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Research Note

Late-*kharif* : Best season for inter-specific hybridization involving greengram [*Vigna radiata* (L.) Wilczek] and blackgram [*Vigna mungo* (L.) Hepper]

Yashpal[1*], M. N. Singh, N. Pathak and S. K. Saroj
Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi- 221005
[1]Present address: Division of Genetics, Indian Agricultural Research Institute, New Delhi 110 012
*Email: yashpaltaak@gmail.com

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Abstract
The present study was undertaken with an objective to identify best season for highest success rate of crossing in inter-specific hybrids involving four genotypes each of greengram and blackgram. Sowing was done on first week of March (Summer season crop), June (*Kharif* season crop) and September (Late-*kharif* season crop), 2011. Crosses were made in line x tester fashion using greengram as female parent during Summer, *Kharif* and Late-*kharif*, with average crossability of 3.19%, 6.37% and 9.33%, respectively. The rate of success during late-*kharif* reached as high as 153.80% and 688.11%, as against *kharif* and summer, respectively. The optimum weather parameter during late-*kharif* such as wind velocity ~2.35 Km/hr, moderately warm ambient temperature (27.87˚C), poorly-rained, longer bright sunshine hours (8.8 hr.) with optimum relative humidity (67.75%) favored pollen germination and highest rate of successful fertilization.

Key words: Greengram, blackgram, inter-specific hybrids, crossability, relative humidity.

Greengram [*Vigna radiata* (L.) Wilczek] and Blackgram [*Vigna mungo* (L.) Hepper] are two important species of food legumes. Both are considered to have originated in India and grown by small farmers throughout the tropical, subtropical and temperate Asian countries (Egawa, 1988). However, productivity of both the crops is very low. Breeding towards enhancement of yield through inter-varietal hybridization resulted in limited successes due to poor genetic variability in the primary gene pool. Inter-specific hybridization can create variability and widens primary gene pool through introgression of gene(s) for desirable trait(s). However, success of inter-specific hybridization varies from low to very low, and has been reported to be in the range of 22.5% (Egawa, 1988), 18-30 % (Barone *et al.,* 1992), 24.1% (Ngampongsai *et al.,* 1998) and 2.3-12.5% (Singh *et al.,*1996). Various pre (Kaur and Satija, 1996) and post (Ahn and Hartmann, 1978) fertilization barriers are responsible for poor success of crossings.

Besides genotype, seasonal and weather conditions *viz.,* temperature, rainfall, relative humidity, wind speed and photoperiods also play a crucial role in success of crossing or crossability (Shrivastava and Chawla, 1993; Talukdar and Shivakumar, 2012; Khattak *et al.,* 2002). Flower dropping under high temperature, precipitation, humidity and desiccating wind worsens the crossing success (Khattak *et al.,* 1999). Therefore, the present study was carried out at the Institute of Agricultural Sciences, Banaras Hindu University (I. Ag. Sc., BHU), Varanasi, in order to identify appropriate time period and ambient conditions for efficient inter-specific hybridization program in greengram and blackgram.

Four diverse and promising genotypes each of greengram (PDM-11, HUM-6, HUM-16 and HUM-26) and blackgram (BHU-U-1, Azad-U-1, KUG-427 and TU94-2) were selected for the study. Genotypes used as female parents were sown on first week of March (Summer season crop), June (*Kharif* season crop) and September (Late-*kharif* season crop), 2011. Genotypes to be used as male parents were sown on different dates (staggered sowing) during summer, *kharif* and late-*kharif* to ensure supply of pollen throughout the flowering period. The plants were grown in fertile sandy loam soil under field conditions.

Crosses were made in line x tester fashion using greengram as female parent during 2-15 April (Summer), 2-15 July (*Kharif*) and 1-14 October (Late-*kharif*). The weather variables during the crossing period were recorded from the Department of Agronomy, I. Ag. Sc., BHU. Hybridization technique was followed as per Boiling *et al.*(1961). Pods developed through self fertilization were removed regularly from the plants. Success of crossing and setting of pods was recorded on the fourth-day after crossing. Pods developed from the hybridized flowers and that having shriveled seeds (morphological marker for hybrid seeds) (Singh *et al.,*1996) were only harvested.

In the present investigation, average crossability during summer, *kharif* and late-*kharif* was 3.19%, 6.37% and 9.33%, respectively (Table 1). Analysis of variance showed that there are significant differences among the seasons for crossability success (Table 2). Besides, success of crossing varied with the genotypes. The inter-specific crosses were successful only when greengram genotypes were used as female parent. In the reciprocal crosses, there was lack of pod setting, even though the chromosome numbers in both the species are same (2n=22). Among the genotypes, HUM-26 and KUG-427 produced highest number of crossed pods when used as female and male respectively, while HUM-6 and BHU-U-1 produced the least as female and male in various cross combinations (Table 3).

Among the weather parameters, relative humidity (RH), temperature, speed of wind affects success of crossings significantly (Shrivastava and Chawla, 1993; Talukdar and Shivakumar, 2012). During summer season hot desiccating wind coupled with lower RH (41%), dried the pollen and the stigma head, resulting in poor rate of successful crossings (Table 4). During *kharif* season due to high RH (71.25%) and moisture pollen germination was normal and in comparison to summer season, pod setting during this period increased from 12.02 to 688.11%. However, heavy rain coupled with wind of high velocity often washes away the pollen from the stigma leading to poor success of crossing. Moreover, heavy rain damages the emasculated and pollinated buds. Therefore, crossing during *kharif* met with limited successes. In the present investigation, highest success in crossing was observed during late-*kharif*. The weather condition of the period favored this success to the most. During this period, the weather remained relatively calm (wind velocity ~2.35 Km/hr), moderately warm (27.87˚C), poorly-rained, had longer bright sunshine hours (8.8 hr.) with optimum RH (67.75%) favoring pollen germination and successful fertilization. The rate of success during late-*kharif* reached as high as 153.80% and 688.11%, as against *kharif* and summer, respectively.

The poor crossability in wide hybridization has been a common problem in several crop species (Stalker, 1980). Even among the compatible species, the success rate varies with the genotypes and season of the year. The differential responses of genotype may be ascribed to the polymorphism of the genes controlling crossability (Snape *et al.*, 1979). Similarly, failure of pod setting in reciprocal crosses was not due to stigmatic and styler morphological features, but due to the stigmatic exudates of the *V. mungo* that caused failure of pollen germination leading to failed crosses (Shanmugam *et al.*1983). Top of all, the weather conditions during crossing period as well as the season of the year plays the deciding role. Based on the findings of the present study, it can be suggested that for successful inter-specific hybridization in greengram and blackgram, sowing of parental lines in crossing block should be delayed till first week of September and crossings should be taken up in the first fortnight of October. It will increase the rate of success in crossing as well as in pod setting.

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Table 1. Percent average crossability of different crosses of greengram × blackgram over different seasons during 2011and percent improvement of crossability in late- *kharif* over summer and *kharif*

Crosses	Percent average crossability			Percent improvement of crossability in Late-*kharif*	
	Summer	*Kharif*	Late-*kharif*	Over Summer	Over *Kharif*
PDM-11×BHU-U-1	0.00	2.13	2.13	213.00	0.00
PDM-11×Azad-U-1	2.44	5.26	9.52	290.16	80.99
PDM-11×KUG-427	2.44	13.33	19.23	688.11	44.26
PDM-11×TU94-2	3.85	7.14	8.33	116.36	16.67
HUM-6×BHU-U-1	0.00	4.17	6.67	667.00	59.95
HUM-6×Azad-U-1	2.08	2.17	2.33	12.02	7.37
HUM-6×KUG-427	5.00	7.14	11.11	122.20	55.60
HUM-6×TU94-2	5.26	6.67	7.14	35.74	7.05
HUM -16×BHU-U-1	4.00	7.14	14.29	257.25	100.14
HUM -16×Azad-U-1	0.00	3.33	4.44	444.00	33.33
HUM -16×KUG-427	3.70	3.03	5.26	42.16	73.60
HUM -16×TU94-2	4.00	3.03	7.69	92.25	153.80
HUM-26×BHU-U-1	3.33	4.17	4.76	42.94	14.15
HUM-26×Azad-U-1	3.33	6.67	12.00	260.36	79.91
HUM-26×KUG-427	8.00	11.11	17.65	120.63	58.87
HUM-26×TU94-2	3.57	15.38	16.67	366.95	8.39
Average crossability	3.19	6.37	9.33		

Table 2. Analysis of variance for greengram x blackgram crosses grown in different seasons

Source	DF	MSS	F Value
Season	2	301.5955	156029.8**
Crosses	15	71.09275	36779.68**
Replication	1	0.004469	2.312033ns
Season*Crosses	30	13.28684	6873.916**
Season*Replication	2	0.003953	2.04492ns
Error	45	0.001933	

** Significant at 1% probability level; ns non significant

Table 3. Percent average crossability of parental genotypes during three different seasons

Greengram	PDM-11	HUM-6	HUM-16	HUM-26
	6.32%	4.98%	4.99%	8.89%
Blackgram	BHU-U-1	Azad-U-1	KUG-427	TU94-2
	4.40%	4.46%	8.92%	7.39%

Table 4. Meteorological observations during April, July and October 2011 at BHU, Varanasi

Month/Period	Rainfall (mm)	Temperature ($^{\circ}$c)	Relative Humidity (%)	Wind Speed (Km/hr)	Sunshine Hours	Evaporation (mm)
Summer (02-15 April)	3.6	28.30	41	2.55	7.7	5.15
Kharif (02-15 July)	15.6	30.87	71.25	5.35	6.85	5.15
Late-*kharif* (01-14 October)	0.0	27.87	67.75	2.35	8.8	3.25