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Status of Genetic Resources in Oilseed Crops and Their Potential Use for Making India Atmanirbhar in Edible Oils

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Plant Genetic Resources play an important role in the genetic enhancement of different crops leading to food and nutritional security of the nation. India is genetic diversity rich country with more than 4.62 lakh accessions of 2065 crop species conserved National Gene Bank at National Bureau of Plant Genetic Resources, New Delhi. Oilseeds are integral part of the various crop breeding programmes under National Agricultural Research System. In case of nine edible oilseed crops grown in India 57977 accessions of 13 species are conserved in the National Gene. In general, it has been observed that the utilization of germplasm conserved in the National Gene Bank is very low. Characterization of the germplasm and identification of trait specific donors is pre-requisite for successful utilization in the various breeding programmes. In this direction efforts have been made by the Oilseed Breeders in the country and in addition to release and notification of 956 varieties of nine oilseed crops since 1969, 193 novel genetic stocks of different oilseed crops for different agro-morphological, biotic and abiotic stress tolerance, high seed meal and oil quality traits have been registered with NBPGR. In addition, a large number of exotic collections have also been procured and being utilized in breeding programmes and more trait specific germplasm of all the oilseed crops has been identified along with their source country. For Atmanirbharta in edible oils in our country, we need to follow two-pronged strategy i.e. horizontal expansion targeting more area under oilseed crops and vertical expansion by deploying high yielding varieties and adoption of good agricultural practices. In vertical expansion breeding high yielding varieties is the main component which can be achieved with the use of diverse germplasm available globally. Hence, characterization and wider use of trait specific diverse germplasm of oilseed crops will be of great help in making the country Atmanirbhar in edible oils.

Background

Oilseed crops are great gift of nature to mankind which are source of food (salad, oil, margarine, vanaspati, shortening, cooking, and bakery), feed and industrial raw material (pharmaceutical products, soap, paints and resins, coatings, linoleum, cosmetics, lubrication, chemicals, plastic coatings, and ethanol). In India total nine oilseed crops viz., soybean (*Glycine max* Merr.), groundnut (*Arachis hypogaea* L.), rapeseed mustard Brassica spp.), sunflower (*Helianthus annus* L.), safflower (*Carthamus tinctorius* L.), sesame (*Sesamum indicum* L.), niger (*Guizotia abyssinica* Cass.), linseed (*Linum usitatissimum* L.) and castor (*Ricinus cummunis* L.) are being grown. Among these nine oilseed crops; soybean (35%), groundnut (26%), rapeseed & mustard (30%) contribute to more than 91% of total oilseeds production and has more than 80% share in indigenous edible oil with major share of mustard (35%), soybean (23%) and groundnut (25%). Other edible oilseeds like sesame, linseed, safflower and sunflower are constantly losing their acreage, as well as their share in gross cropped area. In totality, oilseeds have registered continuous growth in area, production and productivity since 1950-51 which has about 2.70 times increase in area, 7.00 times increase in production and 2.60 times increase in productivity (Fig. 1). The major breakthrough in area, production and productivity was witnessed after implementation of Technology Mission in Oilseeds and pulses during 1985-86. However, the fluctuations in area and variation in yield is a major factor for production variability during all decades, which is an indication of risks associated with oilseeds.

During 2020-21, against the total demand of 23.46 million tons of edible oils in India; 8.97 million tons was met through domestic production and 14.60 million tons through imports which is attributed to increasing population, enhanced per capita consumption and low productivity. The low productivity of oilseeds is due to many reasons including cultivation of these crops on low and marginal lands, impact of climate change

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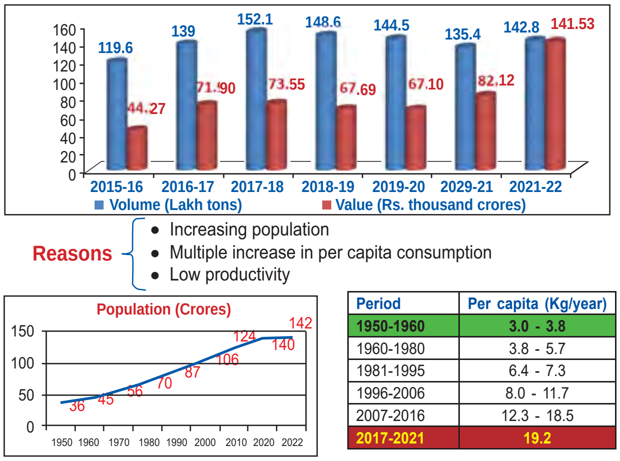

Fig. 1. Ever increasing edible oil imports: A challenge

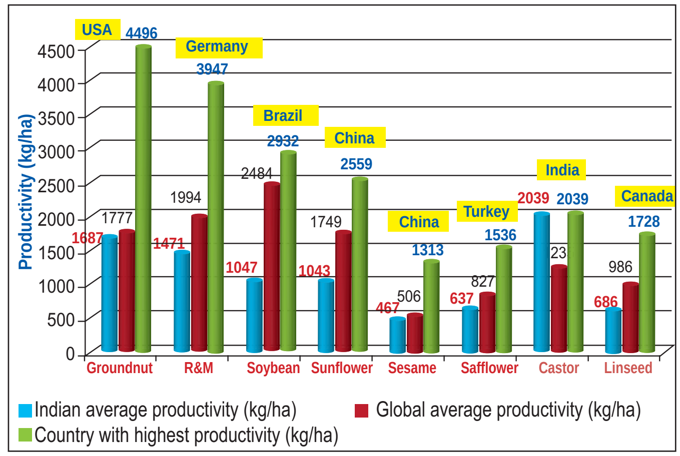

Fig. 2. Comparative productivity status of Oilseeds – India World and Country with highest productivity

like recurring drought and water logging, temperature fluctuations, frost and various emerging biotic stresses in the form of diseases, insect-pests and weeds. In comparison to average global productivity and countries with highest productivity, except castor we are far behind (Fig. 2).

It clearly indicates that ample scopes exist for genetic enhancement of different edible oilseeds crops for making the country Atmanirbhar in edible oils which can be achieved by breeding resistant/ tolerant varieties for the various biotic and abiotic stresses with globally competitive enhanced seed yield, oil content and quality of seed meal and oil is the need of the hour to reduce the constantly increasing import bills on edible oils. Hence, serious research efforts are required to enhance the production and productivity using latest breeding tools to mine and utilize the germplasm with desirable traits.

Present Status

Plant genetic resources (PGR) play an important role as these are the basic constituent in any varietal development programme using naturally occurring variability for different agro-morphological traits. For strengthening genetic resources management; evaluation, conservation and documentation of germplasm, exchange under appropriate quarantine measures and distribution of germplasm for utilization as well as medium- and long-term conservation of valuable germplasm in National Gene Bank for posterity of mankind are essential activities. Characterization and evaluation are important activities under plant genetic resources programmes. The genetic resources can be broadly classified into landraces, wild relatives of crop species, genetic and cytogenetic stocks, breeding lines, modern cultivars and mapping populations which provide basic raw materials to crop improvement programmes and act as reservoir of genes for resistance to various biotic and abiotic stresses. Over 462,606 accessions of various crop plants belonging to 2065 species are currently stored in the repository (as on 31.07.2022), of which 57977 accessions belong to different oilseed crops representing 13 genera and 77 species (Table 1).

In comparison to the total germplasm conserved in the Nation Gene Bank, use of germplasm by breeders is inadequate. For the use of conserved germplasm and efficient utilization of available genetic diversity; large-scale systematic evaluation is generally a pre-requisite. However, except a few crops, the information on the

Table 1. Status of oilseed germplasm base collections in National Genebank (-18°C)

Crop	No. of Species	No. of Accessions
Groundnut (*Arachis* speices)	20	13514
Brassica species	20	11470
Taramira (*Eureca* species)	2	389
Crambe/ abyssinian mustard (*Crambe abyssinica*)	1	20
Garden Cress (*Lepidium sativum*)	1	73
Safflower (*Carthamus* species)	4	7014
Sesame (*Sesamum* species)	10	10121
Soybean (*Glycine* species)	3	5195
Sunflower (*Helianthus* species)	10	1974
Linseed (*Linum* species)	3	2833
Castor (*Ricinus communis*)	1	2672
Niger (*Guizotia abyssinica*)	1	2378
Perilla (*Perilla frutescens*)	1	324
Total	**77**	**57977**

Table 2. Oilseeds crop varieties released (1969-2021) and germplasm registered (till 2021) in National Gene Bank at NBPGR

Crop	Trait specific germplasm (Donors) registered till 2021						Total trait specific germplasm	Varieties released
	Abiotic	Biotic	Breeding value	Agronomic	Nutritional	Quality		
Soybean		1		4	4	5	14	160
Brassica	19	13	17	7	14	8	78	218
Groundnut	2	20	6	13	3	14	58	211
Sunflower		2	2	2		1	7	65
Sesame			1	3	1		5	92
Safflower	1	1	2	1	1	1	7	46
Niger								24
Linseed		1	1	2	2	1	7	88
Castor	2	19	12	2	1	1	37	52
Total	14	57	41	34	26	31	193	956

sources of resistant donors from germplasm conserved in the National Gene Bank at NBPGR, New Delhi and their genetic diversity status based on agronomic traits is also limited. Trait discovery and identification of novel traits is one of the important activities of NBPGR and commodity based ICAR Institutes and ICAR - All India Coordinated Research Projects Centres operating in Central and State Agricultural Universities. Total 193 novel genetic stocks of different oilseed crops, thus, developed and characterized for different agro-morphological, biotic and abiotic stress tolerance, high seed meal and oil quality traits are registered by Plant Breeders and other researchers working in the National Agricultural Research System (NARS) with NBPGR for their use in future breeding programmes. In addition during 1969 to 2021, 956 improved crop varieties of different edible oilseed crops have also been released and notified for cultivation by the farmers (Table 2).

To expedite the process of characterization of available germplasm and for traits discovery, a Consortium Research Platform (CRP) on Agro-biodiversity' was lunched by the Indian Council of Agricultural Research so that germplasm conserved at NBPGR could be effectively linked with enhanced use in crop improvement under National Agricultural Research System (NARS). Under this programme, Indian mustard was prioritized for detailed evaluation at different hotspots for different agro-morphological traits, biotic and abiotic stresses under field conditions and further validate the resistance under laboratory conditions so that the accessions carrying resistance against diseases along with agronomic superiority are identified for use in breeding for disease resistant and high yielding varieties in Indian mustard. Other than the CRP, multi-location evaluation trails in many crops are also carried by ICAR-NBPGR and many trait specific germplasm lines are identified to register and share them as donors for various important traits. During past more than one-decade efforts have been made to identify abiotic stress tolerant germplasm in selected oilseed crops (Table 3).

Access to the exotic germplasm: In general, in most of the crop improvement programmes, it has been observed that use of exotic germplasm leads to higher heterosis as well as transgressive segregants, however some linkage drags are always a limiting factor which can be eliminated by various breeding and biotech tools. In India, during 2019-21, 4377 accessions of ten oilseed crops from USA, Netherlands, Argentina, Canada, Uganda, Niger, Netherlands, United Kingdom, Ethiopia, Kenya, Japan, Czech Republic, France, Switzerland, Australia were introduced based on the indents of public and private sector organizations for use in the different breeding programmes (Table 4).

Way Forward

To increase the total production of oilseeds for making India Atmanirbhar in edible oils, the two approaches are discussed widely viz., 1) Horizontal expansion i.e. Area Expansion under Oilseeds including searching new avenues, crop diversification, oilseeds in non-traditional areas and enhancing cropping intensity by including short duration varieties of oilseed crops; and 2) Vertical increase i.e. Improving Productivity of oilseed crops including breeding of high yielding hybrids/varieties using diverse germplasm and modern biotech tools like marker assisted selection, transgenics and gene editing; crop management and soil and moisture management.

Table 3. Promising germplasm lines of different oilseed crops germplasm idneitifed during past one decade

Crop	Trait	Accessions
Rapeseed mustard	Salt tolerance	CS-52, CS-54, CS-234-2-2, CS-56, RH-8814 (IC-401570), CS-58, CS-1100-1-2-3-5-1, CS-1500-1-2-2-2-1, BPR-540-6
	Drought tolerance	RH-781, RH-819, RH-406, RB-50, RH-725, RVM-2, Pant Rai-20, RGN-298, Aravali, Geeta, Shivani, DRM-541-44
	Heat tolerance	Pusa Vijay (NPJ-93), Pusa Mustard 25 (NPJ-112), Pusa Mustard 27 (EJ-17), Pusa Mustard 28 (NPJ-124), BPR-540, BPR-541-4, BPR-543-2, BPR-549-9, Pant Rai-18, RH-406, RGN-229, RGN-236, RGN-298
	Frost tolerance	RH-819, RGN-48
Groundnut	Low and high temperature tolerance	NRCGs 14480, 14324, 14367, 14414, 14333, 14492, 14454 and released groundnut varieties viz., ALR 2, ALR 3, GJG 9, GG 13, Somnath, KRG 1, JGN 3, LGN 1, TAG 24, JL 220, Narayini, ICGV 00350, ICGV 87846, TG 1, TG 17
	Drought tolerance	NRCGs 14390, 14395, BG 2, ICGV 86590, Kadiri 3, M 197, DRG 12, BG 3, Kadiri 2, TG 1, DSG 1, GAUG 10
Soybean	Drought tolerance	JS 97-52, EC 538828, NRC 7, EC 602288, JS 71-05
	Water logging tolerance	JS 97-52, PK 472, JS 20-38
	Heat tolerance	JS 97-52, EC 538828, NRC 7
	Photo-insensitivity	MACS 330, EC 325097, EC 33897, EC 34101, EC 325197, EC 390977
	Long Juvenility	AGS 25
Sunflower	Drought tolerance	AKSF-42-1, M-1026 , 298-R, GMU-351 and hybrids; Laxmi-225, CO-2, CSFH-12205, DRSH-1, KBSH-44
Castor	Drought tolerance	RG298, RG1437, RG1826

Table 4. Exotic germplasm introduced in India during 2019-21

Crop	Country	Number of accessions		
		Public sector	Private Sector	Total
Sunflower	USA, Netherlands, Argentina	12	60	72
Indian Mustard	Canada	364	364	728
Groundnut	Uganda, Niger	4		4
Crambe/ abyssinian mustard	USA	18		18
Linseed	Netherlands, USA, Canada, United Kingdom	220		220
Niger	Ethiopia, USA, Kenya	24		24
Safflower	USA	278		278
Sesame	USA, Kenya, Taiwan, Japan, Czech Republic	2378		2378
Taramira	USA	247		247
Wild Sesame	USA	3		3
Brassica	USA, France, Switzerland, Australia	157	65	222
Castor	USA		133	133
Total oilseeds		3755	622	4377

Genetic enhancement through use of diverse germplasm available in India and globally is one of the best options for genetic enhancement for yield and other traits and needs to be exploited systematically. The different exotic germplasm of oilseed crops and their crop wild relatives (CWR) with specific traits available globally have been identified by the commodity Institutes (Table 5), which need to be procured on priority for their use in yield enhancement *per se*, trait improvement and for development/ diversification of Cytoplasmic Male Sterility systems for hybrid breeding programmes in various oilseed crops.

To fully utilize the available genetic resources of various oilseed crops, large scale screening is required under different agroclimatic zones to identify the potential lines for using them in breeding programme, as has been done in case of wheat. The promising lines for various traits identified under field screening should further be characterized under controlled stress conditions (phenomics/ phytotronics) and the molecular markers

Table 5. Trait specific germplasm and crop wild relatives of oilseed crops their availability globally

Crops	Country	Specific traits
Groundnut	China, USA, Korea, Brazil	High oil content (≥57%), Resistant to diseases (*Aspergillus flavus*, bacterial wilt, aflatoxins, bacterial wilt, Sclerotinia blight, Pod rot, Leaf spot, web blotch, stem rot); and early maturing landraces (80-90 days)
Soybean	USA, Taiwan, Japan, Brazil, China	Drought , heat. salinity and waterlogging tolerance, mechanical damage tolerant, Near iso-genic lines for photoinsensitivity and long juvenility, high Protein (55-58%), Triple Null lox (1, 2 & 3), High oleic acid (80%)
Mustard	China, Canada, Australia	High yield (>4.0 t/ha), oil content (>50%), oleic acid (>60%), >20 seeds/ siliqua, Sclerotinia stem rot, white rust and Alternaria blight resistant lines, Orobanche tolerant lines
Sunflower	Russia, Serbia, Argentina, France	High seed yield (>60 g/plant) and high oil content (>55%) , dwarf and short duration, Powdery mildew and Alternaria resistant lines
Sesame	China, Ethiopia, Korea	Male-sterility, Drought resistance, Water logging tolerance, Determinate Disease resistance, Earliness
Lentil	Lebanon/ Morocco, Australia, Iran, USA	Mechanized harvesting, Herbicide tolerance, Early maturity, bold and small seed size, high protein and high biomass, tolerance to pod dehiscence and number of pods/ plant, tolerant to heat, drought and boron, high grain Fe and Zn, phosphorus use efficient
Mungbean	Thailand, USA, Japan	Resistant to Powdery mildew resistance, MYMV and bruchid; sprout specific genotypes, pre harvest sprouting, bold seeded, long pods, 15-16 seeds/pod, high seed protein, mechanized harvesting, herbicide tolerance
Chickpea	Australia, USA	Super nodulating chickpea lines, Mechanical Harvesting lines, Salinity tolerant lines, Non nodulating Mutants, Ultra high protein chickpea lines
Pigeonpea	Kenya, Tanzania, Mzmbq, Malawi, Uganda,	Early duration, large seed size, long pod, high number of pods per plant, wilt resistance, SMD resistance and pod borer tolerance

linked to traits of interest should be identified for their use in precision breeding for introgression of these traits. More systematic efforts are required to collect, conserve and regenerate the germplasm, local landraces and wild relatives from the different agroclimatic zones of the country.

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