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Research Note

Consequence of weather conditions for affecting crossability in three *Vigna* species

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Abstract

Eight intraspecific (four each of mungbean x mungbean and urdbean x urdbean) and 24 interspecific (eight each of mungbean x urdbean, mungbean x ricebean and urdbean x ricebean) crosses were made at five different dates of ten days intervals *i.e.,* September 11-20, 21-30, October 1-10, 11-20 and 21-30 during *kharif*/late *kharif* seasons, 2015 to obtain a total of 32 crosses. The per cent crossability at five different dates indicated that it was the highest during October 1-10 in both intra - (mungbean x mungbean, 72.27%, urdbean x urdbean, 55.55%) and interspecific (mungbean x urdbean, 43.24%, mungbean x ricebean, 16% and urdbean x ricebean, 9.92%) crosses. Similarly, the percent ovule fertility recorded was also the highest during October 1-10 in both intra - (mungbean x mungbean, 90.00%, urdbean x urdbean, 83.33%) and interspecific (mungbean x urdbean, 75.00%, mungbean x ricebean, 71.42% and urdbean x ricebean, 60.00%) crosses. Optimum temperature (~22°C) , followed by low humidity (49.0) and comparatively enhanced sunshine (>8.5 hours) might be responsible for accelerating the highest pod sett during October 1-10 and thus may be suggested as appropriate period for obtaining highest pod setting in *Vigna* species studied.

Key words

Intra- and inter-specific crosses, *Vigna*, crossability, pod set, ovule fertility

Mungbean [*Vigna radiata* (L.) Wilczek] and Urdbean [*Vigna mungo* (L.) Hepper] are the two important cultivated species of *Vigna.* Both are self-pollinated plants with indeterminate growth habit and flowers are produced in phases in axillary or terminal racemes. Being the short duration crops, mungbean and urdbean can be the better option for enhancing the production of pulses, as these may be well fitting in rice-wheat cropping system. However, the total production and productivity of mungbean and urdbean is affected by a number of biotic and abiotic factors. Basic reason for limited success is due to the limited variability prevailed among the mungbean and urdbean genotypes used for hybridization in most of the studies. Interspecific hybridization is widely used in crop improvement and has been successfully used to introgress genetic traits from one species into another. Although barriers to hybridization restrict the flow of gene between species and may play a role in the speciation process, many plant species retain their ability to hybridize with close relatives (Arnold, 1997). However, differential amount of success of inter-specific hybridization varying from low to very low has been observed and reported to be in the range of 22.5% to 2.3% (Egawa, 1988; Singh *et al.,* 1996). Numerous pre and post fertilization barriers account for poor success of crossings. The production of hybrids as well as the subsequent fertility of these hybrids is required for the transfer of alien genes by sexual means. To get successful hybrids, high percentage of pod setting during crossing is one of the prerequisites. Talukdar and Shivakumar, 2012; Khattak *et al*., 2002 reported that the flowering and pod setting is affected by photoperiods, genetic response of the genotypes, rain fall, relative humidity, wind speed and temperature. Further, the high frequency of flower drop under artificial pollination makes mungbean crossing very tedious (Khattak *et al.,* 1998). Having the above backdrops taking into consideration, the present investigation was carried out with the objective to identify appropriate period for efficient intraspecific crosses in mungben and urdbean as well as interspecific crossing among mungbean, urbean and ricebean under field conditions during *kharif* season.

Two MYMV susceptible and 2 MYMV resistant genotypes each of mungbean and urdbean and 2 MYMV resistant ricebean genotypes were planted in crossing block in cemented pots at two different dates of sowing of 10 days intervals (August 10 and August 20, 2015) at Agricultural Research Farm, Banaras Hindu University, Varanasi during *Kharif* season, 2015 (Table 1).

Hybridization technique using hand emasculation and pollination was followed as per Boiling *et al.* (1961). Bud of optimum size were selected and emasculation was done in the evening (4 to 6 p.m.) and pollinated in the next morning (6 to 8 a.m.). Nearly, 8-12 flowers per plant were emasculated besides picking the self-pollinated flowers or pods to avoid any severe load (Khattak *et al*., 1998). Total of 32 crosses, 4 intra specific crosses each of mungbean and urdbean, and 8 interspecific crosses each of mungbean and urdbean; mungbean and ricebean (where mungbean was taken as female parent) and urdbean and ricebean (where urdbean was taken as female parent) were obtained during

September 10 to 20, September 21 to 30, October 1 to 10, October 11 to 20 and October 21 to 30. Different colours of threads were used to mark specific cross combinations. Observations were recorded on the number of buds emasculated, pollinated, pod initiated and matured pods harvested during five different periods *i.e.*, September 10 to 20, September 21 to 30, October 1 to 10, October 11 to 20 and October 21 to 30 (Table 2). Percent pod setting was obtained from (number of pods set/ number of buds pollinated) x 100. Percent ovule fertility was calculated by [total number of developed seed/ total number of ovule scars] x 100. Correlation between pod setting and ovule fertility was studied using the Pearson's Correlation method (Pearson, 1895). Meteorological observations were taken from the Meteorological Unit, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (Table 3).

To transfer alien genes by sexual means, both the production of F_1 hybrids and the subsequent fertility of these hybrids is required. A better crossability followed by higher pod setting is the prerequisite for attaining successful hybrids. Sexual reproduction in angiosperms occurs in essentially three stages: (i) gametophyte development (from meiosis to pollination), (ii) progamic phase (from pollination to zygote formation) and (iii) embryo development (from zygote to seed) (Hedhly *et al.*, 2009).To achieve successful fertilization several factors related to the failure of crossing and setting of pods has been documented by many researchers. Stalker (1980) reported that the poor crossability in wide hybridization has been a common problem in several crop species. Even among the compatible species, the success rate varies with the genotypes and season of the year. Snape *et al.* (1979) stated that the variable responses of genotype may be ascribed to the polymorphism of the genes controlling crossability. Likewise, in reciprocal crosses, failure of pod setting 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). Besides this, the weather conditions prevailing during crossing period plays the deciding role.

In the present investigation, consequences of weather condition which affecting the crossability in intra- and inter-specific crosses in three *Vigna* species were determined. It is quite evident from the perusal of the table 2, that pod setting was highest for all the intra and inter specific crosses during October 1-10 (72.27%, 55.55%, 43.24%, 16.00% and 9.92 % for mungbean x mungbean, urdbean x urdbean, mungbean x urdbean, mungbean x ricebean and urdbean x ricebean respectively**)** followed by September 21–30 for intraspecific crosses (50.00% and 40.00% for mungbean x mungbean, urdbean x urdbean respectively**)** and October 11- 20 for interspecific crosses (34.32%, 13.38%, and 6.34% for mungbean x urdbean, mungbean x ricebean and urdbean x ricebean respectively**)** and being the lowest for all intra and inter specific crosses during October 21-30 (12.5%, 16.66%, 4.54%, 8.33%, 0.0 respectively). The differences in pod setting among different crosses during the same time period is because of their cross compatibility among each other as they differ in their genetic architecture. Similarly, the ovule fertility was highest for all the intra and inter specific crosses during October 1-10 (90.00%, 83.33%, 75.00%, 71.42% and 60.00 % for mungbean x mungbean, urdbean x urdbean, mungbean x urdbean, mungbean x ricebean and urdbean x ricebean respectively**)**. The correlation coefficient was calculated between the pod set and ovule fertility.

The value of correlation coefficient was found to be 0.7987. Strong positive correlation between the pod setting and ovule fertility suggested that the conducive weather condition may encourage the crossability and favours better pod set, ultimately leading to normal seed development. If we associate pod setting with the meteorological data (table 2), it is evident that an average of 22.3˚C of lower temperature followed by lower relative humidity (49.0) during evening at the time of emasculation and comparatively enhanced sunshine (>8.5 hours) favoured the better pod setting for both intra and interspecific crosses. Lower relative humidity in the evening during second fortnight of October was due to the bright sun days whereas, enhanced dew in the night resulted an increment in the relative humidity in the morning resulted in increased percent pod set in interspecific crosses as compared to intra specific crosses indicating that during emasculation, lower relative humidity is more conducive for longevity of the buds/ young flowers and hence better pod setting for interspecific crosses. Slight rainfall during second fortnight in the fourth week of September occurred but it had no serious effect on pollinated buds and hence pod setting. The differences in pod setting between seasons have also been reported earlier (Matsunaga, *et al.,* 1988) under natural condition.

From these observations it may be suggested that sowing of the parental lines in the crossing block should be delayed for mungbean and urdbean till II fortnight of August. Consequently, ricebean should be sown a month earlier *i.e.* by II fortnight of July, as flowering in ricebean takes 50-60 days so that synchronous flowering in mungbean, urdbean and ricebean can be achieved and as a result crossing programme should be taken up during I fortnight of October for achieving maximum pod setting in gangetic plains region of the country.

Novel genes and alleles from exotic germplasm and non-plant species must be exploited and accordingly intra and inter specific hybridization should be utilized to create a wide genetic variation for breeding programs in the *Vigna* species. Sowing of parental lines in crossing blocks should be done in such a manner that crossing programme should be taken up during the most effective time for achieving maximum number of pod set. Last but not the least, *in vitro* culture and colchicine treatment can be used to overcome the hybrid sterility problems.

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Table 1. Ten genotypes of *Vigna* species used for intra and interspecific hybridization

S. No.	*Vigna* species	Genotype	Pedigree	Characteristic features
1	*Vigna radiata*	Pusa 0672	11/395 × ML 267	Medium in height and duration, 4.25g/ 100 seeds, tolerant to major diseases like MYMV and CLS
2	*Vigna radiata*	ML1464	ML 613/ML 1159	Resistance to MYMV, Leaf curl virus, leaf crinkle virus and root rot.
3	*Vigna radiata*	SML 1145	-	Highly susceptible to MYMV
4	*Vigna radiata*	HUM 12	HUM5/DPM 90-1	Medium in height and duration, susceptible to MYMV and suitable for summer with high yield potential.
5	*Vigna mungo*	Mash 338	VG 201/ PDU 3	Matures in 90 days, medium dwarf, resistant to MYMV and CLS.
6	*Vigna mungo*	Mash 114	Mash 338/RBL1	Matures in 83 days. It bears on an average 30 pods/plant and each pod contains about 6-7 seeds. Highly resistant to MYMV and CLS
7	*Vigna mungo*	Co 5	Selection from Musiri local	Highly susceptible to MYMV, matures in 90-95 days
8	*Vigna mungo*	Palampur 93	Pure line selection from local material of Himachal Pradesh	Highly susceptible to MYMV, matures in 85-90 days
9	*Vigna umbellata*	RBL 1	Pure line selection from Rajasthan material by PAU, Ludhiana	Resistant to MYMV and CLS, suitable for *Kharif*
10	*Vigna umbellata*	RBL 9	Pure line selection from Rajasthan material by PAU, Ludhiana	Resistant to MYMV and CLS, suitable for *Kharif*

Table 2. Variability in pod setting and ovule fertility (Sep. 11 – Oct. 30) during *Kharif*, 2015

Cross	Observation	No. of buds emasculated	No. of buds pollinated	No. of buds fertilized	No. of pods harvested	% pod set	No. of seeds per pod	Ovule scar	Ovule fertility (%)
Mung x Mung	Sept11-20	12	6	4	2	33.33	5.5	9	61.11
	Sept 21-30	15	8	6	4	50.00	7	9	77.77
	Oct 1-10	**40**	**22**	**18**	**16**	**72.27**	**9**	**10**	**90.00**
	Oct 11-20	26	12	10	5	41.66	7	10	70.00
	Oct 21-30	20	8	6	1	12.5	5	10	50.00
Urd x Urd	Sept11-20	14	8	4	2	25.0	4	6	66.66
	Sept 21-30	16	10	6	4	40.00	4.75	6	79.16
	Oct 1-10	**42**	**27**	**20**	**15**	**55.55**	**5**	**6**	**83.33**
	Oct 11-20	24	14	11	4	28.57	4.25	6	70.83
	Oct 21-30	12	6	3	1	16.66	3	5	60.00
Mung x Urd	Sept11-20	50	31	8	3	9.67	5	9	55.55
	Sept 21-30	103	81	38	14	17.28	5.5	8.5	64.72
	Oct 1-10	**197**	**148**	**73**	**64**	**43.24**	**6**	**8**	**75**
	Oct 11-20	110	74	43	18	34.32	5.66	8	70.75
	Oct 21-30	41	22	4	1	4.54	4	9	44.44
Mung x Ricebean	Sept11-20	78	56	12	5	8.92	2.4	6.4	37.5
	Sept 21-30	168	116	28	15	12.93	2.6	6.4	40.62
	Oct 1-10	**325**	**275**	**71**	**44**	**16.00**	**5**	**7**	**71.42**
	Oct 11-20	198	142	38	18	13.38	3.11	6.16	50.50
	Oct 21-30	68	41	8	2	8.33	2	12	16.66
Urd x Ricebean	Sept11-20	40	29	3	1	3.44	1	5	10.00
	Sept 21-30	92	63	15	4	6.34	2	5	40.00
	Oct 1-10	**174**	**131**	**37**	**13**	**9.92**	**3**	**5**	**60.00**
	Oct 11-20	98	72	20	6	6.94	2.5	5	50.00
	Oct 21-30	36	23	6	0	0.0	0	0	0.0

Table 3. Meteorological observations during September 11 to October 30, 2015 at BHU, Varanasi

Observation	Temperature (˚C) (Minimum)		Temperature (˚C) (Maximum)		Relative humidity (Morning)		Relative humidity (Evening)		Rainfall (mm)		Sunlight hours	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Sept 10-20	26.2-28.4	27.43	32.6-36.6	34.35	82-91	86.63	45-74	62.27	0.0	0	3.8-9.8	7.27
Sept 21-30	22.2-26.4	24.36	30.2-34.5	32.9	77-95	83.1	43-80	61.6	0.0-11.9	1.19	1.8-10	7.64
Oct 1-10	20.0-25.4	22.3	32.8-35.6	34.2	73-89	82.3	39-57	48.9	0.0	0	8.2-9.4	9.14
Oct 11-20	21.2-23.6	22.26	31.0-35.6	32.6	74-87	81	40-69	58.4	0.0	0	6.6-9	7.95
Oct 21-30	15.8-22.5	18.87	19.2-34.2	30.4	78-94	88.7	49-98	64.6	0.0-12.2	2.3	0-9	6.84