Seed Times

The National Seed Association of India Magazine Volume 14, Special Issue (Sept - Dec 2022)

Advancements in seed quality and value addition for improvement of production and productivity of Oilseeds and Pulses

National Seed Association of India

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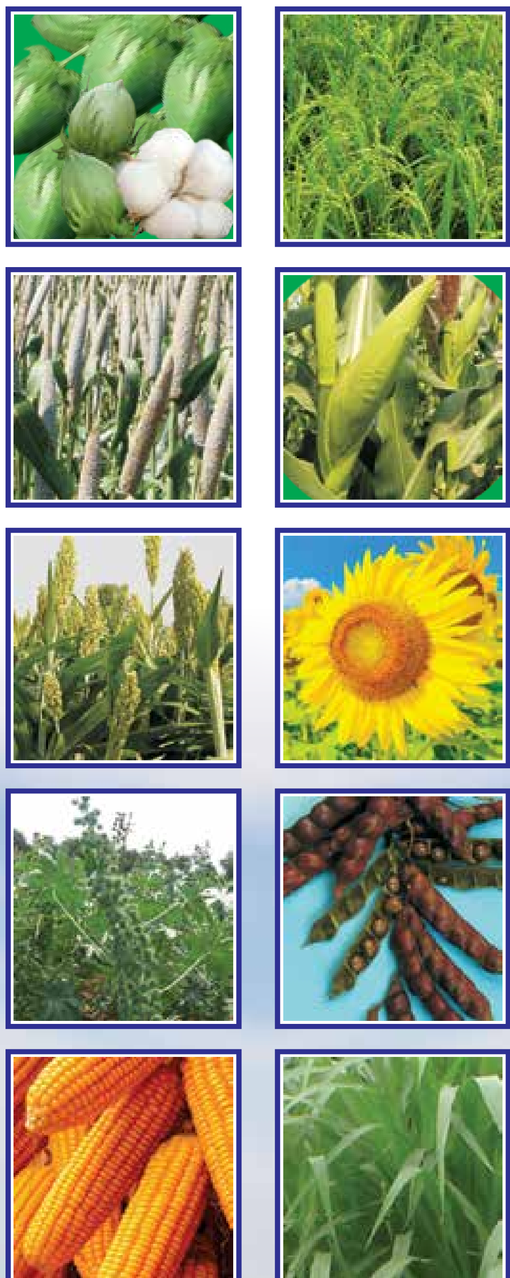

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About NSAI

National Seed Association of India (NSAI) is the apex organization representing the Indian seed industry. The vision of NSAI is to create a dynamic, innovative and internationally competitive, research based industry producing high performance, high quality seeds and planting materials which benefit farmers and significantly contribute to the sustainable growth of Indian Agriculture.

The mission of NSAI is to encourage investment in state of the art R&D to bring to the Indian farmer superior genetics and technologies, which are high performing and adapted to a wide range of agro-climatic zones. It actively contributes to the seed industry policy development, with the concerned governments, to ensure that policies and regulations create an enabling environment, including public acceptance, so that the industry is globally competitive.

NSAI promotes harmonization and adoption of best commercial practices in production, processing, quality control and distribution of seeds.

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Message

President

We all know that Seed is one of the most critical inputs responsible for boosting agricultural production and productivity. Good quality seeds not only provide food security for the rising population but also ensure nutritional security. In order to encourage farmers for using quality seeds, we would require to provide adequate quantity of seeds, meeting quality standards and suited to different agro-ecological situations, with a reasonable price.

Amongst different agricultural crops, oilseeds and pulses have gained more attention as a result of rising demand on account of their nutritional benefits, uses in livestock feeds, vegetable oils, pharmaceuticals, biofuels and other industrial products. Pulses have additional advantage of providing vital nutrient to the biological systems and maintaining soil fertility by nitrogen fixation.

However, quality seed development of oilseeds and pulses is faced with many challenges like low input availability, poor crop management practices, scarcity of genetic resources for developing high yielding, biotic and abiotic stress resistant varieties, attack of variety of pests and diseases, damages during handling and transportation etc. The seed industry can help in overcoming these challenges by developing high yielding varieties of oilseed and pulse crops tolerant to abiotic stresses and having resistance to insect pests, diseases, lodging and shattering. Promoting good agricultural practices in these crops would greatly help in quality seed development and higher productivity of oilseeds and pulses. The seed industry is, therefore, expected to play a greater role by introducing improved cultivars and producing high-quality seeds of oilseeds and pulses that possess the desired traits and have good germination capability and genetic purity.

I am happy to see that this edition of "Seed Times" has been brought out on the theme **"Advancements in seed quality and value addition for improvement of production and productivity of Oilseeds and Pulses"**, which is need of the hour. I am sure, the readers will have opportunity to go through quality articles on importance of seed in oilseeds and pulses, enabling them to contribute their best in achieving sustainable production of these crops and ultimately food security of the nation.

M Prabhakar Rao

Message

Executive Director

Dear Members

The wait is over for the most reputed NSAI quarterly magazine of the seed industry, the Seed Times, which covers scientific/research papers/articles/review articles/information on various aspects related to seed industry. This magazine was discontinued due to COVID-19 pandemic situation. Now, we are back with new design and better contents of Seed Times. This magazine is widely circulated to all the stakeholders of seed industry viz., ICAR, SAUs, Central Govt. Agriculture Departments, State Agriculture Departments, NSC, SSC, Private Seed Companies etc. The theme of October-December issue of the Seed Times is **"Advancements in seed quality and value addition for improvement of production and productivity of Oilseeds and Pulses"**.

Oilseed crops, which fall under the category of field crops, have a second-largest impact on the agricultural economy after cereals. Pulses, on the other hand, are important crops for farmers as they not only improve soil fertility but also ensure economic stability and household food security.

There are many constraints in cultivation of oilseeds and pulses. The major constraints are unavailability of HYV seeds, low seed replacement ratio, biotic and abiotic stress during production, seed damage and viability loss during storage and transportation which affect the productivity and seed quality of oilseeds and pulses. Improved varieties, good agricultural practices during seed production and seed quality maintenance during storage play a very important role in improving the production and productivity of oilseeds and pulses.

Private seed companies have risen steadily and now playing a significant role by putting emphasis on Research and Development activities to increase production and improve seed quality of oilseeds and pulses.

I appreciate NSAI team for focusing on seeds of oilseeds and pulses in this edition of Seed Times which is need of the hour for agricultural growth of the country. This creditable objective will raise the knowledge and skills of our seed industry persons in order to improve seed quality as well as seed production and deliver quality seeds of oilseeds and pulses to farmers.

I hope the readers would greatly be benefited from the magazine.

Happy Reading!

R K Trivedi

About National Seed Association of India

National Seed Association of India is an apex association of the Indian seed industry comprising the small, medium and large companies as well as public state seed corporations. It has more than 450 members from all over the country. NSAI works closely with government departments for developing policies which would spur agricultural growth. Engaging in a continuous dialogue with regulators for the establishment of a transparent, impartial and equitable administrative framework for growth of the seed sector.

The vision of NSAI is to create "a dynamic, innovative, internationally competitive, research based industry producing high performance, high quality seeds and planting materials which benefit farmers and significantly contribute to the sustainable growth of Indian agriculture". The Association is also working towards the responsible use of biotechnology for modernizing Indian agriculture and enhancing the livelihood of Indian farmers. Increasing the general awareness about crop biotechnology amongst the many stakeholders, technology upgradation and engaging in a continuous dialogue with regulators for the establishment of a transparent, fair and equitable regulatory system, are some of the other activities of NSAI.

The mission of NSAI is to encourage investment, innovation and R & D to bring to the Indian farmer superior genetics and technologies, which are high performance and can be adopted to a wide range of agro-climatic zones. It actively contributes to seed industry policy development, with the concerned government to ensure that the policies and regulation create an enabling environment, including public acceptance, so that the industry is globally competitive.

NSAI regularly communicates the latest news and other knowledge related to seed industry to its members besides organizing subject specific Conferences/ Seminars/ Special Lectures, regular training and capacity building programmes. NSAI also promotes harmonization and adoption of best commercial practices in production, processing, quality control and distribution of seeds through regular interactions and networking with global/regional seed industry organizations.

About Indian Seed Congress

Indian Seed Congress (ISC) is NSAI's annual flagship event. It is the biggest seed congress of South East Asia bringing together industry, scientists & governments from across the globe. ISC showcases the latest trends and views of the seed sector; voices their concerns; deliberates on new technological advances to tackle obstacles to growth. ISC is an innovation hub where the barriers are removed and new technology development and innovations are introduced. It provides a chance for delegates to exhibit new products and services across our network for better business development. The Indian Seed Congress provides a platform for the seed Industry to interact closely with technology developers, sector development officials and policymakers. NSAI is pleased to invite you to participate in the Indian Seed Congress 2023, ISC 2023 will be organized in the capital of India, New Delhi, from February - March 2023. ISC attracts delegates from all major stakeholders including industry (seed & allied), policymakers, developmental agencies, the scientific community, and farmers' organizations. The theme for the upcoming congress is, "Seeds: A Gateway for Prosperity".

NSAI regularly communicates the latest news and other knowledge related to seed industry to its members besides organizing subject specific Conferences/ Seminars/ Special Lectures, regular training and capacity building programmes. NSAI also promotes harmonization and adoption of best commercial practices in production, processing, quality control and distribution of seeds through regular interactions and networking with global/regional seed industry organizations.

About Indian Seed Congress

Seed is sacred, it is life. Seeds are most important for agriculture and food sovereignty. Based on this philosophy, the theme of ISC 2023 is ***"Seeds for Global Unity".*** A good harvest depends on quality seed. Timely accessibility to good high performing seeds can change fortunes for the farmers, industry and country. We welcome all to share and explore this theme with us to bring prosperity to the farmers.

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Pulses Production in India: Status and Way Forward

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Dr. Sanjeev Kumar is working as an Agricultural Economist, Department of Economics and Sociology, PAU Ludhiana, Punjab (India). He possesses a meritorious academic record. He did his MSc (Agricultural Economics) from SKUAST-Jammu and PhD (Agricultural Economics) from Dr YSP UHF, Nauni, Solan (HP). During his PhD study, he worked on "An Economic Analysis of Farming Systems for Improving Livelihood Security of Hill Farmers". Dr. Sanjeev Kumar is the recipient of the University Gold Medal for PhD degree programme. He has also qualified National Eligibility Test conducted by ASRB in the discipline of Agricultural Economics. He has published 20 publications including 5 popular articles to his credit. Also he is member of 3 professional societies and is in the editorial board member of 2 magazines and 1 journal. His field of expertise is agricultural production economics and agricultural marketing.

Introduction

Pulse crops—a term derived from "puls," the Latin word for porridge—are low-fat, dry edibles fall within the wider group of legumes. Pulses are a mainstay in many people's diets across the world, and they have the potential to considerably enhance human health, conserve our soils, protect the environment, and contribute to global food security. The United Nations declared 2016 the "International Year of Pulses" in order to raise public awareness for the nutritional benefits of pulses, as a component of sustainable food production, food security and nutrition. Pulses, members of the Leguminosae family, are a highly sought-after crop for small-scale farmers because they can withstand harsh weather conditions, require less water, and fix nitrogen from the atmosphere. India is the world's largest pulse producer (25% of global production), consumer (27% of world consumption), and importer (14%) (FAO, 2022). The National Institute of Nutrition (2011) recommended a daily pulses intake of 80 grams per person per day but India is still far behind having net availability of 47.9 grams per person per day (Economic Survey, 2021-22).

Pulses are popular and reasonably priced plant-based protein source that are consumed all over the world. Pulses are the crucial source of nutritional protein and vital minerals. For vegetarians in particular, pulses are one of the least expensive sources of protein (20-25%). However, the stagnant productivity combined with declining availability has created a significant demand-supply gap that has placed a heavy burden on the exchequer. This has also affected the majority of the population's nutritional security. Pulses play crucial role in farming systems and nutritional diet availability. Pulses are the perfect crops for fulfilling three important developmental objectives at once: lowering poverty, enhancing human health, and boosting environmental sustainability.

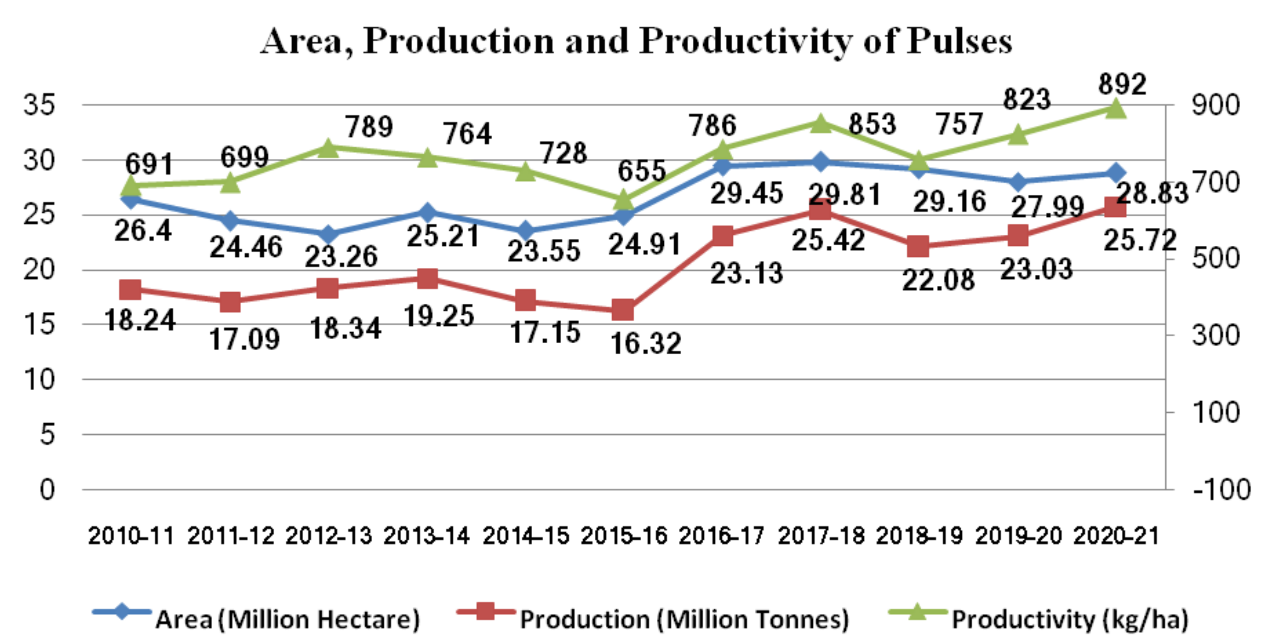
The United Nations declared 2016 the "International Year of Pulses" in order to raise public awareness for the nutritional benefits of pulses

Area, Production and Productivity

India's agricultural development has gone through various stages since independence, with the green revolution being the most notable. The introduction of the "Green Revolution" encouraged the development of rice and wheat utilizing outside assistance and contemporary seed types, which encouraged the large cultivation of pulses on marginal areas and in rain-fed environments. Around 7-10 per cent of the nation's total food grain production comes from pulses, which occupy about 20 per cent of the land planted to food grains (FAO, 2021). Due to the fact that pulses are mostly cultivated in India under rain fed conditions with considerable rainfall variability, the productivity of pulses in India is less than half that of the USA and Canada. By 2050, the UK will need to import 39 million tons of pulses, meaning that production would have to increase by 2.2 per cent annually (FAO, 2021). Although the pulses are produced both in Kharif and Rabi seasons but Rabi pulse production accounts for more than 60 per cent of overall production (Mohanty and Satyasai, 2015). The region covered with pulses has increased by 9.2 per cent, from 26.4 million hectares in 2010-11 to 28.83 million hectares in 2020-21 (Fig 1). During the same time period, pulse production increased by 41 per cent, rising from 18.24 million tonnes to 25.72 million tonnes. Madhya Pradesh, Maharashtra, Uttar Pradesh, Rajasthan, and Karnataka are the primary pulse-growing states. Pulse productivity has increased by 29.08 per cent from 691 kg per hectare in 2010-11 to 892 kg per hectare in 2020-21.

However, the computed compound annual growth rate (CAGR) for area, production and productivity showed much improvement. The area under pulses for the period of 2010-11 to 2020-21, showed an annual growth rate of 0.80 per cent, whereas, the CAGR for production was quite high (3.14 %) for this period. The overall productivity compound annual growth rate (CAGR) of 2.32 percent paints a bleak image.

Fig 1. Area, Production and Productivity of Pulses

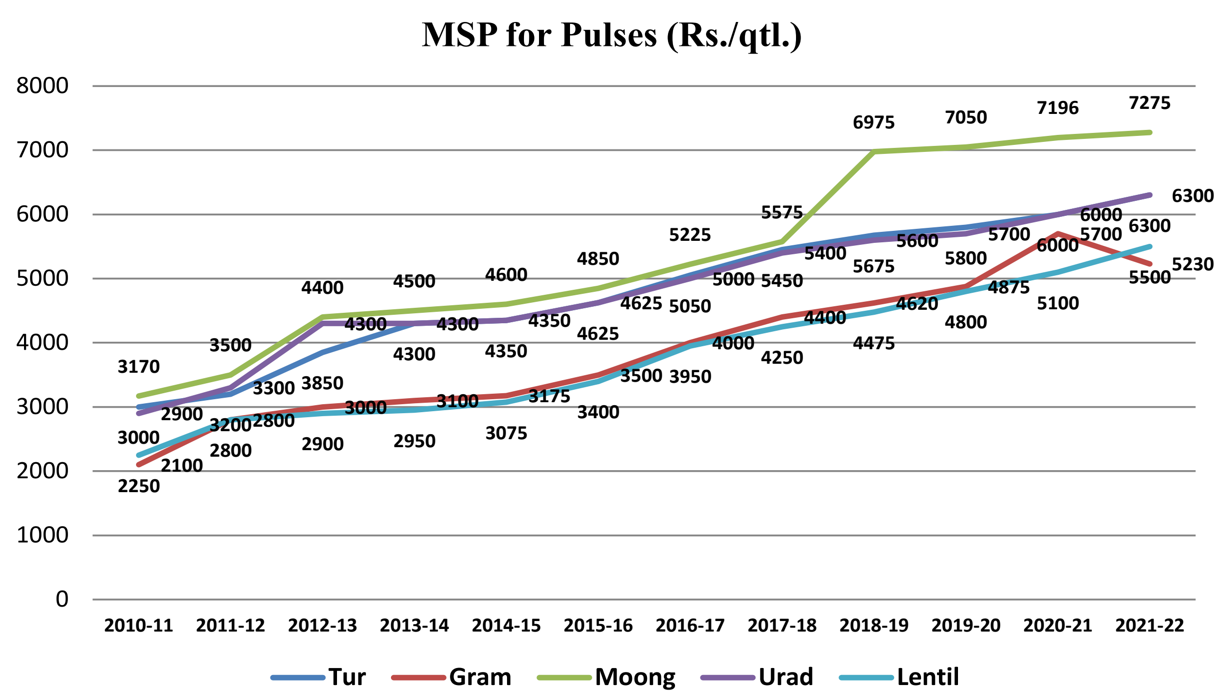


Source: Based on data from various issues of "Agricultural Statistics at Glance", MoA, GoI

Price Support for Pulses

To boost the agricultural production and productivity, the farmers must be guaranteed a lucrative and stable price environment. The MSP for major pulses viz., Tur, Gram, Moong, Urad, Lentil was analyzed and data has been presented in Fig 2. The Minimum Support Price (MSP) for above mentioned pulses in 2010-11 were recorded to be Rs. 3000, Rs. 2100, Rs. 3170, Rs. 2900 and Rs. 2250 respectively. Over a period of a decade, this increased to Rs. 6300, Rs. 5230, Rs.7275, Rs.6300 and Rs. 5500 for Tur, Gram, Moong, Urad and Lentil respectively. The CAGR value for the major pulses was also computed and maximum growth was recorded in gram (8.56%), followed by lentil (8.38%), moong (7.76%), urad (7.32%) and tur (6.91%).

Fig 2. Minimum Support Price (MSP) for Pulses

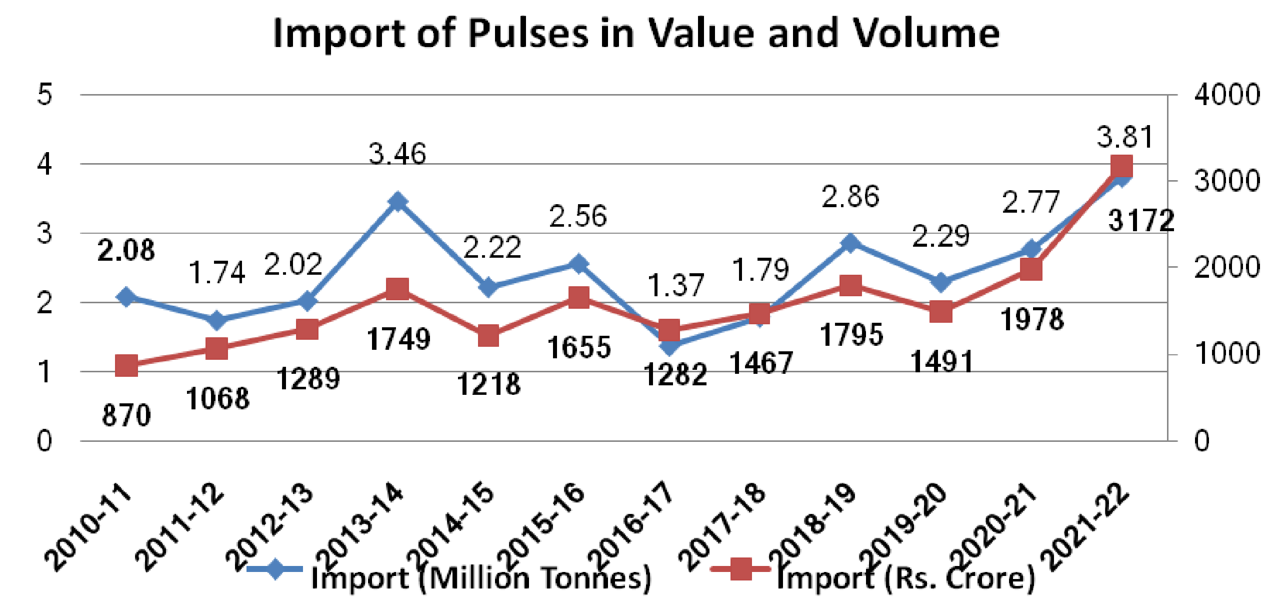


Source: Based on data from various issues of "Agricultural Statistics at Glance", MoA, GoI

Import of Pulses

The growing disparity between pulse production and consumption has led to higher pulse imports in recent years. The import of pulses in terms of value and volume showed similar trends over the decade, except for 2016-17 where value crossed the line of volume. The country imported only 2.08 million tonnes of pulses in the years 2010-11, but that number quickly increased to 3.81 million tonnes in the year 2021-22. Since 2010-11, the import of pulses has increased at 5.6 per cent compound annual growth rate, while the production has increased only at 3.14 per cent rate. In 2010-11, the total import of pulses valued for Rs. 870 crores, which increased to Rs. 3172 crores, depicting a 12.35 per cent compound annual growth rate over the decade.

Fig 3. Import of Pulses in terms of Value and Volume



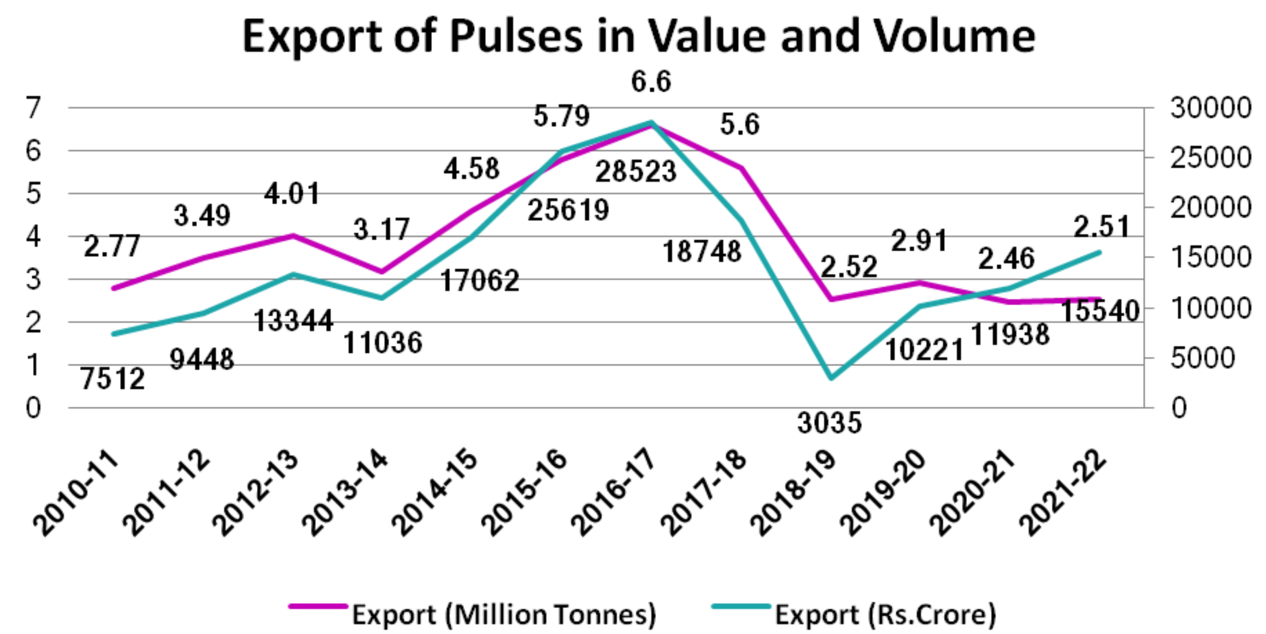
Source: Based on data from various issues of "Agricultural Statistics at Glance", MoA, GoI

Despite the fact that numerous nations import the majority of the pulses, Canada, Myanmar, the United States, Russia, and Australia have historically been the top importers. The majority of the imports are made up of lentils, gram, chickpeas, and pigeon peas. Besan, a staple ingredient in most of the country's sweets and snacks, is made of chickpeas. India typically sells pulses to Asian and African nations such as Turkey, UAE, Pakistan, Algeria, and Sri Lanka, among others (APEDA, 2021).

Export of Pulses

The export of pulses from India during 2010-11 to 2021-22 is given in Fig 4. The total amount of pulses exported by India in 2010-11 was roughly 2.77 million tonnes, which kept increasing till 2012-13 (4.01million tonnes). Later, it again started increasing till 2016-17 (6.6 million tonnes, however, a fluctuating pattern was noticed observed. Further, a decline was observed till 2020-21 (2.51 million tonnes) from 2016-17 (6.6 million tonnes). In terms of value of export, a fluctuating behavior was observed from 2010-11 (Rs. 7512 crore) to 2020-21 (Rs. 15540 crore). The maximum value was observed in 2016-17 (Rs. 28523 crore), whereas, minimum in 2018-19 (Rs. 3035 crore). Further. the CAGR for volume was calculated to be negative (-0.88%) and positive for value (6.76%).

Fig 4. Export of Pulses in term of Value and Volume



Source: Based on data from various issues of "Agricultural Statistics at Glance", MoA, GoI

There are more elements that have an impact on India's export of pulses such as inadequate storage facilities, low pulse preservation quality, uneven seed size, strong domestic demand, and a wide range in pulse maturity (Lal and Verma, 2007). The moisture level is an important component in the production of pulses. Farmers are significantly less aware of the aspects we consider when exporting pulses, such as moisture, machine cleaning, and polishing. As a result, these concerns must be overcome in order for India's pulse exports to expand. The government needs to help exporters by giving them access to warehouses and technical information. In addition, India may think about removing export restrictions and investigating the sale of dal and other value-added goods to expand its export market.

Pulses sustainability and future food system

There will be 9.8 billion people on the earth by 2050, up from the present seven billion (UN, 2022). Future population feeding concerns are contentious. Some individuals are concerned that agricultural yields may not be able to keep up with demand for food, feed, fuel, and fiber, particularly in light of climate change. India's population is expected to exceed 1.68 billion by 2030, necessitating the consumption of 32 million tonnes of pulses (Sarkar et al., 2018). To meet this goal, an additional 3-5 million hectares must be planted, with 1361 kg/ha productivity improvements and considerable reductions in post-harvest losses. Furthermore, according to Indian Institute of Pulse Research

(IIPR, 2015), the demand for pulses has been predicted to reach 39 million tonnes by 2050, which necessitates a 2.2 per cent annual growth rate in pulses production. Recognizing the importance of quality seed production of pulses, the Government of India (GoI) approved a special project during 2016 entitled, "Creation of seed hubs for increasing indigenous production of pulses in India" with the main goal of ensuring supply of quality seed and maintaining sustainability with profitability to the farmers locally by developing suitable infrastructure for seed quality enhancement, safe storage and seeds development. Pulses seed production needs regular and sufficient irrigation because water stressed plants produce seeds that are hard and small with little vitality. Hence, the government should improve/build the irrigational infrastructure in places where farmers practice pulses seed production. Pulses, which are frequently ingested whole or divided, provide minimal value addition. The country must grow enough pulses to meet this rising demand. Making pulses affordable by increasing domestic production is the best option for providing nutritional security to the underprivileged masses who rely on vegetarian diets.

Way Forward

The research in pulses should be prioritized, with an emphasis on variety development to suit local conditions. The focus should be on characterization of climate tolerant pulse germplasm, development of short duration variety to facilitate intercropping and mixed yield, cropping without compromising cereals and other crops. The knowledge of enhanced agronomic procedures, such as timely sowing, routine mechanical weeding, timely harvesting, and post-harvest processing might greatly boost small holders' incomes and close the yield gap. Therefore, it is necessary to involve government bodies, non-governmental organizations (NGOs), farmers' associations, and private business owners in the production of high-quality seeds, transfer of technology, processing and value addition as well as the provision of essential inputs. Furthermore, a comprehensive understanding of the difficulties influencing the pulses value chain is critical. It is also important to focus on substantial changes in agri-food policy and rise in demand for R&D on the input side. The innovations in food processing as well as an increased consumer awareness about pulses' benefits on health, nutrition, and the environment, are especially required.

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Bio-fortified varieties of Oilseed and Pulses

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Presently, he is handling three projects funded from DBT and DA&FW, Government of India. He is also recipient of Young Scientist Award from All India Agricultural Student Association (AIASA) in 2017.

"The 'hidden hunger' due to micronutrients deficiency does not produce hunger as we know it. You might not feel it in the belly, but it strikes at the core of your health and vitality."- **Kul. C. Gautam, Former Deputy Executive Director UNICEF**

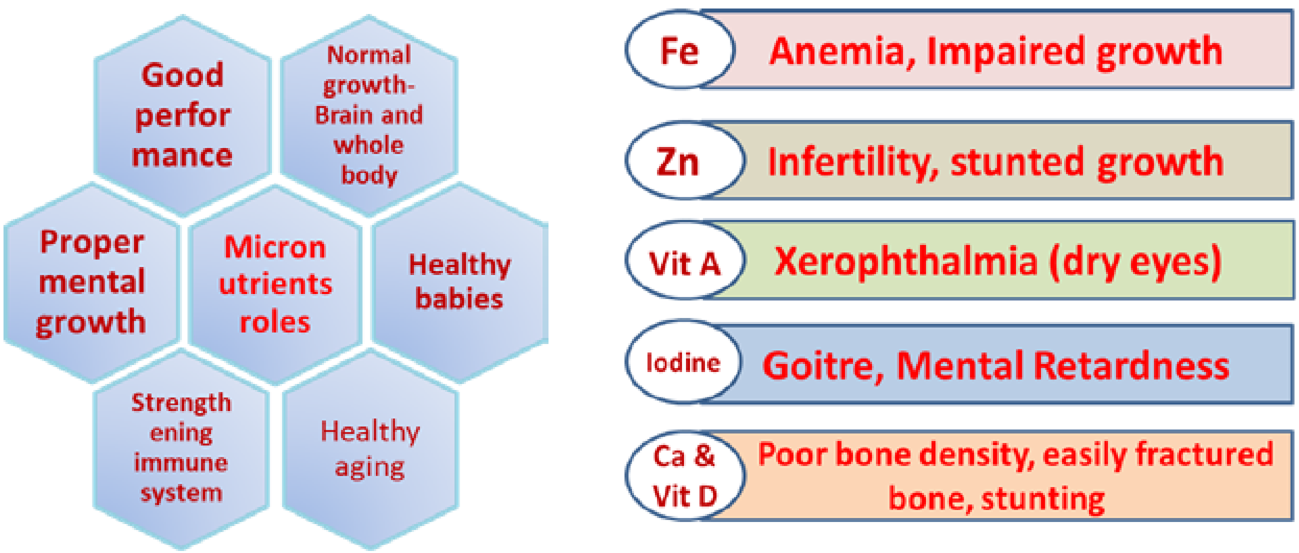
Nutritional security becomes a global threat due to ever growing population under global crisis like climate change and the COVID-19 pandemic. Nutritional security refers to the ingestion of food enriched with essential nutrients in an adequate amount. Global population is expected to rise from 7.87 billion in 2021 to 8.6 billion by 2030. Population burst escalates the challenges of nutritional security by intensifying the hunger and malnutrition. The major concern for the green revolution was to enhance crop productivity of staple food crops, especially cereals but minimum efforts were laid for improvement of nutritional quality of other food products. This scientific breakthrough provided sufficient food for the growing population but led the replacement of the nutri-dense traditional food crops with less nutritive but high yielding crops.The lack of diversity in diet, i.e. cereal-based crops deficient in essential nutrients gave the birth of the problem of micronutrient malnutrition and it become serious socio-economic consequences to humankind. In developing and underdeveloped countries, a large proportion of population still cannot access or afford an adequate balanced diet, which causes malnutrition and undernutrition.

In total about 815 million people are undernourished due to unbalanced or low quality diet or its poor absorption and nearly 95.70 % population (780 million people) belongs to only developing countries. Children are most sensitive to malnutrition and children's death, stunted growth and underweight in proportion to their height are the major impacts of the malnutrition. Nearly 45 % of children's deaths of below 5 years are due to malnutrition, while 151 million children suffer from the problem of stunted growth and 51 million are underweight according to their heights. Globally, around 2 billion people are distressed from key micronutrients, such as, Iron and Zinc malnutrition which is commonly known as "Hidden Hunger" or "micronutrient malnutrition".

Population burst escalates the challenges of nutritional security by intensifying the hunger and malnutrition.

Hidden hunger for Iron (Fe), Zinc (Zn), vitamin A, iodine (I) and calcium (Ca) and selenium (Se) is widespread and it affects human beings of all age groups. Micronutrient are required in very small quantity but plays a vital role in the functions of the human body; thus inadequate intake causes several physiological impacts (stunted growth, anemia, maternal mortality etc.) but effects of impairment can be reversed with balanced diet. However, some of the micronutrient deficiencies may cause lifelong impairments such as iodine deficiency in early pregnancy results intellectual incapacity in the baby (Fig. 1). Thus, to ensure nutritional security, there is need for development of ultra-nourishing food crops.

Fig. 1 Role and deficiency of major micronutrients



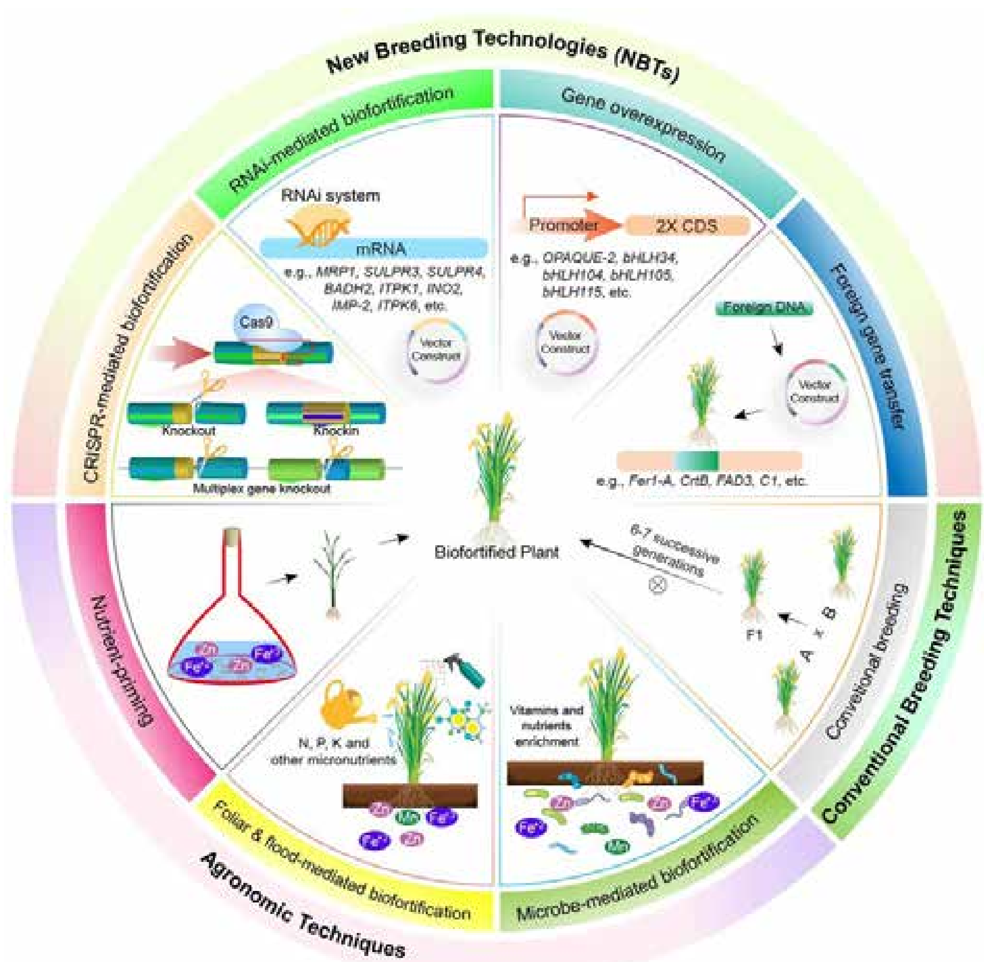
After looking severity of consequences of malnutrition, eradication of malnutrition is the only sustainable way to achieve nutritional security. In 2015, United Nations General Assembly set 17 Sustainable Development Goals (SDG) for the dignity, peace and prosperity for the planet and humankind by the year 2030. Among the 17 SDGs, SDG 2, "Zero Hunger" and SDG 3, "Good health and Well- Being", aim to transform the world by facilitating food and nutritional security for healthy lives of people of all ages. Hence, various ways of nutritional security such as medical supplementation, dietary diversification and food fortification are available but genetic biofortification of food crops is a sustainable approach to alleviate malnutrition.

Biofortification is a process of breeding nutrients into food crops either in terms of increase of nutrient concentration or increasing the bioavailability of micronutrients. Biofortification is possible through different ways such as agronomic methods, conventional breeding or genetic modifications through biotechnology tools. A one-time investment for genetic biofortification provides sustainable, long-term strategy for delivering micronutrients to rural populations forfighting hidden hunger and it also avoids continual financial outlays like supplementation and commercial fortification. An economist, Howarth Bouis took first initiative in the early 1990s to solve hidden hunger through biofortification. The bean researcher "Steve Beebe" coined the term "Biofortification" in 2001.

Biofortification program will be implemented successfully, if three issues are addressed, those are: i) Can significant and measurable amount of micronutrients density be increased or achieved through breeding pogramme? ii) Will the extra nutrients bred into food crops are in the bioavailable form for the consumer? iii) Will farmers adopt the biofortified crops to grow and will consumers buy/eat them in sufficient quantities?

Therefore, to address above questions systematic approach has to be applied for genetic biofortification in three phases of discovery, development and dissemination. Various approaches of biofortifications viz. agronomic bioforticication, conventional breeding techniques, new breeding and biotechnological tools are depicted in the Fig. 2.

Fig. 2 Different approaches of Biofortification



(Source: Shahzad R. et al., 2021)

For the eradication of malnutrition, minimum required amount of essential micronutrients including carbohydrates, fats, proteins, vitamins and minerals must be included in the dietary pattern. Oilseeds and pulses are the major constituent of human diet and these are the important source of energy requirement and consist higher energy than the cereals which reduce bulk consumption of food we take. Pulses are considered as superfood due to their intense nutritional composition, as they provide protein, fibers and several micronutrients like iron, zinc, selenium, calcium, magnesium and vitamins (folate, thiamine, riboflavin and niacin). Similarly, oilseeds are also an excellent source of fat soluble vitamins A, E and K and play important role in biosynthesis of several long chain alcohols. In oilseeds and pulses the biofortification is possible in two dimensions, first one, by increasing the essential micronutrients viz. protein content rich in essential amino acids, iron, zinc, calcium, anthocyanin, oleic acid and linoleic acid and the second one, by removal of anti-nutritional factors which restrict the bioavailability of proteins and nutrients e.g. lectins, phytic acid, trysin inhibitors, saponins, lathyrogens, protease inhibitors, α- amylase inhibitors, erucic acid, glucosinolates and tannins restrict the absorption of essential nutrients. Several biofortified varieties have been developed in the oilseed and pulses through conventional or molecular breeding approaches and presented in Table: 1

Conclusions: Biofortification is a well established phenomenon for alleviating malnutrition in a sustainable and cost effective manner through agricultural strategy. Generation of genetically improved biofortified crops provides sufficient levels of micronutrients and these efforts increases amount of micronutrients and bioavailability of micronutrients. Oilseeds and pulses are major component of the died developing countries but fewer efforts have been made for the nutritional quality improvement of these crops. Therefore, huge scope for the improvement of nutritional status is available which will have a significant impact on the health of millions of needy people.

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Table: 1 Biofortified varieties of different Oilseed and Pulse crops

Crop	Target nutrient	Variety Name and release year	Level of Target Nutrient	Normal level of target nutrient	Breeding approach	Developing Centre	Other Characteristics
Lentil *(Lens culinaris)*	Fe and Zn	IPL-220 (2018)	Fe- 87-112 ppm Zn- 62-63	Fe- 45.0- 50.0 ppm Zn- 35.0- 40.0 ppm	Conventional (Pure line variety)	ICAR-IIPR, Kanpur	Grain yield: 13.8 q/ha, maturity days: 121, suitable for rainfed
	Fe	PusaAgetiMasoor (2017)	Fe -65.0 ppm Fe		Conventional (Pure line variety)	ICAR-IARI, New Delhi	Extra early type biofortified, Yield: 13 q/ha, maturity: 100, suitable for rainfed
		L 4704 (2015)	Fe- 125-130 ppm Zn- 72 ppm		Germplasm line	ICAR-IARI, New Delhi	Maturity days- 130-135 days 100 Seed weight- 2.5 g
		PusaVaibhav (1997)	Fe-100-110 ppm		Conventional	ICAR-IARI, New Delhi	Yield: 17-18 q/ha Iron rich variety
Cow pea *(Vigna unguiculata)*	Fe	Pant Lobia-1 (2008)	Fe- 82 ppm Zn- 40 ppm	Fe- 30 ppm	Conventional	GBPUAT, Pantnagar	White seeds, multiple disease resistance, Yield- 15 q/ha
		Pant Lobia-2 (2010)	Fe- 100 ppm				Red seeds, multiple disease resistance, Yield- 15 q/ha
		Pant Lobia-3 (2013)	Fe- 67 ppm				Brown seeds, multiple disease resistance, Yield- 15 q/ha
		Pant Lobia-4 (2015)	Fe- 51 ppm				Brown seeds, multiple disease resistance, Yield- 17 q/ha

Crop	Target nutrient	Variety Name and release year	Level of Target Nutrient	Normal level of target nutrient	Breeding approach	Developing Centre	Other Characteristics
Soybean *(Glycine max)*	Kunitz Trypsin Inhibitor (KTI)	NRC 127 (2018)	Free	30-45 mg/g of seed meal	Conventional (Pure line variety)	ICAR-IISR, Indore	Country's first KTI free variety, Yield- 18.0 q/ha, Maturity: 104 days
	Lipoxygnenase-2	NRC 132 (2020)	Free		Modified marker assisted backcrossing (MAB)	ICAR-IISR, Indore	Free from lipoxygenase-2, suitable for soybean milk and products, Yield: 22.9 q/ha, maturity: 99 days
	Oleic acid	NRC 147 (2020)	Oleic acid- 42 %	30- 35 % in popular varieties	Conventional (Pure line variety)	ICAR-IISR, Indore	22-25 % higher oleic acid, Yield: 23.6 q/ha, maturity: 96 days
Mustard *(Brassica juncea)*	Erucic acid	Pusa Mustard 30 (2013)	1.20 %	Eucic acid- > 2 % (>40 % in popular varieties) Glucosinolates- > 120 ppm in seed meal	Conventional (Pure line variety)	ICAR-IARI, New Delhi	Timely sown irrigated, Yield- 18.2 q/ha, Maturity- 137 days, Oil- 37.7 %

Crop	Target nutrient	Variety Name and release year	Level of Target Nutrient	Normal level of target nutrient	Breeding approach	Developing Centre	Other Characteristics
	Erucic acid and Glucosinolates	Pusa Mustard 31 (2016)	Erucic acid- 1.32 % Glucosinolates- < 30 ppm				Country's first canola quality, Timely sown irrigated, Oil- 41 % Yield- 23 q/ha Maturity- 142 days
	Erucic acid	Pusa Mustard 32 (2020)	1.32 %				Released for NWPZ, seed yield- 27.1 q/ha, oil- 38 %, maturity- 145 days
	Erucic acid	Pusa Mustard 33 (2021)	Erucic acid- 1.32 % Glucosinolates- < 30 ppm				Timely sown irrigated condition, seed yield- 26.44 q/ha, oil- 38 %, maturity- 141 days
Peanut *(Arachis hypogea)*	Oleic acid	Girnar 4 (2020)	Oleic acid 78.4 -78.5 %	40- 50 % Oleic acid	Marker assisted breeding (MAB)	ICAR-DGR, Junagadh	Virginia bunch genotype, yield- 32 q/ha, maturity- 110-115 days, 100 seed weight- 43 g
		Girnar 5 (2020)	Oleic acid 78.4 -78.5 %		Marker assisted breeding (MAB)	ICAR-DGR, Junagadh	Virginia bunch genotype, yield- 32 q/ha, maturity- 110-115 days, 100 seed weight- 41 g
Linseed *(Linum usitatissimum L.)*	Linoleic acid	TL 99 (2019)	High in Linoleic acid (58.9 %) and lo in linolenic acid (4.1 %)	linolenic acid >40 %	Mutagenesis	BARC, India	Oil content- 36.6 % Seed Yield- 12.7 q/ha Maturity: 131 days

Linseed: Improved varieties, seed production technology & mechanization for higher productivity and profitability

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Abstract

Seed is a crucial significant link in the chain of agricultural inputs. To make available pure and good quality seed to the growers is not less important than release of improved varieties. The deterioration in variety takes place due to developmental variations, mechanical mixture, mutation and natural crossing. The maintenance of genetic purity and production of quality seed require special attention at different levels. The recent production technologies and mechanization should be disseminated with proper education and extension programme. Then another important point in this regard is to take seed production programme of any crop / variety to its suitable ecology on the best piece of land with all essential facilities required for good quality seed production, processing and storage. Efficacy of other agricultural inputs (fertilizers, pesticides and irrigation) in enhancing productivity and production is largely determined by the seed quality. Quality of seed accounts for 20-25 % increase in crop productivity. Therefore, it is important that availability of quality seed to the farmers is viewed as a major step towards doubling farmer's income. To make India self-sufficient in oilseeds production through productivity enhancement, availability of quality seed needs special attention. Non availability of quality seed especially in minor oilseeds crops is a major constraint to become self-sufficient in oilseed production.

Keywords: Linseed, production technology, nutrient management, mechanization

The maintenance of genetic purity and production of quality seed require special attention at different levels.

Introduction

Seed is one of the most important inputs in increasing agricultural production in any farming system. This element has become more crucial than ever for providing enough food security for the rising number of people in the world. Selecting improved (high yielding) varieties adapted to the area of production, with disease, insect, lodging, and shattering resistance, along with other desirable characteristics are basic keys for satisfactory crop performance and yield. The production of quality seed is the major cornern of implementation of any successful program. The practical definition of seed quality can differ depending on the end user. For example, a farmer may desire high-quality seed that produces rapid uniform plants with high yielding capacity under a wide range of field conditions. One of the major factors for low production is low yield, which exists due to non-availability of climate resilient variety, high oil yield and biotic and abiotic resistance, mechanization in harvesting and post-harvest process and development of package of practices for different ecologies.

Linseed(Linum usitatissimum L.) /flaxseed is a Latin name which means "very useful" and is one of the world's oldest cultivated crop plants grown almost in every part of the country for the purpose of oil and fibre. In our country, linseed occupies 3.84 lakh ha area with a production of 1.54 lakh tones and contributes about 10.81% and 5.31%, respectively to the global area and production. The State of Madhya Pradesh contributed nearly 50 % both in area and production of the country which proved it as the major State of linseed crop but the productivity of the crop is very low as compared to other rabi crops. Several efforts have been made to increase the productivity and profitability to make the crop farmers friendly through large scale dissemination of low input cost-based production technologies viz., weeds, nutrients, irrigation management and mechanization.

The area under this crop is decreasing on records, whereas, productivity increased by twice in last 10 years due to premium price in market, suitability of the crop under varying eco-edaphic condition, support of government policies and subsidy under National Food Security Mission for seed production of registered farmers under certifying agency. The objectives of the study was to assess the yield performance & economics of linseed varieties under best agronomic management for high productivity and profitability in large scale technology & mechanization demonstrations at cultivator field of Sagar and Hoshangabad district of Madhya Pradesh by adopting advanced agronomic practices and management viz., weed, irrigation, nutrition and mechanization to attain high productivity. Results of analysis revealed that the linseed crop is more profitable as compared to other major rabi crops under best utilization of available natural resources.

With securing the availability of quality seed and large scale varietal as well as technology demonstrations of improved varieties could play a significant role in area expansion and adoption of linseed as compared to gram, lentil, lathyrus and wheat in rainfed and semi irrigated areas of the State. In the region pulses occupied a sizeable area and are heavily affected by wilt disease. Intercropping of linseed with pulses could help in minimization of wilt problem in pulses. At present, numbers of improved varieties have been developed namely JLS-9, JLS-27, JLS-66, JLS-67, JLS 73, JLS 79, JLS 95, JLS 93 and JL 165 having high seed & oil yield as well as high omega 3 fatty acid. These varieties are having omega 3 ranging from 40-56 %. An effort has been made under NFSM-Seed Hub oilseeds (linseed) with the objectives to assess the yield performance & economics of linseed varieties under best agronomic management for high productivity and profitability in large scale low input-cost based production technology & mechanization at registered cultivators under seed production program (Payasi D.K, 2020).

Improved varieties of linseed under seed chain

S. No.	Name of variety	Dura-tion	Potential yield (q/ha)		Oil (%)	Omega 3	Notifica-tion No	Date
			Rainfed	Irrigated				
1	JLS 79	112-119	-	17-19	36.80	50.00	S.O.3540(E)	22.11.2016
2	JLS 66	110-115	13-15	17-19	42.85	55.96	S.O.399(E)	24.01.2018
3	JLS 95	115-118	13-15	16-18	40.20	51.85	S.O.1379(E)	23.03.2018
4	LSL 93	105-107	10-12	13-15	40.00	50.74	S.O.3220(E)	05.09.2019
5	JLS 122	112-116	10-12	13-15	41.50	52.50	Released for MP	19.09.2022

Farmers participatory seed production program under best possible agronomic management & mechanization in linseed

Dinesh Maheshwari & family members, Village Godrai,block Bankhedi of the district Hoshangabad, Madhya Pradesh: Dinesh Maheshwari & his family members are the progressive farmers having more than 40 years of experience of farming. Breeder seed of two linseed varieties namely JLS 66 and JLS 73 were provided to them for sowing during rabi 2018-19 in area of 30 and 20 ha respectively under seed production program registered with Madhya Pradesh State Seed Certification Agency, Bhopal during 2018-19. Seed was treated with Imidacloprid 48% FS@ 1.25 ml/kg seed. Recommended dose of NPKS :: 80:40:20:20 kg/ha, respectively was applied by fertilizer applicator as basal dose based on soil test report. Dry sowing followed by irrigation was practiced for uniform germination. Application of post emergence herbicide Clodinafop + Metsulfuron methyl @ 0.06 + 0.004 kg a.i./ha (400 g/ha) at 2-3 leaf stage of weed (20-25 days after sowing) was applied for management of weeds which is a major problem in irrigated linseed cultivation. The first irrigation was given at 30-35 days after sowing and second at 60-65 days. Liquid fertilizers NPK:: 19:19:19, with fungicide thiophenate methyl 1.0 kg /ha and Imidacloprid 17.6 SL was also applied after flowering to the crop by tractor mounted sprayer. Harvesting was done by combine harvester with some adjustment and modification as per requirement of the crop. Under National Food Security Mission –Oilseed Funded project entitled “Creation of Seed Hubs for enhancing quality seeds availability of major oilseed crops” underseed production program registered with MPSSCA, Bhopal. By using his experiences, he managed the seed rate of 20 kg/ha under line sowing under dry seeding condition with the help of double box seed drill to raise the healthy crop and adoption of best possible agronomic management. The crop cutting was done by local officers from Department of Agriculture and calculated the productivity of 19.50 and 18.80 q/ha respectively which earned Rs 66445 /ha as NMR with 3.09 IB:C ratio from the variety JLS 66 followed by Rs 63288/ha as NMR with 2.94 IB:C ratio for the linseed variety JLS 73. The farmers had also received the benefits and subsidy of breeder seed

(@7900/q) and production (@ 2500/q) program against the tagged seed quantity by National Food Security Mission Scheme by Department of Farmers Welfare and Agriculture Development, Govt. of Madhya Pradesh.

Photographs:

Photographs of Seed Production Program Linseed variety JLS 73 & JLS 66 at cultivators field under NFSM-Seed hub Oilseeds (Linseed), JNKVV, RARS, Sagar, M.P.

Performance of Linseed Variety JLS 73 at Reproductive stage under large scale seed production program (30 ha) with best possible agronomic management and mechanization

Performance of Linseed Variety JLS 66 at Reproductive stage under large scale seed production program (20 ha) with best possible agronomic management and mechanization

Performance under best possible agronomic management of weed, nutrient, irrigation and mechanization.

Effective utilization of Mechanization in linseed to make the crop farmers friendly

Visit of Hon'ble member of Board of Management, Director Farms, JNKVV, Jabalpur

Visit of Hon'ble member of Board of Management, Director Farms, JNKVV, Jabalpur

Linseed production technology for higher productivity and profitability

1. Soil			
I	Soil type	:	Wide range of soil such as light soil to heavy
Ii	pH value range	:	5-7 but pH range 6-7 is best
Iii	Soil texture	:	Sandy loam to deep clay
Iv	Soil depth	:	20-30

2. Ideal climatic requirement of the crop			
Climate type	Germination	Vegetative growth optimum	Seed development
Temperature	15-20 oC	15-20 oC	20-30 oC
Rainfall	750 mm		
Season	Rabi		

3. Seed Treatment			
i	Seed treatment chemical	:	For seed borne disease -Carbendazim @ 2.0 g/kg of seed/ Thiram @3 g/kg of seed
ii	Seed inoculation	:	Seed inoculation with PSB+ Azatobactor 25 g/kg of seed
iii	Seed storage	:	Seed storage up to 1 year
Iv	Soil depth	:	20-30

4. Sowing practices			
i	Sowing pattern	:	Sole cropping/Linseed + Chickpea (2:4) or (3:1)/ Linseed + Lentil / Safflower (2:4) or (4:2)
ii	Time of sowing	:	Rainfed:First fortnight of October November Irrigated:Last week of October to First fortnight of November
iii	Method of sowing	:	Drilling by using double box seed drill,
iv	Spacing		30 cm between row (30 x 05 cm)
v	Irrigation required for sowing	:	Dry sowing followed by come-up irrigation is best based on soil moisture status
vi	Land preparation	:	One ploughing followed by one or two harrowing depending on soil type for fine tilth

vii	Depth of sowing		2-3 cm
viii	Crop rotation Rainfed Irrigated		Soybean-Linseed, Mung/Urd-Linseed, Mung/Urd-Linseed-Sesame /Summer mung, Paddy-Linseed,
ix	Interculture operation of crop		One hoeing followed by one hand weeding at an interval of 15 days commencing from 15-20 DAS

5. Irrigation time /period in crop		
	Stage	**Days After Sowing**
i	Seedling	25-30
ii	Flowering	50-55
iii	Seed filling	

Season	**Number of irrigations required**		
	Light soil	**Medium soil**	**Heavy soil**
Rabi	3-4	2-4	2-3

(Sprinkler method of irrigation is appropriate method in all stages of crop growth)

6. Uses of fertilizers in the crop			
i	Time of Fertilization	:	**Rainfed**: Full dose of N, P and K at the time of sowing **Irrigated**: 50 % N and full dose of P and K at the time of sowing and top dressing of remaining 50% N at immediately after irrigation in two split doses.
ii	Mode of application	:	Top dressing of 50% N
iii	Amount of fertilizers	:	**For Rainfed**: 40:20:00:20: 5:: N:P:K:S:Zn kg/ha **For Irrigated**: 80:40:20:20: 5:: N:P:K:S:Zn kg/ha
iv	Source of fertilizers		Urea (46% N,), Diammonium phosphate (18%N 46% P2O5), Single Super Phosphate (16% P2O5)
v	Safe usage of fertilizers	:	Apply as per soil test basis

7. Uses of manures in the crop		
Types of manure	:	FYM/Compost
Time of application	:	2-3 weeks prior to sowing
Amount of manure	:	7-8 t/ha

8. Weed management		
Mechanical control	:	One hand hoeing and inter culture at 30 DAS is effective
Chemical control	:	Clodinafop @ 60 g a.i./ha + metsulfuron methyl 4 g a.i./ha at at 2-3 leaf stage or Clodinafop + metsulfuron methyl (Vesta – readymix) @ 400 g/ha.

9. Nutrient management		
Foliar spray	:	One foliar spray of N:P:K :: 19:19:19 @2.5 kg/ in 500 liter of water /ha at 35 DAS is effective
Bio fertilizers	:	Liquid Pseudomonas fluorescens @ 2.5 liter in 500 liter of water is effective

10. Insect pest of linseed and systematic approach for their management: The bud fly (Dasineu-ralini) is a pest throughout the linseed growing area.

Time of practices/ growth stage	Target Pests	Control measures
Pre-sowing	Bud fly and other insect pests	Solarization of soil through summer ploughing, avoid continuous cultivation of linseed in same field.
Land preparation	Termite	Apply 2.5 q neemcake /ha or chloropyriphos 20 EC @ 1 litter/ha. in soil when termites are regular and heavily damaging pest.
Sowing	All major pests	Sowing may be restored 10-15 days earlier to minimize the bud fly infestation; selection of suitable resistant varieties
Seedling stage	Cut worm and termite (moderate infestation)	Dusting of the crop with methyl parathion 2 % @ 25 kg/ha
Vegetative stage	Leaf minor, sap sucking pests and defoliators	Apply dimethioate 30 EC (0.03%) or spray imidacloprid 17.8 SL @ 50 ml/ha as and when required
Flowering stage	Bud fly, leaf minor, defoliators and sap sucking pests (6.0% ETL for bud fly and moderate to severe damage for other pests)	Use light trap for bud fly. Use of attractant (1 kg jaggery in 75 lit. of water and chloropyriphos @ 1ml/lit) for bud fly, use of bamboo/wooden pegs as dead perches for predatory birds, spray forthnightly neem based formulations (0.5%) or spray imidacloprid 17.8 SL (0.04%) or spinosad 45 SC (0.015%) alone or with mancozeb (0.2%) for control of leaf minor, defoliar or and other sap sucking pests as per above given schedules.
Capsule formation stage	Gram pod borer (Moderate to heavy damage)	Apply HaNPV @ 250-300 LE/la

11. Diseases of linseed and systematic approach for their management		
Disease with causal organism	**Prevalence in the country/ specific area**	**Control measures**
Wilt (*Fusarium oxysporum*)	Incidence throughout the country but more prevalent in central part. Average loss 12-15 % if continues certification loss up to 70 %	Timely sowing, Soil solarization by ploughing; avoid continuous cultivation of linseed in the same field; 2-3 years rotation is most effective prevention ; use of the resistant varieties, effective technology for management of better germination and crop growth as well as linseed wilt by use of biofertilizers Azatobactor and Pseudomonas 5 gm / kg seed) after seed treatment with mixed fungicide (carboxin + thiram) fungicide @ 2.5 g/kg seed and soil treatment before planking @ 2.5 kg/ha Trichoderma virdae .
Alternaria blight (*Alternaria lini and Alternaria linicoa*)	Prevalent in Northern region having humidity range of 90-95% and temperature 25-30 0C. average loss 20-35% if atmospheric conditions suitable loss up to 60%	Timely sowing, Use of the resistant varieties, seed treatment with mixed fungicide (carboxin + thiram) @ 2.5 g/kg seed. Spray of carbendazim +mancozeb @ 2.5 g/lit. water.
Rust (*Melampsoralini*)	Prevalent in Northern region of the country & serious in colder hilly regions.	Timely sowing, Use of resistant/tolerant varieties. Destroy plant debris and weeds to reduce the primary source of infection. Use of clean seed, seed treatment with Carbendazim. Spray Propiconozole or hexaconazole (0.1%)) at 15 days interval to control the disease.
Powdery mildew (*Oidium lini*)	Throughout the country losses were dependent on time of sowing, early sown (15 October) no loss, late sown (25 November)	Timely sowing, Use of resistant/tolerant varieties, early sowing, 2-3 spray of Calixin (0.05%) or Sulphex (0.02) or Wettable sulphur (0.3%) reduce the disease.
Dodder/cascuta (*Cascutahylina*) Plant parasite	Chhattisgarh, Madhya Pradesh and Vidarbh region of Maharasthra, Losses up to 5-8 %	Mechanical removing of parasitic vine from fields and parasitic seeds lot; Preventing the movement of grazing animals from infested fields, Restricting the flow of irrigation water from infested area. Spray 2-4 D @ 0.5 kg/ha.

12. Harvesting operation		
Harvesting symptoms	:	Harvested when the leaves are dry, the capsule have turned brown and the seeds have become shiny
Mode of harvesting		
i) Manual harvesting		Cutting of plant from bottom
ii) Harvesting by Reaper cum binder		Very effective for linseed to reduce the cost of cultivation
iii) Combine harvester		Use of combine harvester for harvesting and threshing of linseed is very effective to save time, money and cleaning operations with some modification and setting. Most of the farmers of the State are now practicing this.

13. Post-harvest operation		
Cleaning and drying	:	Drying of the seed to reduce the moisture content to 9%
Packaging	:	Gunny bags
Storage	:	Dry place

14. Realizable yield potential		
		By adopting the recommended package of practices on an average the following yield can be realized under various situations. Rainfed :1200-1400 kg/ha, Irrigated: 1400-1600 kg/ha

Impact of quality seed of linseed produced and supplied to farmers is as given:

- Increase in Seed Replacement Rate (SRR) of linseed
- Improvement in the production and productivity of the crops
- Crop failure risk minimization due to resistance/tolerance of improved varieties against biotic & abiotic stresses
- Decrease in yield gap
- Upliftment in socio-economic status of farmers & farm families
- Quality seed availability builds faith & creates support of the scientist in the area.

The strategies for enhancing the productivity (and profitability) of oilseeds are as under:

i. Increasing seed production and distribution of newly released varieties.

ii. Low input cost-based technologies with high impact on productivity will result in higher income which will encourage farmers to go for linseed farming.

iii. Strategies with emphasis on quality improvement and value addition leveraging technologies with a bearing on the employment through skill/ entrepreneurship development

iv. Introduction of mechanization to reduce the dependency on farm labourers is the need of the day to reduce the cost of cultivation.

v. Minimum Support Price (MSP) is not available to Linseed crop.

vi. The linseed crop is not covered in crop insurance scheme therefore it has to be incorporated under this scheme.

Conclusions:

Seed security is a prerequisite for food security and in the past few decades, we have made significant strides in this aspect. Analysis of Seed replacement rate reflects the incremental trend in nation-wide SRR in crop. Pace of varietal replacement rate of the crop is being rapidly increasing year by year. Establishment of such crop Seed Hub centre may play a major role in production of quality seed at local level which helps in timely supply of seed to the farmers.

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2. Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh

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Quality Seed Production of Sesame: Problem and Way Forward

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The availability of the quality seed of Sesame is vital and crucial for sustainable production. The seed production chain and the ultimate availability of quality seed had been very poor and more than 80 % of the area is still sown with the seed saved by the farmers. With the increased movement of seed and removal of the trade barriers, the need for improved technology for seed production has become essential to make these crops globally competitive. There will be greater demand for the supply of the quality seed in the future to saturate larger areas. Therefore, it becomes imperative to produce genetically pure, quality seed for raising the productivity. Three paradoxes of very low seed rate (3-5 kg/ha), very high seed multiplication ratio (1:250) and very poor seed replacement rate (5-10%) coexist in sesame.

Important diagnostic characters: The criteria used in the identification and seed certification of a variety is the distinct morphological traits. The distinct traits with high heritability as specified by breeders are important in the production of genetically pure seed and for the identification of true to the type plants. These characters are exclusively used to remove off types and to get a pure stand required viz; Seedling vigour; Branching pattern; Branching habit; Stem hairiness; Flower colour; Days to flower; Corolla hairiness; Density of capsule hair; Capsule shape; Capsules per leaf axil; Seed coat colour; Capsule length; Days to maturity; 1000 seed weight (g); Oil content; Reaction to diseases and Reaction to pests.

Sesame is a self-pollinated crop with an average cross pollination of about 5%.

Suitable areas: Seed production shall be under taken preferably in the areas where soil and climate are highly suitable for the growth and development with optimum expression of diagnostic characters; facilities for protective irrigation exist; the incidence of diseases and pests is very low; the productivity and seed quality is very high. Seed production should not be undertaken in the hot spots of seed borne diseases. Sesame is highly sensitive to seasonal variation in terms of day length and temperature. Therefore, varieties recommended for cultivation are location and season specific. The varieties, which are popular with the farmers, shall be chosen for seed production.

Floral biology

Usually in sesame 1 to 2 flowers open at a time on any inflorescence, while in some types, about 3 to 4 flowers open at a time. Flowering starts after 30-35 days after sowing and flowers starts opening between 5 to 7 am, fade soon after midday. In the mature flower buds, just before the flower open, the 4 unripe anthers are much below the stigma which at this stage are not receptive. The anthers began to burst longitudinally after 4 A.M. and liberate the pollen. Sesame has bifid stigma which begins to separate and become receptive. The stamens of sesame are at same level and another two stamens are at lower level. Sesame is a self -pollinating crop but honeybees bring about some natural amount of cross pollination.

Pollination systems

Sesame is a self-pollinated crop with an average cross pollination of about 5%. However, the amount of out crossing ranges from 0 to 50% depending upon the pollinating insects and weather conditions. The insects are the only agents where as wind plays no part for natural cross pollination. The seed quality deteriorates proportionate to the amount of out crossing and can be minimized by maintaining proper isolation distance.

Seed production technology:

The non-availability of quality seed to the farmers at proper time is one of the important reasons for low productivity. However, improved varieties and agro production techniques capable of boosting the productivity levels have been developed for different agro ecological situations.

Isolation

The seed crop should be essentially raised on an isolated plot to maintain seed purity. Isolation from other plots/field of the same crop is essential and more important than other crops. The seed crop should be raised in isolation and the isolation distance maintained between varieties is 50 metres for certified and 100 metres for foundation seed production.

Seed production stages

Breeder seed-Foundation Seed-Certified seed

Climate

Normally, the crop is grown in plains. For maximum seed yield, sesame requires fairly high temperatures and evenly distributed rainfall. It cannot withstand frost, prolonged drought, water logged conditions, specially at flowering and capsule development stages. Low temperatures at flowering may lead to premature flower drop or production of sterile pollens. Sesame can be grown on a wide variety of soils but well drained fertile light to medium textured soils with good depth are preferred. It does best on sandy loams with adequate moisture. The optimum pH range is 5.5 to 7.5. Acidic or alkaline soils are unsuitable for seed production.

Land selection

The land selected should have not been cultivated with the same crop in the previous season. The land should be fertile with proper drainage facility.

Varietal Development

Eighty-three varieties of sesame have been developed for different agroecological situations. Seed yield of these varieties range from 800-1000 kg/ha, days to maturity 80-95 and oil content 48-52%. In Sesame breeder seed of 370.04 q. was produced, higher than indents 163.45 q. from 2002-03 to 2010-11.

State wise recommended varieties

State	Varieties
Gujarat	GujaratTil-1,GujaratTil-2,Gujarat Til-10,GujaratTil-3
Madhya Pradesh	TKG-21,TKG-22,TKG-55,JTS-8,PKDS-11,PKDS-8,PKDS-12, TKG-306,TKG-308
Chhattisgarh	TKG-21,TKG-22,Uma,RT-54,TKG-55,JTS-8
Rajasthan	RT-46,RT-54,RT-103,RT-125,RT-127,RT-346,RT-351,
Maharashtra	PhuleTil-1,Tapi,Padma,AKT-64,AKT-101,PKV-NT-11,JLT-408
UttarPradesh	T-12,T-13,T-78,Sekhar,Pragati,Tarun
TamilNadu	TMV-3,TMV-4,TMV-5,TMV-6,CO-1,TSS-6,Paiyur-1,VRI-1, VRI-2,TMV-7
WestBengal	Savitri,Rama
Orissa	Uma,Usha,Nirmala,Prachi,Amrit
Andhra Pradesh	Madhavi,Rajeshwari,Varaha,Gautama,Swetha,Chandana,Hima, Sarada
Kerala	Kayamkulam-1,Thilak, Thilathara,Thilarani
Karnataka	DS-1,DSS-9
Punjab	PunjabTil-1,TC-25,TC-289
Bihar	B-67,Krishna

Seed selection and sowing

Good quality Breeder/Foundation Seeds should be taken from an authentic source i.e. ICAR Institutes, Agriculture Universities, NSC, SFCI. Seeds should be healthy with a good germination percentage. Seed rate is 2 kg/acre (5 kg/ha). Selected seeds should be treated with bio-control agents like Trichoderma viride @ 4 g/kg of seeds. Mix Trichoderma viride in rice gruel and mix the solution with seeds. Shade dry the seeds for 30 minutes before sowing. Soaking the seeds in hot water at 52 0C for 30 minutes before sowing will control the bacterial leaf spot disease.

Treated seeds should be mixed with ash or fine sand to increase the volume for easy sowing. Seeds can be sown in beds and channels or in ridges and furrows. The spacing maintained is 60 x 30 cm (11 plants / m^2).

Nutrient management

FYM or compost @ 4 tonnes/acre (10 tonnes/ha) is thoroughly incorporated into the soil before the last plough. This will improve the texture as well as the nutrient content of the soil. To improve the nitrogen content of the soil green manuring with subabul @ 2 tonnes/acre (5 tonnes/ha) should be done or castor cake or neem cake @ 400 kg/acre (1 tonne/ha) should be applied.

Trichoderma viride @ 1.5 kg/acre mixed with 300 kg compost and kept as such for one week is applied to the field as top dressing. It will protect the crop from root rot and pathogens like Pythium and Phytophthora. In prolonged dry condition top dressing can be done using vermiwash. Rainfed sesame requires 17 kg of nitrogen, 13 kg of Phosphorous and 13 kg of Potassium, whereas the irrigated crop requires 21, 23 and 23 kg respectively. Appropriate biofertilisers can be used to meet the nutritional need of the crop.

Weed management

Sesame is very sensitive to weed competition during the first 25 days after sowing. The first weeding is done 20 days after sowing followed by the second one in 15 days interval. Another weeding may be done in 15 days gap. Apart from hand weeding, implements such as hand hoe, bullock drawn blade harrow, rotary or finger weeders are used for weeding.

Pest and disease management

Incidence of Antigastra and bud fly may be managed with alternate sprays of NSKE 5% or Quinalphos. Among new insecticides, Thiamethoxam 0.25 g/l and Imidacloprid 0.25 ml/l proved to be effective for the management of pod bug. Seed treatment with T. viride (4 g/kg) + soil application of T. viride 2.5 kg/ha and neem cake 250 kg/ha was effective for Phytophthora, Macrophomina. Solarization + Mancozeb spray was effective to manage Phytophthora. IDM module comprising seed treatment with Carbendazim (1.0 g/kg) + Thiram (2.0 g/kg) and two sprays of Mancozeb and Endosulfan minimized the incidence of diseases.

Interculture practices

Earthing up should be done at the stage of fruit setting to avoid lodging of the crop.

Irrigation

Irrigation should be done once in 15 days. It is critical during flowering and pot filling stage.

Roguing

Roguing should be done from vegetative phase to harvesting phase. Off-types are removed based on the branching type, capsule size and colour of the seeds. Maximum percentage of off-types permitted is 0.10% and 0.20% and permitted percentage of plants affected by seed borne diseases is 0.50% and 1.0% for foundation and certified seed production respectively.

Field inspection

A minimum of three field inspections should be done from pre flowering stage to harvesting stage by the Seed Certification Officer. First inspection is done before flowering followed by the second inspection during flowering stage. The third inspection is scheduled between fruit maturity and harvest.

Field standards

Particular	Foundation Seed	Certified Seed
Isolation Distance	100 m	50 m
Off-Types	0.10%	0.20%
Plant affected by seed borne diseases	0.50%	1.00%

Harvesting

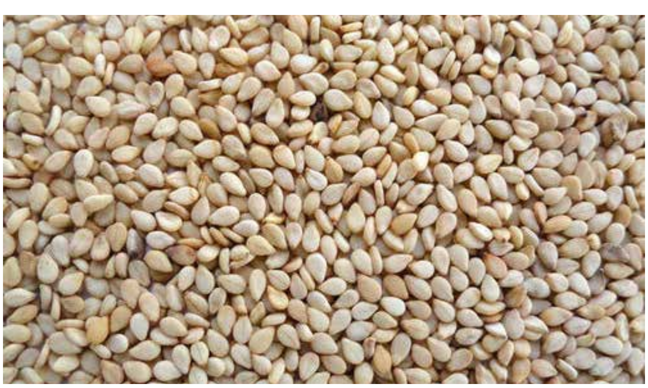
Harvesting should be done when 75 – 80% of the pods become brown in colour and few at the bottom have dehisced (burst open). At this stage the moisture content of the pods and seeds will be 50 – 60% and 25 – 30%, respectively. For black seeded variety, check the colour of the seeds in the 10th capsule from the bottom of the crop. If the seeds are black in colour then harvest should be done. Delaying harvest may result in yield loss.

Threshing and processing

Threshing is carried out manually by beating the capsules with pliable bamboo sticks. The seeds removed from the pods are graded using round perforated metal sieves of 5/64” size.

Seed storage

Seeds are dried under the sun for 3-4 days to reduce the moisture content to 5.0% before storage. After proper drying the seeds should be mixed with activated clay @ 1 kg/100 kg of seeds. Seeds are then stored in gunny bags or bins. Seeds can be stored upto one year under open storage conditions.



Seed standards

The percentage of physical purity of foundation and certified seeds should be 97% with 80% of germination capacity and 9% of moisture content. The maximum presence of seeds of other crops and weeds should be 10/kg for foundation and 20/kg for certified seeds.

Factor	Standards for each class (%)	
	Foundation	Certified
Pureseed (minimum)	97.0	97.0
Inert matter (maximum)	3.0	3.0
Other crop seeds (maximum)	10/kg	20/kg
Weed seeds (maximum)	10/kg	20/kg

Poor seed replacement

The nucleus and breeder seed production in sesame exceed the indents by 2-3 times. However, the seed production chain at foundation and certified stages is so week that inspite of the advantages, the seed replacement rate is low exhibiting a range from a minimum of 1-2% in Bihar, Madhya Pradesh and Maharashtra to a maximum of 10% in Gujarat, where availability of improved seed to the farmers has been assured through direct supply by the breeders without depending upon the distribution of certified seed.

Organic production for export

Bio/natural inputs 3.5 t/ha FYM + 900 kg/ ha neem cake + 75 kg/ha Ash + 75 kg/ha Bone meal + 20 kg/ha elemental sulphur + 5 kg/ha PSB soil application + seed treatment of Trichoderma viride + neem oil spray at 15 and 30 DAS resulted in the production of pesticide residue free crop suitable for export. It also improved the soil health.

Problems in seed production

Asynchronous maturity

In most of the varieties, the maturity of the capsules is not synchronous as a result the earlier capsules start shattering while others are still green. Shattering is the main problem to adversely effects the seed yield in sesame and source of mechanical mixture.

High multiplication ratio with very low conversion: The production of seed ranges from 0 to 15 q/ha. As a result, in spite of very low seed rate and very high multiplication ratio, the conversion from one to the other stage of seed multiplication is very low.

Frequent crop failures: Sesame is mainly grown in kharif crop. Prolonged exposure to variations in temperature and relative humidity may lead to shrinkage and attack of pathogens. It is sensitive to excessive moisture and highly susceptible to Phytophthora and Macrophomina at early stage. Crop failure due to these reasons is quite frequent.

Mechanical mixture: Very small, light seeds and shattering of capsules make the crop prone to mechanical mixture at harvesting, threshing and processing stages.

Lack of protective measures

To protect the seed from seed borne pathogens and storage fungi, a protective spray of systemic fungicide like Bavistin is recommended but not actually practiced.

Non-lifting

As also in other crops, non lifting and delayed lifting of seed is a common problem of breeder seed production process.

On farm seed production and supply

Some resourceful progressive farmers can be trained, who can take up seed production programme on a scientific basis. These farmers will serve both as the source for seed supply to other farmers and also as role models for increasing the production. In this system, the breeders have to establish effective collaboration with the farmers and the training for the farmers should be a regular feature.

Tips to obtain higher yield of quality seed

Facility for irrigation is essential for seed crop. Separate areas should be allotted for each variety. Use good quality source seed of recommended varieties after ascertaining 100% genetic purity. Maintain a minimum isolation distance of 100 m. for nucleus, breeder and foundation stages and 50 m for certified or other commercial stages. Grow five border rows of the same variety around the seed plot to serve as barrier. Time isolation should be avoided. Take up sowing at appropriate time with proper row spacing and maintain plant population by thinning 15-20 days after sowing. Adopt need based recommended plant protection measures. Give a protective spray of systemic fungicide like Bavistin to protect the seed. Inspect the field at early growth stage, flowering, capsule formation and maturity stages. Complete the joint inspection of the seed plot between capsule formation to maturity stage by the team as per norms. Follow grow out test to ascertain the genetic purity. The seed should be completely dried in sun to bring down moisture level to<9% and treated with Thiram + Bavistin 1:1 ratio, before packaging is done in cloth bags treated with Malathion.

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Challenges of rapeseed mustard production on the face of changing climate in Eastern India with an emphasis on West Bengal

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Dr. Subhendu Deb Chatterjee is a doctorate in Agriculture with specialization in Genetics and Plant Breeding from Calcutta University. In addition to having 24 years of Research Experience as a Breeder, he has further contributed for over 16 years in the Higher Agricultural Research Service in Breeding and Research Management in Rice and Oilseeds Crops with the Department of Agriculture, Government of West Bengal which also includes a 7 Years assignment from 1997 to 2004 as General Manager and Managing Director in West Bengal State Seed Corporation. He also served as Additional Director followed by the Director of Agriculture and Ex-Officio Secretary in the Department of Agriculture, Government of West Bengal during 2004 to 2009.

During his tenure in various reputed organization, he significantly contributed in seed research activities by breeding and releasing seven varieties of Rapeseed-Mustard namely Panchali, Subinoy, Jhumka Bhagirathi, Sarama, Sanjukta Asech and Kalyan; one variety of sesame (Rama) and six varieties of Rice (Kishan, Purnendu, Jitendra, Saraswati, Jalaprava & Sashi) for commercial Cultivation in Eastern India. Dr. Chatterjee is also credited with Breeding & Release of the First Boro Rice (CNHR –3) Hybrid in Eastern India.

Abstract

Rapeseed-Mustard (Brassica spp.) is the second major oilseed crop, widely grown during rabi season in various agro-climatic zones across the country. Eastern India especially West Bengal, occupies an important position in acreage and production in the national scenario. Despite all efforts the country never achieved a linear growth in production over a period. The change in climatic factors such as decline in duration and intensity of winter and rising trends of rainfall during the post-monsoon, the season area and production of this crop have shown wide fluctuation over the past few decades. While change in these parameters exerted large negative effect on central and north-western Indian states that are habituated to grow long duration Brassicas, while majority of eastern Indian states traditionally raising short duration Brassicas remain unaffected exhibiting rather positive growth. Brassica campestris is predominantly grown in the eastern zone especially in West Bengal because of its short duration to complete its life cycle within characteristic warmer and shorter winter span of this region. However Brassica campestris is comparatively low yielder and susceptible to biotic stress than Brassica juncea. The yield level of this zone (951 kg / ha) is much below the yield level recorded in other two zones. West Bengal towards its drive to boost the yield level has currently started inducting short duration (100-110 days duration) varieties of Indian mustard (Brassica juncea) to replace B. campestris. As a result the productivity of this State has started rising. But it is still much below than that of Haryana or Gujarat. The paper discussed the possible strategy to enhance the genetic yield potential of mustard genotype within the duration frame work of 100-110 days duration.

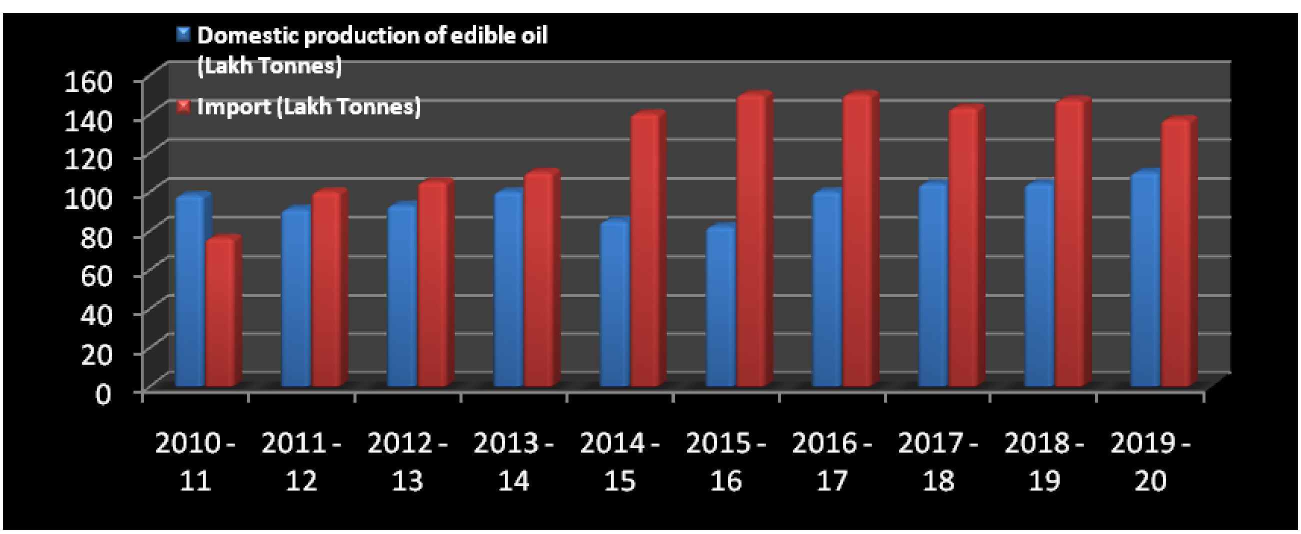
Eastern India especially West Bengal, occupies an important position in acreage and production in the national scenario.

Keywords: Rapeseed Mustard, Climate Change, Biotic Stress, Eastern India, West Bengal

Introduction

The global scenario of edible oilseed depicts India ranked second in terms of acreage (19.81%), behind only Canada, and fourth in terms of production (10.37%), after China, the European Union, and Canada (AIRCP (R&M) PC Report-2021, ICAR-DRMR). The Country grows as many as eight different edible oilseed crops in its diverse agro-climatic zones in different seasons. Among these eight annual edible oilseed crops grown in India Rapeseed-Mustard (Brassica spp.) is the second largest oilseed crop after soybean. Currently the annual domestic production of rapeseed mustard on an average is 8.30 million tonnes from 0.61 million hectare area with an average yield of 1349 kg / ha (2015-16 to 2019-20) (Directorate of Economics and Statistics, Govt. of India 2021). Rajasthan, Madhya Pradesh, Uttar Pradesh, Haryana, West Bengal, Assam, Jharkhand, Gujarat, and Bihar are the major rapeseed-mustard growing States in the country. Amongst different zones, eastern zone alone shares 20.1% of national acreage. In this zone, however, West Bengal plays the key role by contributing 56.12% to its rapeseed- mustard basket taking zone's 44.64% share in acreage. Eastern India especially West Bengal thus occupies an important position in rapeseed- mustard map of the country. In this context it may also be noted that this zone having more than 20% of total rapeseed- mustard area of the country shares only 13.57 % of domestic production primarily due to low productivity i.e. 951 kg/ha as against the national average of 1349 kg / ha) (Directorate of Economics and Statistics, Govt. of India 2021). This region therefore deserves special attention towards nation's drive to break the stagnation in country's edible oil production front. The nature of stagnation in edible oil production front vis-à-vis its reflection in import arena is delineated in Fig-1.

Fig 1. Edible oil production and import trends in India



Source: 28th Annual AIRCP (R&M) Group Meeting, ICAR-Directorate of Rapeseed-Mustard Research

Since rapeseed-mustard is the second largest oilseed crop, major efforts are underway to boost its production particularly in the face of its large fluctuations since last three decades as envisaged by FAO in their recent analysis Fig-2.

Fig 2. Scenario of Rapeseed Mustard production and area harvested in India during 1990-2020 (FAOSTAT 2021)

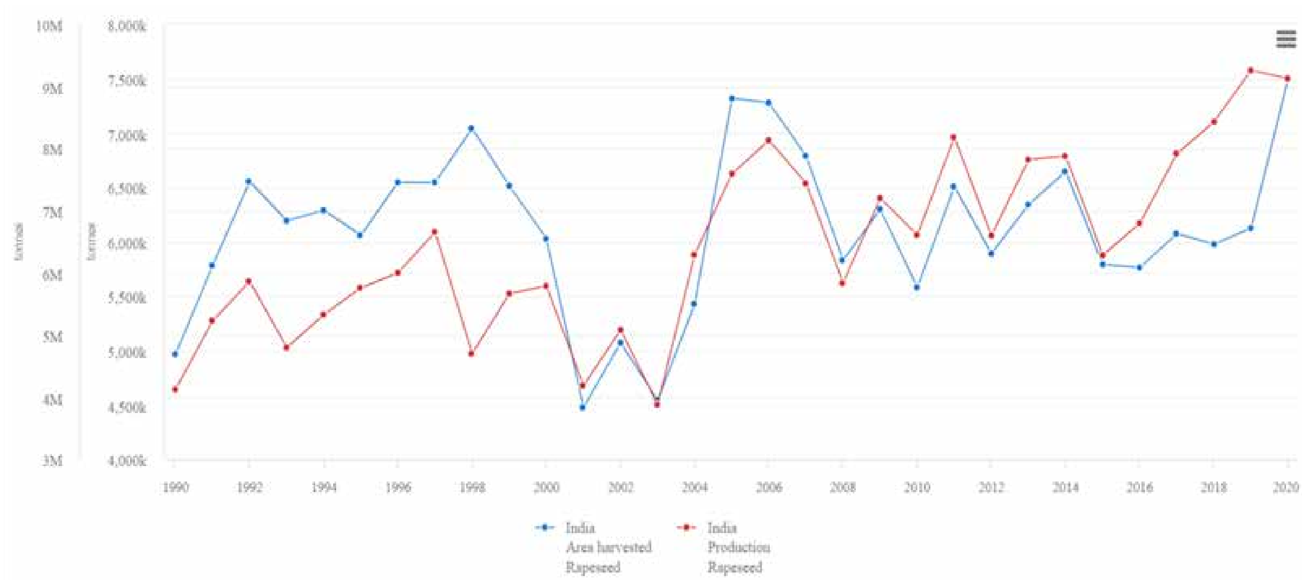
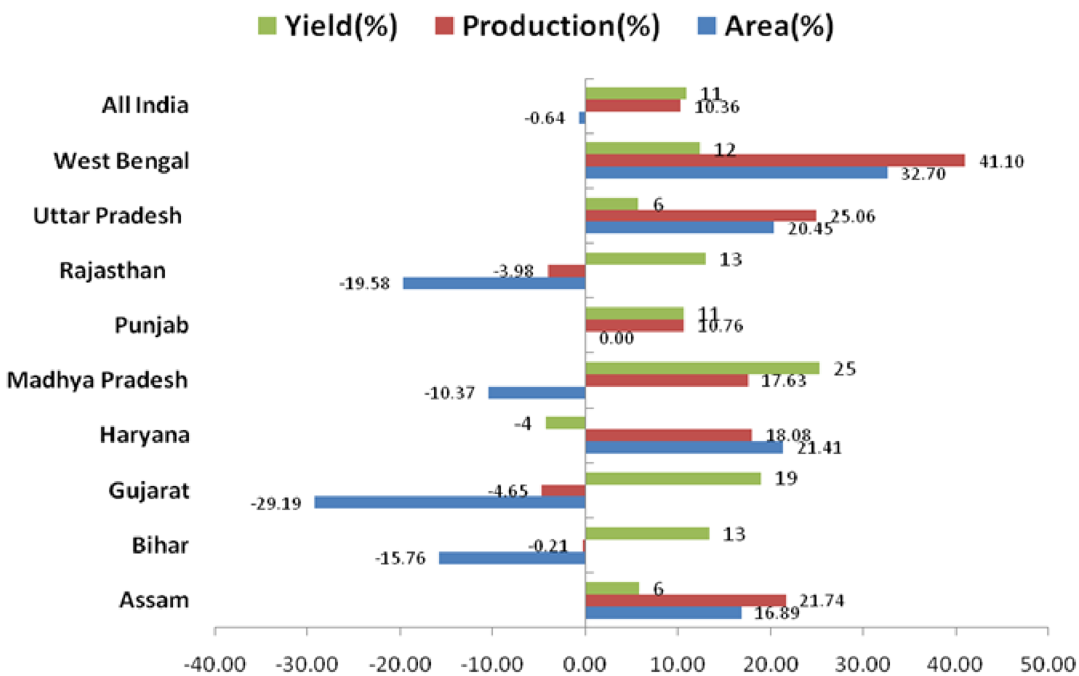


Fig-2 indicates that there has been severe ups and downs in acreage and production all along the past three decades except short spell of linear growth between 1992-1994 and 2004-06. This may be attributed to changes in vital agro-climatic parameters especially duration, intensity and rainfall status of winter that are potential to impact yield and area. Taking into consideration 2010-11 as the base year changes in area, production and yield rate of rapeseed-mustard was assessed for eight major Brassica growing States viz. UP, MP, Haryana, Rajasthan, Punjab, Gujarat, Assam, Bihar and West Bengal up to 2019-20 by Kumar et al. 2022 as presented in Fig-3.

Fig 3. Percent change in area, production and productivity in Rapeseed - mustard in 2019-20 (base year: 2010-11)



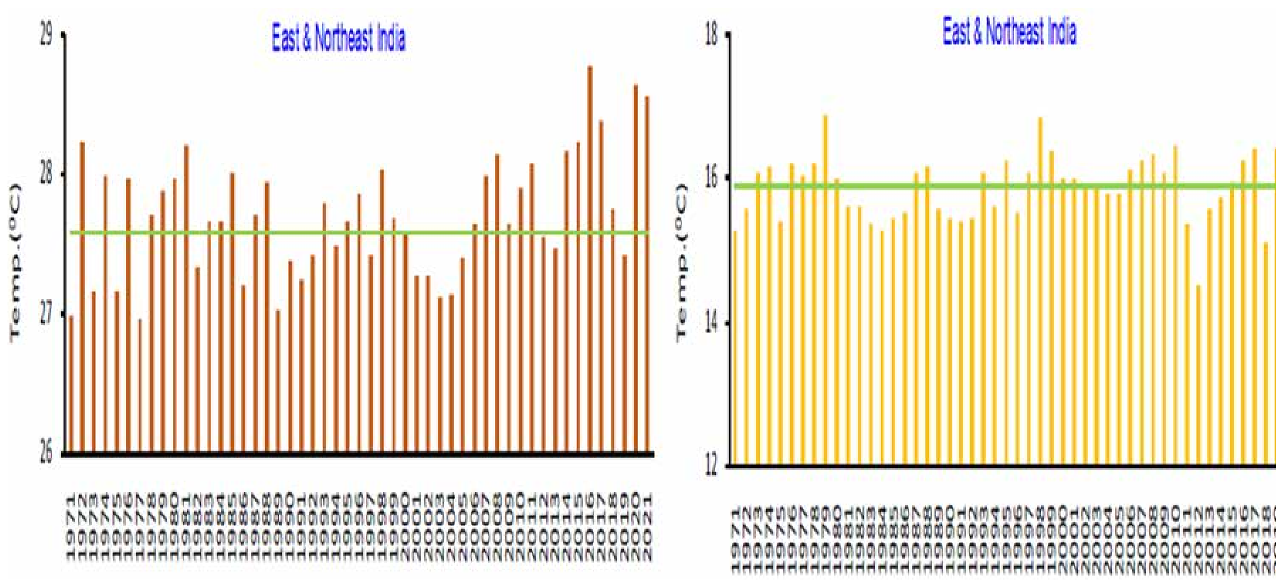
The study revealed that there had been drastic decline in area in four States out of eight studied States namely, Rajasthan, Madhya Pradesh, Gujarat and Bihar ranging from 29.19% for Gujarat to 1.17 % in MP. It is interesting to note here that during this time span West Bengal achieved maximum growth in production (41.1%) as also in area (32.70%). At the national level, however the change in production and yield rate was positive (10.16% & 11 % respectively). This is primarily due to the positive change in two eastern Indian states (West Bengal and Assam). It may further be pointed out at this stage the States which showed significant decline in area and production are traditionally equipped with prolonged cool winter and primarily grow long duration Brassicas. Constraints of these States for registering such negative effect on rapeseed- mustard production seem to be marked deviation in characteristic winter due to global warming. The improved Varieties and cultural package under use in these States are, therefore, highly sensitive to this deviation. On the contrary West Bengal and Assam have characteristic shorter winter and predominantly grow short duration Brassica campestris. Varieties and agro-practices followed in these two States are thus appearing to be adapted to such changes in winter parameters.

Congenial climate for Brassicas Vis-à-vis constrains in Eastern India

Brassicas in general are cold loving crop, although a little higher temperature (28°C) favors germination. But it needs cool and dry weather during entire growth stage. The optimal range of temperature for mustard growth is between 15°C and 25°C. However the crop can accommodate low temperature to the tune of 10°C at any stage during its entire growth phase without showing any adverse effect on yield. Ideal temperature for seed setting of mustard is 20°C ± 5°C. Extreme low temp/frost on the other hand causes severe injury to the crop. Similarly, an increase in temperature beyond 28°C affects growth, seed setting and yield by inducing forced maturity. The crop during its entire life span also requires good amount of soil moisture. Cloudy weather coupled with continuous rain following flowering hampers growth, invites diseases and thereby reduces yield (Kalra et al. 2002). The fore stated ideal climate optimizes expression of its yield attributing traits to result yield maximization (Chauhan et al. 2011, Meena et al. 2006, Verma et al. 2008).

Receipt of ideal climate for raising rapeseed-mustard, in major rapeseed-mustard growing States in eastern India is nothing but an illusory dream. The reasons are many, primarily the geographical position. The eastern States are bordered on the south west by the Bay of Bengal, and positioned in the humid-subtropical zone. As a consequence this region exhibits hot or warm temperatures, high rainfall, short & mild winter besides its vulnerability to climate extremes. In this region mustard is predominantly sown after harvest of long duration kharif rice. As a result delayed sowing and high temperature stress at the terminal stage are common occurrence in mustard cultivation which play significant role in yield reduction. In addition study unveiled that since last three decades the mean maximum and minimum temperature of East & Northeast India for the post monsoon season (1971-2021) are on the rise (IMD Annual Report, 2021) as highlighted in Fig- 4. The situation therefore is clear indicative of the fact that the prevalent current environment of this zone is apparently unfavorable for harvesting potential yield of rapeseed- mustard crop.

Fig 4: Time series of mean temperature averaged East & Northeast India (vertical bars) and five year running mean (continuous line) for the post monsoon season (1971-2021) (a) Maximum (b) Minimum

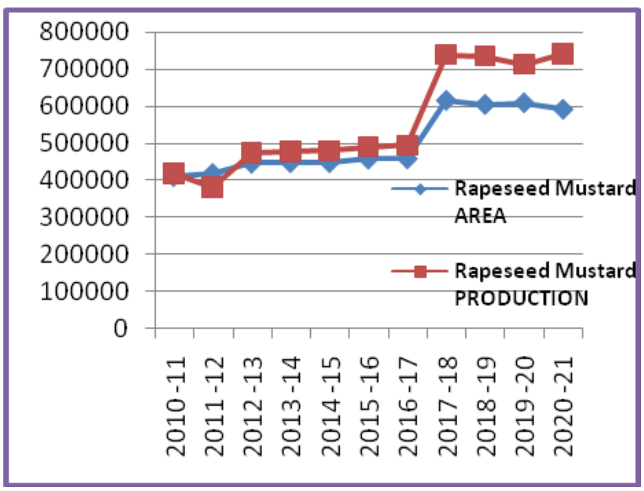


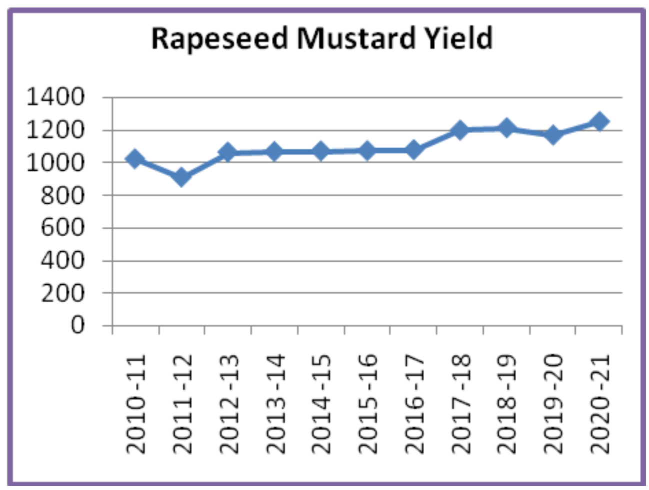
Source: Annual Report of India Meteorological Department (IMD) for the year 2021

The strategy to overcome environmental bottle neck

Since mustard is a crop that flourishes in the cold, it is very vulnerable to variations in the intensity and duration of winter. It is therefore, prerequisite to first analyze growing environment to fit in a genotype and decide upon its breeding requirement. The growing environment of eastern zone especially West Bengal has been amply discussed above with respect to two spp of Brassica namely campestris and juncea under cultivation in the State. Farmers at their own selected B. campestris primarily for its early maturity and higher oil as against juncea. Improved early maturing B. juncea with high yield and oil at par with Yellow Sarson variety "Binoy" could not be made available to the farmers before commercialization of "Shivani". Induction of these varieties started bringing tangible change in area, production and yield of this crop as is evident in Fig-5.

Fig 5: Rapeseed Mustard area and production of different districts of West Bengal





Source: Directorate of Agriculture, Govt, of West Bengal

But the yield in this State also has virtually stagnated since 2017-18. The need of the hour is therefore, to break the yield plateau of currently available B. juncea varieties in the desired maturity group. The other most important strategy is genetic tailoring of B. juncea genotypes to tolerate high temperature at terminal stage of crop growth, since, delayed seeding during end November is inevitable in this region either due to post monsoon rain or harvest of preceding long duration rice. Alterneria blight and aphids are other vital factors whose incidence is on the rise in this State due to delayed sowing on one hand and increasing trend of erratic rain during winter on the other. Both these biotic stresses have profound negative effect on yield potential of rapeseed-mustard. Breeding for above stated biotic and abiotic stress tolerance requires intensive search for effective donors within the spp / across the spp and thereafter staking genes following conventional or advanced molecular breeding approaches to develop multiple stress tolerant varieties. For the circumstances in eastern India and West Bengal to fit in the rice-mustard-rice/maize/sesame cropping ecosystem, high yielding Indian mustard varieties with short duration less than 100 days, resistance to biotic stress and high oil content are essential which can be utilized as a catch crop and increase the farmer's gross revenue. Private seed sector in India has evolved gradually and also emphasizes on research and development activities to enhance the production of Indian mustard throughout the eastern India.

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Seed Technology – Some Researchable Issues, Areas, Gaps and Concerns

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A doctorate in Agriculture Seed Technology from TNAU, Dr. V. Sankaran is a legendary personality with over 57 years of professional experience in the Indian seed industry. He had a bright academic career with a Gold Medal in Post-graduation from TNAU. Having joined the premier seed organisation of the country, the National Seeds Corporation (NSC) in the initial inception period - 1965 itself, he held various positions in the organisation, with significant devotion towards the performance of the corporation and also the seed sector development in the country. During his tenure with the Krishidhan Seeds, Jalna (Maharashtra) as Vice President (Tech), Director and also as Mentor from 2007 to 2015, he contributed significantly in standardising and applying the technical norms and procedures in the company.

He has been Member of a number of committees, core groups and seed study missions, to quote a few, Technical assistance to the Govt. of India's Seed Review Team [1968], supporting the Member of the Seed Group of the National Commission on Agriculture [1976] and in the two Member NSC's Seed Certification Consultancy Team for the GOI in 1980. He also extended his consultancy support to the Govt. of India in finalizing the National Seed Mission Document during October 2009 to September 2010. Dr.

Sankaran is a Founder Member of Indian Society of Seed Technology [ISST] since inception in 1971 and has served as Councillor, Editor, President and Fellow during different periods.

Dr. Sankaran also has to his credit 45 papers including 4 books as co- author, the latest being NSC publication "NSC's Journey in the Service of Farmers- August, 2020" released by the Hon'ble Union Minister of Agriculture, Shri Narendra Singh Tomer on the 28th January, 2021. After getting relieved of the formal organizational engagement with Krishidhan Seeds in 2015, he is still actively sharing his knowledge and experience on honorary basis through seed related trainings, especially for the next generation of seed professionals, advisory support to the seed industry and also with number of articles for development of seed sector in the country.

The Indian Seed Sector has made significant progress in every sphere / component involved in any well organised seed program. Over the years, as the program expanded, several issues relating to Seed Science and Technology have been handled by the industry, research groups etc. leading to meaningful results / conclusions/ practices. However, in any such activity there is no end for issues to be resolved. Accordingly, out of the many issues requiring attention, to start with, a set of 25 have been identified and are listed below. Hope, this short listing will generate interest among the concerned to work upon and contribute.

1. Seed quality differences between Normally produced seed vs Organically produced seed. Is there any influence of Organic seed production on seed quality factors such as Physical Appearance, Size, Weight, Viability, Germination, Vigour, Storability and Health?

2. In Bio fortified crop varieties, is there any influence of bio fortification on the seed quality factors such as ovule –to- seed ratio, physical features viz. size, weight, filling etc. and physiological viz. Viability, Germination, Vigour and Storability?

3. Whether all Hard Seeds [HS] will always result in Normal Seedlings in all the species in which HSs are reported? This has relevance because, according to IMSCS, in the crops with HSs, the term mentioned for the minimum standard prescribed for certification is"Germination – including Hard Seeds". Thus, the IMSCS assumes that HSs will end up as Normal Seedlings. Whether this assumption is cent per cent correct? Better to confirm this assumption by extensive studies.

4. Review the IMSCS crop wise and list out those crops in which Hard Seeds are seen or known, but not so far mentioned so in the Seed Standard. On confirmation, the list can be submitted to the Central Seed Certification Board (CSCB), MoA, GoI for consideration and inclusion.

5. As of now, the term ODV denotes “Other Distinguishable Varieties”. Actually, the term ‘Varieties’ does not appear proper here, because, to say so, the Analyst / any one has to identify the ODV up to its actual Variety name level. But, most often that is not possible; nor, is it necessary. Therefore, the alphabet ‘V’ in ODV may stand for ‘Variant’instead of ‘Variety’. For, actually what any Analyst or any one distinguishes is just a ‘Variant’ and not necessarily tracing it to the actual name .This correction i.e.“Other Distinguishable Variant”of ‘Other Distinguishable Variety” has to be carried out in the IMSCS wherever relevant.

6. In the interest of knowledge up gradation on the one hand and rendering advice to the farmers/ seed growers on the other, it will be a wise practice ,as an internal system with in the Lab, to grow out the ODVs and confirm the correctness of the identification as ODV . The GOT observation may enhance the Analyst’s / Lab’s confidence or help in improving the identification skills.

7. In maize (corn), based on seed texture, dent, flint, waxy, sweet, and pop and flour types are known. Similarly, based on colour, orange, yellow, and white grain types are there. As of now, the Indian Minimum Seed Certification Standards (IMSCS) has the standards for Maize crop as a whole, irrespective of the colour / texture differences. However, considering the chemical composition and cell-tissue structures of these types, one may expect some differences between these types in terms of seed quality factors. Hence, a comparative study of the seed viability, germinability, vigour, storability and longevity and seedling features, their vigour potential, etc. of the maize types cited above may be of interest; and may help in fixing the realistic minimum Germination standards for these types for certification / labelling. This is an area for further study.

8. In Seed Vigour Tests for F1 hybrids, especially involving Radicle Emergence, Germination and Seedling features – length / dry weight, it may be better to putthe corresponding /related female and male parents also simultaneously. By comparison, this may help in verifying the expression/availability of ‘Heterotic / Hybrid Vigour ‘in the earliest stages of the F1. So also, the same approach in GOTs of F1 hybrids, by comparison will help in verifying the Hybrid Vigour, as an additional information, apart from confirming the Genetic Purity.

9. Seed Testing procedures especially for Physical Purity and Germination, for “legume – grass mixtures” is an area for study using the possible mixtures in the Indian context. In Forage grass - legume mixtures, the seed testing methods especially for Germination for the crop species involved may differ. How do we handle such situations? The component seeds are of diverse types and features; and hence may need different testing procedures.

10. “Insect Damage “(ID) is an important aspect of Seed Quality. The ISTA Rules cover such damaged / broken / partly eaten seeds under the Half Seed Rule of Physical Purity Analysis. But, that takes care of only those seeds in the sample which are damaged by the insects actually affecting their Sizes. But, when viewed from both the angles – i.e. insect and seed, there are various other types of damages. From Insect angle, they can be in any stage – egg, larva, pupa or adult. One or infinite numbers of each or all the stages. All alive or all dead – in each stage. A combination of one or more or all the types is possible. From Seed angle, it can range from a simple scratch on one seed to all the seeds turning to powder. With such a complex situation, how to assess / test and report insect damage? Uniform testing and reporting procedure need to be developed and prescribed.

11. Physical Appearance (PA) is an aspect of seed quality influenced by size, shape, colour, lustre, shine, structure, texture, weight, etc. But, too difficult to quantify and evaluate by any quantifiable measure. It is purely based on ' Visual examination of the seeds and their appeal to the human eyes ' ; and which can differ between persons or even for the same person for the same sample on second, third look etc. Hence, collective judgement -assessment - evaluation by a Physical Appearance Examination Committee (PAEC) comprising of 2-3 Members at the Lab level issuggested.

12. An authentic survey of the Seed Health Testing (SHT) Status by the Labs (CSTL-STLs- SSCAs-SSCs-NSC- Pvt Seed cos.) is needed. Though, so much is talked about SHT, in actual practice, this is rarely a routine. What is coming in the way of regular SHT in the Labs need to be identified and remedial measures taken.

13. In the seed industry, most often there is a practice of making 'pin holes' in vapour –proof foil pouches / cartons etc. used for the final packets, and remove the air inside so that the pouches / packets can be pressed and made compact for handling. This helps in placing many pouches in an outer-packing or box for transport etc. With air inside, the pouches after sealing become bulged making packing in boxes difficult. By pressing / removing the air, the packet/ pouch is made compact, fit for handling / transport etc. However, the effect of such ' pin holes' on the seed quality in general and moisture in particular of the seed inside , over a period needs to be studied for various seeds in different packing materials .

14. Heterogeneity Test is presented in the Seed Testing Rules / Procedures, to ascertain the status of homo/ heterogeneity of seed lots through the Submitted Samples. But, in practice, this test is rarely put to use in any lab. A survey by the CSTL or any other appropriate body will reveal the status of this test in India. Also, the testing procedure is found a bit tedious to follow. Is it possible to develop a simplified version and arrange a training / technology transfer session exclusively devoted to Hetero/ homogeneity test.

15. Procedure for Moisture Meter calibration – if the results by Meter and Oven methods do not tally, what's the Tolerance – Acceptance level / limit? If it is beyond the Tolerance, what next, how to proceed? Can we add / deduct the difference as the Correction Factor and use the Meter? Also, Moisture Meters in use are based on different physical concepts. Among the various ' Moisture Meters' based tests which Concept / Principle is better ; which is more , realistic, dependable and near to/ comparable to Hot -air oven method results?

16. Will hidden insect infestation in seed, influence the moisture test result? For, the insect(s) inside may be respiring adding to the moisture content. It may also vary according to the insect life stage – larva or pupa or adult. Any information on this issue?

17. Seed coating with polymers (mostly coloured) has become a common practice in the seed industry. Does polymer coating influence seed moisture content during storage over a period? Also, will polymer coating slow down the seed drying process?

18. In Maize, over the years, Single Crosses for commercial crop production have become common. Accordingly, commercial single cross seed production adopting 'wet cob method' in the Rabi season in the South especially –AP and Karnataka has become common. In this method, in

order to ensure maximum seed vigour, cross fertilized cobs in the female parent are harvested at "full physiological maturity" when seed moisture is high, i.e. around 30 -35%, without waiting for "normal harvest maturity". This involves speedy harvesting, dehusking, transport from field to processing plant for immediate sorting and drying, followed by shelling. At harvest, in this method, the moisture of the shank / pith and that of the seed can be expected to be different. For better judgement for harvest, measuring cob moisture can be an additional step. The moisture meters are designed to measure the seed moisture. A standard authentic procedure for 'cob moisture estimation' is needed.

19. In order to ensure reasonable representation of the seed lot in the Samples meant for testing etc. automatic sampling can be ensured by providing holes of 2-3 suitable sizes in the channel / tube/ spout that delivers the final cleaned / graded seed from the equipment in to the containers , collecting drums-tubs etc. In this arrangement, while the final seed flows through the last stage channel / tube/ spout of the equipment, some seeds randomly automatically fall through the holes into a Sample Collection Box. The sample so gathered by the 'Auto –Sampler' is the Composite Sample from which the Submitted Samples can be derived.

20. Sampling seed in different types of containers, as per the prescribed 'Sampling Intensity' haslimitations, especially when they are in stacks, one over the other. Here, only the containers along the outer part of the stack are amenable for drawing the Primary Samples; and the inner layers are inaccessible. Also, despite best efforts, the containers do get spoiled due to trier insertions. Therefore, during final packing of any seed lot, prepare 4-5 additional samples equal to the Submitted Sample size and suitably place / store them all in different portions of the stack , thus providing the same environment as the main seed lot .Those additional samples so kept can be submitted for testing as and when needed.

21. What is the minimum plant population within the isolation distance that would make it a 'Contaminant'? Can it be the Max OT permissible (i.e. the prescribed standard) in the seed field based on the 'Seed Crop Population'.

22. Absence of embryo i.e. Embryolessness is common in some species of Umbelliferae (ranging from 8 to 34 %). This is one reason for keeping the G standard at 60%-65% in the IMSCS for Carrot, Coriander, Cumin, Dill and Fennel. Improving embryo formation in this group is an area for work.

23. In Seed Moisture Test, will there not be any influence on the Seed Moisture test result due to ' Polymer Coating ' now common in the Seed Industry? Will not the polymer interfere with the expression of actual moisture in the seed? If so, how to take care of it in the Testing/ Reporting?

24. Dormancy and storability – whether dormant seeds store better; have more longevity? Viability loss status in Dormant vs Non dormant seeds? Studies are needed with crop varieties known to have dormancy; and also, to estimate the difference, if any, between Physical vs Physiological Dormancy with reference to storability / longevity.

25. Is it possible to trace back the origin of Abnormal Seedlings in the G test as to Mechanical injury, Chemical toxicity, bad weather effect etc. so that such reasons can be taken care of in the seed programmes?

Lesser Known facts about Seeds

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1. The year 1961 was declared and celebrated as the **World Seed Year** by the FAO.
2. The year 1966 was declared and celebrated as the **International Rice Year** by the FAO. This coincided with NSC's first ever large scale paddy seed production (about 1.5 lakh q) using Taichung Native 1 (TN1) variety of Taiwan with which NSC started its paddy seed programme in 1966-1967.
3. The world's **first seed testing station** was established in 1869 by Frederich Nobbe in Tharandt, Saxony, Germany.
4. The world's **first catalogue on seeds** is reported to have been published as early as in 1784 in Germany.
5. The term **Green Revolution** was coined by Dr. William Gaud, Director –USAID in 1969 while describing the spectacular increases in cereal crop yields achieved in developing countries (including India) during the 1960s.
6. The 18000 tonnes of **Mexican wheat seed** [vars. Lerma Rojo 64A and Sonora 64] imported by NSC in 1966 from Mexico and distributed for rabi '66 sowings was the largest ever seed import by any country till then.
7. Seed of **Double Coconut** (Lodoicea javanica), family Lodoiceae, which weighs around 8 to 15kg is perhaps the largest and heaviest seed known – of course, botanically a fruit is Drupe.
8. The **first fertile cross of wheat x rye** resulting in Triticale (Triticum x Secale) was produced in Germany in 1880.

9. **Seeds of Indian Lotus** *(Nelumbo sp)* were found in a viable state in a drained lake bed in Manchuria where it was suspected to have remained buried atleast 160 years on even up to 250 years.

10. The **world's largest seed collection**: Svalbard Global Seed Vault in North Pole -1000 km off Norway Coast, at 120 meters depth into the ice rock. 4.5 million seed samples (with about 500 seeds per sample). Stored at minus 18 0C [naturally prevailing temperature] to conserve valuable genotypes for posterity and the future of humanity.

11. Certain native species of horticultural potential such as Eriostemon australasius, Rutaceae (Citrus family) occurring in eastern Australia are known to **germinate better / readily often after bush fire** only.

12. Number of hybrids that can be developed with a given No. of Inbred Lines:

No. of inbreds	No. of hybrids that can be produced		
	Top Crosses	Single Crosses	Double Crosses
5	5	10	15
10	10	45	630
20	20	190	14535
100	100	4950	117,63,625
500	500	124750	77,19,09,33,725

13. **Senna *(Cassia angustifolia)***, Fabaceae, is a legume, but does not produce nodules for fixing Nitogen.

14. ***Sesbania rostrata***, Fabaceae, a legume with nodules both in root and on the aerial stem is known as the fastest N fixing plant; 100 to 285 kg/ha in 45 days.

15. ***Vicia sativa*** sub sp amphicarpa, Fabaceaea, native of Turkey is perhaps one of the few species that produce both aerial and sub-terranean flowers and pods .

16. **Seeds of Candle nut tree** *(Aleurites moluccanus)*, Euphorbiaceae can slowly burn like candle/lamp and hence were used by the Natives in Hawaii to provide light.

17. **Papaya is Dioeceous**; i.e. female and male flowers are borne on different plants. Thus, papaya plants are either female or male; and can be easily identified after flower bud initiation. However, distinction in the seedling stage may be possible; female seedlings have 3 lobed leaves while male seedlings have 5 lobed leaves.

18. Absorption Index (AI): As a measure of **Seed Hardness** is derived as follows:
    AI= (A/B) x (100/Y);

    Where, A=Weight of soaked seed after 24 h of soaking in water; B = Initial weight of seed; and Y= No. of Hard Seeds (HS). More the Hard Seeds, lesser is the AI; and lesser the HS more is the AI.

19. In some species of Euphorbiaceae such as Jatropha multifeda and Hevea brasiliensis (rubber) cotyledons are never fully freed from the seed coat. This feature is known as **'Cryptocotylor'**.

20. Absence of embryo ie **Embryolessness** is common in some species of Umbelliferae (ranging from 8 to 34 %). This is one reason for fixing the low Germination standard at 60%-65% only in the IMSCS-2013 for Carrot, Coriander, Cumin, Dill and Fennel. Improving embryo formation in this group is an area for further work.

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