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Exchange of plant genetic resources: Prospects in India

S K YADAV[1], NIDHI VERMA[2], VANDANA TYAGI[3], ANITHA P[4], S P SINGH[5], S S RANGA[6], P C BINDA[7] and PRATIBHA BRAHMI[8]

National Bureau of Plant Genetic Resources, New Delhi 110 012

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ABSTRACT

National Bureau of Plant Genetic Resources has the major responsibility of introducing genetic resources and distributing the same to various research Institutes/organizations within the country. It is involved in enrichment of plant genetic resources through germplasm exchange, procurement and collection from centres of diversity suitable for different agro-climatic conditions. Different biotic and abiotic stresses are the major production constraints in many crops, hence, introduction of crops from the centre of diversity is much needed to bring into superior seeds of various crops with high yield, quality, resistance to pest and diseases and tolerant to abiotic stresses through crop improvements programmes. Future emphasis is to introduce specific genotypes with special characters especially like high quality lines and lines resistant to various biotic and abiotic stresses. During the past five years 211 298 accessions including 467 995 samples of seed/planting material were introduced from 103 countries. Out of theses 116 149 accessions having 138 352 samples were germplasm while 58 024 entries having 329 704 samples were trials/nurseries entries and 1 139 wild species of different agri-horticultural crops were also introduced. During this period a total of 78 298 accessions were exported as per norms/regulation lay down by NBA and with permission of ICAR/DARE, for research purposes only. NBPGR has supplied 50 657 samples of various crops to national users in different institutes/organizations across the country for various crop improvement and breeding programmes.

Key words: Biotic and abiotic stresses, Genetic resources, Introduction, Trait specific

National Bureau of Plant Genetic Resource (NBPGR) is a key component of the Indian National Agricultural Research System (NARS). NBPGR is mandated for Plant Genetic Resources (PGR) systematic management and its utilization and undertakes activities, viz. introduction, evaluation and maintenance of PGR of various crops. There is a wide gap in average productivity of food crops in India with that of the world productivity. The low yield potential is further aggravated by numerous pests and disease infestation. Besides, Indian soil and climate is afflicted by numerous abiotic stresses like salinity, alkalinity, drought, flood etc. Therefore, to design location specific breeding programme for catering to the local needs, introduction of exotic germplasm possessing desirable traits is very important. In past introduced materials have been utilized in various ways to breed/develop varieties for different purposes.

[1]Senior Scientist (e mail: skyadav@nbpgr.ernet.in), [2]Senior Scientist (e mail: nidhi@nbpgr.ernet.in), [3]Principal Scientist (e mail: vtyagi@nbpgr.ernet.in), [4]Scientist (e mail: anitha@nbpgr.ernet.in), [5]Assistant Chief Technical Officer (e mail: satyapal @nbpgr.ernet.in), [6]Assistant Chief Technical Officer (e mail: ssranga @ nbpgr.ernet.in), [7]Technical Assistant (e mail: pcbinda @nbpgr.ernet.in), [8]Principal Scientist (e mail: pratibha@nbpgr.ernet.in), Germplasm Echange Unit

Germplasm introductions have had tremendous impact on Indian agriculture. Significant primary introductions and selections have a great impact on growth and development of Indian agriculture; viz. tomato varieties Roma, La-bonita, Sioux, Money Maker from USA; Sweet pepper/Capsicum varieties California Wonder, Yolo Wonder, Chinese Giant, Bullnose from USA; Pea varieties Early Superb, Arkel, Little Marvel from UK and Early Badger, Bonneville, Lincon, Alderman, Perfection New Line from USA; French bean varieties Contender, Kentucky Wonder, Bountiful from USA; Cowpea variety Philippines Early from Philippines; Cucumber variety Japanese Long Green from Japan and Straight Eight, Poinsette from USA; Water melon variety Sugar Baby from USA; Cauliflower variety Improved Japanese from Israel; Cabbage varieties Pusa drumhead from USA and Golden Acre from Denmark; Knolkhol varieties White Vienna, Purple Vienna from Europe; Radish varieties White Icicle from Europe and Japanese White from Japan; Turnip varieties Purple Top White Globe, Golden Ball, Snowball from Europe; Onion varieties Pusa Ratnar and Early Grano from USA; Wheat varieties Ridley from Australia, Lerma Rojo and Sonora 64 from Mexico; Rice varieties 1R 8, IR 20, IR 36, IR 50 from Philippines; Oat varieties Kent from Australia, Rapida from USA; Cowpea varieties Pusa Barsati from Philippines, Pusa Phalguni Canada; French bean varieities Kentucky wonder

USA, Contender USA; Soybean varieties Bragg and Lee from USA; Sunflower varieties Peredovik from erstwhile USSR. Keeping the importance and significant contributions of various introduced materials in breeding/development of numerous high yielding, trait specific genotypes, the present study is presented for the benefit of all involved in crop improvement programmes of different crops in the country.

MATERIALS AND METHODS

In India, The National Bureau of Plant Genetic Resources, New Delhi is the nodal agency for facilitating import for research purposes as per the regulations of the Plant Quarantine (Regulation of Import into India) Order, 2003 (www.plantquarantineindia.org). The two mandatory requirements for import are:

1. Import permit
2. Phytosanitary certificate from the country of origin.

Survey of the world literature is being done regularly through the published catalogues, crop databases and germplasm/varieties with specific traits and suitable to Indian climatic conditions were identified. The import request was made in Form PQ 08 (NBPGR website) and Import Permits (IP) were issued by the Director, National Bureau of Plant Genetic Resources (NBPGR), New Delhi. The import requests were sent to various sources in the world. The introduced material, after the custom clearance, was subjected to quarantine examination and healthy samples were allotted the national identity number (Exotic collection-EC number). The crop germplasm was received in the form of seed/bulbs/cuttings (perishable material) and therefore utmost care was taken in handling of the material. The material was provided to the National Active Germplasm Site (NAGS) for its establishment and maintenance.

As per the provisions of the Convention on Biological Diversity (CBD), Government of India enacted the legislation of Biological Diversity Act (BDA), 2002 and notified the Biological Diversity Rules, 2004. As per Section 3 of the Act, no person from outside India or a body corporate, association, organization incorporated or registered in India having non Indian participation in its share capital or management, can access any biological resources or knowledege associated, for research, commercial utilization, bioprospecting or bioutilization, without prior approval of National Biodiversity Authority (NBA). As per Section 5 of BDA, 2002, exchange of germplasm for research under the bilateral agreements/ collaborative projects are however exempted which confirm to the policy guidelines (Secton 5.1) issued by the Government of India.

All such persons or organizations who are eligible to take the approval of the NBA are required to apply in the prescribed form for seeking approval of the Authority (NBA, India) for access to biological resources and associated knowledge for research or for commercial utilization. Export of PGR under collaborative research projects is facilitated by NBPGR in the light of notification of the BDA 2002. PGR Export Facilitation Comittee (PGREFC) has been constituted at NBPGR, New Delhi with a team of following members: Concerned crop coordinator/Director, ADG of respective crop group, Director NBPGR, Head Plant Quarantine Division, Officer Incharge Germplasm Exchange Unit and PGR Policy Planning Unit. The cases are considered under two categories: Collaborative research projects and Non-collaborative research projects

The following documents are mandatory for review by the PGREFC to consider the export case under both the above mentioned categories;

- Copy of approved collaborative research project as per guidelines notified by Ministry of Environment & Forests
- Copy of Material Transfer Agreement (MTA) signed by both the parties, i e supplier and recepient of the material.
- Copy of request letter along with list of germplasm.

The PGREFC decides the case and submits its recommendation to DARE/Chairman NBA for final approval/clearance. After the approval from DARE, the germplasm is sent to Plant Qurantine Division, NBPGR for qurantine purpose and issuance of Phytosanitary Certificate, before the germplasm is supplied to the indentor.

NBPGR received a large number of requests from scientists/students in the country for already available germplasm. The requested germplasm were supplied from NBPGR headquarters and its regional stations located in different agro-ecological zones of the country. If the material was not available with NBPGR, the requests were forwarded to Project Coordinators/Project Directors/AICRIP's/ National Active Germplasm sites/crop based research institutes etc., thus procured and supplied to the indentor. All the germplasm was supplied under signed Material Transfer Agreement (MTA) and GEX 01 forms.

RESULTS AND DISCUSSION

During the past five years (2008-12), introduction of PGR was facilitated from more than 103 countries and International Agricultural Research Centres (IARCs). Thus, during this period a total of 211 298 accessions including 467 995 samples of seed/planting material were introduced. Out of these 116 149 accessions having 138 352 samples of germplasm, while 58 024 entries having 329 704 samples were trials/nurseries entries. This valuable germplasm including 1 139 wild species of different agri-horticultural crops was introduced in response to 3 207 import permits issued during this period. During this period a total of 78 298 accessions were exported as per norms/ regulation laid down by NBA and with permission of ICAR/DARE, for research purposes only. NBPGR has supplied 50 657 samples of various crops to recipients/users in different institutes/ organizations across the country. The detail of PGR exchange during the period is provided in Table 1 and Fig 1 and 2 some of the important introductions in Fig 3.

Exotic wild relatives in different crops

The wild relatives of crop plants and related species

Table 1 Number of accessions/samples exchanged (imported/exported) and supplied nationally in major crop groups

Crop group	2007-08	2008-09	2009-10	2010-11	2011-12
	Import of germplasm				
Cereals & millets	14 317	15 804	22 971	18 958	28 275
Grain legumes	1 631	477	604	540	2 990
Oilseeds	2 432	1 560	3 610	730	
Vegetable crops	2 710	1 858	1 483	5 203	2 846
Fruit plants	75	31	399	199	7
Ornamentals			28	01	
Forages	110	34	111	145	256
Fiber crops	85	1 021	335	210	579
Tuber crops	145	389	261	167	93
M & AP		17	16	11	255
Spices & condiments		9	29		
Under utilized crops	7	13	132	152	19
Sugar yielding plants	6				2
Narcotics	181	186		488	3
Plantation crops			118		
Agro-forestry			19	62	
Grand total	21 699	21 399	30 116	26 866	35 325
	Import of germplasm as International nurseries/exotic trials from CG centres				
	2006-07	*2007-2008*	*2008-09*	*2009-10*	*2010-11*
Cereals & grain legumes	6 925	6 835	5 487	11 234	7 044
	(59 352)	(52 022)	(44 064)	(58 853)	(90 165)
	Export of germplasm from NBPGR- headquarters				
Cereals & millets	320	759	1229	494	1 092
Grain legumes		2	45		3
Oilseeds	25	110	14	28	
Vegetable crops				145	102
Fruit plants				28	58
Ornamentals					
Tuber crops			6	5	
Under utilized crops		4	4	80	
Fibers			22		23
Total	355	875	1320	780	1 278
	Export of germplasm from NBPGR regional station - Hyderabad				
	2007-2008	*2008-09*	*2009-10*	*2010-11*	*2011-12*
Millets (ICRISAT Mandated crops)	10 292	19 268	9 311	10 183	3 544
Maize (CIMMYT material)		678	4 207		1 814
Grain legumes			4 983	4 686	2 082
Groundnut			1 405	946	291
Total	10 292	19 946	19 906	15 815	7 731
G total (Export)	10 647	20 821	21 226	16 595	9 009
	National supply of Plant Genetic Resources				
HQ & Regional stations	13 744	13 685	13 391	11 946	4 043

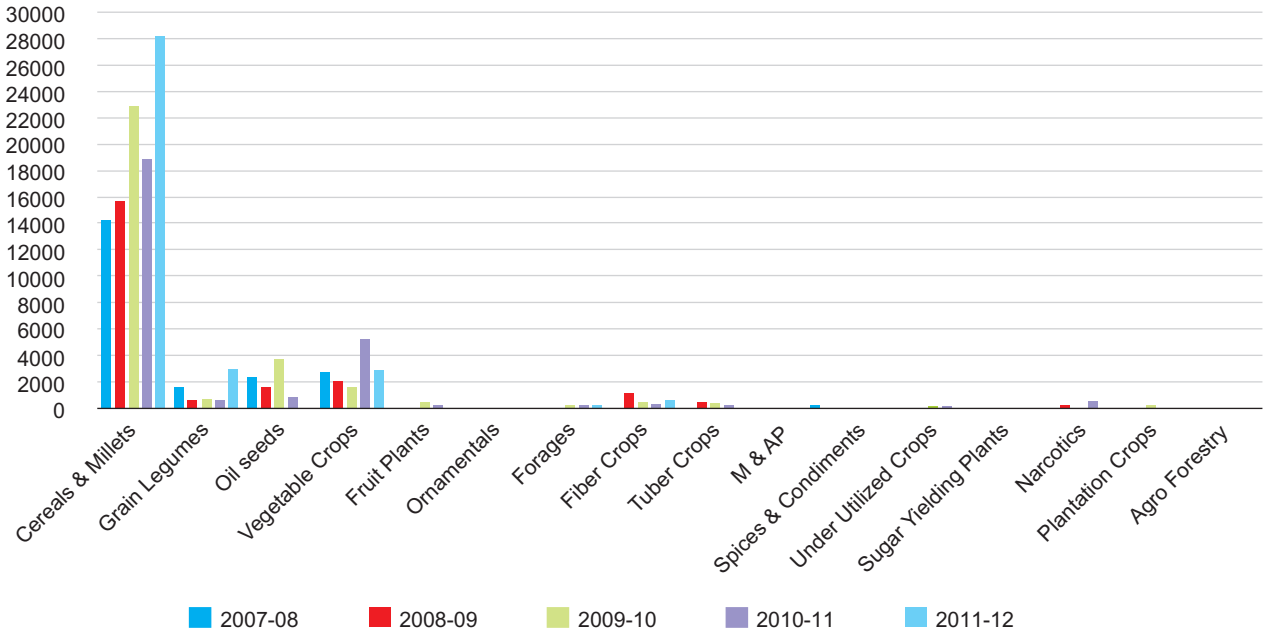

Fig 1 Import of germplasm

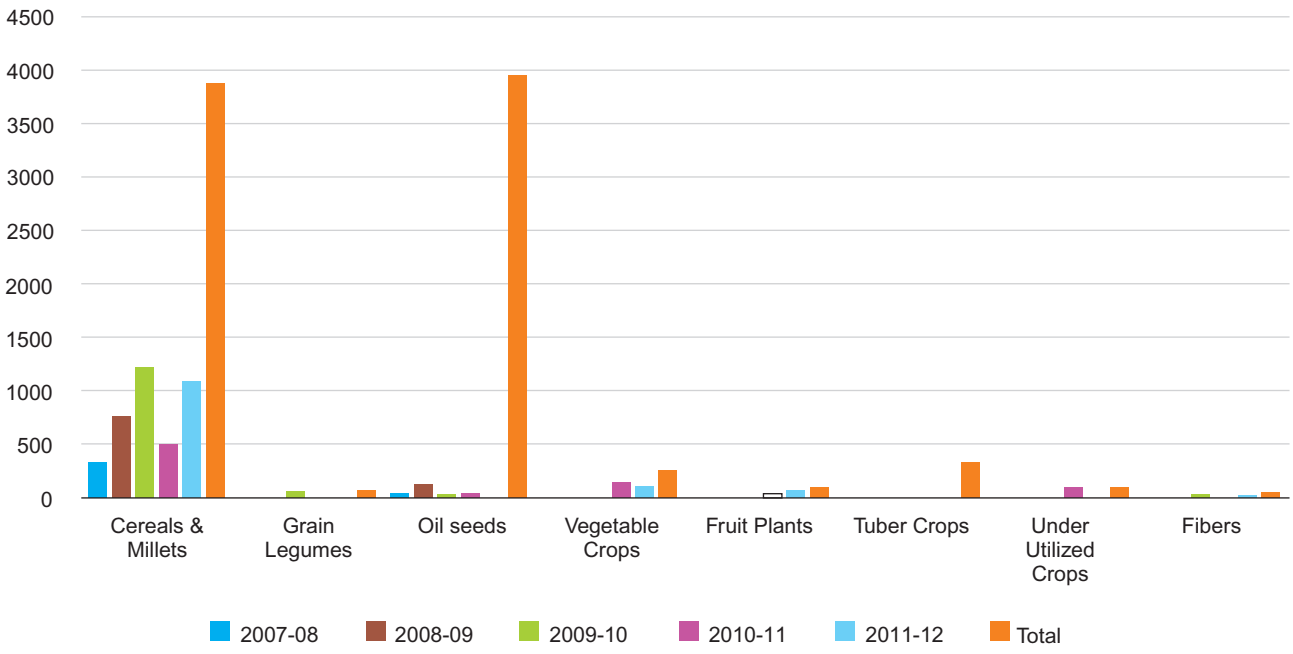

Fig 2 Export of germplasm from NBPGR New Delhi

assume great significance in crop improvement, as a source of disease and pest resistance stress tolerance and quality improvement.. In spite of the diversity available in cultivated plants, the wild relatives constitute a rich reservoir of genetic variation in the gene centres. The wild relatives have played a significant role in crop improvement in major crop plants such as rice, wheat, sugarcane, potato and tomato, besides several forages and other crops (Hawkes 1975, Kalloo and Bergh 1993). The use of crop wild relative genes to improve crop performance had been in practice since decades. The improved interspecific hybridization techniques have led to an increase in use of secondary and tertiary gene pool of many crops (Hajjar and Hodgkin 2007). There has been steady increase in rate of release of cultivars containing genes from wild relatives. Large number of exotic wild species were introduced as presented in Table 2.

Introduction of trait specific material

These introductions can be of immense utility if the associated traits are well characterized and thus can directly

Table 2 Details of wild species introduced

Cereals & millets:	Avena species (15), Eleusine species (4), Oryza species (19), Panicum species (9), Pennisetum species (12), Setaria species (8), Sorghum species (1), Triticum species (14)
Grain legumes:	Cicer species (4), Cyamopsis species (2), Lathyurs species (20), Lens species (8), Pisum species (3), Rhynchosia species (5), Vicia species (28), Vigna species (59)
Oilseeds:	Acrocomia species (1), Arachis species (37), Brassica species (2), Carthamus species (9), Glycine species (13), Helianthus species (45)
Vegetables:	Allium species (21), Capsicum species (13), Citrullus species (2), Praecitrullus species (1), Cucumis species (15), Lycopersicon species (12)
Fruits:	Fragaria species (1), Irvingia species (1), Juglans species (4), Mangifera species (1), Mespilus species (3), Nephelium species (1), Opuntia species (9), Prunus species (5), Pyrus species (1), Ribes species (11), Rubus species (22), Sorbus species (12), Vaccinium species (12), Vitis species (15)
Fibres:	Corchorus species (7), Crotolaria species (8)
Sugar yelding:	Saccharum species (2)
Tubers:	Solanum species (94)
Narcotics:	Nicotiana species (47)
Forages:	Agropyron species (1), Brachiaria species (1), Clitoria species(1), Desmodium species(2), Elymus species(1), Lotus species (6), Macroptilium species (2), Medicago species (18), Melilotus species (5), Stylosanthes species(2), Trifolium species (27)
Agroforestry :	Acacia species (4),Casuarina species (1),Eucalyptus species (3). Salix sp. (39)
Plantation crop:	Hevea species (6)
	Aconitum species (4), Anthemis (1), Arbus species (1), Arnica (1), Asclepias species (1), Calendula species (5), Centaurea species (10), Centrosema species (1), Datura species (2), Glycyrrhiza species(2), Lavandula species (1), Matricaria species (1), Papaver species (6), Plantago species (14), Podophyllum species (1), Salvia species (1), Taxus species (1), Thuja species (1)
Spices & condiments:	Trigonella species (1)

Cnidoscolus aconitifolius
EC589423, Hawaii, USA

Variety Clancy (EC619155) of strawberry from Geneva Experimental Station, Cornell University, USA

Hypoxis hemerocallidea
EC717953 (Swaziland)

Variety Ponoko of barley from Canada (EC570289)

Date palm variety Siwi from Egypt (EC636502)

Variety Manny of barley from Canada (EC570290)

Fig 3 Some important introductions

be utilized for the country's crop improvement programmes. Several trait specific introductions in all the major crops were introduced detailed discussion follows:

Biotic stress

Biotic stresses are the most important limitations for all the crops. In Modern agriculture, the genetic base is narrowing, which is potential threat under adverse conditions for crops and favourable conditions for biotic agent. Insect, pest, disease causing elements are commonly known as biotic stress causing agents (Singh *et al.* 2011). There is an urgent need to major focus on agricultural research to mitigate these biotic stresses through improvement of crops by introducing resistant germplasm from diverse areas. In rice, important introductions included lines resistant to brown plant hopper (EC670423-45 and EC582484), bacterial blight (EC582443-47), stem borer tolerant (EC582455-61), resistant to Grassy stunt virus (EC583411-53), resistant to blast (EC688321) and stripe and leaf rust (EC589025) from Philippines. In wheat, lines resistant to stripe rust (EC671601 and EC673058), powdery mildew, strip rust and stem rust (EC675842 and EC675844), yellow brown rust and powdery mildew (EC582225-441), stripe rust, leaf rust, powdery mildew, net blotch and scald (EC 538160) from USA; stem, leaf & stripe rust resistant (EC589421) from Greece, resistant to yellow, brown, black rusts and powdery mildew (EC592591) from China; pre harvest sprouting tolerant (EC675838-41) from Australia and sawfly resistant (EC580485-86) from Canada were introduced. In barley, the introduced germplasm particularly, resistant to stripe rust, barley yellow dwarf virus (BYDV), leaf rust, powdery mildew, net blotch and scald (EC538157), resistant to BYDV, leaf rust, net blotch and scald (EC538158), resistant to BYDY, leaf rust, powdery mildew, net blotch and scald (EC538159-60) from USA; resistant to surface borne smut (EC670538) and resistant to surface borne smuts, spot form of net blotch and scald (EC548499) from Canada. In soybean white fly and downy mildew resistant (EC592181- 212), resistant to white fly transmitted gemini virus conditioned by TY-2 gene, bacterial wilt, *Fusarium* wilt race 1 (EC552129-37) from AVRDC, Taiwan; resistant to stem canker and soybean mosaic virus (EC586966) and southern stem canker, soybean cyst nematode, reniform nematode, sudden death syndrome, frog eye leaf spot (EC586967) from USA and necrosis virus and root rot (EC39139-44) from Germany were introduced. In chickpea, germplasm resistant to *Ascochyta* blight (EC539009) from Spain, different species of wild chickpea introduced from ICARDA, Syria are resistant to *Fusarium* wilt (EC 539329, EC 541559 and EC541555-56), leaf minor, bruchids and *Ascochyta* blight (EC541549-50 and EC541557-58) and resistant to bruchids and cyst nematode (EC541561-62). In sunflower, source of resistance to races of loose smut (EC634078-80) and downy mildew (EC586972) were introduced from USA. In safflower thrips resistant line (EC548849) introduced from USA. *Capsicum* sp introduced from AVRDC, Taiwan are resistant to anthracnose, tolerant to aphids (EC538331-32), bacterial wilt, bacterial black spot and potato virus Y (EC538333-34, 538351) and pepper venial mottle virus (PVMV), chilli veinal mottle virus (CVMV), potato virus Y (PVY) and potato virus V (PVV) (EC538335-339). In muskmelon, resistant to powdery mildew (EC589374) from USA and very vigorous hybrid variety Alien tolerant to both powdery and downy mildew, prolific, medium early, can be harvested within 40-45 days weighing about 1.2-1.3 kg/fruit, green flesh, juicy and sweet (EC612133) were introduced from Vietnam. In tomato, lines resistant to tomato yellow leaf curl virus (EC687094-98), Ty2-TMV, F1 (EC687099 -EC687103, EC687104-05), TMV, BW, F1 (EC687108), root knot nematode (EC631955-963), tomato leaf curl virus (EC635523-27), bacterial wilt (EC635528-33), resistant to tomato mosaic virus conditioned by the TM 2a allele (EC552143-48), resistant to white fly transmitted gemini virus conditioned by the Ty-2 gene from H 24 (WTG), bacterial wilt, tomato mosaic virus conditioned by the TM2a allele (TMV), gray leaf spot pathogen (*Stemphyllium* sp.) and *Fusarium* wilt race 1 (F1) (EC548605-13) and lines tolerant to bacterial wilt, tomato mosaic virus, *Fusarium* wilt and gray leaf spot (EC632003-21) were introduced from AVRDC, Taiwan. Resistant to bacterial leaf blight, brown plant hopper and blast (EC592058-59) were introduced from Sri Lanka. Germplasm introduced from USA in potato are resistant to late blight and pythium leak (EC670758) and tuber and foliage late blight (EC670764). In peas genotype resistant to *Fusarium* race-1, powdery mildew and common pea mosaic virus (EC 538180) was introduced from USA. Strawberry introduced from USA are resistant to leaf spot, leaf scorch, powdery mildew and red stele (EC571812), *Botrytis, Verticillium* wilt, red stele, powdery mildew and spotted spider mite (EC571816) and red stele races A-I, A-3, A-4 and fruit rots (EC571820).

Abiotic stress

Abiotic stresses such as drought, salinity and mineral toxicity negatively impact growth, development, yield and seed quality of plants. It is, therefore, important that plant breeders should identify the most important biotic and abiotic constraints in a particular crop and enrich the material by introducing germplasm from different agro-climatic conditions. In rice, different abiotic stress tolerant lines introduced from Philippines are salt tolerant (EC678586-634), heat tolerant (EC681702-902), submergence tolerant (EC699258, EC725250-52, EC581120-23 and EC541909-916, EC541917-928), salinity and submergence tolerant (EC714174 -76), salinity tolerant (EC699098-257, EC548158-81), salinity tolerant, zinc deficiency tolerant (EC541929-939), phosphorus deficiency tolerant (EC546319-340), iron toxicity tolerant (EC546341, 50, 52, 53, 56, 57,59 and EC582463, 64, 68, 69, 71), aluminum toxicity tolerant (EC546354, 60, 61), QTL lines (EC581124-27), aerobic, moderate drought tolerance (EC582211-24). In wheat, resistance different lines tolerant to high temperature (EC671602, EC673058), frost and lodging

(EC582225-441), lodging (EC586941) and homozygous for the blue aleurone trait (EC557028-30) were introduced from USA and lines tolerant to lodging, low temperature and diverse climatic conditions (EC589421) from Greece. Pre-harvest sprouting tolerance (EC675838-41) from Australia and (EC693905) Canada and tolerant to cold (EC592591) were introduced from China. Maize germplasm introduced from Columbia were tolerant to acid soils (EC552705-08). In barley, lines adapted to brown, black and gray soil, resistant to lodging (EC670538) and drought tolerant (EC540807) were introduced from Canada. In soybean, tolerant lines augmented from USA are lodging tolerant (EC537946), drought tolerant (EC538805, 538811-12) and drought and heat tolerant (EC538823-30). Pea genotypes with stiff stem, lodging resistance (EC548807-13) and linseed resistant to lodging (EC541198, EC541204 and EC541206) were introduced from Russia. In cotton, upland cotton resistant to adverse conditions (EC541867-76) was imported from USA. In sunflower, excellent lodging resistance germplasm (EC586971) was introduced from USA.

In tomato, heat tolerant lines introduced from Taiwan (EC538417-28), drought and heat tolerant lines (EC677032 -130) and heat tolerant varieties were introduced from Srilanka (EC581525, EC592058, EC550834 and 550836). Celery tolerant to high temperatures (EC587045) was introduced from China. In chilli, heat and drought tolerant line (EC582593) was introduced from USA. In cauliflower cold tolerant lines (EC548146-49) were introduced from USA.

Agronomic traits

High fodder yielding (EC671603-629) red clover was introduced from USA. In musk melon, yellow skinned with oblong shape and cream colored flesh line (EC612134) was introduced from Vietnam. In lettuce, variety Minetto, crisp headed, iceberg type, black seeded, resistant to heat, tolerant to tip burn (EC612126), fast fall a mid early variety, black seeded and loose leaf type (EC612127) and butter head type, suitable for winter and autumn season in temperate areas and tolerant to Bremia (EC612128) were introduced from Vietnam. Strawberry with excellent fruit quality, flavour, firm flesh and good texture lines (EC619154-56) were received from USA. Avocado with low oil, early type, very large fruits weighing 750 g (EC632072) was introduced from USA variety Pinkerton with long pear shaped fruits, excellent peeling characteristics (EC632073) introduced from USA. Lentil lines having high yield and high level of winter hardiness (EC631332) from Turkey and high yielding line (EC550084) from USA were introduced. In chicory, voluminous heads with white compact heart, slow bolting and good tolerance to tip burn and bolting (EC612129), suitable for spring production, performs well both in open fields and protected cropping and tolerant to bolting (EC612130) and large broad leaves, escarole endive tight and very well filled with curled heart suitable for spring and summer production in temperate areas, used for both fresh markets and salad packs and good resistance to bolting (EC612131) were introduced from Vietnam. In rice, lines having early flowering (EC 552825), early maturing (EC550889, EC550177-78 and EC571549-52) were introduced from USA, early and late maintainer population and weed competitive lines (EC550177) from Philippines. In wheat, high grain yielding lines (EC550180-81) from USA. In maize, early maturing line (EC 546871) introduced from Indonesia. In barley early maturing (EC538157-58), high yielding (EC538160) lines were introduced from USA and high grain yielding and shattering resistant (EC540807), high yielding and early maturing (EC548499) lines from Canada. In sunflower, high oil content (EC699730-31, 738, 740, 742, 762, 770-71, EC699816) and high oleic acid content (EC699735-36, 756) germplasm lines were introduced from USA. In soybean, high yielding and resistant to shattering (EC537946), high yielding (EC 537947) lines were introduced from USA. In linseed, early maturing lines (EC541202 and EC541226) were from Russia. In French bean, high yielding, excellent cooking quality line (EC541908) was introduced from Brazil and early flowering (EC539009) in chickpea from Spain. In faba bean, unifoliate genetic stock significantly higher branching from basal

Table 3 Introduction of new crops

Crop	EC No./ Source	Traits	Distribution
Hypoxis hemerocallidea (African potato)	EC717953/ Swaziland	Medicinal plant native to South Africa. Efficaceous in treatment of benign prostatic hyperplasia	Jamia Hamdard, New Delhi
Siraitia grosvenorii (Siraitia)	EC697455/USA	Fruit extract is nearly 300 times sweet than sugar, used in traditional Chinese medicine	NBPGR Shimla & Bhowali
Monarada sp.	EC538844 Canada	Dwarf type, good winter hardiness and resistant to powdery mildew	IARI, New Delhi
Brachiaria hybrid Cv Mulato	EC549024-25/USA	Stoloniferous growth, excellent forage production, vigorous re-growth excellent palatability, resists burning and drought, tolerant to spilt be bug and produces forage round the year	IGFRI, RRS, Dharwad
Glaucium flavum	EC587081Denmark	High glycyrrhizic content	NRC M&AP Anand

nodes (EC550179) was introduced from Spain. In tomato, high beta carotene line (EC721238- 41) and early maturing line (EC538398-400) were introduced from Taiwan.

Value added traits

In rice, low phytic acid (EC552817), gold hull and low phytic acid germplasm (EC552822), good aroma and cooking quality of basmati 370 (EC550889), long grained, superior parboiling and canning quality (EC550177 and EC550178) from USA and high iron content (EC541907 and EC549244) were introduced from Philippines. In wheat, high grain protein content, high grain weight, superior bread baking quality and resistant to hessian fly (EC556386), excellent for bread and noodle production (EC538959), and strong gluten (EC550180 and EC550181) were introduced from USA. In maize, germplasm with high amylose content, high lysine content and waxy (EC539005-7) were introduced from USA. In sorghum, sweet grain lines (EC538162-76) introduced from USA. In soybean, germplasm with low lipoxygenase (EC538824) and less than 5.5% linolenic acid (EC 538833) were introduced from USA. In lentil, large seeded (EC550084) genotypes were imported from USA. In safflower, high oleic acid content lines (EC548814-15 and 548818-21) and high oil content lines (EC548816-17 and 548833-36) were introduced from USA. In chilli, Cayenne type large thick red (EC 538330) from AVRDC, Taiwan and non-pungent, tolerant, excellent keeping quality suitable for ornamental and culinary applications (EC582593) from USA were introduced. In tomato lines with Carotene rich and high lycopene content (EC572692-708) and large fruited, good flavor and outstanding fruit quality (EC571814, 817) were introduced from USA. In strawberry, large fruited (EC571812) and large fruited, good flavor, outstanding fruit quality germplasm lines (EC571814, 817) were introduced from USA. In muskmelon, high TSS content, orange fleshed, netted exterior lines (EC539195 219) were introduced from USA. Many new crops were also introduced as per the details given in Table 3.

CONCLUSIONS

To keep up the current requirements and future needs of the country, we have to widen our genetic resources in India through introduction of suitable species. The trait specific genetic materials from different agro-climatic conditions are needed to sustain country's long term needs. Efforts should be made to introduce improved varieties and breeding material including cytoplasmic male sterile lines, fertility restorer lines, lines with improved quality triats and genotypes resistant to biotic and abiotic stresses. Though, we have achieved a lot particularly in genetic enhancement of many crop species and breeders are trying their level best for improving the productivity by applying various latest techniques; yet we have go a long way in achieving the future projections. Hence, there is a need to diversify the base of Indian gene pool by introduction of valuable genetic diversity from the centres of diversity to help improving our genetic stocks for future utilization.

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