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Screening for days to Flowering and Photo Insensitivity in *Vigna mungo*

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ABSTRACT

Earliness and photo insensitivity is a crucial factor for accommodation of crops in different cropping systems across different agro ecological zones. In the current study we used a core set of 98 genotypes consisting of germplasm as well as released varieties of blackgram to screen it for its response to photoperiodism. Data on days to first flowering and days to fifty percent flowering (DFF) was noted for the individual lines in all the three seasons (Kharif, late kharif, and zaid). An absolute mean difference for days to flowering in all possible combinations and mean of all absolute mean differences were calculated. The core set of genotypes display a huge difference in days to flowering, and thus their differential response to photoperiodism. The set of genotypes were further categorized into early, medium and late flowering according to the mean number of days required for flowering. A total of 32 early, 21 medium, and 2 late flowering lines were identified and were common across both season and years. Similarly, 13 photoperiod insensitive and 8 photoperiod sensitive lines were identified for further validation and studies.

Key words : *Photosensitivity, Flowering, Blackgram, Photoperiod etc.*

Introduction

Blackgram (*Vigna mungo* L.) is a protein-rich, short-duration crop of the semi-arid tropics, popularly known as urdbean or mash. It is a self-pollinated, dicotyledonous, leguminous plant having chromosome number 2n=22. The major constraints in achieving the potential yield of this crop are the lack of genetic variability and susceptibility to several biotic (Sudhir *et al.*, 2022) and abiotic factors, besides the availability of suitable ideotypes that can be accommodated in different cropping systems. In general, blackgram is a tropical crop, but is also grown in both kharif and zaid in several parts of India. Though tremendous progress has been made in achieving quantum jumps in cereal crops, which ushered in an era of green revolution, the gains made in the improvement of the productivity of pulses in general and blackgram in particular are very meagre.

Early flowering lines with higher yield potential along with the photo-insensitive trait can be useful so as to be accommodated into any cropping system in order to achieve maximum economic output (Kumar *et al.*, 2022). Flowering is the most important phase of the plant's life cycle. The time and stage of flowering in a plant is a highly regulated process which is controlled by age, nutrition, stress, and most importantly, by light period and duration. Also, it is reported that the phenomenon of floral transition is regulated at both pre and post fertilization level (Putterill *et al.*, 2004 and Cho *et al.*, 2017).

The pathways regulated by plant hormones such as auxin and gibberellic acid, sugar, temperature, and light period are known to regulate floral transition besides the autonomous flowering pathway in plants and the vital genes involved, such as *FLC*, *FVE*, and *SOC*, have also been reported (Samach *et al.*, 2012 and Kumar *et al.*, 2020).

Although several efforts have been made in identification of early flowering and photo-insensitive genotypes in several legume crops including *Medicago* (Clarkson and Russel, 1975), pigeonpea and soybean, not enough evidence and reports are there for blackgram genotypes. Keeping this in mind a field experiment was done in the main campus of ICAR-IIPR, Kanpur, Uttar Pradesh in order to identify the putative early flowering and photoperiod insensitive lines. The lines obtained from the current experiment will pave a way for research for accommodation of these lines in different cropping systems.

Materials and Methodology

Plant material

Blackgram is a moisture loving crop that is mostly cultivated during the *kharif* season in the northern part of India, but is cultivated throughout the cropping season in other parts of the country where climatic conditions are favorable. A core set of 98 genotypes consisting of germplasm as well as released varieties were used in the current study (Fig.1).

Phenotypic data and analysis

Data on days to first flowering and days to fifty percent flowering (DFF) was noted for the individual lines in all the three seasons. Days to fifty percent flowering was recorded when a minimum fifty percent of plants of a line had at least one completely opened flower.

Day length and temperature data

Day length (sunshine hours) and temperature data were procured from the weather data collection center ICAR-IIPR, Kanpur, Uttar Pradesh, India.

Identification of photoperiod insensitive line

As there is a huge difference in the day length or light period during the different sowing dates (July, September, and April) used in the current study, data on flowering can be indicative of photoperiod sensitivity/insensitivity of the genotypes. The absolute mean difference for days to flowering in all possible combinations (between July 2021 and September 2021; September 2021 and April 2022; July 2021 and April 2022) was calculated for each accession. The mean of all absolute mean differences was calculated further. All statistical analysis was done in

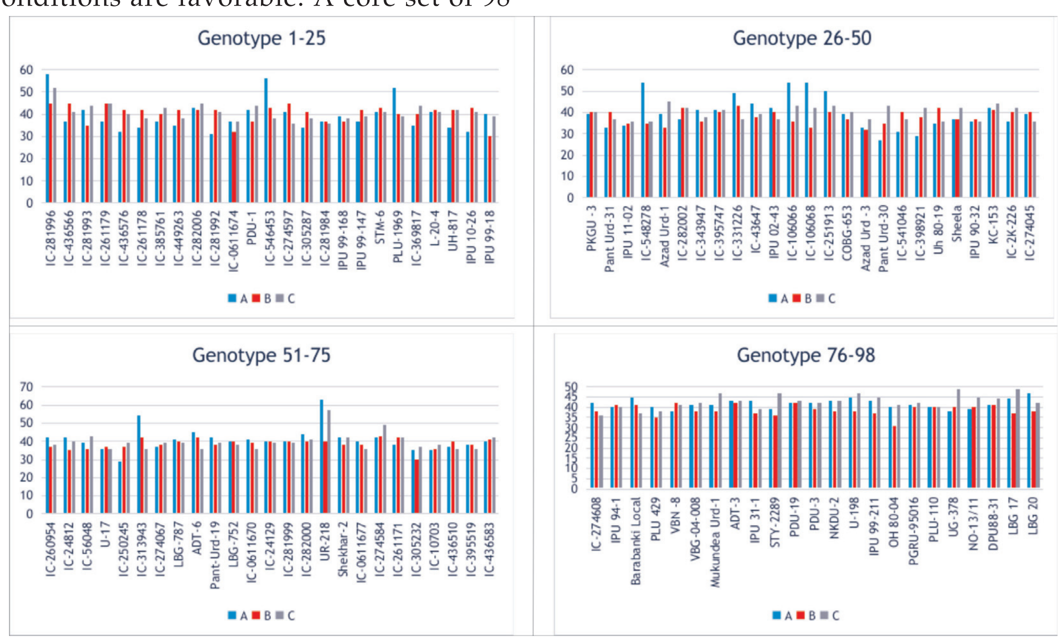

Fig. 1. Variation in days to fifty percent flowering in the set of 98 blackgram genotypes used in the study. A (July 2021), B (September 2021), C (April 2022).

MS-excel, 2016. Venn diagram was made by venny web server (https://bioinfogp.cnb.csic.es/tools/venny/).

Results and Discussion

Statistical Analysis of Field Data

The core set used in the current study displays huge diversity for days to flowering, as depicted by the statistical analysis of the field data on flowering (Table 1, Figure 1). Identification of early flowering as well as photo-insensitive flowering lines will be of great benefit not only for the molecular biologist and breeders, but also to the farmers in various aspects. These early flowering as well as photo-insensitive lines are the most vital candidates to accomodate in any cropping system, as they require less days for maturity, and can be grown into vacant and marginal lands. With less days to mature, less monetary input is involved, as well as they can escape several biotic and abiotic stresses encountered during the later stages of their life cycle, otherwise in case of late maturing lines.

Early flowering and photoperiod insensitive lines

On the basis of days required for DFF, all 98 lines were categorized into three groups *viz.* Early (≤40 days for DFF), medium (40-50 days for DFF) and late flowering lines (≥50 days for DFF). In total, 53 early, 36 medium, and 9 late flowering lines were identified in the July, 2021 experiment. In total, 50 early, 46 medium, and 2 late flowering lines were found in the April, 2022 experiment (Table 2). The phenotypic data for flowering in September, 2021 was not included to identify the early flowering lines, as forced maturity was observed in them. A total of 32 genotypes were found to be early flowering in both seasons as depicted by the *Venn* diagram (Table 2, Figure 2). These lines could be potential candidates for early flowering and their accommodation into different cropping systems.

Similarly, on comparing the absolute mean difference and their means for all the three seasons, a range of 0-15.33 was observed. The mean value of the absolute mean difference towards 0 (zero) means photoperiod insensitive lines, as these lines require almost the same days to flower in different seasons, while other extreme indicates photoperiod sensitive lines. In field screening and subsequent data analysis, we observed 13 and 8 genotypes to be at the extreme value (0-15.33) and common across both seasons and were identified as photo-insensitive and photo-sensitive lines respectively (Table 3). Usually, farmers have to shift their date of sowing many times due to erratic changes in weather, which sometimes have an adverse effect on the crop yield.

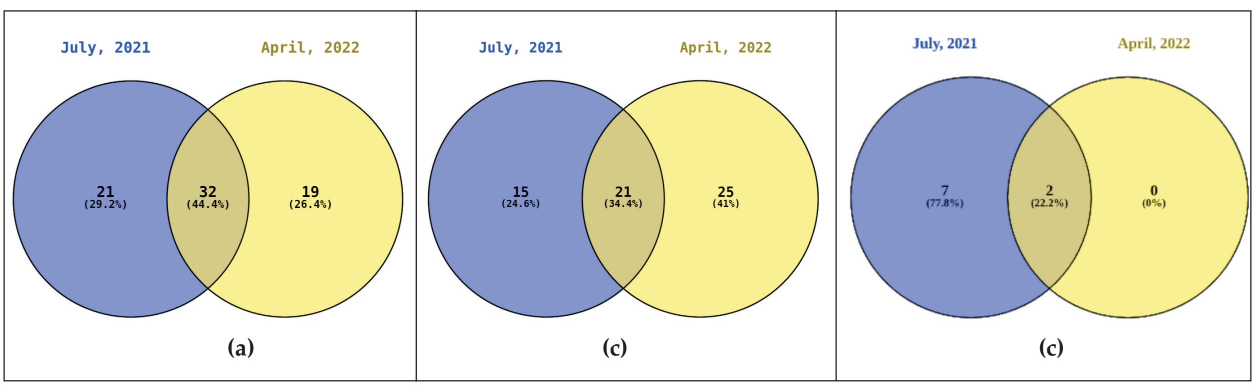

Fig. 2. *Venn* diagram depicting the number of early (a), medium (b) and late (c) flowering genotypes common across two years (July, 2021 and April, 2022).

Table 1. Statistical data analysis depicting the phenotypic diversity for days to flowering in the blackgram genotypes set used in the current study.

Sl. No.	Attributes	July, 2021	September, 2021	April, 2022
1.	Mean DFF	40.37	39.00	40.65
2.	Standard error	0.65	0.33	0.41
3.	Standard deviation	6.44	3.26	3.99
4.	Range of DFF	27-63	30-45	34-57

Table 2. Flowering response of blackgram genotypes in terms of days to fifty percent flowering

Season	Early	Medium	Late
July, 2021	Pant Urd-30, PKGU -3, IC-398921, IC-250245,IC-281992, IC-541046, IC-436576, IPU 10-26,LBG-17, Pant Urd-31, Azad Urd -3, IC-261178, IC-305287, UH-817, IPU 11-02, IC-449263, IC-369817, Uh 80-19, IC-305232, IC-10703, IPU 90-32, IC-2K-226, U-17, IC-436566, IC-261179, IC-385761, IC-0611674, IC-281984, IPU 99-147,IC-282002, Sheela, IC-274067, IC-24129, IC-436510, IC-261171, IC-395519, VBN-8, UG-378, IPU 99-168, Azad Urd-1, COBG-653, IC-274045, IC-56048, STY-2289, NO-13/11, IPU 99-18, IC-281999, IC-0611677, IC-436583, IPU 94-1, PLU 429, OH 80-04, PLU-110	IC-274597, STM-6,L-20-4, IC-343947,IC-395747, LBG-787, IC-0611670, VBG-04-008, Mukund Urd-1, PGRU-95016, DPU88-31,IC-281993, PDU-1, KC-153, IC-260954, IC-24812, Pant-Urd-19, Shekhar-2, IC-274584, IC-274608, PDU-19, PDU-3, IC-282006, ADT-3, IPU 31-1, NKDU-2, IPU 99-211, IC-43647, LBG-752, IC-282000, ADT-6, Barabanki Local, U-198, LBG 20, IC-331226, IC-251913	PLU-1969, IPU 02-43, IC-548278, IC-106066, IC-106068, IC-313943, IC-546453, IC-281996, UR-218
April, 2022	IC-281996, IC-436566,IC-281993, IC-261179,IC-436576, IC-261178,IC-385761, IC-449263,IC-282006, IC-281992,IC-0611674, PDU-1, IC-546453, IC-274597,IC-305287, IC-281984, IPU 99-168, IPU 99-147, STM-6,PLU-1969, IC-369817, L-20-4, UH-817, IPU 10-26,IPU 99-18, PKGU-3, LBG-17, Pant Urd-31, IPU 11-02, IC-548278, Azad Urd-1, IC-282002, IC-343947, IC-395747, IC-331226, IC-43647, IPU 02-43, IC-106066, IC-106068, IC-251913, COBG-653, Azad Urd -3, Pant Urd-30, IC-541046, IC-398921, Uh80-19, Sheela, IPU 90-32, KC-153,IC-2K-226, IC-274045	IC-281992, IPU 10-26,IC-436566, VBN-8,OH 80-04, STM-6,L-20-4, IC-395747, IC-282000, IC-398921,UH-817, IC-2K-226,IC-282002, Sheela,IC-261171, IC-436583,VBG-04-008, Shekhar-2,PDU-3, LBG 20, IC-106068, Pant Urd-30,IC-385761, IC-56048,PDU-1, PDU-19, ADT-3,NKDU-2, IC-251913, IC-106066, IC-369817,DPU 88-31, IC-281993,KC-153, IC-261179, Azad Urd-1, NO-13/11, IC-282006, IPU 99-211,STY-2289, Mukund Urd-1PGRU-95016, U-198, UG-378, IC-274584,LBG 17	IC-281996, UR-218

Table 3. List of genotypes identified to be photoperiod sensitive and photoperiod insensitive

Photoperiod sensitive lines	Photoperiod insensitive lines
UR-218, IC-106068, IC-548278, IC-546453, IC-10066, PDU-1, IC-313943, LBG 17	IC-281984, PKGU-3, IC-395747, IPU 02-43, U-17, IC-24129, IC-281999, ADT-3, PDU-19, PLU-110, PGRU 95016, LBG 752, LBG 787

These photoperiod insensitive lines could be a way forward for such a scenario.

Conclusion

The current study used a set of 98 blackgram genotypes made up of germplasm as well as released varieties. For each line in each of the three seasons (Kharif, late kharif, and zaid), information on the days to first flowering and days to fifty percent flowering (DFF) was recorded. An absolute mean difference for days to flowering in all possible combinations and mean of all absolute mean differences was calculated. The genotypes show a significant variation in the number of days till flowering, which explains their varied responses to photoperiodism. According to the average number of days needed for flowering, the genotype set was further divided into early, medium, and late flowering. A total of 32 early, 21 medium, and 2 late flowering lines were identified and were common across both season and years. Similarly, 13 photoperiod insensitive and 8 photoperiod sensitive lines were identified across both seasons/years. Based on these results, further validation of few selected genotypes can be done in plant phytotron or growth chamber with controlled conditions. These results can be further used to breed varieties for earliness as well as for photo insensitivity in blackgram. It will lead to include more areas under blackgram cultivation and further increase the production to meet the demand of pulses for food and nutritional security.

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