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DISTANT HYBRIDIZATION IN GENUS *VIGNA* — A REVIEW

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ABSTRACT

Wide crosses in *Vigna* viz., mung bean x black gram, mung bean x *V. radiata* var. *sublobata*, black gram x *V. mungo* var. *silvestris*, mung bean x rice bean, and moth bean x *V. trilobata*, are described in detail in this review, while other wide crosses are dealt in brief about their utility in crop improvement.

Key words: Mung bean, black gram, rice bean, adzuki bean, moth bean, cowpea, distant hybridization.

The cultivated species of *Vigna* are: mung bean or green gram (*Vigna radiata* (L.) Wilczek), urd bean or black gram bean (*V. mungo* (L.) Hepper), cowpea (*V. unguiculata* (L.) Walp.), moth bean (*V. aconitifolia* (Jacq.) Marechal), rice bean (*V. umbellata* (Thunb.) Ohwi and Ohashi) and adzuki bean (*V. angularis* (Wild.) Ohwi and Ohashi) and the wild species are *V. trilobata*, *V. grandis*, *V. dalzalliana*, *V. vexillata*, *V. radiata* var. *sublobata*, and *V. mungo* var. *silvestris*.

Generally, intervarietal hybridization has been used for the improvement of cultivated *Vigna* species. The wide crosses will increase the available gene pool. In addition specific gene(s) for resistance to diseases, insect-pests and other edaphic stresses can be transferred from the wild/related species. Therefore, in this review the possibilities and limitations of using distant hybridization in an on-going breeding programme are discussed.

Mung bean x *black gram*. The black gram has more durable resistance to mung bean yellow mosaic virus (MYMV). It is also synchronous in maturity, and resistant to shattering and *Cercospora* leaf spot. In addition, it has higher methionine content than mung bean. Mung bean has more seeds per pod and better quality traits. The desirable features of both the species could be combined by hybridization. Such crosses have been made successfully by several workers [1–7]. The genes for MYMV resistance from black gram to mung bean have been transferred [8, 9]. Ahn and Hartmann [6] observed that the F_1 seeds were small, shrunken and the plants were weak and semisterile with 58.6% pod set. No differential effect of black gram pollen on pod set was noticed. The pods developed normally up to maturity and were partially filled. The hybrids were partially fertile and pod set was very low. The ripe pods contained one or rarely two seeds.

The colchicine treated mung bean x black gram amphiploids [10] were studied in C_3, C_4 and C_5 generations. The early generation hybrids were vigorous, with the vegetative and reproductive parts bigger than in the parents. However, as the generations advanced, the amphiploids lost the initial vigour and reverted to the parental types in morphological appearance and chromosome number. The derivatives showed large variation in yield and its attributes, suggesting exchange of genetic material between the parent species.

A wide variation was observed in the F_2 generation for plant height, number of branches, clusters and pods, pod length, and seeds/pod in the mung bean x black gram crosses [11]: 79, 24 and 20% F_2, F_3 and F_4 segregates, respectively showed more black gram traits. Based on yield, four progenies, COGB 2, COGB 10, COGB 11, and COGB 17 were identified as stable genotypes and were carried over to the advanced yield trials.

Black gram x *mung bean*. The cross was reported to be unsuccessful due to embryo abortion [12]. This problem was overcome through the culture of hybrid embryos (11–17 days after pollination) on the modified Murashige–Skoog medium [13]. The F_1 plants were partially fertile, late maturing, and intermediate for characters like leaf shape, plant height, and number of branches. The pod-set percentage and the number of seeds/pod were highly reduced because of meiotic irregularities. In the F_2 generation, grown in the field, different combinations of desirable characters appeared and pod set percentage also improved. However, the success was limited as only a few hybrid seedlings survived and produced normal fertile plants in the F_1 generation [14]. It is, therefore, essential to generate more information on this aspect.

Mung bean x *V. radiata* var. *sublobata*. A few accessions of the wild progenitor are reported to be resistant to MYMV [15]. While for bruchids others have shown non-preference [16]. Therefore, gene(s) for these characters can be transferred to cultivated types. Hybrid seed germination, hybrid survival, pollen fertility and seed fertility were very high and meiosis in F_1 was regular indicating that post zygotic isolating mechanisms were not operative between *V. radiata* and its wild relative [18]. The gene(s) for MYMV resistance in the cultivated types and the wild progenitor, *V. radiata* var. *sublobata*, are different [17, 19], suggesting that crosses among such genotypes would facilitate the incorporation of nonallelic gene(s). Such distant crosses were made at Pantnagar [17, 19–23]. The F_1 hybrids were normal and fertile, the trailing habit of wild type being dominant. The germination and overall growth of the wild types is poor under domestication. The poor germination is ascribed to hard seed coat. The seeds of F_1 and segregating generations may be scratched with blade opposite to the hilum or scarified with the sand paper. The hard seededness was demonstrated to be controlled by a single dominant gene [22].

The variation for yield and yield components in F_2 generation was compared in five wide and two varietal crosses by Parida [23]. The wide crosses exhibited larger variation for these characters than the varietal crosses (Table 1). The segregates with profuse podding and MYMV resistance were selected. The lines developed from these crosses are in advance stage of testing. Some of these segregates/lines are prone to pod shattering and have mottled grain. It is suggested that restricted backcrossing may be attempted with recurrent parent(s) or the segregates may be crossed again with cultivated types to remove the undesirable characters.

Table 1. Coefficient of variation in F_2 generation for yield and its components in the wide and varietal crosses of mungbean [23]

Cross	Character				
	pods per plant	pods per cluster	seeds per pod	100-seed weight	yield per plant
Wide crosses					
L 80 x *V. radiata* var. *sublobata*	81.6	42.5	31.0	24.2	98.4
Hyb 4-3 x V. *radiata* var. *sublobata*	72.1	44.0	34.0	22.0	97.0
G65 x *V. radiata* var. *sublobata*	70.4	46.2	33.0	20.0	94.2
T44 x *V. radiata* var. *sublobata*	73.1	38.0	28.2	31.2	95.3
LM 293 x *V. radiata* var. *sublobata*	73.6	43.0	25.6	20.3	82.0
Varietal crosses					
ML 33 x L80	71.2	33.5	16.5	14.7	73.1
G65 x LM 293	60.9	34.0	15.3	11.5	59.3

Black gram x *V. mungo* var. *silvestris*. Variation for MYMV resistance and yield components is available in the wild taxon, *V. mungo* var. *silvestris*. The cross between a MYMV resistant line of black gram, Pant U 84, and the wild progenitor was made with a view to generate more variability and to study the inheritance of MYMV resistance [24]. The trailing growth habit and susceptibility to MYMV were dominant in F_1. The MYMV resistance is caused by two recessive genes. The F_2 segregates of different maturity duration with higher pod number and moderate to high MYMV resistance were selected. However, some of them were prone to pod shattering.

One of the lines, IW3390 of the wild taxon was crossed to cultivated types [19]. The F_1s were backcrossed to the cultivated type(s) to obtain BC_1 and BC_2 generations. The F_2, BC_1F_2 and BC_2F_2 were compared for the variation in yield and yield components, and for the frequency of higher transgressive segregates (Table 2). The wide crosses displayed higher mean and larger variance as compared to varietal crosses for all the characters, except 100-seed weight. In general, larger number of transgressive segregates were recovered in the BC_1F_2 generation, suggesting that only one back cross with the recurrent parent may be sufficient to restore fertility in the wide crosses of black gram [25].

Table 2. Wide and varietal crosses with high mean and high variance and the cross showing significantly higher transgressive segregates in black gram [19]

Character	Cross with high mean and high variance
Clusters per plant	UL 2 x IW 3390 (BC_1F_2)*
	UPU 82-5 x IW 3390 (BC_1F_2)
Pods per plant	UPU 82-5 x IW 3390 (BC_1F_2*, BC_1* F_2*)
	UL 2 x IW 3390 (BC_1 F_2)
Pods per cluster	UPU 82-5 x IW 3390 (BC_2F_2)
	Plant U 19 x IW 3390 (BC_1F_2, BC_2F_2*)
Seeds per pod	RU 2 x IW 3390 (F_2)
100-seed weight	UL 2 x UPU 82-5 (F_2)
	Pant U 19 x UL 2 (F_2)
	RU 2 x IW 3390 (BC_1F_2)*
Yield per plant	UL 2 x IW 3390 (BC_1F_2)*

*Crosses giving significantly higher transgressive segregates.

Mung bean x *rice bean.* The interspecific cross between mung bean and rice bean was made using the former as female parent. The cross proved twice as successful when an immunosuppressant, E-aminocaproic acid (EACA), was sprayed at the concentration of 100 ppm on the foliage of the female parent [27]. Viable but sterile F_1 plants were obtained [26, 28]. When *V. radiata* var. *sublobata* was used as a bridge species for the interspecific cross between mung bean and rice bean, viable and fertile F_1 plants were obtained from all combinations, except a cross in which rice bean was used as female parent. The pod set was 53.1% on mung bean [6]. The hybrid seedlings were weak and grew slowly. Once the seedling stage was over the growth of hybrid was vigorous. The hybrid plant was intermediate in most morphological characteristics. Flowering was profuse but the hybrid was both female and male sterile [29].

Cross has also been attempted between mung bean and rice bean [30] with a view to transfer MYMV resistance genes from rice bean to mung bean. The F_1 hybrids were sterile and susceptible to MYMV. Colchicine induced amphiploids were of gigas type and partially fertile. Majority of C_2 and C_3 generations showed resistance to MYMV under artificial inoculation. Pollen stainability was 63.2% in the C_2 generation of colchiploids from this cross [31], indicating a probable high level of homologous chromosome pairing at meiosis.

The seed set increased remarkably when intraspecific hybrid (*V. radiata* or *V. umbellata*) were used as parents in wide hybridization [32]. The reciprocal cross was not successful even with embryo culture [6].

Mung bean x *V. trilobata*. The interspecific hybrids between moth bean and *V. trilobata* produced viable seeds [33]. The F_1 hybrids had 5.7% pollen fertility, but complete seed sterility. Colchicine induced amphiploids had 89.7% pollen fertility and such plants had fairly regular meiosis, suggesting the possibility of such crosses. The hybrid sterility is segregational in nature.

Other distant crosses. The crosses black gram x adzuki bean, mungbean x adzuki bean and their reciprocals were not successful [6, 34]. However, through the use of intraspecific hybrid parents (black gram or adzuki bean) a successful interspecific hybrid was accomplished [32]. The crosses involving black gram and rice bean were not successful [35] owing to embryo abortion which was correlated with an early degeneration of the endosperm [36]. The adzuki bean x rice bean cross was not successful [6]. Rice bean x adzuki bean cross was successful only with embryo culture. Viable seeds were obtained in crosses with either species used as female parent. The *V. minima* x *V. umbellata* cross was made [37], the F_1 plants were completely sterile for pollen. Attempts to cross cowpea with *V. angularis* [38], black gram with *V. trilobata* [39], and tetraploid *Vigna* species with *V. riccicardianus* Ten. [40], were unsuccessful. There is preliminary evidence that the *V. vexillata* may be useful as a bridging host between cowpea and the Asiatic *Vigna*. Completely fertile *V. umbellata* x *V. unguiculata* cross has also been reported [2].

REFERENCES

1. N. K. Sen and A. K. Ghosh. 1960. Interspecific hybridization between *Phaseolus aureus* and *Phaseolus mungo*. Bull. Bot. Soc. Bengal, **14**: 1–4.

2. B. Singh, A. N. Khanna and S. M. Vaidya. 1964. Crossability in the genus *Phaseolus*. J. Post Graduate Sch. (Indian Agri. Res. Inst.), **2**: 47–50.

3. V. M. Chavan, G. D. Patil and D. G. Phapkar. 1966. Improvement of cultivated *Phaseolus* species-need for interspecific hybridization. Indian J. Genet., **26A**: 152–154.

4. S. Dana. 1966a. The cross between *Phaseolus aureus* Roxb. and *P. mungo* . Genetics, **37**: 259–274.

5. N. D. De and R. Krishnan. 1966. Cytological studies of the hybrid *Phaseolus aureus* x *P. mungo*. Genetica, **37**: 588–600.

6. C. S. Ahn and R. W. Hartmann. 1978a. Interspecific hybridization among four species of the genus *Vigna* Savi. *In:* Proc. I Intern. Mungbean Symp., 16-19 August, 1977. University of the Philippines, Los Banos: 240–246.

7. D. Subramanian. 1980. Interspecific hybridization in *Vigna*. Indian J. Genet., **40**: 437–438.

8. A. S. Gill, M. M. Verma, H. S. Dhaliwal and T. S. Sandhu. 1983. Interspecific transfer of resistance to mungbean yellow mosaic virus from *Vigna mungo* to *Vigna radiata*. Curr. Sci., **52**: 31–33.

9. R. P. S. Verma. 1985. Inheritance of Resistance to Mungbean Yellow Mosaic Virus in the Interspecific and Inter- Varietal Crosses of Greengram and Blackgram. Ph. D. Thesis. G. B. Pant University of Agriculture and Technology, Pantnagar: 80.

10. R. C. Yadav, R. K. Singh and K. P. Singh. 1986. Amphidiploids of greengram and blackgram. *In:* Genetics and Crop Improvement (eds. P. K. Gupta and J. R. Bahl). Rastogi Publishers, Meerut: 349–358.

11. S. R. Sree Rangasamy, V. Muralidharan and R. Rathnasamy. 1988. Breeding behaviour of *Vigna radiata–V. mungo* hybrid progenies for crop improvement in mungbean. Proc. II Intern. Symp. on Mungbean. AVRDC, Shanhua, Taiwan: 187–199.

12. S. Miyazaki. 1982. Classification and phylogenentic relationships of the *Vigna radiata – mungo – sublobata* complex. Bull. Natl. Inst. Agric. Sci. Ser. D, **33**: 1–61.

13. S. S. Gosal and Y. P. S. Bajaj. 1983. Interspecific hybridization between *Vigna mungo* and *Vigna radiata* through embryo culture. Euphytica, **32**: 129–137.

14. R. P. S. Verma and D. P. Singh. 1987. Problems and Prospects of interspecific hybridization involving greengram and blackgram. Indian J. agric. Sci., **56**: 535–537.

15. B. V. Singh and M. R. Ahuja. 1977. *Phaseolus sublobatus* Roxb., a source of resistance to yellow mosaic virus for cultivated mung. Indian J. Genet., **37**: 130–132.

16. A. Ali, C. R. Babu and M. M. R. K. Afridi. 1983. Resistance to bruchids in *Vigna sublobata*. Abstr. XV Intern. Genet. Congr. 12–21 December, 1983, New Delhi: 718.

17. D. P. Singh and B. L. Sharma. 1983. Inheritance of resistance to yellow mosaic virus in *Vigna radiata* x *V. radiata* var. *sublobata* crosses. Abstr. XV Intern. Genet. Congr. 12–21 December, 1983, New Delhi: 735.

18. M. R. Biswas and S. Dana. 1975. Cytogenetic status of *Phaseolus sublobatus* Roxb. *In:* Proc. II All India Congr. Cytol. Genet. 1975. J. Cytol. Genet. Congr. Suppl: 39–41.

19. K. R. Reddy. 1986. Introgression of Qualitative and Quantitative Genes from Wild Progenitors into Greengram and Blackgram. Ph. D. Thesis. G. B. Pant University of Agriculture and Technology, Pantnagar: 98.

20. D. Parida and D. P. Singh. 1985. Performance of wide and varietal crosses of mungbean. Indian J. Genet., **45**: 12–15.

21. M. R. Ahuja and B. V. Singh. 1977. Induced genetic variability in mungbean through interspecific hybridization. Indian J. Genet., **37**: 133–136.

22. D. P. Singh, B. L. Sharma and S. Dwivedi. 1983. Inheritance of hard seeds in interspecific crosses of mungbean. Indian J. Genet., **43**: 378–379.

23. D. Parida. 1982. The Evaluation of Varietal and Wide Crosses in Greengram. M. Sc. (Ag.) Thesis. G. B. Pant University of Agriculture and Technology, Pantnagar: 85.

24. S. Dwivedi and D. P. Singh. 1985. Inheritance of resistance to yellow mosaic virus in a wide cross of blackgram (*Vigna mungo* (L.) Hepper). Z. Pflanzenzuchtg., **95**: 281–284.

25. K. R. Reddy and D. P. Singh. 1989. Transgressive segregation in the wide and varietal crosses of blackgram (*Vigna mungo* (L.) Hepper). Indian J. Genet., **49**: 131–134.

26. S. Dana. 1967. Hybrid from the cross *Phaseolus aureus* Roxb. x *P. calcaratus* Roxb. J. Cytol. Genet., **2**: 92–97.

27. Anonymous. 1979. Progress Report 1978. Asian Vegetable Research and Development Centre. Shanhua, Taiwan: 71–91.

28. Anonymous. 1976. Mungbean Report 1975. Asian Vegetable Research and Development Centre. Shanhua, Taiwan: 35–40.

29. N. C. Chen, J. F. Parrot, J. Jacobs, L. R. Baker and P. S. Carlson. 1978. Interspecific hybridization of food legumes by unconventional methods of plant breeding. *In*: Proc. I Intern. Mungbean Symp. 16–19 August, 1977, University of the Philippines, Los Banos: 247–252.

30. B. A. Satyan, K. S. Prakash, V. Muniappa, G. Shivashankar and P. Gopala Reddy. 1983. Incorporation of yellow mosaic resistance in mungbean through interspecific hybridization. Abstr. XV Intern. Genet. Congr. 12–21 December, 1983, New Delhi: 609.

31. K. A. Rashid, J. Smartt and N. Haq. 1988. Hybridization in the genus *Vigna*. Proc. II Intern. Symp. on Mungbean. AVRDC, Shanhua, Taiwan: 205–214.

32. N. C. Chen, L. R. Baker and S. Honma. 1983. Interspecific crossability among four species of *Vigna* food legumes. Euphytica, **32:** 925–927.

33. M. R. Biswas and S. Dana. 1976. *Phaseolus aconitifolius* x *Phaseolus trilobatus*. Indian J. Genet., **36:** 125–131.

34. C. S. Ahn and R. W. Hartmann. 1978b. Interspecific hybridization between mungbean (*Vigna radiata* (L.) Wilczek) and adzuki bean (*V. angularis* (Willd.) Ohwi and Ohashi). J. Am. Soc. Hort. Sci., **103:** 435–438.

35. S. Dana and M. R. Biswas. 1975. Blackgram and rice bean cross. Cytologia, **40:** 787–795.

36. R. K. Chowdhury and J. B. Chowdhury. 1977. Intergeneric hybridization between *Vigna mungo* (L.) Hepper and *Phaseolus calcaratus* Roxb. Indian J. agric. Sci., **47:** 117–121.

37. M. C. Gopinathan, C. R. Babu and K. R. Shivanna. 1986. Interspecific hybridization between rice bean and its wild relatives (*V. minima*) fertility sterility relationships. Euphytica, **35:** 1–6.

38. A. M. Evans. 1976. Species hybridization in the genus *Vigna*. *In:* Proc. IITA Collaborators Meeting on Grain Legume Improvement. June 9-13, 1975, Ibadan, Nigeria: 31–34.

39. S. Dana. 1966b. Interspecific hybrid between *Phaseolus mungo* L. x *P. trilobatus* Ait. J. Cytol. Genet., **1:** 61–66.

40. S. Dana. 1964. Interspecific cross between tetraploid *Phaseolus* species and *P. riccicardianus* Ten. Nucleus, **7:** 7–10.