Enhancing the value of genetic resources for use in pigeonpea improvement

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Abstract: The ICRISAT genebank conserves over 13,700 accessions of pigeonpea from 74 countries. The collection serves as insurance against genetic erosion and provides rich source of diversity for crop improvement. Pigeonpea is often cross pollinated crop, therefore regenerated under insect proof cages, and characterized for morpho-agronomic traits, with most of the traits showing abundant genetic variation. Core and mini core collections representing diversity of the entire collection were developed to discover new sources of variation for use in pigeonpea improvement.
Key words: collection, genetic resources, germplasm, mini core collection

Plant genetic resources are the key to the success of crop improvement programs. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India, has global responsibility to collect, conserve, maintain, characterize, evaluate, and document the wealth of genetic variation for use in improving pigeonpea (*Cajanus cajan* (L.) Millsp.). Major pigeonpea germplasm holdings are at ICRISAT, India (13,771 accessions), National Bureau of Plant Genetic Resources (NBPGR), India (7,488 accessions) and National Plant Genetic Resources Laboratory (NPGRL), Philippines (433 accessions) (2).

Germplasm assembly

Genebank at ICRISAT holds 13,771 accessions, including 555 accessions of wild relatives belonging to 66 species of six genera, from 74 countries (Table 1). The collection includes 9,888 accessions introduced from various organizations located in 68 countries and 3,883 accessions collected by ICRISAT through 100 collection missions in 33 countries.

Conserving the collection

At ICRISAT, pigeonpea germplasm seeds are conserved as active and base collections. About 400 g seeds in aluminum cans are preserved as active collection at 4°C and 30% RH to maintain the seed viability above 85% for 15-20 years. About 120 g seeds are vacuum sealed in aluminium foil packets to preserve at -20°C as base collection for about 50 years (10). To meet the germplasm needs for research in African countries, ICRISAT conserves 8,869 accessions at its regional genebank at Nairobi, Kenya. As a safety backup, samples of 80% accessions were deposited in Svalbard Global Seed Vault, Norway.

Regeneration

Continuous supply of germplasm for research and loss of seed viability during storage necessitates monitoring of seed viability and quantity at regular intervals. Accessions are regenerated when the seed viability is below 85% and/or seed quantity is critical (< 1/4 of total quantity) in medium-term (active collection) store, using a cost effective method of growing under insect proof cages (10).

Value addition

Pigeonpea accessions were characterized for 34 morpho-agronomic traits (3), with ~90% of the collection already characterized and additional data on abiotic (drought, salinity, and water logging) and biotic (alternaria blight, nematode, phytophthora blight, pod borer and sterility mosaic) stresses were added to enhance the value of pigeonpea genetic resources. Promising sources were identified in the collection for wilt (108 accessions), sterility mosaic disease (410), phytophthora blight (152), stem canker (26), alternaria blight (25), pod borer (27), pod fly (21), nematodes (19), drought (7), water logging (62) and salinity (56).

Diversity in the collection

Analysis of characterization data revealed abundant genetic variation for agronomic and seed traits (Table 2 and Fig. 1). Range variation for quantitative traits was maximum in the collection from primary center of diversity for pigeonpea and minimum in collection from Europe and Oceania. Shannon-Weaver diversity index (H`) (7) indicated that the accessions from South-East Asian countries such as India, Indonesia, Philippines and Thailand had the highest pooled H` for qualitative traits (0.349 + 0.059) and accessions from Africa for quantitative traits (0.613 + 0.006) (11).

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Table 1. Geographical distribution of pigeonpea germplasm accessions assembled at the ICRISAT, genebank, Patancheru, India

Country	Improved cultivars	Breeding materials	Landraces	Wild	Total
Angola				1	1
Antigua and Barbuda			2	4	6
Argentina			1	8	9
Australia	2	59		73	134
Bangladesh		40	35		75
Barbados			25		25
Belgium		2			2
Belize				2	2
Bolivia				8	8
Botswana				3	3
Brazil		16	2	10	28
Cape Verde		6			6
Central African Republic			2		2
China		1		1	2
Colombia		4	1	3	8
Costa Rica				1	1
Cuba				6	6
Dominican Republic		5	58		63
Ecuador				1	1
Ethiopia			14		14
Fiji				2	2
Germany		2			2
Ghana		1	1		2
Grenada			15		15
Guadeloupe		14	8		22
Guyana		7	21		28
Honduras				1	1
ICRISAT	11	1659	6		1676
India	54	2568	6378	201	9201
Indonesia		7	14	36	57
Iran		1			1
Italy		5	10		15
Jamaica		20	44		64
Kenya		26	312	5	343
Madagascar		1			1
Malawi		1	244	4	249
Maldives			1		1
Mali				4	4
Martinique			1		1
Mexico		3		59	62
Montserrat			4		4
Mozambique			31	1	32
Myanmar		60	13	8	81
Namibia				5	5
Nepal		8	112		120
Nicaragua				4	4
Nigeria		34	148		182
Oman				3	3
Pakistan		15	2	1	18
Panama				2	2
Papua New Guinea				3	3
Paraguay				5	5
Peru	1	2	2	2	7
Philippines		2	57	2	61
Puerto Rico		44	34		78
Rwanda			5		5
Saint Kitts and Nevis			6		6
Saint Lucia			17		17
Saint Vincent and the Grenadines			22		22
Senegal			10	1	11
Sierra Leone			3		3
South Africa		21	4	15	40
Sri Lanka		59	18	33	110
Taiwan		2	1		3
Tanzania		3	259	13	275
Thailand		1	40		41
Trinidad and Tobago		39	74	1	114
Uganda		1	97		98
Union of Soviet Socialist Republics			2		2
United Kingdom		5	5	1	11
United States of America		4			4
Unknown		6	3	2	11
Venezuela		75	56	3	134
Zaire			13		13
Zambia			86	7	93
Zimbabwe				10	10
Total	68	4,829	8,319	555	13,771

Wealth from the wild

Promising sources for agronomic and nutritional traits and for higher levels of resistance to various biotic and abiotic stresses were identified in wild species. Important sources include, *C. scarabaeoides* (L.) Thouars for wilt, water logging tolerance and high pod setting (9); *C. albicans* (Wight & Arn.) Maesen, *C. scarabaeoides* and *C. sericeus* (Benth. ex Baker) Maesen for sterility mosaic disease; *C. platycarpus* (Benth.) Maesen, *C. scarabaeoides and C. sericeus* for phytophthora blight; *C. albicans, C. platycarpus, C. scarabaeoides* and *C. sericeus* for alternaria blight; *C. acutifolius* (F. Muell.) Maesen, *C. albicans, C. lineatus* (Wight & Arn.) Maesen and *C. sericeus* for drought; *C. platycarpus* and *C. scarabaeoides* for early flowering (from 35 to 50 days) (5); *C. albicans, C. scarabaeoides, C. sericeus, C. reticulatus* (Aiton) F. Muell. and *Rhynchosia bracteata* Baker for pod borer, pod fly and pod wasp (6); *C. acutifolius, C. albicans, C. cajanifolius* (Haines) Maesen, *C. platycarpus, C. scarabaeoides, C. sericeus* and *D. ferruginea* Wight & Arn. for salinity (8) and *C. lineatus, C. crassus* (Prain ex King) Maesen, *C. cajanifolius*, *C. mollis* (Benth.) Maesen, *C. platycarpus*, *C. scarabaeoides* and *C. albicans* for seed protein content (31% - 34%) (4).

Documentation

Documentation of information on germplasm collections is very essential for enhanced utilization. Four types information (passport, characterization, inventory and distribution) on each accession is being maintained at ICRISAT genebank using Genebank Information Management System (GIMS). The passport information of the pigeonpea collection can be browsed through www.genesys-pgr.org or http://www.icrisat.org/crop-pigeonpea-genebank.htm.

Core and mini core collections

Non-availability of reliable information on traits of economic importance in germplasm collections of large size is the major reason for poor utilization of genetic resources in crop breeding. Representative subsets of pigeonpea germplasm in the form of core (5) and mini core collections (13) and genotype-based reference set (12) were formed for enhancing the use of germplasm in pigeonpea improvement. Evaluation of mini core resulted in identification of 23 accessions tolerant to water logging, 16 to salinity, six to wilt, 24 to sterility mosaic disease, and 11 to pod borer (14). A number of accessions with early flowering (< 85 days), large seeds (>15 g 100 seeds^{-1}), and seed nutrient dense types (seed protein, > 24%, iron, > 40 ppm, and zinc, > 40 ppm) were identified (14). Twenty seven sets of mini core were provided to the NARS in six countries for evaluation and identification of promising sources for use in pigeonpea improvement.

Access to the collection

Seeds of all FAO designated accessions are available at ICRISAT genebank under Standard Material Transfer Agreement (SMTA) of International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). To date, ICRISAT genebank provided 51,348 samples to researchers in India, 22,226 samples to researchers in 112 countries and 85,881 samples to researchers in ICRISAT.

Table 2. Variation of some economically important traits of the pigeonpea germplasm assembled at ICRISAT genebank, Patancheru, India

Character	Mean	Minimum	Maximum
Number of days to 50% of flowering	133.54	52	237
Number of days to 75% of maturity	192.12	100	299
Plant height (cm)	177.89	39.0	310
Number of primary branches (plant^{-1})	13.52	1.1	107
Number of secondary branches (plant^{-1})	31.30	0.0	145.3
Number of tertiary branches (plant^{-1})	8.80	0.0	218.7
Number of racemes per plant (plant^{-1})	150.32	6.0	915
Pod length (cm)	5.71	2.5	13.1
Number of pods (plant^{-1})	287.26	9.3	1819.3
Number of seeds (pod^{-1})	3.72	1.6	7.2
100-seed weight (g)	9.28	2.7	25.8
Seed yield (g plant^{-1})	97.37	1.0	720.0
Harvest index (%)	21.00	0.6	73.9
Seed protein content (%)	21.25	13	30.8

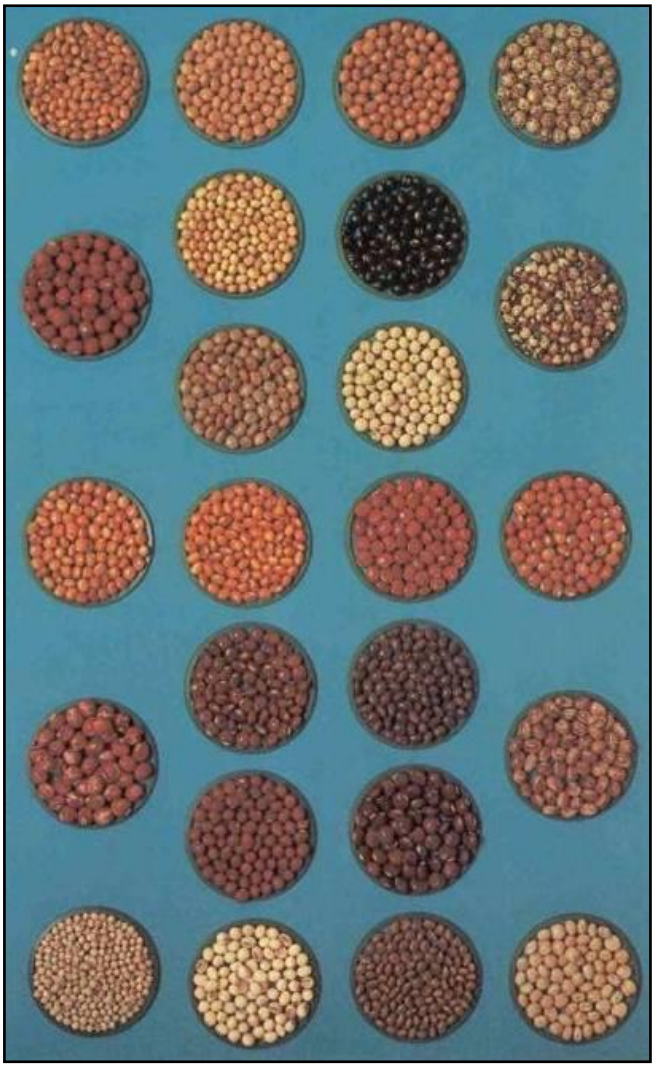

Figure 1. Diversity for seed traits in the world collection of pigeonpea at the ICRISAT genebank, Patancheru, India

Impact of conserved germplasm

The pigeonpea collection conserved in genebank provides an insurance against genetic erosion. Nine accessions were released as cultivars in seven countries. A vegetable pigeonpea landrace from India (ICP 7035) was released as cultivar in India, Fiji, Nepal, China and Philippines. Wilt resistant pigeonpea landrace ICP 8863 released as Maruti in India resulted in about US$ 62 million as net present value of benefits from collaborative fusarium wilt research representing an internal rate of return of 65% by year 1996 (1). ICP 9905, ICP 11914 and ICP 13828 released in Venezuela reportedly solved major economic problem of importing soybean worth $300 million annually. Mini core collection, an International Public Good (IPG), is serving as gateway to access entire pigeonpea collection at ICRISAT genebank. 

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