Identification of photoperiod insensitive sources in the world collection of pigeonpea at ICRISAT

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Pigeonpea (*Cajanus cajan*) is cultivated in a multitude of production systems, and in a wide range of climatic conditions throughout the tropics and subtropics. Because of its multiple uses (source of food, fodder and fuel wood; material for thatching and fencing; and for soil improvement and as windbreaks), pigeonpea plays an important role in subsistence agriculture. It is grown as a field crop as well as a backyard crop in more than 80 countries. During 2005, pigeonpea was grown on an estimated 4.6 million ha, with a production of 3.5 million t and an average productivity of 0.9 t ha^{-1}. India has the largest area under pigeonpea (3.3 million ha) followed by Myanmar (0.58 million ha), Kenya (0.15 million ha), Malawi (0.12 million ha), Uganda (0.08 million ha), Tanzania (0.07 million ha), Nepal (0.03 million ha) and Dominican Republic (0.01 million ha) (FAO 2005).

Pigeonpea is a quantitative short-day species and most cultivars flower in day lengths 11 to 11.5 h (Gooding 1962, Spence and Williams 1972). The critical photoperiod required to trigger flowering is species-specific and even cultivar-specific. In India, when grown in the rainy season, flowering is triggered by short days after the rains cease while low temperature in the post-monsoon period delays flowering (van der Maesen 1990). No pigeonpea cultivar is truly photoperiod insensitive and the degree of sensitivity varies quantitatively (Saxena and Sharma 1990). Photoperiod response has been related to particular uses in traditional cropping systems. Exploitation of germplasm for use in crop improvement suitable for specific locations in a wide range of photoperiods is possible only when the knowledge of photoperiod responses of parental material is known.

The world collection of cultivated pigeonpea germplasm (13,077 accessions) assembled at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) genebank from 74 countries originating from a wide range of environments may include highly photoperiod sensitive to insensitive accessions. Screening of these germplasm accessions for their response to photoperiod is very important for well-targeted use in crop improvement. As part of characterization of germplasm, a total of 10,390 cultivated pigeonpea accessions were screened for their response to photoperiod at ICRISAT, Patancheru, India during 1977/78 to 1988/89. Insensitive or less sensitive accessions were identified after three cycles.

First cycle of screening

Pigeonpea germplasm sets ranging from 186 to 1526 accessions were sown on three dates, ie, middle of November, December and February every year. By sowing the germplasm sets during these months, accessions were exposed to full spectrum of day length for flowering. Each accession was sown in a single row of 2 m length, on ridges spaced at 75 cm apart with plant spacing of 25 cm. Two to three seeds were sown per hill and later thinned to one plant per hill. All crop management practices including irrigation and plant protection were provided at research level. Accessions that flowered on or

Table 1. Passport and characterization data of pigeonpea germplasm accessions found promising for photoperiod insensitivity when screened at ICRISAT, Patancheru, India.

Accession (ICP)	Identity	Origin of source	Time to 50% flowering (days) Control	Extended light	Photoperiod insensitivity Index	Score[1]	Flowering pattern	Growth habit[2]
14885	ICP 1143 Sel	India	119	126	0.94	INS	Indeterminate	C
14886	ICP 1146 Sel	India	95	102	0.93	INS	Indeterminate	S
14896	ICP 7003 Sel	India	109	123	0.87	MIS	Indeterminate	SS
14897	ICP 7028 Sel	India	98	107	0.91	INS	Indeterminate	SS
14900	ICP 7179 Sel	India	87	87	1	INS	Indeterminate	SS
14902	ICP 7219 Sel	India	93	105	0.87	MIS	Indeterminate	SS
14905	ICP 7295 Sel	India	80	85	0.94	INS	Determinate	C
14908	ICP 7627 Sel	India	105	109	0.96	INS	Indeterminate	SS
14913	ICP 7645 Sel	India	84	95	0.87	MIS	Indeterminate	SS
14915	ICP 8013 Sel	India	119	128	0.92	INS	Indeterminate	SS
14926	ICP 10906 Sel	Australia	70	80	0.86	MIS	Determinate	C
14929	ICP 10911 Sel	Australia	67	74	0.9	MIS	Determinate	C
14935	ICP 10925 Sel	Australia	65	70	0.92	INS	Determinate	C
14884	ICP 1016 Sel	India	127	137	0.92	INS	Indeterminate	C
14887	ICP 1188 Sel	India	98	112	0.86	MIS	Indeterminate	S
14888	ICP 1211 Sel	India	77	89	0.84	MIS	Indeterminate	SS
14889	ICP 3284 Sel	India	107	116	0.92	INS	Indeterminate	SS
14890	ICP 3749 Sel	India	87	99	0.86	MIS	Indeterminate	SS
14891	ICP 3861 Sel	Unknown	74	87	0.82	MIS	Determinate	C
14892	ICP 5545 Sel	India	89	102	0.85	MIS	Indeterminate	SS
14895	ICP 7000 Sel	India	84	98	0.83	MIS	Indeterminate	SS
14899	ICP 7172 Sel	Nigeria	84	98	0.83	MIS	Determinate	C
14901	ICP 7180 Sel	India	74	86	0.84	MIS	Indeterminate	SS
14904	ICP 7231 Sel	Pakistan	98	108	0.9	MIS	Indeterminate	SS
14906	ICP 7417 Sel	India	77	88	0.86	MIS	Indeterminate	SS
14907	ICP 7472 Sel	India	107	121	0.87	MIS	Indeterminate	SS
14910	ICP 7634 Sel	India	84	97	0.85	MIS	Indeterminate	C
14912	ICP 7643 Sel	India	91	102	0.88	MIS	Indeterminate	SS
14914	ICP 7808 Sel	India	105	118	0.88	MIS	Indeterminate	SS
14916	ICP 8018 Sel	India	112	119	0.94	INS	Indeterminate	SS
14918	ICP 8780 Sel	India	82	97	0.82	MIS	Indeterminate	SS
14919	ICP 8845 Sel	India	105	113	0.92	INS	Semideterminate	SS
14921	ICP 9036 Sel	India	82	93	0.87	MIS	Indeterminate	SS
14922	ICP 10897 Sel	Australia	70	74	0.94	INS	Determinate	C
14923	ICP 10898 Sel	Australia	74	74	1	INS	Determinate	C

contd.

Table 1. (contd.)

Accession (ICP)	Identity	Origin of source	Time to 50% flowering (days)		Photoperiod insensitivity		Flowering pattern	Growth habit[2]
			Control	Extended light	Index	Score[1]		
14924	ICP 10901 Sel	Australia	60	74	0.77	MIS	Determinate	C
14925	ICP 10905 Sel	Australia	77	80	0.96	INS	Determinate	C
14927	ICP 10909 Sel	Australia	65	70	0.92	INS	Determinate	SS
14928	ICP 10910 Sel	Australia	70	77	0.9	MIS	Determinate	C
14930	ICP 10913 Sel	Australia	70	77	0.9	MIS	Determinate	C
14931	ICP 10916 Sel	Australia	77	80	0.96	INS	Determinate	C
14932	ICP 10920 Sel	Australia	77	84	0.91	INS	Determinate	C
14933	ICP 10921 Sel	Australia	70	84	0.8	MIS	Determinate	C
14934	ICP 10923 Sel	Australia	70	82	0.83	MIS	Determinate	C
14936	ICP 10926 Sel	Australia	65	74	0.86	MIS	Determinate	C
14937	ICP 10927 Sel	Australia	70	80	0.86	MIS	Determinate	C
14938	ICP 10929 Sel	Australia	56	67	0.8	MIS	Determinate	C
14939	ICP 11548 Sel	ICRISAT	70	80	0.86	MIS	Determinate	SS
14940	ICP 11599 Sel	ICRISAT	70	80	0.86	MIS	Determinate	C
14941	ICP 11601 Sel	ICRISAT	65	80	0.77	MIS	Determinate	SS
14942	ICP 11607 Sel	ICRISAT	70	80	0.86	MIS	Determinate	C
14943	ICP 11609 Sel	ICRISAT	82	86	0.95	INS	Determinate	C
14944	ICP 11611 Sel	ICRISAT	77	88	0.86	MIS	Determinate	SS
14945	ICP 11613 Sel	ICRISAT	70	74	0.94	INS	Indeterminate	SS
14946	ICP 11629 Sel	ICRISAT	80	93	0.84	MIS	Determinate	SS
14948	ICP 11641 Sel	ICRISAT	80	84	0.95	INS	Indeterminate	SS
14949	ICP 11654 Sel	ICRISAT	84	88	0.95	INS	Determinate	C
14950	ICP 11655 Sel	ICRISAT	80	86	0.93	INS	Determinate	SS
14951	ICP 11656 Sel	ICRISAT	77	91	0.82	MIS	Determinate	C
14952	ICP 11662 Sel	ICRISAT	77	77	1	INS	Determinate	C
14953	ICP 11737 Sel	ICRISAT	84	88	0.95	INS	Determinate	SS
14955	ICP 13193 Sel	Australia	84	93	0.89	MIS	Determinate	SS
14957	ICP 13195 Sel	Australia	70	77	0.9	MIS	Determinate	SS
14903	ICP 7220 Sel	India	70	81	0.84	MIS	Determinate	SS

1. INS = Insensitive; MIS = Moderately insensitive.
2. C = Compact; S = Spreading; SS = Semispreading.

before 19 June in the three (sowing date) sets were selected as likely insensitive accessions while discarding others. We screened 10,390 accessions during 1977/78 to 1986/87. In this first cycle, 1004 accessions that flowered in all the three sowings were selected as potential insensitive accessions.

Second cycle of screening and purification

As suggested by physiologists, sets of promising (photoperiod insensitive) accessions identified in the first cycle of screening were tested again by sowing under normal as well as extended photoperiod during 1983 to

1986 to assess the insensitivity of accessions to light. Uniform extended photoperiod of 16 h was achieved for all plants in each plot, using incandescent bulbs (100 watt) at a spacing of 3 m × 3 m. Extended day length (EDL) was provided from the day of seedling emergence till the end of flowering. The lighting intensity was arranged by adjusting the bulbs at least 50 cm above the crop canopy. The same set of germplasm was sown in the adjacent plot in normal day length conditions. To avoid interference of light, a barricade of black cloth separated the two germplasm sets. In both the sets, the data on 50% flowering was recorded. The accessions (64) that flowered with a difference of less than 15 days in EDL compared to the normal conditions were considered as promising photoperiod insensitive (ICRISAT 1976). The early flowering plants under extended light were selfed to get pure seeds for next cycle of screening.

Third cycle of screening and purification

From the second cycle of screening, 64 lines were identified. These were planted in 1987/88 rainy season in augmented design, with a control (Prabhat), repeated thrice. As in the second cycle of screening, these lines were grown in two sets, one under normal days and second under EDL of 16 h. All other agronomic practices were the same as under the preceding cycle. In both the sets, data were recorded on time to 50% flowering. To characterize the lines for their response, photoperiod insensitivity index was derived using the formula developed by physiologists at ICRISAT:

Photoperiod Insensitivity Index (PII) = 1−[(B−A)/A]

where, A= number of days to flowering under normal days; and B = number of days to flowering in EDL conditions.

The accessions with PII ranging from 0.91 to 1.0 were classified as insensitive (INS), 0.71 to 0.90 as moderately insensitive (MIS), and those with an index less than 0.71 as photoperiod sensitive (S). Three accessions, namely, ICP 14900, ICP 14923 and ICP 14952 flowered on the same day whether grown in normal days or in extended photoperiod revealing high level of photoperiod insensitivity. The early flowering plants in each accession were selfed and the seeds obtained were bulked, registered and maintained as photoperiod insensitive accessions in the ICRISAT genebank (Table 1). Seed samples of these photoperiod insensitive pigeonpea accessions are available for research under the Standard Material Transfer Agreement (SMTA).

Photoperiod insensitive lines are of particular interest to breeders to develop cultivars for niches and also to ensure synchrony in flowering of parental material for hybrid seed production. Short-duration photoperiod insensitive accessions are very useful in double or multiple cropping systems. Response to photoperiod could be utilized to maximize the production. The photoperiod insensitivity trait was well distributed across the classes of flowering pattern and growth habit indicating that the photoperiod insensitivity can be easily combined with other traits in efforts to maximize the pigeonpea yields.

References

FAO (Food and Agriculture Organization of the United Nations). 2005. http://www/FAO.ORG/FAOSTAT database.

Gooding HJ. 1962. The agronomic aspects of pigeonpeas. Field Crop Abstracts 15:1–5.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1976. Annual report 1975/76. Patancheru 502 324, Andhra Pradesh, India: ICRISAT. 268 pp.

Saxena KB and **Sharma D.** 1990. Pigeonpea: Genetics. Pages 137–158 *in* The pigeonpea (Nene YL, Hall SD and Sheila VK, eds.). Wallingford, Oxon OX 10 8DE, UK: CAB International.

Spence JA and **Williams SJA.** 1972. Use of photoperiod response to change plant design. Crop Science 12:121–122.

van der Maesen LJG. 1990. Pigeonpea: Origin, history, evolution, and taxonomy. Pages 15–46 *in* The pigeonpea (Nene YL, Hall SD and Sheila VK, eds.). Wallingford, Oxon OX 10 8DE, UK: CAB International.