The Bioscan 11(2):1053-1057,2016(Supplement on Genetics and Plant Breeding) www.thebioscan.com
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES

HETEROSIS AND INBREEDING DEPRESSION FOR YIELD AND ITS COMPONENTS IN MUNGBEAN [*VIGNA RADIATA* (L.) WILCZEK]

S. Y. DHURAI*, M. N. SINGH AND S. K. SAROJ
Department of Genetics and Plant Breeding,
Institute of Agricultural Sciences, Banaras Hindu University, Varanasi - 221 005, UP
e-mail: samir.dhurai@gmail.com

KEYWORDS
Mungbean
Heterosis
Line × tester analysis
Yield

Received on :
24.10.2015

Accepted on :
06.05.2016

***Corresponding author**

ABSTRACT

Ten mungbean hybrids derived from line × tester mating design along with their parents were evaluated to get information on the extent of heterosis over mid parent (MP), better parent (BP) and standard check (EH) and inbreeding depression (ID) for yield and yield contributing characters. The highest mid parent (71.02%) and better parent (43.04 %) heterosis for seed yield was recorded by cross Kopergoan × HUM 12. The crosses ML 5 × HUM 12 observed the highest standard heterosis (52.45%) and low inbreeding depression (-1.77) for seed yield followed by Kopergoan × HUM 12 (43.11%). These crosses also showed significant standard heterosis for the component traits like days to 50% flowering, days to maturity, number of primary branches, number of seeds per plant and pods per plant. The crosses showing heterosis for seed yield was not heterotic for all characters. HUM 16 × HUM 12, HUM 8 × ML-1720, Pusa Vishal × ML 1720 and HUM 16 × ML 1720 hybrids were identified as promising for many desirable traits and they could be exploited for developing high yielding mungbean varieties.

INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) is an economically important pulse crop ranking after chickpea and pigeonpea, covering 3.38 m ha area in India with an annual production of 1.61 m tonnes and productivity 474 kg/ha during 2013-14 (Anonymous, 2014). It is an outstanding source of easily palatable, nutritive, high quality and easily digestible, non-flatulent proteins than other pulses and constitutes an important source of cereal based diets in Asia (Kamleshwar *et al.,* 2014). It has been grown as a supplemental crop or cash crop by the farmers. The annual increase in production comes mainly from the increase in cultivated area. Low productivity is due to its cultivation under rainfed situation on marginal lands with low application and also use of low yielding cultivars (Reddy *et al.,* 2011). Yield productivity is not easily achieved by the current methods of cultivars improvement and cultural practices. Therefore, to get maximum yield, exploitation of heterosis breeding is gaining importance, which has been generally associated with deviation from the parent means which is generally expressed in increased vigour and productivity obtained by crossing inbred lines. The exploitation of heterosis to raise productivity in grain legumes depends on the direction and magnitude of heterosis, feasibility of large scale production and involvement of type of gene action (Soehendi and Srinives, 2005). Heterosis is exploited in most of the field crops yet its usefulness remained unexplored in legumes mainly because most of these are highly self pollinated and lack of male sterile lines. In mungbean, the utility of heterosis *per se* may not be of much use but cross combinations can be used in developing high yielding pure line varieties (Singh, 1971). Manifestation of heterosis for yield is expressed in the form of increased yield which in turn is dependent on the contribution of its components traits. Therefore, in present study, an attempt has been made to estimate the magnitude of heterosis and inbreeding depression for yield and its components in ten crosses of mungbean.

MATERIALS AND METHODS

The experimental material for the present investigation consisted of five lines (HUM 8, Kopergaon, HUM 16, ML 5 and Pusa Vishal), two testers (ML 1720 and HUM 12), their ten F_1s and their respective F_2s derived out of a line × tester mating design given by Kempthorne (1957). The experiment was conducted in a randomized block design with three replications at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University,,Varanasi during *kharif*, 2014. In each plot, one row of 1.5 meter length of each F_1 hybrid seed and parent line and five rows of F_2s seeds were dibbled by keeping inter and intra row spacing of 30 cm and 10 cm, respectively. All the optimum recommended practices for mungbean growth were applied (Park, 1978). Heterosis was assessed over mid parent, better parent (heterobeltiosis) and standard variety (standard hetersosis) for 11 characters *viz.,* days to 50% flowering, days to maturity, plant height (cm), number of primary branches, number of secondary branches, clusters per plant, pods per plant, pod length (cm), number of seeds per plant, 100-seed weight (g) and seed yield per plant (g) using the formulae given by Fonseca and Patternson (1968). The previous traits were also used to estimate inbreeding depression calculated as per the standard formula.

RESULTS AND DISCUSSION

The magnitude of heterosis provides a basis for determining genetic diversity and also serves a guide to the choice of desirable parents (Swindell and Poelhman, 1976). The analysis of variance revealed significant differences among parents suggesting good amount of genetic differences among the parents (Table 1). Presence of variation in parents has resulted into significant variations in hybrids as well. The significance of parents vs. crosses source of variation for almost all characters suggested that the average performance of the crosses was different from the parents indicating high heterotic response in the materials.

In the present investigation, for seed yield per plant, eight and four hybrids observed positively significant heterosis over mid parent and better parent, respectively while the maximum standard heterosis for seed yield per plant were exhibited by ML 5 × HUM 12 (52.45%) followed by the hybrid Kopergaon × HUM 12 (43.11%), HUM 16 × HUM 12 (36.04%) and HUM 8 × HUM 12 (33.58%). All the crosses were showed negative inbreeding depression values. The hybrids Kopergaon × HUM 12 and ML 5 × HUM 12 also expressed high relative, better parent and standard heterotic effects for yield contributing traits *viz*., days to 50% flowering, days to maturity, plant height, number of primary branches, pod length and number of seeds per pod (Table 2). However, these crosses were not heterotic for all the characters. This suggested that heterosis is a complex character like yield can be expressed by single or several gene combinations. This finding was also earlier reported by some workers, Tantasawat *et al*. (2015), Yadav *et al*. (2015), Makani *et al*. (2013) Kant and Srivastava (2012), Sujatha *et al*. (2011), Patel *et al*. (2009), Sirohi *et al*. (2008) and Dathe and Patil, (2008). Thus, heterosis for seed yield was achieved through either heterosis for individual yield components or additive effects of the various yield contributing component traits/characters. The diverse magnitude of heterosis for different characters in F_1 over the parental lines indicated over all dominance or positively acting genes and increased diversity among the parental genotypes in the appearance of heterosis (Srivastava and Singh, 2013).

For days to 50% flowering, days to maturity and plant height, significant negative heterosis was recorded, which is desirable for earliness and dwarfness, respectively. The cross, ML 5 × HUM 12 showed significant negative heterosis over mid parent (-10.50%), over better parent (-2.42%) and standard heterosis (-27.34%) in desirable direction for days to 50% flowering and days to maturity. The early flowering and maturity in the crosses might be due to their higher growth rate, which was in agreement with the earlier findings of Katiyar (2003). Eight crosses showed negative inbreeding depression, being significant in one cross (HUM 8 × HUM 12), indicating the presence of transgressive segregants for earliness. Out of ten crosses, the crosses ML 5 × HUM 12 and Pusa Vishal × ML 1720 exhibited negative significant heterosis over mid and better parent while other crosses Kopergaon × ML 1720, HUM 16 × ML 1720 and Pusa Vishal × HUM 12 also showed desirable heterobeltiosis whereas none of the crosses showed desirable standard heterosis for plant height which revealed that short stature cultivars could be developed. Similar observations were reported by Patil *et al*. (2014), Sujatha *et al*. (2011), Zubair *et al*. (2010), Sirohi *et al*. (2008) and Kuldeep Tyagi Tomer *et al*. (2006) for days to 50% flowering, days to maturity and plant height (Table 2).

Five and one cross combinations showed significantly positive heterosis over mid and better parents, whereas two hybrids *viz*., Kopergaon × HUM 12 (10.71%) and HUM 16 × ML 1720 (16.07%) could manage to supersede the standard check, HUM 12 with significant margin for number of primary branches whereas for number of secondary branches, positive mid parent and better parent heterosis was observed in eight and six crosses, respectively but none of them show significant values which indicating lack of genetic variability in the parents for this character. Two hybrids *viz*., ML 5 × ML1720 (44.44%) and Pusa Vishal × HUM 12 (41.11%) were observed to be significantly and positively superior to the standard variety. In case of cluster per plant, the cross ML 5 × ML 1720 showed positive heterosis over mid parent (30.21%) and standard variety (27.18%) but none over better parent. Similar findings were observed by Yadav *et al*. (2015), Srivastava and Singh (2013), Kumar and Prakash (2011) and Kumar *et al*. (2006).

The magnitude of relative heterosis and heterobeltiosis for pods per plant was positive significant 33.63 per cent and 31.13 per cent, respectively in cross HUM 16 × ML 1720 whereas cross ML 5 × HUM 12 (29.03%) for economic heterosis. The estimates of heterosis for pod length over mid parents, better parent and standard variety was found

Table 1: Analysis of variance of parents and hybrids for eleven characters in line × tester analysis in mungbean.

Mean squares												
Source	d.f.	Days to 50% Flowering	Days to maturity	Plant height (cm)	No. of primary branches	No. of secondary branches	Clusters/ plant	plant Pods/	Pod length (cm)	No. of Seeds per pod	100-seed weight (g)	Seed yield per plant (g)
Replication	2	0.55	11.31	6.32	0.34	0.06	1.56	1.82	0.15	1.59	0.44	1.95
Parents	6	37.75**	69.15**	387.05**	2.37**	0.07*	2.22*	21.99*	2.84**	4.23	2.36**	14.40**
Line	4	52.50**	95.57**	527.20**	2.53**	0.1	2.73*	28.37*	3.96**	6.29	2.84**	11.77*
Testers	1	13.5	16.67	48.39*	3.84**	0.06	2.28	18.37	0.92**	0.22	2.57**	38.91**
Line vs tester	1	2.98	16.01	165.09**	0.26**	0.09	0.09	0.05	0.29*	0.04	0.03	0.52
Parents vs crosses	1	2.27	5.26	210.32**	11.85**	0.1	3.16	67.52**	2.95**	21.71*	1.98*	203.60**
Crosses	9	56.81**	68.32**	167.48**	1.72**	0.10*	2.51*	16.74**	2.72**	2.53*	1.26**	23.87**
Error	32	3.8	4.83	8.86	0.2	0.08	0.88	8.13	0.06	3.76	0.23	2.79

*Significant at P d" 0.05, **Significant at P d" 0.01

Table 2:Estimation of Heterosis over Mid parent (MP), Better parent (BP) and Economic heterosis (EH) as well as Inbreeding depression (ID) for eleven characters in mungbean.

S.No.	Cross	Days to 50 % flowering				Days to maturity				Plant height (cm)				No. of primary branches			
		MP	BP	EH	ID	MP	BP	EH	ID	MP	BP	EH	ID	MP	BP	EH	ID
1	HUM-8 × ML-1720	-3.48	-6.73	2.08	-8.25	-1.83	-2.08	3.3	-6.38	-5.3	-7.82	3.02	-7.54	23.58**	20.63*	-9.46	-14.47
2	HUM-8 × HUM-12	-6.25	-7.22	-5.27	-22.22*	-1.88	-4.19	0.54	-5.46	1.94	-0.86	4.9	-0.01	25.17**	9.52	9.46	-0.76
3	Kopergaon × ML-1720	-2.94	-4.81	4.2	-3.03	-1.55	-2.06	4.38	-4.21	-8.31	-11.08*	-0.62	-18.17*	11.55	6.87	-16.61*	-10.21
4	Kopergaon × HUM-12	-4.62	-7	-2.12	-20.43	-1.06	-4.12	2.19	-5.38	-1.47	-3.81	1.01	-8.51	24.41**	10.71	10.71*	-3.92
5	HUM-16 × ML-1720	-3.55	-8.65	0	-3.16	-9.89**	4.17	9.89**	-1	-3.96	-12.20*	-1.88	-7.7	30.00**	8.33	16.07*	-0.15
6	HUM-16 × HUM-12	-8.51	-9.47	-9.47	-11.63	-2.26	-4.95	-4.94	-9.25	-5.22	-8.74	-8.72	-1.32	8.05	4.44	11.96	-1.06
7	ML-5 × ML-1720	10.53**	1.61	-32.62**	5.56	-6.57**	0	-20.32**	5.48	7.84*	-8.9	47.63**	-10.87*	14.94	6.38	-10.71	-26.73
8	ML-5 × HUM-12	-10.50*	-2.42**	-27.34**	-12.4	6.23*	-2.74*	-17.03**	7.51	-20.12**	-35.42**	4.67	-14.76	11.97	2.98	3.04	7.51
9	Pusa Vishal × ML-1720	-1	-4.81	4.2	-6.06	3.68	2.6	-8.24**	-1.02	-14.52**	-19.98**	2.5	-5.47	16.44	9.17	-21.96**	-15.04
10	Pusa Vishal × HUM-12	-1.57	-2.08	0.54	-7.45	-1.62	-3.19	0	-2.75	-1.23	-12.06**	12.65*	-0.98	33.33**	8.33	8.39	-0.16
S.E. ±		1.38	1.59	1.59	3.8	1.55	1.79	1.79	5.06	2.1	2.43	2.43	5.64	0.31	0.37	0.37	0.93

	Crosses	No. of secondary branches				Clusters/Plant				Pods/ Plant				Pod length (cm)			
		MP	BP	EH	ID	MP	BP	EH	ID	MP	BP	EH	ID	MP	BP	EH	ID
1	HUM-8 × ML-1720	16.36	10.34	18.89	-12.5	5.19	1.89	-17.56	-9.88	15.68	7.37	1.77	-2.11	4.04	-0.35	10.90**	8.73
2	HUM-8 × HUM-12	9.43	7.41	7.78	-5.86	4.35	-8.16	-8.4	-3.67	5.8	3.05	3.06	2.73	-0.26	-1.24	0.73	-9.24
3	Kopergaon × ML-1720	10.71	6.9	14.44	-16.13	12	2.62	-0.31	-4.59	5.99	1.2	-9.68	-6.21	16.49**	5.74*	17.73**	-0.21
4	Kopergaon × HUM-12	29.63	29.63	30	-2.86	12.66	11.22	10.99	-2.29	11.17	5.2	5.22	-7.16	8.20**	3.25	3.2	0
5	HUM-16 × ML-1720	-18.03	-21.87	-7.78	-52	15.69	13.25	-4.27	0.9	33.63*	31.13*	6.45	-10.15	13.10**	5.20*	36.19**	-5.34*
6	HUM-16 × HUM-12	-25.42	-31.25	-18.89	-55.91	-0.55	-8.16	-8.4	-7.22	12.07	-0.18	-0.16	3.07	13.65**	0.71	30.38**	-1.12
7	ML-5 × ML-1720	16.42	2.63	44.44*	-6.41	30.21*	11.11	27.18*	-3.48	20.04	1.53	19.19	-0.72	10.22**	4.87	16.72**	-2.49
8	ML-5 × HUM-12	10.77	-5.26	33.33	6.39	4.99	-1.78	12.52	-3.71	18.71	9.92	29.03*	21.85*	-0.92	-1.2	-0.73	-4.88
9	Pusa Vishal × ML-1720	9.43	0	7.78	4.48	-2.96	-8.38	-16.49	-18.66	18.32	14.79	-6.83	2.94	13.28**	7.18**	33.72**	-1.45
10	Pusa Vishal × HUM-12	49.02	40.74	41.11*	3.42	6.67	2.04	1.83	5.35	-0.41	-12.19	-12.2	-10.06	-5.56*	-14.95**	6.1	-10.50*
S.E. ±		0.21	0.24	0.24	0.54	0.66	0.77	0.77	1.62	2.02	2.33	2.33	4.75	0.18	0.22	0.22	0.99

*Significant at P≤0.05, ** Significant at P≤0.01

Table 2: Contd.

S.n.	Cross	No. of Seeds per pod				100-seed weight (g)				Seed yield per plant (g)			
		MP	BP	EH	ID	MP	BP	EH	ID	MP	BP	EH	ID
1	HUM-8 × ML-1720	7.49	-1.73	2.9	-6.5	4.79	4.42	-22.44**	-2.12	27.72	9.96	-20.85	-16.04
2	HUM-8 × HUM-12	20.4	12.4	12.44	1.9	16.27	0.98	0.98	-0.84	55.25**	33.51*	33.58*	-2.05
3	Kopergaon × ML-1720	30.81	19.54	25.12	4.99	9.43	3.29	-13.58	-6.53	50.70*	33.55	-10.09	-6.72
4	Kopergaon × HUM-12	44.52*	34.86	34.90**	15.82	8.57	-0.33	-0.2	-1.12	71.02**	43.04**	43.11**	-2.04
5	HUM-16 × ML-1720	8.35	2	20.89	-1	11.54	-7.5	4.33	-3.4	61.32**	28.48	12.64	-1.42
6	HUM-16 × HUM-12	6.8	-1.56	16.67	-3.17	3.39	-2.44	10.04	2.92	44.92**	35.96*	36.04**	-4.72
7	ML-5 × ML-1720	15.59	6.52	32.25	-0.88	4.08	0.27	-25.59**	-5.46	54.61**	14.54	23.58	-6.56
8	ML-5 × HUM-12	15.01	3.83	28.86	-6	17.33*	-0.98	-0.98	-17.95	46.65**	41.29**	52.45**	-1.77
9	Pusa Vishal × ML-1720	9.37	7.69	12.68	-0.79	9.22	-6.8	-1.97	-4.22	36.19	25.5	-22.64	-11.34
10	Pusa Vishal × HUM-12	4.32	3.57	5.07	0.57	9.05	6.43	11.81	2.87	47.02**	18.83	18.87	-4.1
S.E.	±	1.37	1.59	1.59	3.87	0.34	0.4	0.4	0.93	1.18	1.37	1.37	3.26

*Significant at $P \leq 0.05$, ** Significant at $P \leq 0.01$

significant positive in six, three and six, respectively. Inbreeding depression varying from 10.50 to 0.21 but two hybrids *viz.,* HUM 16 × ML 1720 and Pusa Vishal × HUM 12 show negative significant value for pod length. For number of seeds per pod, the cross, Kopergaon × HUM 12 revealed positive significant heterosis over mid parent and none over better parent as well as over top parent. For 100-seed weight, only one hybrid ML 5 × HUM 12 (17.33%) manifested positive significant heterosis over mid parent. In case of heterobeltiosis and economic hetrosis, none of the crosses expressed positive significant value (Table 2). The results obtained in this study are in conformity with the findings of Patel *et al.* (2009), Kumar *et al.* (2006), Sawale *et al.* (2003).

It is concluded that exhibited heterosis for grain yield were not heterotic for all the contributing traits. In general, the varieties ML 5, Kopergaon, HUM 16 and HUM 12 were performed well giving high heterosis and low inbreeding depression for most of the characters studied. The The promising hybrids ML 5 × HUM 12, ML 5 × ML 1720, Kopergaon × HUM 12, Pusa Vishal × HUM 12 have enormous potential to make use of the heterosis or to isolate desirable segregants. The variable number of hybrids showed heterosis in both positive and negative direction which indicate that genes with negative as well as positive effects were dominant. The negative heterosis observed in some of the crosses may be attributed to non-allelic interaction which can either increase or decrease the expression of heterosis. Therefore, the crosses exhibiting significant heterosis should be exploited to develop high yielding varieties of mungbean.

REFERENCES

Anonymous, 2014. Online pulse data book, ICAR, IIPR.

Dathe, A. M. and Patil, J. V. 2008. Heterosis study in mungbean. *Leg Res.* **31(1):** 36-39.

Fonseca, S. and Patterson, F. L. 1968. Hybrid vigour in a seven-parent diallel crosses in common winter wheat (*Triticum aestivum* L.). *Crop Sciences.* **8:** 85-88.

Kant, R. and Srivastava, R. K. 2012. Heterosis and inbreeding depression studies in urdbean [*Vigna mungo (*L.) Hepper]. *J. of Food Leg.* **25(2):** 102-108.

Katiyar, R. P. 2003. In: national symposium on pulses for crop diversification and natural resources management, 20-22 December, Kanpur, p. 86.

Kempthorne, O. 1957. An introduction to genetic statistics. *J. Wiley and Sons. Inc.*, New York.

Reddy, D. K. R., Venkateswarlu, O., Obaiah, M. C. and Siva Jyothi, G. L . 2011. Heterosis for yield and yield components in green gram [*Vigna radiata* (L.) Wilczek]. *Legume Res.* **34(3):** 207-211.

Kamleshwar, K., Yogendra, P., Mishra, S. B., Pandey, S. S. and Ravi, K. 2014. Study on genetic variability, correlation and path analysis with grain yield and yield attributing traits in green gram [*Vigna radiata* (L.) Wilczek]. *The Bioscan.* **8(4):** 1551-1555.

Kuldeep Tyagi Tomer, A. K., Singh, V. K. and Nandan. R. 2006. Heterosis and inbreeding depression in mungbean [*Vigna radiata* (L.) Wilczek]. *Res. Crops.* **7(2):** 458-460.

Kumar, B. S. and Prakash, M. 2011. Heterosis for biometric and biochemical components in mungbean [*Vigna radiata* (L.) Wilczek]. *Karnataka J. Agric. Sci.* **24(4):** 523-524.

Kumar, B. S., Prakash, M., Saravanan, K. and Ganesan, J. 2006. Biophysical and morpho-physiological basis of heterosis in mungbean [*Vigna radiata* (L.) Wilczek]. *Res. Crops.* **7(1):** 318-320.

Makani, A. Y., Patel, A. L., Bhatt, M. M. and Patel, P. C. 2013. Heterosis for yield and its contributing attributes in Brinjal (*Solanum melongena* L.) *The Bioscan.* **8(4):** 1369-1371.

Park, H. G. 1978. *Suggested Cultural Practices for Mungbean.* International Cooperator's Guide. *Asian Vegetable Research and Development Center, Shanhua, Taiwan.* p. 2

Patel, M. B., Patel, B. N., Savaliya, J. J. and Tikka, S. B. S. 2009. Heterosis and genetic architecture of yield, yield contributing traits and yellow mosaic virus in mungbean [*Vigna radiata* (L.) Wilczek]. *Leg. Res.* **32(4):** 260-264.

Patil, A. B., Desai, N. C., Chuahan, D. A. and Chougule G. R. 2014. Heterosis for seed yield and yield attributing traits in mungbean (*Vigna radiata* L. Wilczek.). *Bioinfolet.* **11(2a):** 386-390.

Sawale, V. S., Patil, J. V., Deshmukh, R. B. and Kute, N. S. 2003. Heterosis and inbreeding depression for yield and it's components in mungbean. *Leg. Res.* **26(2):** 134-136.

Singh, K. B. 1971. Heterosis breeding in pulse crops. Paper presented at the 5th All India Pulse Conference held at the Haryana Agricultural University, Hissar.

Sirohi, S. P. S., Gaurav, S. S., Singh, S. P. and Yadav, R. 2008. Heterosis in mungbean [*Vigna radiata* (L.) Wilczek]. *Progressive Res.* **3(1):** 35-37.

Soehendi, R. and Srinives, P. 2005. Significance of heterosis and heterosbeltiosis in F_1 hybrid of mungbean [*Vigna radiate* (L.) Wilczek] for hybrid seed production. *SABRAO J. Breeding and Genetics.* **37(2):**

97-105.

Srivastava, R. L. and Singh, G. 2013. Heterosis for yield and its contributing characters in mungbean [*Vigna radiata* (L.) Wilczek]. *Indian J. Sci. Res*. **4(1):** 131-134.

Sujata, K., Kajjidoni, S. T., Patil, P. V. and Somashekhar, G. 2011. Heterosis for productivity related traits involving diverse parents for powdery mildew reaction in mungbean. *J. Food Leg.* **24(2):** 101-105.

Swindell, R. E. and Poelhman, J. M. 1976. Heterosis in mungbean. *Trop. Agric*. **53:** 25-30.

Tantasawat, P. A., Khajudparn, P., Prajongjai, T. and Poolsawat, O. 2015. Heterosis for the improvement of yield in mungbean [*Vigna radiata* (L.) Wilczek]. *Genetics and Molecular Research.* **14(3):** 10444-10451.

Yadav, P. S., Roopa lavanya, G., Vishwakarma, M. K., Saxesena, R. R., Baranwal, D. K. and Singh, S. 2015. Heterosis studies using diallel analysis for yield and component characters in mungbean (*Vigna radiata* L.Wilczek). *The Bioscan.* **10(2):** 711-713.

Zubair, M., Ajaml, S. U. and Ali, M. 2010. Heterosis for yield related attributes in mungbean [*Vigna radiata* (L.) Wilczek]. *Pak. J. Bot*. **42(5):** 3209-3214.