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Combining Ability in Mungbean (*Vigna radiata* (L.) Wilczek) II. Traits Related to Indetemination

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ABSTRCT : Combining ability study was carried out on the components of synchronization in maturity and determinate growth habit in mungbean, using 6x6 diallel cross. Both additive and non-additive gene effects were found conditioning the inheritance of days to first flower, days between first pod and 90% pod maturity (DDd1), plant height from first pod stage to 90% pod maturity (DDh1, DDh2, and DDh3). Only non-additive gene action was important in degree of determination from first pod stage to 90% pod maturity (DDd2). While only additive action was important in plant height at first flower. The predominant additive gene action was observed in all traits but non-additive was significant in only DDd$_2$. For synchronization in maturity, determinate growth habit, and their components, the best combiners were NM92, VC1560D, and NM89, whereas the best indeterminate combinations were NM92 x NM89, NM92 X VC1560D, and NM92 x ML-5.

Keywords : *Vigna radiata*, mungbean, combining ability, indetermination, maturity synchronization.

Indeterminate growth habit in mungbean causes flowering to come in different flushes. The flowering, once started, continues untill harvesting and even thereafter, provided that the plants left standing with enough moisture in the field. Mungbean plants often bear flower, green (immature) pods, and ripe pods at the same time, requiring many pickings to obtain maximum grain yield. Reduction of the length from flowering to 90% pod maturity period, so as to give more uniform maturity and thus require only one harvesting is a major objective in mungbean breeding. Wide variation of indeterminate growth habit is available among various mungbean accessions (AVRDC, 1976). Na Lampang *et al.* (1988) described this variation as the degree of indetermination for height (DDh) and pod maturity (DDd), respectively. The existing mungbean germplasm, though not determinate in the true sense of the word, are nevertheless technically not determinate. Some work has been done on the association of indeterminate growth habit with yield and its components (Kuo *et al.,* 1978; Pawar & Bhatia, 1980). However no information is available regarding the inheritance of indeterminate growth habit and maturity synchronization.

The present investigation was carried out to verify the inheritance and combining ability of the components of synchronization in maturity and determinate growth habit in mungbean.

MATERIALS AND METHODS

Six divergent mungbean genotypes, viz. MN 92, Var. 6601 and NM 89 from Pakistan, VC1560D and VC3902A from the Asian Vegetable Research and Development Center (AVRDC), Taiwan, and ML-5 from India, were crossed in a diallel fashion excluding reciprocals during spring season of 1997. The resultant 15 F_1s along with their 6 parents were grown in a randomized complete block design with three replications during spring 1998 at the research farm of the Nuclear Institute for Agriculture and Biology, Faisalabad (latitude 31.5°N), Pakistan. Each genotype was represented by single row plot of 4 meters long. Spacings between and within the rows were kept at 30 cm and 10 cm, respectively. Five competitive plants were randomly chosen for recording the observations on days to first flower (D_1), days to first pod maturity (D_2), days to 90% pod maturity (D_3), plant height at first flower (H_1), plant height at first pod maturity (H_2), and at 90% pod maturity (H_3).

The degrees of indetermination for days to pod maturity (DDd) and plant height (DDh) were calculated using the methods described by AVRDC (1976) and Na Lampang *et al.* (1988) as depicted below.

DDd from first flower to 90% pod maturity $\frac{(DDd_1)}{D_3}$
$=D_3 - D_1 \times 100$

DDd from first pod maturity to 90% pod $\frac{(DDd_2)}{D_3}$
$=D_3 - D_2 \times 100$

DDh from first flower to first pod maturity $\frac{(DDh_1)}{H_2}$

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$=H_2 - H_1 \times 100$

DDh from first flower to 90% pod maturity $\frac{(DDh_2)}{H_3}$
$=H_3 - H_1 \times 100$

DDh from first pod maturity to 90% pod maturity $\frac{(DDh_3)}{H_3}$
$=H_3 - H_2 \times 100$

Statistical analysis was done on the basis of mean of the five plants and diallel analysis according to method II model I of Griffing (1956) through MSTAT-C Michigan State University Statistical Package Version C) micro computer statistical program.

RESULTS AND DISCUSSION

The analysis of variance in Table 1 revealed an adequate amount of variability present in the parental materials. The gca and sca variances were significant in days to first pod maturity, days to 90% pod maturity, DDd_1, plant height at first pod maturity and at 90% pod maturity, DDh_1, DDh_2, and DDh_3. This indicated that both additive and non-additive gene actions were involved in the expression of these traits. However, only non-additive and additive gene actions were important for DDd_2 and plant height at first flower, and days to first flower, respectively. The variance due to gca was found consistantly larger than the corresponding variance due to sca, except for DDd_2. This revealed the predominance of additive gene action in all traits, while the non-additive was predominant in DDd_2. Additive gene action was reportedly important in the inheritance of days to flowering in mungbean (Malik & Singh, 1983; Wilson *et al.,* 1985). Rao *et al.* (1984) reported the predominance of additive gene effects for days to maturity. The plant height in mungbean was inherited both by additive and non-additive genes, but additive gene effect was more important (Rao *et al.,* 1984; Wilson *et al.,* 1985). All of the above results are in confirmity with the present findings, whereas Tiwari *et al.* (1993) reported contradictory results. He found the predominance of non-additive gene action in the expression of plant height and days to maturity.

The estimates of gca effects for all the traits are presented in Table 2. The best general combiner was NM 92 for earliness of the first flower, first pod maturity, and 90% pods maturity, for dwarfness at first and 90% pod maturity, and for DDh_1 and DDh_2. VC1560D expressed superior general combining ability in DDd_1 and DDh_3, while NM 89 were superior in DDd_2 and plant height at first flower. These three parents could be employed to increase synchronization in maturity and to reduce the degree of indetermination in plant height. An apparent positive association was found between the mean performance and the respective gca effect. Therefore, mean performance of the parent could be used for selection of the better general combiners.

The mean performance and estimates of sca effects for crosses which showed signficant sca effect are given in Table 3. The best combinations on the basis of sca effects are NM 92 × NM 89 for earliness in first pod and 90% pod maturity, NM 92 × ML5 for DDd_1, NM 92 × Var. 6601 for DDd_2 and DDh_1, NM 92 × VC1560D and NM 89 × ML-5 for short stature at first pod and 90% pod maturity, and NM 9 × VC3902A for DDh_3. The combination NM 92 × ML-5 had highest sca effects for DDd_2, therefore it could be used directly for exploitation of heterosis to obtain desirable segregants maturing in short period of time from first flower to 90% pod maturity. The segregants with negligible degree of indetermination in plant height after flowering to physiological maturity may be picked up directly from a combination of NM 92 × NM 89. The progenies of the last two crosses (double cross) may be used to develop pure line genotypes with minimum degree of indetermination in plant height and maximum synchronization in maturity.

Table 1. Analysis of variance for genotypic difference and combining ability of days to flowering, pod maturity, plant height, and their degrees of indetermination (DD) in 6 parent diallel crosses of mungbean.

Sources of Variation	df	Mean square										
		Days to			DDd		Plant height at			DDh		
		first flower	first pod maturity	90% pod maturity	DDd_1	DDd_2	first flower	first pod maturity	90% pod maturity	DDh_1	DDh_2	DDh_3
Blocks	2	2.54	7.73	1.30	2.87	6.29	1.63	7.39	9.13	16.82	18.02	1.64
Genotypes	20	54.30**	41.43**	69.06**	31.73**	10.59**	7.43**	99.69**	112.34**	268.15**	249.76**	56.72**
gca	5	196.25**	134.02**	199.25**	55.22**	6.90	15.02**	329.11**	387.59**	859.72**	833.03**	79.10**
sca	15	6.99	10.5*	25.56**	23.90**	11.82**	4.89	23.22**	20.60**	70.95**	55.34**	49.26**
Error	40	6.48	5.24	6.10	5.11	3.01	2.97	4.11	5.19	31.29	19.76	3.11

*, **Significant at P = .05 and P = .01, respectively.

Table 2. Estimates of gca effects and mean performance (in parenthesis) of days to flowering, pod maturity, plant height, and their degrees of indetermination (DD) in 6 parent diallel crosses of mungbean.

Genotypes	Days to			DDd		Plant height at			DDh		
	first flower	frst pod maturity	90% pod maturity	DDd_1	DDd_2	first flower	frst pod maturity	90% pod maturity	DDh_1	DDh_2	DDh_3
NM 92	-5.58(43.3)	-4.51(61.5)	-4.58(70.7)	2.85(38.8)	0.05(12.5)	0.69(16.6)	-6.66(23.2)	-6.58(28.1)	-10.76(27.7)	-10.74(41.0)	2.81(17.3)
Var. 6601	-0.25(53.1)	-0.77(69.1)	-2.61(78.7)	-0.06(32.5)	-0.14(12.1)	1.10(18.9)	0.21(36.7)	0.29(40.3)	-3.37(48.4)	-2.12(52.8)	-0.04(8.9)
NM 89	1.04(57.1)	1.37(74.2)	1.15(83.5)	0.24(31.5)	-0.79(11.1)	-1.09(13.3)	-0.50(32.2)	-1.03(37.4)	3.87(59.7)	2.28(64.1)	-1.01(10.9)
VC1560D	2.36(58.8)	1.39(71.6)	1.97(82.7)	-1.32(28.2)	-0.05(13.4)	-0.46(17.1)	0.24(37.3)	-0.76(39.0)	2.74(53.9)	1.02(55.7)	-2.53(5.8)
VC3902A	1.07(55.7)	1.38(71.5)	1.65(81.7)	-1.07(31.9)	0.04(12.3)	-0.11(16.6)	2.54(40.8)	2.80(46.7)	2.97(60.2)	3.79(64.8)	-0.27(15.5)
ML 5	1.37(55.7)	1.14(71.5)	2.42(81.7)	-0.64(31.9)	0.89(12.3)	-0.13(16.6)	4.17(40.8)	5.38(46.7)	4.55(60.2)	5.76(64.8)	1.03(15.5)
S.E. gi	0.47	0.43	0.46	0.42	0.32	0.32	0.38	0.43	1.04	0.83	0.33
S.E.(gi-gj)	0.73	0.66	0.71	0.62	0.50	0.50	0.59	0.66	1.61	1.28	0.51

Table 3. Estimates of sca effects and mean performance (in parenthesis) of days to maturity, plant height, and their degrees of indetermination (DD) in a 6 parent diallel crosses of mungbean.

Cross combinations	Days to		DDd		Plant height at		DDh		
	first pod maturity	90% pods maturity	DDd_1	DDd_2	first pod maturity	90% pods maturity	DDh_1	Ddh_2	DDh_3
NM 92 X Var. 6601	2.11(68.1)	0.88(74.3)	2.50(38.4)	-3.47(8.6)	-0.12(28.5)	-0.90(32.6)	-7.64(29.5)	-8.05(34.3)	-2.14(12.4)
NM 92 X NM 89	-2.89(65.0)	-2.22(75.5)	3.60(39.8)	1.92(13.4)	-0.34(27.6)	-0.11(32.1)	6.49(50.9)	-8.12(38.6)	0.33(13.9)
NM 92 X VC1560D	0.76(68.7)	-0.97(77.1)	-2.54(32.1)	-2.69(9.5)	-3.58(25.1)	-1.24(36.2)	9.63(52.9)	17.1(47.2)	7.59(19.6)
NM 92 X VC3902A	-0.96(66.9)	-2.11(75.6)	2.38(37.3)	-0.54(11.7)	1.92(32.9)	-0.08(35.9)	-2.34(41.2)	-2.10(46.1)	-5.91(8.4)
NM 92 X ML 5	1.94(69.6)	5.92(84.4)	-5.92(29.4)	4.37(17.5)	-0.87(31.7)	-0.69(37.8)	-1.92(43.2)	2.03(52.2)	0.39(16.0)
Var. 6601 X NM 89	0.71(72.3)	2.55(81.7)	0.25(33.5)	-0.76(10.5)	-0.24(34.5)	1.15(40.2)	-3.50(48.3)	0.23(55.6)	3.24(14.0)
Var. 6001 X VC 1560D	1.88(73.5)	4.20(84.2)	-1.39(30.3)	0.63(12.6)	1.12(36.6)	-0.59(38.7)	1.46(52.1)	0.66(54.7)	-3.90(5.3)
Var. 6601 X VC 3902A	-1.64(70.0)	0.72(80.4)	-2.44(29.5)	0.98(13.1)	-2.66(35.2)	0.78(43.7)	0.63(51.5)	2.13(59.0)	7.91(19.4)
Var. 6601 X ML 5	-2.34(69.1)	1.02(81.5)	1.99(34.4)	2.26(15.2)	-0.45(39.0)	-0.36(45.0)	1.42(53.9)	1.29(60.1)	0.47(12.2)
NM 89 X VC1560D	-0.52(73.3)	-1.37(82.4)	-0.49(31.5)	-0.28(11.1)	1.83(36.6)	0.94(38.9)	1.63(59.5)	3.32(61.8)	-2.46(5.8)
NM 89 X VC3902A	0.16(73.9)	-0.31(83.1)	0.59(32.9)	-0.43(11.0)	1.16(38.3)	0.77(42.3)	-1.67(56.5)	-0.51(60.7)	-0.93(9.6)
NM 89 X ML 5	1.66(75.2)	0.25(84.5)	0.16(32.9)	-1.38(10.9)	-0.76(38.0)	-2.10(41.9)	-4.28(55.4)	-3.58(59.6)	-2.46(9.3)
VC1560D X VC3902A	-0.46(73.3)	-0.46(83.8)	3.72(34.4)	0.26(12.4)	-2.65(35.2)	-1.09(40.7)	-7.21(49.8)	-3.42(56.6)	4.67(13.6)
VC1560D X ML 5	2.77(76.3)	2.30(87.3)	3.96(35.1)	-0.46(12.6)	-0.17(39.3)	-0.84(43.5)	0.15(58.7)	0.71(62.7)	-0.77(9.5)
VC3902 X ML - 5	-0.48(73.1)	-1.98(82.7)	-0.26(31.1)	-1.48(11.6)	7.52(49.3)	8.00(55.9)	4.95(63.8)	3.28(68.0)	-0.96(11.6)
S.E. Sij	1.17	1.26	1.16	0.89	1.04	1.17	2.86	2.27	0.90
S.E.(Sij-Sik)	1.75	1.89	1.73	1.32	1.55	1.74	4.27	3.40	1.35
S.E.(Sij-Skl)	1.62	1.75	1.60	1.23	1.43	1.61	3.96	3.14	1.25

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