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GENOTYPE-DEPENDANT PHOTOPERIOD-INDUCED SENSITIVITY TO FLOWERING TIME IN DOLICHOS BEAN (*LABLAB PURPUREUS* L.) SWEET VAR. LIGNOSUS

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Abstract

The degree of photoperiod sensitivity (PS) among the working germplasm accessions varied from 0.63 to 1.00 depending on the extent of delay in flowering during long days in comparison to short days. While a few accessions maintained constant days to flowering in long days, a few others delayed flowering by >30 days in long days in comparison to short days. The accessions were classified into PS, photoperiod insensitive (IPS) and moderately photoperiod sensitive (MPS). The results suggested independence of degree of photoperiod-induced sensitivity with growth habit, pod and seed traits. These results are discussed in relation to the strategies for breeding PS/PIS dolichos bean varieties.

Introduction

Dolichos bean (*Lablab purpureus* L.) Sweet is one of the important grain legume crops grown in India (Vishwanath *et al.* 1971, Shivashankar and Kulkarni 1989) and Bangladesh (Raihan and Newaz 2008) for use as a vegetable. It is also known for its forage value (Magoon *et al.* 1974). It is believed that dolichos bean has originated in India (Nene 2006). In India, it is grown as an intercrop/sole crop mainly in rain-fed areas. In Karnataka, dolichos bean (*Lablab purpureus* var. lignosus) is grown in an area of 0.65 lakh hectares with a production of 0.71 lakh t and contributes to nearly 90 per cent of both area and production in India. It is primarily grown for fresh grains for use as a vegetable. Therefore, fresh pods containing immature grains are marketable economic products in dolichos bean (Vishwanath *et al.* 1971, Shivashankar and Kulkarni 1989). It has evolved as a photoperiod sensitive (PS), indeterminate self pollinated crop (Shivashankar and Kulkarni 1989). Most of the varieties grown by the farmers are PS and display indeterminate growth habit. However, the degree of photoperiod-induced responses to flowering is genotype dependent (Keerthi *et al*. 2014). From plant breeding point of view, a precise knowledge about the degree of photoperiod sensitivity of working germplasm/breeding material would help develop cultivars suitable for adaptation to a range of photoperiods (Upadhyaya *et al.* 2007). The objectives of the investigation are to assess genetic differences for degree of photoperiod-induced sensitivity to flowering time and its relationships with growth habit, pod and seed traits in dolichos bean.

Materials and Methods

The materials for the study consisted of 36 dolichos bean germplasm accessions (representing Indian states and Kenya) being maintained at All India Coordinated Research Project (AICRP) on pigeonpea, University of Agricultural Sciences, Bengaluru, India.

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The seeds of 36 germplasm accessions were divided into two sets and sown separately following RBD with two replications during August and December at the experimental plot of the Department of Genetics and Plant Breeding, UAS, Bengaluru. The experimental plot is located at an altitude of 930 m above mean sea level 12º58' north and 77º35' east latitude and longitude, respectively. Each entry was sown in a single row of 2.5 meters length with a row spacing of 0.45 m and 0.3 m between plants within a row. Ten days after sowing, the seedlings were thinned to maintain a total of 10 plants within a row. Based on the meteorological data, sowing was planned such that the accessions sown during August (12: 32: 32) and December (11: 24: 44) experienced long and short days, respectively.

Data were recorded on days to 50% flowering of accessions sown during August and December. Analysis of variance for days to flowering of accessions sown during August and December were performed to detect differences among germplasm accessions for days to flowering in response to short and long day lengths.

Being a short day plant, dolichos bean flowers when it is exposed to critical minimum day length (CMDL) of 11.33 hrs beyond which flowering is delayed to an extent that depends on the genotype (unpublished data). The extent of delay in flowering time of accessions that are exposed to > CMDL in comparison to their flowering time when they are exposed to ≤ CMDL was used as a criterion to assess the degree of photoperiod-induced sensitivity to flowering time. Accordingly, degree of photoperiod-induced sensitivity of accessions to flowering time was estimated following methods proposed by White and Laing (1989) and Upadhyaya *et al.* (2007).

White and Laing (1989) proposed relative response to photoperiod (RRP) as an index of degree of photoperiod sensitivity. RRP was estimated by initially calculating the rate of flowering (R) of accessions sown in August (long days) and December (short days) as R = 1/F, where F is days from sowing to 50% flowering. RRP was then estimated as RRP = R_A/R_D, where R_A and R_D are the rates of flowering of accessions sown during August and December, respectively. Upadhyaya *et al.* (2007) proposed photoperiod insensitivity index (PII) which was estimated as PII = 1 – [(B-A)/A], where, A and B are days to 50% flowering of germplasm accessions in response to their exposure to short day length (December sowing) and long day length (August sowing), respectively.

As correlation coefficient between RRP and PII was very high [r = 0.99), germplasm accessions were classified into three photoperiod-induced response groups. The accessions with RRP/PII ranging from 0.91 to 1.0 were classified as photoperiod insensitive (PIS), 0.71 to 0.90 as moderately photoperiod sensitive (MPS) and those with RRP/PII ≤ 0.70 as photoperiod sensitive (PS) (Upadhyaya *et al.* 2007).

Results and Discussion

The degree of photoperiod sensitivity of germplasm accessions varied from 0.63 to 1.00 depending on the extent of delay in flowering during long days in comparison to short days (Table 1). While a few accessions maintained constant days to flowering in long days, a few others delayed flowering by > 30 days in long days in comparison to short days. The germplasm accessions used in the present study are farmers' varieties which have sustained several years of natural and human selection pressures in the production environments which differ in day lengths among others. Consequently, it is likely that there have been accumulated mutations coupled with recombination at photoperiod-induced flowering time loci leading to genetic differences. Genetic differences in flowering time as influenced by differences in photoperiod are amply reflected by analysis of variance (Table 2). Considerable genetic variation in the relative photoperiod sensitivity to flowering time has been reported in comparable short day legume crops such as soybean (Byth 1968, Palson 1972, Nisssly *et al.* 1981, Sinclair and Hinson 1992, Bhatia *et al.* 2003), common bean (White and Laing 1989), pigeonpea (Upadhyaya *et al.* 2007), and cowpea (Patel and Hall 1990, Ehlers and Hall 1996).

Table 1. Degree of photoperiod-induced sensitivity of dolichos bean germplasm accessions to flowering time.

Sl. No.	Germplasm accession	Source of collection	Days to 50% flowering		Number of days delay in flowering	Photoperiod sensitivity indices		Photoperiod-induced response class
			August sowing	December sowing		PII	RRP	
1	GL 66	Karnataka	67	55	12	0.82	0.82	MPS
2	GL 68	″	78	64	14	0.82	0.82	MPS
3	GL 80	″	76	65	11	0.86	0.86	MPS
4	GL 142	″	71	62	9	0.87	0.87	MPS
5	GL 199	″	76	51	25	0.67	0.67	PS
6	GL 201	″	65	51	14	0.78	0.78	MPS
7	GL 204	Andhra Pradesh	84	73	11	0.87	0.87	MPS
8	GL 205	″	65	65	00	1.00	1.00	PIS
9	GL 228	″	71	71	00	1.00	1.00	PIS
10	GL 237	″	56	54	02	0.96	0.96	PIS
11	GL 238	Gujarat	49	49	00	1.00	1.04	PIS
12	GL 247	″	79	65	14	0.82	0.82	MPS
13	GL 252	″	78	60	18	0.77	0.77	MPS
14	GL 289	Karnataka	80	54	26	0.68	0.68	PS
15	GL 326	″	44	40	04	0.91	0.91	PIS
16	GL 360	″	61	58	03	0.95	0.95	PIS
17	GL 372	″	71	51	20	0.72	0.72	MPS
18	GL 382	″	81	51	30	0.63	0.63	PS
19	GL 385	″	89	58	31	0.65	0.65	PS
20	GL 391	″	92	60	32	0.65	0.65	PS
21	GL 412	Kenya	67	51	16	0.76	0.76	MPS
22	GL 434	″	81	73	08	0.90	0.90	PIS
23	GL 506	Karnataka	70	70	00	1.00	1.00	PIS
24	GL 527	Andhra Pradesh	75	60	15	0.80	0.80	MPS
25	GL 530	″	76	54	22	0.71	0.71	MPS
26	GL 576	Maharashtra	57	52	05	0.91	0.91	PIS
27	GL 577	Tamil Nadu	62	51	11	0.82	0.82	MPS
28	GL 579	″	73	60	13	0.82	0.82	MPS
29	GL 606	Unknown	83	73	10	0.88	0.88	MPS
30	GL 621	″	82	60	22	0.73	0.73	MPS
31	GL 626	″	84	72	12	0.86	0.86	MPS
32	GL 633	″	66	61	05	0.92	0.92	PIS
33	GL 658	Karnataka	73	71	02	0.97	0.97	PIS
34	FPB 20	Advanced breeding line	38	36	02	0.95	0.95	PIS
35	HA-12-9	″	54	46	08	0.85	0.85	MPS
36	KNR	Unknown	57	53	04	0.93	0.93	PIS

PS: Photoperiod sensitive, MPS: Moderately photoperiod sensitive and PIS: Photoperiod insensitive, PII: Photoperiod insensitive index and RRP: Relative response to photoperiod.

Five of the accessions were PS which showed ≥ 25 days delayed flowering. About 50% of the accessions were MPS which delayed flowering by 8 to 22 days and 36% of the accessions were PIS with no more than 8 days delay in flowering (Table 1). Several researchers have classified germplasm accessions into similar photoperiod response-based groups in short day PS grain legume crops such as common bean (White and Laing 1989), cowpea (Patel and Hall 1990, Ehlers and Hall 1996), pigeonpea (Upadhyaya *et al.* 2007) and soybean (Roberts *et al*. 1996, Bhatia *et al.* 2003). Photoperiod-induced response-based classification of germplasm accessions/breeding lines assist plant breeders in their choice of most appropriate germplasm/breeding lines and their testing environment for targeted use in breeding programs (Ehlers and Hall 1996, Upadhyaya *et al.* 2007).

Table 2. Analysis of variance for days to flowering under August and December sowing dates in dolichos bean.

Source of variation	Degree of freedom	Days to flowering			
		August		December	
		MSS	Probability	MSS	Probability
Replication	01	4.50	0.47	24.50	0.10
Genotypes	35	309.24	0.00	170.77	0.00
Error	35	8.39		8.73	

Photoperiod is one of the important environmental factors that influence adaptation of dolichos bean through its effect on days to flowering (Keerthi *et al.* 2014). Photoperiod influences the duration of vegetative phase vs. reproductive phase, partitioning of photosynthates and hence crop yield and its stability (Huyghe 1998). Consequently, photoperiod-induced flowering time response of dolichos bean genotypes could be exploited to meet two contrasting production-consumption requirements, namely (1) round-the-year commercial scale production and consumption and (2) traditional single season (rainy) subsistence production and consumption. While PIS response of genotypes is useful for round-the the year production and consumption, PS response of genotypes is useful for rainy season production and subsistence consumption.

Traditionally, dolichos bean is grown in rain-fed ecosystem for subsistence consumption. Most cultivars used by farmers are PS to flowering time (Keerthi *et al.* 2014). Market-led economy has necessitated production of dolichos bean throughout the year and development of cultivars with synchronous pod bearing ability to enable single harvest which is possible only from PIS cultivars with a determinate growth habit. PIS response has been successfully exploited for developing wheat and rice cultivars for wide adaptation (Simmonds 1979). When using PIS dolichos bean cultivars, farmers can control date of flowering and hence maturity simply by either varying the sowing date or choosing cultivars with different heat-unit requirements (Keerthi *et al.* 2014). Being grown predominantly in rain-fed ecosystem, dolichos bean is frequently experience end-of-season drought stress. One of the easiest ways to combat the production losses due to drought stress is by developing short-duration cultivars. The useful sources of earliness in PS crops such as dolichos bean are PIS germplasm accessions/genotypes. Coyne (1966) and Wallace and Enriquez (1980) have also suggested usefulness of PIS accessions/genotypes as source of earliness in common bean. The selection for photoperiod insensitivity may result in reduced vegetative phase, fewer braches, racemes and pods and hence reduced economic product yield (Huyghe 1998). However, developing PIS varieties with a minimum of 45 days from seedling emergence to flowering would enable vegetative growth adequate enough to produce acceptable economic product yield even under normal density of planting as is practiced for PS cultivars (Hartwig 1970). Besides this genetic intervention, yields of such PIS varieties could be maximized by high density planting (Vishwanath *et al.* 1971). Hence, major emphasis/objective of dolichos bean breeding has been to develop PIS determinate cultivars.

Despite benefits associated with PIS cultivars, a certain degree of photoperiod sensitivity is necessary to maintain homeostasis of crop maturity duration to enable accumulation of adequate biomass for satisfactory economic product production under variable sowing dates, a common feature in regions of unpredictable onset and cessation of rainfall (Roberts *et al.* 1996) as is true in dolichos bean production areas in India. Recent report provides preliminary evidence for higher economic product yield potential of PS dolichos bean cultivars compared to PIS cultivars under variable sowing dates (Keerthi *et al.* 2014). PS cultivars also enable planting during short days as a double crop after the harvest of a commonly grown long season crop with little compromise in pod productivity (Ehlers and Hall 1996). More specifically, photoperiod sensitivity is a useful trait to develop cultivars for producing fresh pods with immature seeds, where an extended staggered fruiting is preferred for subsistence consumption as is desired by dolichos bean producers in southern districts of Karnataka and adjoining districts of neighboring states such as Tamil Nadu and Andhra Pradesh in India.

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