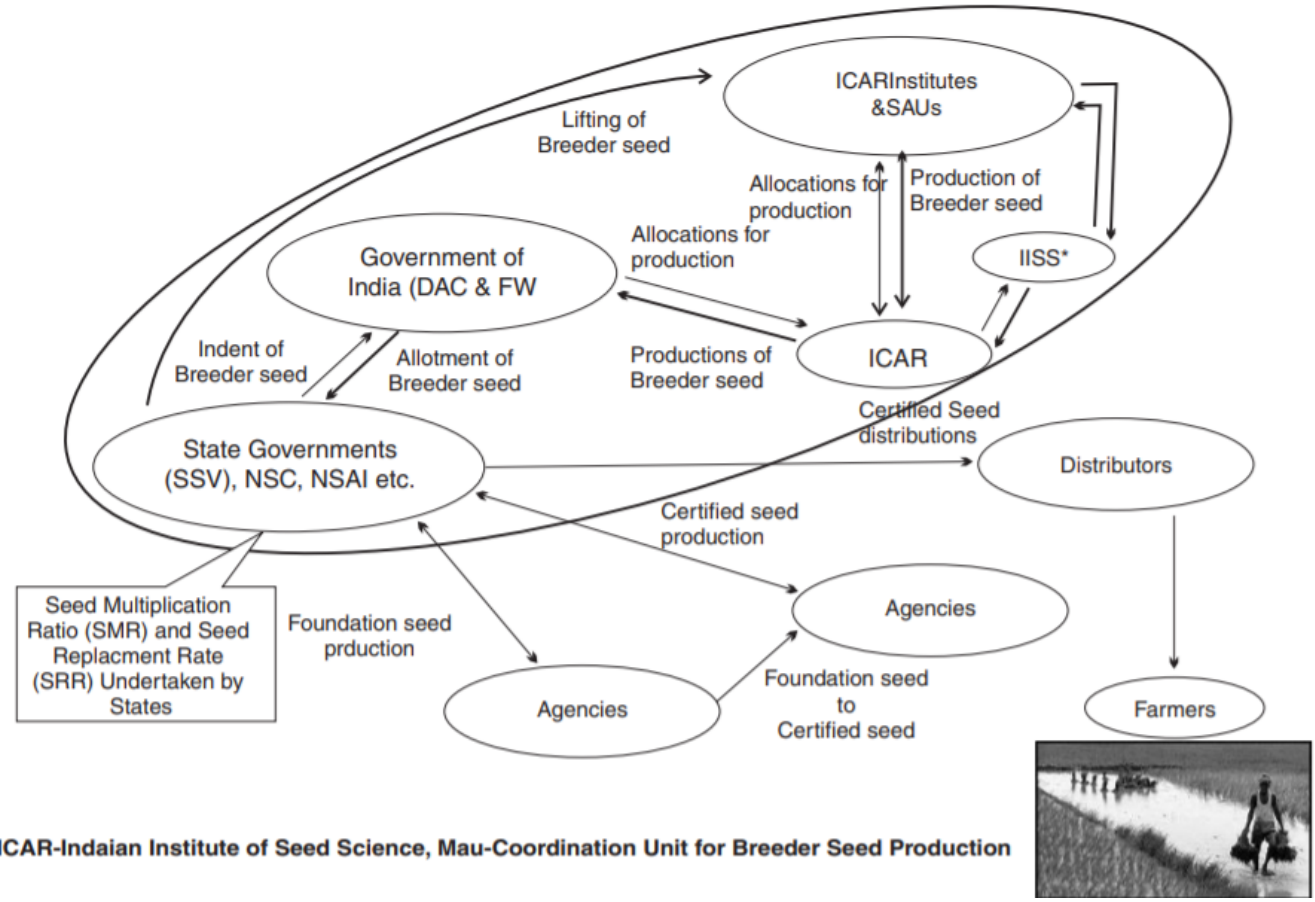


**Fig. 2:** Seed production and supply chain in India (https://seednet.gov.in/Material/Channels_of_Seed_Supply.aspx)

National Seeds Corporation (NSC), 16 State Seeds Corporations (SSCs) (Nandi *et al*, 2013) Indian Council of Agricultural Research (ICAR) institutions and State Agricultural Universities. In view of the importance of vegetables, Indian Council of Agricultural Research (ICAR) established All India Coordinated Research Project on Vegetable Crops (AICRP-VC) in the year 1971 at the Indian Agricultural Research Institute (IARI), New Delhi to plan, coordinate and monitor the research activities on vegetable crops. To give a fillip to vegetable research and to meet the emerging challenges, the status of AICRP-VC was elevated to the Project Directorate of Vegetable Research (PDVR) in 1986. North eastern plain being the major vegetable producing area, the headquarter of PDVR was shifted to Varanasi in 1992. To further boost systematic vegetable research in the country a full-fledged Indian Institute of Vegetable Research (IIVR) was established in 1999 at Varanasi. AICRP-VC was also continued with its headquarter at Indian Institute of Vegetable Research (IIVR) and a chain of AICRP centers located in different agro-climatic regions of the country. ICAR launched an All India Coordinated Research Improvement project (AICRP) on seed production called National Seed Project in 1979 with 14 centers in different Agricultural Universities (Nandi *et al*, 2013). AICRP on production of breeder seed in vegetable crops is started under National Seed Project in 1994. Twenty-five State Seed Certification Agencies and one hundred thirty-two State Seed Testing Laboratories are involved in quality control and certification (Nandi *et al*, 2013). The private sector comprises around 150 seed companies of national and foreign origin. The Indian public sector seed industry used to dominate the private sector in the very beginning. The order of type of seeds dominating the market in terms of quantity and value has been open-pollinated varieties followed by public hybrids and private hybrids (APEDA, 2013). The situation is quite reversed currently. Seeds of the private hybrids are forming a significant portion of the total vegetable seed market.

The Indian seed programme largely adheres to the limited generations' system for seed multiplication in a phased manner. The system recognizes three generations namely breeder, foundation and certified seeds and provides adequate safeguards for quality assurance in the seed multiplication chain to maintain the purity of the variety as it flows from the breeder to the farmer.

**Breeder Seed**: Breeder seed is the progeny of nucleus seed of a variety and is produced by the originating breeder or by a sponsored breeder. Breeder seed production is the mandate of the Indian Council of Agricultural Research (ICAR) and is being undertaken with the help of:

i. ICAR Research Institutions, National Research Centres and All India Coordinated Research Project of different crops;
ii. State Agricultural Universities (SAUs) with 14 centres established in different States;
iii. Sponsored breeders recognized by selected State Seed Corporations, and
iv. Non-Governmental Organizations.

The Indian Council of Agricultural Research (ICAR) also promotes sponsored breeder seed production programme through the National Seeds Corporation (NSC), State Seeds Corporation (SSCs), and Krishi Vigyan Kendras (KVKs). There has been a steady increase in the production of breeder seed over the years.

The indents from various government seeds producing agencies are collected by the State Departments of Agriculture and that of private seed companies by National Seed Association of India (NSAI) and submitted to the Department of Agriculture Cooperation and Farmers Welfare, Ministry of Agriculture Cooperation and Farmers Welfare, Government of India, which in turn compiles the information crop-wise, organizes meeting to finalize the breeder seed indents with representatives of State Department of Agriculture, Central Seed Producing Agencies, National Seed Association of India (NSAI) and Project Coordinator/Project Director of the respective crops. After rigorous deliberation on the indents received between all the stake holders, the finalized indents were sent to Indian Council of Agricultural Research (ICAR) and which in turn forward it to concerned Project Coordinator/Project Director of the respective crops (in ICAR) for final allocation of responsibility to different SAUs/ICAR institutions for production of breeder seed in the crop-specific national workshop. Official allocation orders are then made to various centres as per the facilities and capabilities available at the centres and the availability of nucleus seed of a particular variety. Indents are compiled and forwarded to ICAR at least 15 to18 months in advance. To make the programme systematic and for proper evaluation of the breeder seed production programme monitoring teams have been constituted and reporting proforma have been devised. The monitoring teams consist of breeder of the variety, the concerned Project Director or his nominee, representative of NSC, representative of State Seed Certification agency. The production of breeder seed is reviewed every year by ICAR-DAC in the Annual Seed Review Meeting. The actual production of breeder seed by different centres is intimated to Department of Agriculture and Co-operation (DAC) by Indian Council of Agricultural Research (ICAR). On receipt of information from Indian Council of Agricultural Research (ICAR), the available breeder seed is allocated to all the indenters in an equitable manner. In the case of varieties which are relevant only to a particular State, the indents for breeder seed are placed by the concerned Director of Agriculture with the SAUs/ICAR institutions located in the State. The breeder seed produced is lifted directly by the Director of Agriculture or foundation seed producing agencies authorized by him.

**Foundation Seed**: Foundation seed is the progeny of breeder seed and is required to be produced from breeder seed or from foundation seed which can be clearly traced to breeder seed. The responsibility for production of foundation seed has been entrusted to the National Seeds Corporation (NSC), State Agriculture Departments, State Seeds Corporation, Other Central Seed Producing Agencies and Private Seed Producers, who have the necessary infrastructure facilities. Foundation seed is required to meet the standards of seed certification prescribed in the Indian Minimum Seeds Certification Standards, both at the field and laboratory testing.

**Certified Seed:** Certified seed is the progeny of foundation seed and must meet the standards of seed certification prescribed in the Indian Minimum Seeds Certification Standards, 2013. In case of self- pollinated crops, certified seeds can also be produced from certified seeds provided it does not go beyond three generations from Foundation Seed Stage-I.

**Distribution systems and distributors:** As agriculture is a State subject, production and distribution of certified seeds is primarily the responsibility of the State Governments. Certified seed production is organized through State Seed Corporation, Departmental Agricultural Farms, Cooperatives, private seed companies and other seed producing agencies working in the State. The distribution of seeds is undertaken through a number of channels i.e. agriculture departmental outlets at block and village level, cooperatives, outlets of seed corporations, private dealers etc. The efforts of the State Governments are being supplemented by National Seeds Corporation (NSC) and other Central Seed Producing Agencies which produces certified seed of varieties which are of national importance. These agencies market their seeds through its own marketing network or through dealer network. The production of certified seed by National Seeds Corporation (NSC), different Central Seed Producing Agencies and State Seed Corporations is mainly organized through contract growing arrangements with progressive farmers. National Seeds Corporation (NSC) also undertakes seed production on its own farms. The private sector has also started to play an important role in the supply of quality seeds of vegetables and crops like hybrid maize, sorghum, pearl millet, cotton, castor, sunflower, paddy etc.

**Import-export channels and stakeholders:** The export/import of seeds and planting material in India is governed by the Export and Import (EXIM) Policy 2002-07 and amendments made therein. Restrictions on export of all cultivated varieties of seeds have been removed w.e.f. 01.04.2002, except the following:

i. Breeder or foundation or wild varieties;
ii. Onion, clover cashew, nux vomica, rubber, pepper cuttings, sandalwood, saffron, neem, forestry species and wild ornamental plants;
iii. Export of Niger which is channelized through Tribal Cooperative Marketing Federation of India (TRIFED), National Agricultural Cooperative Marketing Federation of India (NAFED), etc.

iv. Groundnuts, exports of which is subject to compulsory registration of contract with APEDA

The export of these seeds is restricted and is only allowed on case-to-case basis under license issued by Director General Foreign Trade (DGFT) on the basis of the recommendations of Department of Agriculture and Cooperation. The provisions regarding import of seeds and planting material are as under:

i. Import of seeds/tubers/bulbs/cuttings/saplings of vegetables, flowers and fruits is allowed without a license in accordance with import permit granted under Plant Quarantine (Order), 2003 and amendment made therein.

ii. Import of seeds, planting materials and living plants by Indian Council of Agricultural Research (ICAR), etc. is allowed without a licence in accordance with conditions specified by the Ministry of Agriculture.

iii. Import of seeds/tubers of potato, garlic, fennel, coriander, cumin, etc. is allowed in accordance with import permit granted under Plant Quarantine Order, 2003.

iv. Import of seeds of wheat, rye, barley, oat, maize, rice, millet, sorghum, pearl millet, finger millet, other cereals, soybean, groundnut, linseed, palmnut, cotton, castor, sesame, mustard, safflower, clover, jojoba, etc. is allowed without licensing subject to the New Policy on Seed Development, 1988 and in accordance with import permit granted under Plant Quarantine Order, 2003.

The Export and Import Policy (EXIM Policy) reiterates that all imports of seeds and planting material would be regulated under the Plant Quarantine Order, 2003. Import licenses would be granted by Directorate General of Foreign Trade (DGFT) only on the recommendations of DAC. A small quantity of seeds sought to be imported would be given to Indian Council of Agricultural Research (ICAR), or farms accredited by Indian Council of Agricultural Research (ICAR), for trial and evaluation for one crop season. On receipt of applications for commercial import, DAC would consider the trial/evaluation report on the performance of the seed and their resistance to seed/soil borne diseases. Department of Agriculture and Co-operation (DAC) is required to either reject or recommend the application to Directorate General of Foreign Trade (DGFT) for grant of import license within 30 days of receipt. All importers have to make available a small specified quantity of the imported seeds to the Indian Council of Agricultural Research (ICAR) at cost price for testing/accession to the gene bank of National Bureau of Plant Genetic Resources (NBPGR). The import of seeds has to be cleared/rejected by Plant Protection Adviser (PPA) after quarantine checks within three weeks. The rejected consignment has to be destroyed. During quarantine, the imported consignment is kept in a bonded warehouse at the cost of the importer. While importing seeds and plating material, it has to be ensured that there is absolutely no compromise on plant quarantine procedures. Every effort has to be made to prevent the entry of any exotic pests, diseases and weeds that are detrimental to the interests of the farmers of the country.

An Export and Import Committee was constituted in the Seeds Division to deal with application for exports/imports of seeds and planting materials in accordance with the New Policy on Seed Development and Export and Import Regulations. The Committee meets every month, subject to tendency of proposals for import/export of seeds and planting material, and analyzes applications and furnishes recommendations to Plant Protection Adviser (PPA)/Director General Foreign Trade (DGFT) for issuing of otherwise of the license for import/export of seeds and planting material. Exporters/importers are required to submit 20 copies of applications for export/import in the prescribed formats. The minutes of the Export and Import Policy (EXIM Policy) Committee are posted on the Seednet Portal (https://seednet.gov.in/material/IndianSeedSector.htm#Seed%20Export%20/%20Import).

To give a boost to seed export, India has decided to participate in Organization for Economic Co-operation and Development (OECD) Seed Schemes for the following categories of crops:

i. Grasses and legumes,

ii. Crucifers and other oil or fiber species,

iii. Cereals,

iv. Maize and sorghum,

v. Vegetables

Organization for Economic Co-operation and Development (OECD) Seed Schemes is one of the international frameworks available for certification of agricultural seeds moving in international trade. The objective of the Organization for Economic Co-operation and Development (OECD) Seed Schemes is to encourage use of seeds of consistently high quality in participating countries. The Scheme authorizes use of labels and certificates for seed produced and processed for international trade according to agreed principles. The Joint Secretary (Seeds) in the Department of Agriculture & Cooperation has been nominated as the National Designated Authority. Further, Heads of Seed Certification Agencies in Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Rajasthan, Uttaranchal, Uttar Pradesh Haryana, Bihar and Assam have been nominated as the Designated Authorities under the Scheme to undertake certification work under Organization for Economic Co-operation and Development (OECD) Seed Schemes. The department is in the process of completing other formalities under the Organization for Economic Co-operation and Development (OECD) Seed Scheme guidelines before the certification work gets started (https://seednet.gov.in/material/IndianSeedSector.htm#Seed%20Export%20/%20Import).

**PROSPECTS IN VEGETABLE SEED**

**i. Ever Increasing Demand:** The worldwide production of vegetables has doubled over the past quarter century and the value of global trade in vegetables now exceeds that of cereals. India is emerging as the second largest producer of vegetables (17.3 t/ha) after China (22.5 t/ha). In the past two decades, the vegetable production in India has been increased

2.5 times from 58.5 m t in 1991-92 to 146.5 m t in 2010-11 (Koundinya and Kumar, 2014). Increase in yield is mainly attributed to expanding areas under high yielding vegetable varieties and hybrids. Total cultivated area under vegetables has been increased from 5.59 m ha in 1991-92 to 8.49 m ha in 2010-11 (Koundinya and Kumar, 2014). Finally, it leads to ever increasing demand for the quality vegetable seed. Moreover, the yield of crops is higher when produced from and replaced seeds than own saved seeds. Seed replacement rates are high for vegetables like cabbage (100%), tomato (99.3%) compared to other cereals and oil seeds (Mazumdar, 2012). Total quantity of vegetable seeds produced in the country is not sufficient to meet the country's ever-increasing demand. Currently quality seeds are met to the extent of 30-35% only. Framers themselves meet the 60-65% through own saved seeds (Nandi *et al*, 2013). India is still importing the vegetable seeds from other countries major being radish followed by cabbage and pea (Sudha *et al*, 2006).

ii. **Varied Agro- Climatic Conditions:** India has the advantage of assorted agro-climatic conditions ranging from tropical to temperate which make possible the cultivation and seed production of all most all vegetables belonging to different temperature regimes. Seed production of warm season vegetables is possible in Indian plains and Deccan Plateau and seed production of winter vegetables like cabbage, cauliflower, broccoli, beetroot, European carrot and radish is possible in hill stations of Himalayan range. Some winter vegetables like Onion, Asiatic Carrot, Asiatic Radish and tropical cauliflower produce seeds during winter season in North Indian Plains and Solanaceous vegetables, Cucurbits and Legumes set seeds throughout the year under South Indian conditions (Prasad *et al*, 2009).

iii. **Cheap labour availability:** Vegetable seed production particularly hybrid seed production demands much labour. Labour is needed for performing various cultural operations. Though mechanization reduces the human effort up to some extent, high cost fuel and energy limitations reduce full scale mechanization. Moreover, emasculation and pollination steps during hybrid seed production of vegetables solely depend on human labour (Sharma, 2011). Smaller flower structure of some vegetables need more devotion of time and reduces human efficiency. These operations require specially trained and skilled labour. India is ranked second in hand pollinated vegetable seed production in Asia next to China (Hazra *et al*, 2005). Average number of man-days per acre required for hybrid seed production of various vegetables as follows: Tomato-480; Chilli-1800; Okra-180; Brinjal-600; Cucurbits -150 to 450 (Gadwal, 2003). India is having huge human resources availing at reasonably cheaper rates (Prasad *et al*, 2009). This is attracting various corporate sectors of national and international origin to invest in seed business in India.

**iv.Vast Domestic and International mark et:** Due to high profits in vegetable cultivation area under vegetable cultivation is expanding enormously year by year. This creates huge demand for vegetable seed in the market. Requirement of vegetable seed is increasing annually. Requirement of the seed of open pollinated varieties is increased to 48000 tonnes in 2005 from 30550 tonnes in 2001-02 and the requirement of hybrid vegetable seed is increased from 346.2 tonnes in 2001-02 to 994 tonnes in 2005 (Gadwal, 2003). This must have further increased due to increase in area to 8.49 mha in 2010-11. Now a day, hybrids are replacing the Open Pollinated Varieties (OPV) largely due to higher yield, uniformity and their improved quality, for instance, India is second largest user of hybrid tomato seed after USA (Hazra *et al*, 2005). Vegetable seed exports consist of 70% of total seed exports (Hazra *et al*, 2005). Vegetable seeds of either Open Pollinated Varieties (OPV) or hybrids from India are having cosmic demand in foreign countries like Pakistan, Bangladesh and Saudi Arabia.

**ISSUES AND CHALLENGES**

**i. High Cost and Vague Market Demand:** Vegetable seeds are highly expensive especially hybrid seeds due to involvement of more labour and other inputs (Sudha *et al*, 2006). Small and marginal farmers cannot afford the high cost of vegetable seeds. Moreover, farmers have to purchase the hybrid seeds (F1 generation) every time, as the seeds harvested from the previous season (F1) get altered in their genetic constitution due to segregation and recombination in F2 generation. The demand for vegetable seeds in the market is vague. Unlike cereal seeds, excess cannot be used for human consumption. Hence, surplus production of vegetable seeds will lead to huge economic loss (Sharma, 2011).

**ii.Perishable Nature of Seed :** Seed is a living entity and a biological product unlike fertilizers and chemicals manufactured in factories. So, it is subjected to death depending upon its genetic potentiality to remain viable and storage conditions (Sharma, 2011). Storage for longer period shows negative effect on given germination percentage and optimum crop stand and specified yield. Sometimes seeds may attain expiry time within storage or transport due to delay in marketing and performing long formalities to export. Unlike cereals, vegetable seeds are not the edible portions in majority of vegetables (Sharma, 2011). Even in cereals also seeds are not intended for consumption as they are treated with poison i.e., fungicide.

**iii.Problems linked with contract farming :** Seed production by multinational companies in developed countries is carried out in their own fields. But, in India seed production is being done in farmers' fields through contract farming. Besides giving credit benefit to the farmers, it adversely affects the quality of the seed (Mazumdar, 2012). Most of the Indian farmers are small and marginal and they may not be having scientific and technical knowledge on floral biology pollination mechanism, isolation distance, rouging etc. which plays a major role in quality seed production. Moreover, seed production is distributed over large areas. These not only result in the lack of uniformity in the seeds but also lead to contamination (Mazumdar, 2012).

**iv.Climate, Pest and Disease related problems :** Seed production is a seasonal activity. Seed crops are grown in open conditions which are subjected to environmental extremes. High or low temperature and heavy or low rainfall leads to huge losses through crop failure. Moreover, flowering in most of the vegetables like tomato, okra, cucurbits and some temperate vegetables is temperature sensitive. Under climate change scenario flowering and pollination of these vegetables is going to be hampered (Koundinya and Kumar, 2014). Generally, seed production is done over larger area with same variety to avoid contamination, but it is favorable for outbreak of pest and diseases epidemics. Insect borers like Helicoverpa, Leucinodes and Eariesand diseases like purple blotch in onion, powdery mildew in cucurbits and bacterial and fungal wilts and rots can cause complete failure of the crop (Hazra *et al*, 2005). Management of these pest and diseases again increases the cost of production.

**v.Stringent seed policies and laws :** Varietal notification and registration are compulsory and is a time taking system. Seed certification is another important time-consuming task, though truthfully labeled seeds do not need of certification (Sharma, 2011). Varietal registration demands these details. Though Protection of Plant Varieties and Farmers' Rights Act, 2001protects the rights of these firms by preventing the reproduction of branded seed by farmers, it allows the researchers to conduct research except using these varieties as parents in hybridization programme without prior permission from originating plant breeder or institution. Export and Import regulations are still cumbersome (Verma, 2008). Pricing policy of vegetable seeds is ambiguous and does not provide the means to predict the market demand pricing in the ensuing season (Sharma, 2011). Arbitrary prices lead to cost-cutting even in critical processes which could affect seed quality adversely (Verma, 2008).

**vi.Climate Resilient Seed Production :** The reproduction success in plants is determined largely by the environmental conditions prevailing during the growing season. Among the various environmental factors, moisture and temperature have direct influence on reproduction. Early reproductive processes like pollen viability, stigma receptivity, anthesis, pollination, fertilization, and early embryo development are all highly prone to moisture and/ or temperature stresses. Failure of any of these processes increases early embryo abortion, leading to poor seed set, thus limiting the seed yield. The physiological mechanisms of reproductive failure under stress are not well understood. Hence, considerable efforts should be made to study the effect of climate change on seed production of various crops to develop suitable crop management technologies and mitigate the adverse effects on the reproductive phase.

**vii. Disruptive climate vis-à-vis climate change**: Seed production chain, which involves several stakeholders, primarily the Departments of Agriculture of different States, State and National Seed Corporations, farmer producer organizations and private sector needs to be strengthened for efficient conversion of breeder seed into downstream classes to achieve higher output. In recent years, the climate changes had adversely affected agricultural production in the country and the seed production programme is not an exception. Therefore, there is an urgent need to identify alternate areas or new niches in non-traditional season/areas for compensatory seed production. Unemployed youths can be trained in the field of seed quality assurance and with financial support and seed quality assurance laboratories, "seed clinic" may be established in major seed growing areas. Seed quality comprises several parameters, viz. physical and genetic purity of seeds, seed germination, viability, vigour, seed health and appearance like size, shape, weight and colour. Each of these parameters depends on climatic variables prevailing during the crop growth period and subsequent seed processing. If climatic factors are adverse during crop growth, the resultant poor-quality seeds fetch lower market value and causes economic loss to the farmers (Maity and Pramanik, 2013).

**viii.Inconsistency in standard operating protocols in seed testing vis-à-vis International Seed Testing Association (ISTA) rules:** International Seed Testing Association (ISTA) produces internationally agreed rules for seed sampling and testing, accredits laboratories, promotes research, provides international seed analysis certificates and disseminates knowledge in seed science and technology. This ensures seed quality and facilitates national and international seed trade, and also contributes to food security. International Seed Testing Association (ISTA) provides testing services for companies trading seed internationally. North American countries follow the Association of Official Seed Analysts (AOSA) rules, especially adapted for their market which, however, differs only in minor aspects from that of the International Seed Testing Association (ISTA). International Seed Testing Association (ISTA) and the Association of Official Seed Analysts (AOSA) have a joint committee on the harmonization of rules. The Organization for Economic Co-operation and Development (OECD) Seed Schemes provide a system for the assurance of varietal purity and identity for international seed trade, and are normally used in conjunction with International Seed Testing Association (ISTA) seed lot certificates, which also carry the results of other quality tests. There are certain disparities between seed testing methods in India and International Seed Testing Association (ISTA).

**ix.Indian Minimum Seed Certification Standards (IMSCS), 2013 vis-à-vis Organization for Economic Co-operation and Development (OECD) seed schemes:** The Organization for Economic Co-operation and Development (OECD) Seed Schemes provide an international framework for the seed certification with an aim of facilitating the seed trade by reducing technical barriers. Rapidly growing seed trade, regulatory requirements in some countries, development of off-season production, the large breeding and production potential of exporting countries were the compelling factors for the establishment of seed scheme (Cortes, 2009). The purpose of these schemes is to encourage the use of "quality-guaranteed" seed in participating countries (Trivedi, 2012). The schemes authorize the use of labels and certificates for seed produced and

processed for international trade according to agreed principles. They are based on two key criteria: varietal identity and purity. There are seven distinct and independent seed schemes and admission to each scheme is voluntary. Presently, India participates in five schemes namely, cereal, maize and sorghum, vegetable, grass and legume and crucifer and other oil or fiber species (Trivedi and Gunasekaran, 2015). The IMSCS have been developed and adopted in 1988 and updated in 2013 to cater the needs of domestic seed certification system (Santhy *et al*, 2009) and (Trivedi and Gunasekaran, 2013) whereas Organization for Economic Co-operation and Development (OECD) seed certification are mainly meant to satisfy the needs of 59 member countries to meet the international seed standards and trade. Indian Minimum Seed Certification Standards (IMSCS) also satisfy many requirements of Organization for Economic Co-operation and Development (OECD) rules and directions for field inspection to ensure varietal identity and purity. A seed crop when offers for Organization for Economic Co-operation and Development (OECD) certification, then Organization for Economic Co-operation and Development (OECD) rules and directions will be applied for field inspection and this process is well monitored through a comprehensive system of checks and balances. There exist wide differences in the modus operandi and standards in the two systems. In India, there are five recognized classes of seed while in Organization for Economic Co-operation and Development (OECD) scheme, there are six classes including two sub-classes within certified seed. The nucleus, breeder and foundation seed in Indian Minimum Seed Certification Standards (IMSCS) are equivalent to breeder's maintenance material, pre-basic and basic seed, respectively, of Organization for Economic Co-operation and Development (OECD) seed schemes. In India, varieties notified under Seeds Act 1966 will only qualify for seed certification but in Organization for Economic Co-operation and Development (OECD) schemes, varieties included in the national list after checking against Distinctness, Uniformity and Stability (DUS) characters or acceptable for Value for Cultivation and Use (VCU) in at least one country also qualify for certification.

**RECOMMENDATIONS OF SYSTEM DEVELOPMENT**

**i.** In general, globally, the seed trade is one of the most regulated sectors, with a plethora of seed laws, testing and certification procedures (Singh *et al*, 2008). The simplification and harmonization of testing and certification procedures helps to improve farmers' access to high-quality seed across the world. In Indian system, certification is carried out by a team consisting of officials from public sector organizations only at foundation and certified seed production stage while in Organization for Economic Co-operation and Development (OECD) scheme, non-official inspectors are allowed for certification (Trivedi, 2013). Further, it also allows non-official laboratories for seed analysis, while under Seeds Act 1966 it is carried out only by notified seed testing laboratories. Apart from other differences, in general, as well as crop specific standards, the major difference between Indian Minimum Seed Certification Standards (IMSCS), 2013 and Organization for Economic Co-operation and Development (OECD) seed scheme is the involvement of non-official inspectors, laboratories and designated authority for seed sampling, seed analysis and issuance of certificates. In India, 10 State Seed Certification Agencies covering all the regions of the country were nominated as Designated Agencies to carry out the varietal certification of the Organization for Economic Co-operation and Development (OECD) Seed Scheme (Trivedi, 2012).

**ii.** Introduce Bar/QR code is desirable for traceability of breeder seed source in multiplication chain for quality seed production. Development of variety specific molecular markers to enable rapid genetic purity testing, management of nucleus seed and its maintenance to either replace or supplement grow out test and a network on developing national database of crop varietal DNA profile (finger-printing) should be created to facilitate quality breeder seed production is foremost.

**iii.** Seed production chain, which involves several stakeholders, primarily the Departments of Agriculture of different States, State and National Seed Corporations, farmer producer organizations and private sector needs to be strengthened for efficient conversion of breeder seed into downstream classes to achieve higher output. In recent years, the climate changes had adversely affected agricultural production in the country and the seed production programme is not an exception. Therefore, there is an urgent need to identify alternate areas or new niches in non-traditional season/areas for compensatory seed production. Institution of 'National Seed Grid' and identification of provenances for off-season seed production will help in meeting the seed requirement and mitigating effects of climatic vagaries, along-with formulation of sustainable seed plan for contingency under natural calamities. Unemployed youths can be trained in the field of seed quality assurance and with financial support and seed quality assurance laboratories, "seed clinic" may be established in major seed growing areas.

**iv.** Development of seed quality testing laboratories and strengthening them into seed quality assurance hubs will play an important role for energizing the quality seed production in the country. Besides state-of-art infrastructure, these laboratories should be staffed with qualified and well trained personnel. There is also need for regular updating the handbook on seed testing with all details like infrastructure needs such as construction, equipment, testing protocols/methods and stewardship in seed quality assurance. International Seed Testing Association (ISTA) accredited laboratories are authorized to issue orange and blue international seed analysis certificate which is indispensable for global seed trade. Seed testing laboratories in India should be motivated to participate in proficiency testing to assess competency. A number of laboratories issuing ISTA's International Seed Analysis Certificates, which can be seen as a passport for international seed trade can serve as a promoter for seed industry (Masilamani and Murugesan, 2012). As of now, 134 Seed

Testing Laboratories from 60 countries are accredited to International Seed Testing Association, which includes six laboratories from India (Chauhan *et al*, 2016) Building capacity and establishment of more v accredited laboratories for seed quality assurance will create an enabling environment for seed export.

**v.** Development of seed-post-harvest technologies through dry chain concept needs special attention in order to assure long-term seed vigor and viability. Establishing crop-wise advisory body/referral lab for implementation of quality control system and India, being one of the predominant players in South Asian Association for Regional Cooperation (SAARC) seed market, it should also explore feasibility of quality seed production of common varieties in other South Asian Association for Regional Cooperation (SAARC) countries.

**vi.** In conclusion, strengthening the quality seed production chain in the era of climatic vagaries through off-season seed production and harnessing the inherent potential of rice fallow cropping systems especially for pulse and oilseed crops can usher the much awaited second green revolution.

**vii.** Indian Minimum Seed Certification Standards (IMSCS) standards were developed and adopted since 1974 to cater the needs of various stakeholders of Indian seed industry, whereas Organization for Economic Co-operation and Development (OECD) seed scheme seed schemes and International Seed Testing Association (ISTA) standards are developed per se for promoting global seed business. As these are two different streams, certain variations in varietal certification procedures and standards exist, which needs to be addressed appropriately to open the Indian seed industry to global market. There are two options Indian Minimum Seed Certification Standards (IMSCS), Organization for Economic Co-operation and Development (OECD) and International Seed Testing Association (ISTA) standards be harmonized to facilitate seed trade or Organization for Economic Co-operation and Development (OECD) Rules and Guidelines applicable only whenever, a variety is being registered/offered for the Organization for Economic Co-operation and Development (OECD) Seed Schemes and International varietal certification process has to be carried out. India being a participant since 2008 of Organization for Economic Co-operation and Development (OECD) seed schemes; harmonizing seed standards, seed testing and establishment of International Seed Testing Association (ISTA) accredited seed testing laboratories seems to be appropriate to globalize fast emerging Indian seed market.

## CONCLUSION

It can be concluded that vegetable seed business will ever have huge scope to success and will play an important role in economy in countries like India where the occupation of majority of the people is agriculture. There is a greater need to make available quality seeds to the farmers in time and in sufficient quantity at reasonable prices. Seed laws are to be implemented strictly to ensure supply of quality seeds and to protect the farmers from spurious seeds. Policy making and implementations shall be based on the need of the hour and should be harmonized with the need of the farmers and country. Strengthening of public sector in R&D is needed to compete with private seed companies so as to provide good quality seeds to the farmers at cheaper rates. The collaboration of both public and private sector may obviously help in quality vegetable seed production in India. There should be exchange of germplasm and other inputs between public and private sectors. The mammoth seed companies may not be interested in such deals as these companies are having established R&D wings and their own technical staff. But, nascent seed firms with moderate level of establishment and technical staff may find better option by such covenant. Like many other countries, India has invested considerable resources in public sector agricultural research. Within this framework, the focus has been in generating, testing and diffusing relevant technologies. The public sector driven picture of agricultural research has, however, been changing. Because of new technologies and stronger intellectual property rights, innovators can now appropriate a significant enough share of the gains from research. This has transformed the seed industry as the private sector has grown to be a sizeable presence in many crops. As the payoff to research and higher agricultural productivity is high in developing countries, the investment of private capital in agricultural research will also contributes in economic development.

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