**Innovative approaches to break yield barrier in oilseeds and improved strategies in quality seed supply**

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Indian oil economy, being the world’s fourth largest economy after USA, China, Brazil, is based from an area of about 260 lakh ha, under highly risk prone rainfed areas, accounting to 72% of cropped area. Oilseeds account for 13% of gross cropped area, 3% of Gross National Product (GNP) and 10% value of all agricultural commodities (NMOOP, 2014). Despite a gradual decrease in annual growth rates of area and production, the productivity enhanced even in post Technology Mission on Oilseeds (Anonymous, 2015). Favorable weather conditions and supportive government policies during 2013-14 led to highest production of 328.77 lakh tonnes of oilseeds with a productivity level of 1153 kg/ha (NMOOP, 2014). Among the nine oilseeds, soybean (39%), groundnut (26%), Rapeseed & Mustard (24%) contribute >88% of total oilseed production in the country while mustard, soybean and groundnut contribute >31%, 26% and 25% of vegetable oil production (Table 1).

**Table 1 Area, production and productivity of major oilseed crops (2009 to 2014)**

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| --- | --- | --- | --- | --- | --- |
| Crop | Area  (lakh ha) | Production  (lakh tonnes) | Productivity  (kg/ha) | Seed multiplication ratio (SMR) | Seed replacement rate (SRR) % |
| Groundnut | 53.78 | 70.05 | 1302 | 1 : 8 | 18 |
| Soybean | 104.98 | 123.14 | 1173 | 1 :16 | 49 |
| Rapeseed-Mustard | 62.84 | 74.76 | 1190 | 1: 100 | 36 |
| Sunflower | 9.30 | 6.22 | 669 | 1:50 | 100 |
| Safflower | 2.26 | 1.39 | 618 | 1: 60 | 15 |
| Castor | 10.80 | 16.61 | 1537 | 1: 60 | 50 |
| Sesame | 18.53 | 7.30 | 394 | 1:250 | 20 |
| Linseed | 3.21 | 1.49 | 464 | 1:50 | 1 |
| Niger | 3.38 | 0.99 | 294 |  | <1 |
| Total oilseeds | 269.09 | 302.08 | 1123 |  |  |

In order to match the oil requirement of the nation, oilseeds production need to be doubled in the next five years. Hence the above production and productivity need special attention to reduce the import bill. An attempt has been made in the present paper to address the key research issues particularly relating to seed.

Seed, the basic input in agriculture, has more value when good quality seed is available at the right time in right quality and quantity. Farmers rely mainly on two types of seed systems-formal seed system and informal system or informal or traditional or farmers seed system. The paper is mainly aimed to pinpoint the gaps in quality seed production with an emphasis on researchable issues and policy implications for improving the quality seed production in oilseed crops.

**Groundnut:** A highly self-pollinated crop and production is mostly confined to Asia and Africa. Asia accounts for about 50% of area and 60% of world production of groundnut while India has largest share (>20%) of area, followed by China (>18%). But China accounts for 37% of total groundnut production while India ranks fourth in productivity (1750 kg/ha). Six states account for about 90% of the total groundnut area while AP and Gujarat contribute >55% of the total area and production of groundnut in the country. A large gap of 36% over world average (1780 kg/ha) and 277% over highest yield of USA (4496 kg/ha) indicate the scope for further yield enhancement.

A large number of varieties (>150) have been released after inception of AICRP for different agro-ecological situations. Among them few old varieties like TMV-2, TMV-7, GG-11, Chitra Kaushal, SV-xi, JL-24, AK-12-24, K-6, Co-2, Polachi-1, GAUG-10 and new varieties like TG37-A, GPBD-4, Narayani, ICGV-91114, TPG-41, TG-38, VRI-6 are cultivated in large scale.

The total requirement of certified groundnut seed is 84 lakh quintals to cover an area of 52.64 lakh ha and only 17.83 lakh quintals of certified seed was used by farmers indicating a very low SRR at national level (NMOOP, 20014). SRR is less than 20% at national level. Among the few groundnut varieties under cultivation, TMV-2 which is released in 1975 still holds largest share (>30%) in supply of certified seeds of groundnut. Low seed replacement and non-adoption of high yielding varieties are the two major issues of concern in quality seed supply of groundnut.

**Soybean:** Aself-pollinated, leguminous crop is cultivated across the continents except Europe and Australia. India along with USA, Brazil, Argentina and China contribute 90% of total soybean production in the world. It is now cultivated in several states with an average rainfall of 750-900 mm and replaced millets, upland paddy and cotton. India has an average yield of 1168 kg/ha against the world average of 2436 kg/ha (2014). Higher productivity in other countries is mainly due to high organic matter in the soils and longer crop duration. A yield gap of 24-61% over highest (1510 kg/ha) and 32-76 % over state average yield (1367 kg/ha) is mainly due to lack of adoption of improved technologies.

After inception of AICRP, more than 100 varieties of soybean were released. Among them, JS-335, JS-93-05, JS 95-60, JS 97-52, MAUS-71, PS 1042 are popular. Seed replacement rate of 48.59% with a supply of 36.48 lakh qtl certified seed as against the total requirement of 75.82 lakh quintal seed of soybean for a total area of 101.09 l ha during 2011-12. Seed supply position indicates variety JS-335 has >80% share in certified seed supply of soybean. Availability and adoption of high yielding varieties in soybean are the two major issues of seed production.

**Sesame:** Though a self-pollinated crop, sesame is often cross pollinated due to insects. It is largely a kharif crop in arid and semi-arid tropics, rabi-summer crop in cooler areas. Among the four major sesame countries *viz*., India, Myanmar, Sudan, China, India has the largest area but China has highest yield. Sesame is cultivated throughout the year in one or other part of the country and in more than one season in a region. It is cultivated in an area of >17 lakh ha with a production of > 7 lakh tonnes and productivity of 413 kg/ha during the last three years. Maximum sesame production (>85%) comes from West Bengal, Madhya Pradesh, Rajasthan, Uttar Pradesh, Gujarat and AP. Among them, West Bengal has highest productivity (939 k/ha) which is still lower than that of China (1234 kg/ha). Average yield gap, as per FLD is 84% over national average yield and 58-209% over state average yield.

Around 70 varieties were released since establishment of PC unit at Jabalpur which are very highly location specific and suitable for different agro-ecological situations. Farmer’s preference is mainly for location specific varieties and seed color-white, black and brown seeds. Following are the major issues hampering the quality seed supply in sesame.

* Availability of quality seed is a major problem in sesame leading to low SRR of about 20%.
* Often cross pollinated nature, especially with honey bees, leading to pollen contamination and occurrence of off-types in seed production plots of varieties
* Low seed yield even in seed production plots. It is highly sensitive crop and cannot tolerate both drought and waterlogging.
* Standard agronomic practices with good plant protection measures to control phyllody, antigastra, capsule borer, Alternaria and bacterial leaf spot, powdery mildew need to be followed to fully exploit genotype potential.
* Maintenance of genetically pure nucleus and breeder seed is the key issue as distinct characteristics need to be clearly established.

**Sunflower:** Sunflower, a highly cross pollinated, photo and thermo insensitive crop is grown in all the seasons and across the country. It is grown in an area of >25 m.ha in >70 countries with an average yield of 1611 kg/ha. China, France, Turkey yield on an average >2 tonnes/ha while Kazakistan, Myanmar and India yield < 1 tonne per ha.

Though an introduced crop, sunflower gained an instant popularity due to its several positive features like wide adaptability, suitable for inter-cropping, short duration crop, fits well as a contingency crop, even under rice fallows. Major advantage of sunflower is the availability of high yielding hybrids with standard seed production technology and higher market demand for sunflower oil.

A large number of hybrids, composite varieties of hybrids were developed both by public and private sector. Among the public sector bred genotypes, hybrids like KBSH-41, 42, 44,DRSH-1 and varieties like DRSF-108, DRSF-113 compete with the private seed sector hybrids.

* More than 90% area of sunflower is under hybrid cultivation and SRR is 100 % as seed is replaced every year.
* In case of varieties/ composites also, seed has to be replaced every year as sunflower is a highly cross pollinated crop. Farmers also use farm saved seed, based on mass selection in case of composite varieties.
* Seed setting and filling is a major agronomic problem that hampers seed production in large scale. Even under good management conditions, seed filling is up to 75% due to both genetic and environmental factors.
  + Seed filling is high in rabi/summer than kharif season
  + Application of boron at ray floret stage to improve seed set, filling percent, test weight, yield and quality
  + Availability of pollinators *viz*., honey bees increase seed setting and seed yield.

**Researchable gaps**

* Breakthrough in yield barrier of the existing hybrids especially with public sector hybrids is crucial.
* Creation of genetic diversity in parental lines
* Though public sector hybrids are comparable with private sector hybrids, marketing and large scale seed production of parental lines-A, B and R is a cumbersome process. Licensing of parental lines is a good option to be explored.

**Safflower:** A day-neutral plant but thermo-sensitive crop, safflower is mostly cultivated in rabi season. Among more than 20 safflower growing countries, India has the largest area but lowest yield. Two states-Karnataka and Maharashtra contribute >90% of safflower production. The area under safflower is declining over the few years due to labor shortage and non-preference especially due to the spiny nature of the crop. Scope for new/nontraditional areas in rice fallows of several states can be explored due to its hardy nature under rainfed conditions.

Safflower is predominantly self-pollinated but often cross pollinated in the presence of honey bees. Both high yielding varieties and hybrids are developed unlike other often cross pollinated oilseed crop like sesame. Among 12 varieties/hybrids developed after 2001, JSF-97, hybrid NARI-NH-1 are non-spiny. Varieties like PBNS-12, A2, Bhima, Sharada, AKS-207, JSF-99, JSF-1, JSI-73 and hybrid NARI-H-15 are in seed chain.

Often cross pollinated nature, especially with honey bees, will lead to pollen contamination and occurrence of off-types in seed production plots of both varieties and parental lines of hybrids

**Researchable issues**

* Development of CMS based hybrids by resolving seed production issues and varieties with high seed yield and oil content (35 to 38%)
* Early maturing and non-spiny varieties for rice fallows
* Popularization of best agronomic practices with IPM/IDM modules

**Castor:** India has the largest area (10 lakh ha) and highest productivity (1689 kg/ha) of castor in the world. It is cultivated both under irrigated and rainfed conditions. Highest productivity (2061 kg/ha) in Gujarat is achieved due to intensive cultivation of high yielding hybrids under high input conditions. Productivity levels in states like Telangana, Karnataka, Tamil Nadu is low (500-700 kg/ha) due to low input cultivation, low productive varieties under rainfed conditions.

**Success story of castor hybrids**

* Castor, a unique cross pollinated crop with polymorphic sex expression is the best example for commercial exploitation of heterosis.
* Two line system of hybrid seed production is standardized based on the environmental sensitive nature of the pistillate lines (Lavanya and Varaprasad, 2012).
* More than 70% of castor growing areas is under hybrid cultivation with an SRR of 100 %.
* Among the 15 public sector hybrids released so far, GCH-4, GCH-5, GCH-7, DCH-177, DCH-519, PCH-111 are in the seed chain. Among them GCH-4 and GCH-7 occupy 50-70 % of the area under castor cultivation.
* GCH-7, is the most popular hybrid in Gujarat. A unique examples is set by seed production of this public bred hybrid to the tune of 20,000 quintals by over 45 private seed companies.
* Research efforts under AICRP system led to the development of stable pistillate lines like VP-1, SKP-84, DPC-9, M-574 and commercially exploited by private companies also either through licensing of parental lines or linkages between public vs private sector.
* In about 30% of castor area, open pollinated varieties (OPVs) are cultivated where the SRR is low; 28-30%. Among 19 OPVs released, Kranthi, Haritha, Jyothi, GC-3, 48-1, DCS-107 are cultivated in southern states. The variety Aruna, thermal mutant of HC-6, is another successful example of mutation breeding during early 1970s.

**Researchable issues**

* Development of medium / late duration (120-150 DAS), high yielding (2 -3 t /ha), wilt, leafhopper resistant hybrids suitable for irrigated conditions in Gujarat, Rajasthan, Haryana, UP
* Development of early to medium duration (90-120 days), high yielding (1-2 t/ha), wilt and Botrytis resistant OPVs/ hybrids for rainfed conditions of Telangana, AP, Karnataka, TN, Odisha
* Development of high yielding (1-2 t/ha), wilt and leafhopper resistant, early duration hybrids (90 days to first picking) suitable for rabi season and high density planting

**Improved strategies to enhance quality seed supply:** Major problems identified in quality seed supply of oilseed crops

* Low seed replacement rates
* Access to quality seed

**Low seed replacement rates (SRR):** Ideally seed should be replaced every year for hybrids and every three to four years for OPVs. However, in practice seed is replaced less often especially in case of open pollinated crops. As a consequence, seed replacement rates are lower than recommended for different crop varieties. Seed replacement / use of improved seed by farmers is governed by many factors such as rain fall situation / availability of water, per unit return from the crop, availability of quality seed, awareness about the benefit of seed replacement and above all, the economic status of farmers. The following strategies will enhance the low level of SRR especially in both self and often cross pollinated crops like groundnut, sesame, and safflower.

**Adequate availability of breeder seeds of desired varieties through SAUs & other ICAR institutions:** Breeder seeds indents (crop/variety wise) are submitted in advance to the Govt. of India for organizing production programmes through ICAR Institutions, SAUs, etc. Measures to ensure the full conversion of breeder seed (lifted) in to foundation seed during the same year and full utilization of foundation seed for production of certified seed by seed certification agencies are not built in the system. Mechanisms to ensure utilization of excess foundation seed produced by providing foundation seed to other seed producing agencies including private seed sector and organizing certified seed production programme on Public private partnership (PPP) / MoU basis under supervision of State seed certification agencies (SSCA). Seed thus produced, may be shared between SSCA & participating agency. Seed certification agencies play a greater role to convert foundation seed to Certified seed with desired seed multiplication rate (SMR). Technological back up to the seed producing farmers and stage wise monitoring of seed production programs i.e from sowing to packing is very crucial.

* Identification of villages (crop wise) as per seed village scheme approach.
* Identification of potential seed producers – crop wise.
* Capacity building of seed producers with the technical support of SAU/ICAR institutes (Training - orientation towards seed production, technical literature etc)
* Plan for field inspection & seed certification.
* Strengthening of seed processing / storage infrastructure facilities & marketing network.
* Tie-up arrangement with other seed producing agencies including private sector and organizing certified seed production programme on PPP / MoU basis under supervision of SSCA.

**Success story of Groundnut through Community managed seed systems (CMSS)**

The above strategies are best utilized in case of groundnut through a community managed seed system programme (CMSS). A CMSS programme has evolved in Ananthapur district in groundnut with a collaborative programme between Govt. of AP, an NGO named WASSAN as the Lead Technical Agency and the AP Agricultural University, named as “Mana vittanam”. Under this program, seed required for a Cluster of Villages is produced, procured, processed and distributed within the Cluster; all the processes managed by Community Based Organizations with the support of a local NGO and the Dept of Agriculture. The seed subsidy will go directly to the farmer’s account and the facilitation charges are paid by the Department to the farmers' groups pro rata. At present the target is 1.5 lakh q with a goal to reach 3.5 lakh quintals of groundnut seed by 2018 to reach equal number of farmers. The breeder seed of K-6 (500 q) supplied by ANGRAU, is under multiplication.

**CMSS Programme**

CMSS program integrates

a) foundation seed production using breeder seed supplied by the Agriculture University,

b) production of certified seed through ‘Seed Village Program’ and

c) distribution of certified seed with subsidy to eligible farmers. The purpose is to internalize seed value chain within a cluster of Gram Panchayats / Mandals/ district and resting the processes with farmers’ organisations

**Access to quality seed**: Among the different categories of quality seed, farmers have a direct access to certified seed and truthfully labelled seeds (TFLs). TFLs though not under the purview of the Department of Seed Certification, seeds are tested only for physical purity and germination. By this method, any farmer can produce seeds and market it as truthfully labeled seeds. Labeling is compulsory but certification is voluntary. Though TFLs are mostly available in case of OPVs of self-pollinated crops like groundnut, strengthening the access to quality seed can be ensured by extending the Institutional technical support, tie-up with seed producers and community based organizations. Morphological descriptors which are very unique to the varieties are neither fully revealed nor disclosed, documented leading to gradual varietal degeneration which is fast and high in case of TFLs. Considering the importance of TFLs especially in high volume crops like groundnut, institutional mechanisms like licensing, technical support to community seed organizations through participatory varietal selection (PVS) and participatory plant breeding programmes (PPB) need to be strengthened.

**Seed availability**: Several high yielding hybrids and varieties are available in many oilseed crops but the seed availability cannot be ensured if the seed production is restricted to the concerned SAU/ICAR institute etc. In case of sunflower, ideal combinations of hybrids, though available with the public sector breeders, seed production and marketing strategy can never match with that of private sector. In case of castor, high yielding hybrids of IIOR, SAUs cannot be widely spread unless and until tie up with private sector is ensured.

**Licensing of parental lines of hybrids:** It gives a viable option to popularize most superior hybrid combination and ensure quality of hybrid seed to the farmers. The guidelines need to be worked out case by case in each crop, keeping in view to ensure good quality hybrid seed to specific states. Evaluation of hybrids in specific niches like early kharif, late kharif, rabi, rice fallows, high density planting etc., need to be ensured in collaboration with AICRP centres, KVKs, SAU, NGOs. Medium and small agri-entrepreneurs need to be encouraged.

Seed production programs are mostly restricted to the genotypes released during the last ten years. In cross pollinated crops like castor and sunflower, development of parental lines and their identification is a cumbersome process. Seed multiplication of parental lines in large quantities and their standardization is unique for each combination of hybrid. Thus a hybrid may take > 10 years to reach the farmer’s fields. Castor hybrid, DCH-177 though released in the year 2001, is still gaining popularity even in non-conventional areas like Haryana and Odisha.

Tendering system currently being followed by several state governments is risky in getting spurious seeds and often counterproductive.

In many contingent situations like delayed monsoon, prolonged dry spell, drought and high rainfall suitable oilseeds and pulses are recommended for aberrant weather conditions. There is a need to make arrangements for seed production and access to quality seed of oilseeds and pulses in times of contingency.

Enhancing the oilseed productivity through appropriate exploitation of genetic potential and through alternative approaches including transgenic technology need to be explored. Alternative seed systems involving individual farmers and communities for quality seed production and supply need to be strengthened. Existing technologies for quality seed production and supply systems including the use of molecular based hybrid purity tests need to be either developed or utilized, if already existing.

References

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