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Full Length Research Paper

Genetic variability, heritability and correlation studies of various quantitative traits of mungbean (*Vigna radiate* L.) at different radiation levels

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Abstract

The experiment was conducted in the research area of the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, during spring season 2010. The experimental material was comprised of four irradiated mungbean genotypes as AUM-18, AUM-19, AUM-3 and Mung 2004. From the experiment it was concluded that maximum emergence rate was observed by AUM-31 at the level D_2 followed by the genotype AUM-18 which gave the maximum yield at dose level D_1. AUM-19 produced maximum plant height at first pod maturity followed by AUM- 18, while regarding dose level maximum plant height was produced at the level D_1. Maximum plant height at 90% pod maturity was obtained by genotype AUM-19 at D_1, AUM-19 at level D_2 and AUM-18 at dose level D_3. AUM-31 produced maximum clusters per plant at D_1 and D_2 and D_3 levels and Mung-2004 gave the minimum cluster per plant at D_2 and D_3. AUM-19 produced maximum pods per plant at all three levels while it remained minimum regarding the genotype AUM-31 at all three levels. AUM-31 produced maximum seeds per pod at D_1, D_2 and D_3 levels. AUM-18 showed no effects for seed per pod on all dose levels. Maximum seed yield per plant was produced by AUM-18 at dose level D_1 while it was observed minimum for AUM-19 at D_3. The phenotypic correlation for emergence rate with plant height at first pod maturity, plant height at 90% pod maturity, pods per plant, Grains per pod was negative and non significant while it was positive with cluster per plant and 100-seed weight. It was suggested that the selection of higher yielding mungbean genotypes may be helpful on the basis of induced mutations and Germplasm may be used for mutation breeding programme.

Keywords: Legumes, mungbean, *Vigna radiate,* genotypic, phenotypic, correlation.

INTRODUCTION

Pakistan is an agricultural country having a vast natural resources base. It consists on a variety of climates and ecological zones due to this reason it has large potential to produce all types of food commodities. At present about 27% area of the country is under cultivation, out of which 80 % area is irrigated. In this regards, Pakistan has one of the highest proportion of irrigated cropped area in the world. Agriculture is an important source of our national income. In the country 70% people are living in rural areas and about 80% from them are engaged with this sector. Agriculture is contributing about 60% of total export earnings in Pakistan. 24% of the gross domestic product is contributed by this sector and it has engaged 47% of our national labor force. Therefore prime importance is being given by the government in order to bring improvements in this sector. In Pakistan among the cultivated legumes, mungbean (*Vigna radiata* L.) occupies second position succeeding to chickpea. The total area under cultivation of mungbean in Pakistan is 183.3 (000 hectares) and production per annual is 118.7 (000 tons) (Anonymous 2011). As compared to other legumes, the seeds of mungbean are tasty, easily

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digestible and having more nutritional values. Its seed contains 24.7% protein, 0.6% fat, 0.9% fiber and 3.7% ash (Potter and Hotchkiss, 1997). Sprouts of mungbean are an important source of food and are very commonly used to protect from scurvy.

Agronomic traits of pulses can be improved by induced mutations (Mlcochova *et al.* 2004). Differences in mutation frequency and spectrum depend on the interaction of three factors such as mutagen, plant genotype, and physiological state of the organism at the moment of treatment (Singh and Yadav, 1991). The yield and quality controlling traits such as disease resistance, early maturity, plant height and seed shattering can be controlled through mutation breeding. Genetically mutant varieties show maximum yield and good quality of the crop (Ahloowalia, 2004). In the world 2252 mutant varieties have been registered out of which 311 are legumes. 64 % of mutant varieties are produced through the treatment of Gamma radiation (Souframanien *et al.,* 2002). The objective of the present research was to estimate the genetic variability and correlation for various morphological traits in mungbean at different radiation levels so that the information derived would be helpful in developing appropriate selection methods and improving the economically important characters.

MATERIALS AND METHODS

The experiment was conducted in the research area of the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, during spring season 2010. The experimental material was comprised of four irradiated mungbean genotypes as AUM-18, AUM-19, AUM-3 and Mung 2004. Dry seed of these genotypes were treated with different doses of gamma radiations i.e., 25 kR (D_1), 35 kR (D_2) and 45 kR (D_3) at the Nuclear Institute for Agriculture and Biology, Faisalabad, using CO_{60} as the source. The seeds of radiated genotypes along with control (D_0) were dibbled in the field. The experiment was laid out in Split Plot Design, with two replications. Each replication was divided into main plot and sub plot. Varieties were assigned to main plot and dose levels to sub plots. Each treatment comprised 3 lines, 4 meters in length, row-to-row and plant-to-plant distances were 30 and 10cm respectively. Uniform agronomic practices were applied to all entries throughout growing period of the crop. Ten plants from each of the treatment were selected randomly and data was recorded for following morphological traits; Emergence rate, Plant height at first pod maturity, Plant height at 90% pod maturity, Cluster per plant, Pods per plant, Branches per plant, Grains per pod, Grains per plant, 100-seed weight and Biological yield. The data for each character was statistically analyzed for variance (steel *et al.* 1997). Heritability estimates (h^2_{BS}) was calculated by performing analysis of variance and estimating genetic and phenotypic components of variance as given by Cochran and Cox (1957). Phenotypic (r_p) and genotypic (r_g) correlation coefficient was calculated as outlined by Kwon and Torrie (1964).

RESULTS AND DISCUSSIONS

Emergence rate

Coefficient of variability was 1.09%. Genotypic coefficient of variability and phenotypic coefficient of variability were 4.60% and 4.93%, respectively (Table 11). Heritability estimate was high (97%) with high genetic advance (4.85). The result are in agreement with Gill *et al.* (2000), Arshad *et al.* (2002), Khan *et al.* (2004), Sadiq (2005) Hakim *et al.* (2006) and Jagadeesan *et al.* (2008) Pavadai *et al* (2010) who reported high heritability. As regards radiation doses, significantly maximum emergence rate (59.085%) was obtained at D_1 whereas minimum emergence rate (54.675%) was produced by D_3. At D_1 level the varieties AUM-18 (59.97%) and AUM-19 (59.55%) were ranked at first and second positions respectively. AUM-31 (60.5%) and Mung-04 (58.5%) were ranked at first and second position at D_2 dose level whereas the result regarding AUM-81 (57.61%) and AUM-19 (57.61%) are at par. At dose level D_3 among genotype AUM-18 (59.5%) produced maximum emergence rate followed by AUM-31 (58.12) whereas minimum (50.05) was observed for Mung-04 followed by the AUM-19 (51.03%).

Plant height at first pod maturity (cm)

The genotypes showed sufficient range of variability for plant height at first pod maturity. Mean value for plant height at first pod maturity ranged from 44.85 cm to 69.63 cm. Maximum mean value was observed for AUM-19 followed by AUM-31. Coefficient of variability was 1.59%. Genotypic coefficient of variability and phenotypic coefficient of variability were 17.46% and 19.35% respectively (Table 11). Heritability estimate was high (98.37%) with high genetic advance (16.41). The results are in agreement with Sinha *et al.* (1996), Islam *et al.* (1999) and Gill *et al.* (2000) who reported high heritability and genetic advance for plant height but differ from Loganathan *et al.* (2001). As regards radiation doses, significantly maximum plant height at first pod maturity (56.965 cm) was obtained at D_1 while the results regarding the D_2 (52.85), D_3 (52.43 cm) and D_0 (52.96 cm) are statistically at par.

The interaction between genotypes and doses for plant height at first pod maturity showed that AUM-19 produced maximum plant height (69.63 cm) at first pod maturity followed by AUM- 18 (57.98 cm) and Aum-31 (50.23 cm) was ranked at third position whereas mini-

Table 1. Interaction between genotypes and irradiation doses affecting emergence rate

Doses	Varieties				
	AUM-31	AUM-18	AUM-19	Mung-04	Average
Control (D_0)	58.19^{bcde}	59.5^{abcd}	55.23^{cd}	56.9^{cd}	**57.455**
25kR (D_1)	58.97^{cd}	59.97^{abcd}	59.55^{ab}	57.85^{bc}	**59.085**
35kR (D_2)	60.5^{a}	57.65^{e}	57.61^{bc}	58.5^{ab}	**58.565**
45kR (D_3)	58.12^{cde}	59.5^{abc}	51.03^{e}	50.05^{e}	**54.675**
Average	**58.945**	**59.155**	**55.855**	**55.825**	

Means sharing the common letters for a given trait do not differ significantly at 5% probability level
LSD value at 5% probability level = 1.008

Table 2. Interaction between genotypes and irradiation doses affecting plant height at 1st pod maturity

Doses	Varieties				
	AUM-31	AUM-18	AUM-19	Mung-04	Average
Control (D_0)	48.02^{cd}	$55.23ab^{c}$	60.33^{c}	$48.29b^{cd}$	**52.9675**
25kR (D_1)	50.23^{abc}	57.98^{ab}	69.63^{a}	50.02^{b}	**56.965**
35kR (D_2)	44.85^{e}	52.66^{e}	64.25^{b}	$49.65b^{c}$	**52.8525**
45kR (D_3)	50.05^{ab}	54.87^{abcd}	51.54^{d}	53.26^{a}	**52.43**
Average	**48.2875**	**55.185**	**61.4375**	**50.305**	

Means sharing the common letters for a given trait do not differ significantly at 5% probability level
LSD value at 5% probability level = 1.45

Table 3. Interaction between genotypes and irradiation doses affecting plant height at 90% pod maturity

Doses	Varieties				
	AUM-31	AUM-18	AUM-19	Mung-04	Average
Control (D_0)	39.99^{d}	55.96^{b}	51.26^{cd}	54.23^{ab}	**50.36**
25kR (D_1)	51.47^{a}	58.95^{a}	69.36^{a}	55.09^{a}	**58.085**
35kR (D_2)	45.83^{b}	52.86^{d}	66.58^{b}	52.56^{bc}	**54.287**
45kR (D_3)	40.05^{c}	55.96^{bc}	$51.21cd^{e}$	51.88^{bcd}	**50.59**
Average	**44.335**	**55.9325**	**59.615**	**53.44**	

Means sharing the common letters for a given trait do not differ significantly at 5% probability level
LSD value at 5% probability level = 1.49

mum plant height was observed (50.02 cm) by Mung-04 at D_1. For dose level D_2, genotypes AUM-19 (64.25 cm) produced maximum plant height at first pod maturity followed by AUM-18 (52.66 cm) whereas Mung-04 (49.65 cm) was ranked at third position and minimum plant height was observed for AUM-31 (44.85 cm). At dose level D_3, genotype AUM-18 (54.87 cm) produced maximum plant height at 1st pod maturity followed by Mung-04 (53.26 cm) whereas AUM-19 ranked at third position (51.54 cm) and minimum (50.05cm) was observed for AUM-31. It is clear from the results that AUM-19 produced maximum plant height at 1st pod maturity at D_1 level and D_2.

Plant height at 90% pod maturity (cm)

The genotypes showed sufficient range of variability for plant height at 90% pod maturity. Mean value for plant height at 90% pod maturity ranged from 39.99 cm to 69.36 cm. Maximum mean value was observed for AUM-19 followed by AUM-18, whereas Mung-04 got the third position and minimum plant height at 90% pod maturity was recorded for AUM-31. 1.54% coefficient of variability was found for plant height at 90% pod maturity. Genotypic coefficient of variability and phenotypic coefficient of variability were 16.47% and 18.21% respectively. Heritability estimate was highly (97.48%)

Table 4. Interaction between genotypes and irradiation doses affecting clusters per plant

Doses	Varieties				
	AUM-31	AUM-18	AUM-19	Mung-04	Average
Control (D_0)	9.9^{bc}	8.58^{bcd}	8.55^{bc}	7.78^{bc}	**8.70**
25kR (D_1)	14.57a	10.04^{a}	12.57^{a}	11.54^{a}	**12.18**
35kR (D_2)	10.07^{ab}	9.04^{ab}	8.51^{bcd}	8.03^{b}	**8.66**
45kR (D_3)	9.09^{bcde}	8.51^{bcde}	7.09^{de}	6.7^{cd}	**8.09**
Average	**10.9075**	**9.0425**	**9.18**	**8.5125**	

Means sharing the common letters for a given trait do not differ significantly at 5% probability level
LSD value at 5% probability level = 0.7485

Table 5. Interaction between genotypes and irradiation doses affecting pods per plant

Doses	Varieties				
	AUM-31	AUM-18	AUM-19	Mung-04	Average
Control (D_0)	23.22^{bcde}	28.56^{bc}	30.25^{c}	25.25^{c}	**26.82**
25kR (D_1)	26.08^{a}	34.02^{a}	36.07^{a}	32.02^{a}	**32.0475**
35kR (D_2)	24.09^{bc}	30.57^{b}	34.04^{b}	27.06^{b}	**28.94**
45kR (D_3)	23.54^{bcd}	24.08^{d}	25.02^{d}	24.5^{cd}	**24.285**
Average	**24.2325**	**29.3075**	**31.345**	**27.2075**	

Means sharing the common letters for a given trait do not differ significantly at 5% probability level
LSD value at 5% probability level = 1.152

Table 6. Interaction between genotypes and irradiation doses affecting branches per plant

DOSES	Varieties			
	AUM-19	M-04	AUM-18	AUM-31
25kR (D_1)	13.25^{e}	14.85^{bc}	16.00^{a}	14.50^{bcd}
35kR (D_2)	12.95^{ef}	15.25^{ab}	13.05^{ef}	13.60^{de}
45kR (D_3)	11.40^{g}	12.95^{ef}	14.25^{cd}	12.10^{fg}

Means sharing the common letters for a given trait do not differ significantly at 5% probability level LSD value at 5% probability level = 1.210

Table 7. Interaction between genotypes and irradiation doses affecting grains per pod

Doses	Varieties				
	AUM-31	AUM-18	AUM-19	Mung-04	Average
Control (D_0)	8.08^{cd}	6.15^{bc}	6.8^{ab}	7.05^{ab}	**7.065**
25kR (D_1)	10.85^{a}	8.65^{a}	6.02^{bcd}	8.59^{a}	**8.5275**
35kR (D_2)	9.5^{bc}	7.24^{ab}	6.1^{bc}	6.89^{cd}	**7.4325**
45kR (D_3)	8.62^{cde}	5.18^{cd}	7.43^{a}	7.03^{abc}	**7.02**
Average	**9.2625**	**6.805**	**6.5875**	**7.39**	

Means sharing the common letters for a given trait do not differ significantly at 5% probability level
LSD value at 5% probability level = 0.275

with high genetic advance (16.52) (Table 11). The results are in agreement with Arshad *et al*. (2002), Sadiq *et al*. (2005), Sadiq (2005), Jagadeesan *et al* (2008) and Tah (2009) who reported high heritability and partial agree with Neha *et al*. (2005) and Veerasmani *et al*. (2005).

In response of radiation doses, maximum plant height at 90% pod maturity (58.085 cm) was obtained at D_1 whereas (54.287 cm) was at D_2 and the results regarding D_3 (50.59 cm) and D_0 (50.36 cm) are statically at par. Interaction effect of genotypes and radiation doses on

Table 8. Interaction between genotypes and irradiation doses affecting seed yield per plant

Doses	Varieties				
	AUM-31	AUM-18	AUM-19	Mung-04	Average
Control (D_0)	6.06^{bc}	5.56^{cd}	4.22^{cde}	5.99^{ab}	**5.4575**
25kR (D_1)	7.28^{a}	7.61^{a}	5.57^{a}	6.23^{a}	**6.6725**
35kR (D_2)	7.05^{ab}	6.28^{bc}	4.33^{bc}	4.27^{de}	**5.4825**
45kR (D_3)	5.18^{cd}	4.73^{de}	4.3^{bcd}	5.43^{bcd}	**4.91**
Average	**6.3925**	**6.045**	**4.605**	**5.48**	

Means sharing the common letters for a given trait do not differ significantly at 5% probability level
LSD value at 5% probability level = 0.2564

Table 9. Interaction between genotypes and irradiation doses affecting 100-seed weight

Doses	Varieties				
	AUM-31	AUM-18	AUM-19	Mung-04	Average
Control (D_0)	5.22^{bcd}	5^{bcd}	4.9^{bcd}	5^{bcd}	**5.2075**
25kR (D_1)	6.32^{a}	5.24^{a}	5.3^{a}	5.3^{a}	**5.515**
35kR (D_2)	5.1^{cde}	5.2^{ab}	5.1^{bc}	5.1^{bc}	**5.125**
45kR (D_3)	5.33^{bc}	5.1^{abc}	5.2^{ab}	5.2^{ab}	**5.03**
Average	**5.4925**	**5.135**	**5.125**	**5.125**	

Means sharing the common letters for a given trait do not differ significantly at 5% probability level
LSD value at 5% probability level = 0.235

Table 10. Interaction between genotypes and irradiation doses affecting seed yield per plant

Doses	Varieties				
	AUM-31	AUM-18	AUM-19	Mung-04	Average
Control (D_0)	87.01^{bc}	85.1^{bc}	67^{bcde}	60.42^{bc}	**74.8825**
25kR (D_1)	90.28^{a}	92.06^{a}	77.5^{a}	80.23^{a}	**85.1525**
35kR (D_2)	90.05^{ab}	88.2^{bcd}	66.3^{bcd}	62.27^{bcd}	**76.1875**
45kR (D_3)	77.81^{cd}	56.7^{de}	66.32^{bc}	77.43^{ab}	**69.565**
Average	**86.2875**	**80.65**	**69.28**	**70.0875**	

Means sharing the common letters for a given trait do not differ significantly at 5% probability level
LSD value at 5% probability level = 0.528

number of plant height at 90% pod maturity was found highly significant (Table 3). Mean values for plant height at 90%pod maturity ranged from 46.93% to 70.00%. Plant height at 90% pod maturity showed interaction between genotypes and irradiation doses (Table 3). AUM-19 produced maximum plant height (69.36 cm) at 90% pod maturity followed by AUM-18 (58.95 cm) where as third position was occupied by Mung-04 (55.09cm) and minimum plant height was gained by the (52.22cm) by AUM-31 at D_1. Significant differences were observed for interaction of AUM-18 with others (Table 3). For dose level D_2, genotype AUM-19 (66.58 cm) produced maximum plant height at 90% pod maturity followed by AUM-18 (52.86 cm), Mung-04 (52.56 cm) was ranked at third position where as minimum (45.83 cm) was observed for AUM-31. At dose level D_3, genotype AUM-18 (55.96 cm) produced maximum plant height at 90% pod maturity followed by Mung-04 (51.88 cm). AUM-19 (51.21 cm) got the third position where as minimum (40.05 cm) was observed for AUM-31. It is clear from the results that AUM-19 produced maximum plant height at 90% pod maturity at D_1.

Clusters per plant

The genotypes showed sufficient range of variability for clusters per plant. Mean value for clusters per plant

Table 11. Genetic components for various traits of mungbean

Traits	Heritability (%)	Genetic advance (%)	Coefficient of variance (%)	Genotypic coefficient of variance (%)	Phenotypic coefficient of variance (%)
Emergence rate	97	4.85	1.09	4.60	4.93
Plant height at first pod maturity	98.37	16.41	1.59	17.46	19.35
Plant height at 90% pod maturity	97.58	16.52	1.54	16.47	18.21
Cluster per plant	94.52	4.58	5.58	23.58	24.32
Pods per plant	97.85	10.415	2.70	18.85	19.30
Branches per plant	83.49	2.375	2.88	10.83	11.85
Grains per pod	97.81	5.28	3.74	32.57	31.45
Grains per plant	98.39	4.425	5.39	28.58	29.58
100-seed weight	92.52	0.576	7.32	8.37	8.47
Biological yield	93.68	4.874	4.57	25.85	25.82

ranged from 6.7 to 14.57. Maximum mean value was observed for AUM-31 followed by AUM-19 and Aum-18 whereas minimum emergence rate was recorded for Mung-04. Coefficient of variability, genotypic coefficients of variability, and phenotypic coefficients of variability was 5.58%, 23.58 % and 24.32% respectively. Heritability estimate was highly (94.52%) with high genetic advance (4.58) (Table 11). The results are in agreement with Gill *et al.* (2000), Arshad *et al*. (2002), Veerasmani *et al.* (2005) and Sadiq (2005) who reported high heritability for clusters per plant. Significantly maximum clusters per plant (12.18) were obtained at D_1 followed by D_2 (8.66) where as minimum clusters per plant (8.09) were produced by D_3 in response to radiation doses.

It was revealed from the results of interaction between genotypes and doses for clusters per plant that maximum clusters per plant (14.57) were produced by AUM-31 followed by AUM-19 (12.57) and Mung-04 (11.54) where as minimum (10.04) by AUM-18 at D_1. For dose level D_2, genotypes AUM-31 (10.07) produced maximum clusters per plant followed by AUM-18 (9.04) and AUM-19 (9.04) where as minimum (8.03) was observed for Mung-04. At dose level D_3, genotype AUM-31 (9.09) produced maximum clusters per plant followed by AUM-18 (8.51) and AUM-19 (7.09) where as minimum (6.700) was observed for Mung-04. It is clear from the results that AUM-31 produced maximum clusters at D_1 and D_2 and D_3 levels.

Pods per plant

Mean value for pods per plant ranged from 23.22 to 36.07. Maximum mean value was observed for AUM-19 followed by AUM-18 and Mung-04, whereas minimum pods per plant were recorded for AUM-31. Genotypic coefficient of variability and phenotypic coefficient of variability were 18.85% and 19.30%, respectively while coefficient of variability was 2.70% (Table 11). Heritability estimate was highly (97.85%) with high genetic advance (10.415). The results are in agreement with Singh (2004), Neha *et al.* (2005), Sadiq (2005), Veerasmani *et al*. (2005), Khan *et al*. (2005), Hakim *et al*. (2006), Idrees *et al*. (2006), Tadele *et al.* (2006) and Gul *et al.* (2007) who reported high heritability. As regards radiation doses, significantly maximum pods per plant (32.047) were obtained whereas minimum (24.285) was produced by D_3.

Interaction effects of genotypes and radiation doses on number of pods per plant were found highly significant (Table 5). The interaction between genotypes and doses for pods per plant showed that AUM-19 (36.07) produced maximum pods per plant followed by AUM-18 (34.02) and Mung-04 (36.07) whereas minimum (26.08) by AUM-31 at D_1. Significant differences were observed for interaction of AUM-19 with all others. For dose level D_2, genotypes AUM-19 (34.04) produced maximum pods per plant followed by AUM-18 (30.75) and Mung-04 (27.06) whereas minimum (24.09) was observed for AUM-31. There was significant interaction of AUM-19 with all others. At dose level D_3, genotype AUM-19 (25.04) produced maximum pods per plant followed by Mung-04 (24.5) and Aum-18 (24.08) whereas minimum (23.54) was observed for AUM-31. It is clear from the results that AUM-19 produced maximum pods per plant at all three levels. AUM-31 produced minimum pods per plant at all three levels.

Branches per plant

The genotypes showed sufficient range of variability for branch per plant. Mean value for branch per plant ranged from 12.53 to 14.43. Maximum mean value was observed for AUM-18 followed by M-04, while it remained minimum for AUM-19. The value for coefficient of variability was 1.15%. Genotypic coefficient of variability and phenotypic coefficient of variability were 10.83% and 11.85%, respectively. Heritability estimate was highly (83.49%) with high genetic advance (2.374) (Table 11). The result are in agreement with Tiwari et al (1996), Arshad et al. (2004), Veerasmani *et al*. (2005) and Sadiq (2005) who reported high heritability. As regards radiation doses, significantly maximum branches per plant (14.65) were obtained at D_1 which was statistically at par with D_2 whereas minimum branch per plant (12.68) was produced by D_3.

Interaction effect of genotypes and radiation doses on number of branches per plant was found highly significant (Table 6). Mean values for branches per plant ranged from 11.40 to 16.00.The interaction between genotypes and doses for branches per plant showed that AUM-18 produced maximum branch per plant followed by M-04 (14.85) whereas minimum (13.25) by AUM-19 at D_1. Significant differences were observed for interaction of AUM-18 with all others (Table 6A). For dose level D_2, genotype M-04 produced maximum branches per plant followed by AUM-31 (13.60) whereas minimum (12.95) was observed for AUM-19. There was significant interaction of M-04 with all others. At dose level D_3, genotype AUM-18 produced maximum branches per plant followed by M-04 (12.95) whereas minimum (11.40) was observed for AUM-19 .There was significant interaction of AUM-19 with all others. It is clear from the results that AUM-18 produced maximum branches per plant at D_1, D_3 and M-04 at D_2 level.

Grains per pod

The genotypes showed sufficient range of variability for grains per pod. Mean value for grains per pod ranged from 5.18 to 10.85. Maximum mean value was observed for AUM-31 followed by Mung-04 and AUM-18; where as minimum grain per pod was recorded for AUM-19. Heritability estimate was high (97.81%) with high genetic advance (5.28). Coefficient of variability was 3.74%. Genotypic coefficient of variability and phenotypic coefficient of variability were 32.57% and 31.45%, respectively (Table 11). The results are in agreement with Arshad *et al*. (2002), Neha *et al*. (2005), Veerasmani *et al*. (2005), Kapoor *et al*. (2005), Sadiq (2005), Khan *et al*. (2005), Hakim *et al*. (2006), Tadele *et al.* (2006) and Gul *et al*. (2007) who reported high heritability.

In response of radiation doses, significantly maximum grains per pod (8.52) were obtained at D_1 where as least number of grains per pod (7.02) were recorded by D_3. Significant interaction effect was showed by genotypes and radiation doses on number of grains per pod (Table 7). The interaction between genotypes and doses for grains per pod showed that AUM-31 (10.85) produced maximum grains per pod followed by AUM-18 (8.65) and Mung-04 (8.59) whereas minimum (6.02) by AUM-19 at D_1. Significant differences were observed for interaction of AUM-31 with all others. For dose level D_2, genotypes AUM-31 (9.5) produced maximum grains per pod followed by AUM-18 (7.24) and Mung-04 (6.89) where as minimum (6.1) was observed for AUM-19. Significant interaction was observed for AUM-31 with all other genotypes. At dose level D_3 genotype AUM-31 (8.62) produced maximum grains per pod followed by AUM-19 (7.43) and Mung-04 (7.03) where as minimum grains per pod (5.18) was observed for AUM-18. It is clear from the results that AUM-31 produced maximum grains per pod at D_1, D_2 and D_3 levels. AUM-18 showed no effects on all dose levels.

Seed yield per plant (g)

The genotypes showed sufficient range of variability for seed yield per plant. Mean value for seed yield per plant ranged from 4.22g to 7.61g. Maximum mean value was observed for AUM-31 followed by AUM-18 and Mung-04 while it remained low for genotype AUM-19. It was found from the results regarding seed yield per plant that coefficient of variability was 5.39%. Genotypic coefficient of variability and phenotypic coefficient of variability were 5.39% and 29.58% respectively (Table 11). Heritability estimate was highly (98.39%) with high genetic advance (4.425). The result are in agreement with Sing (2004), Neha *et al*. (2005), Sadiq (2005), Kapoor *et al*. (2005) Khan *et al*. (2005), Hakim *et al*. (2006), Idrees *et al*. (2006), Tadele *et al*. (2006), Sadiq *et al*. (2007), Gul *et al*. (2007), Khan and Goyal (2009), Jagadeesan *et al* (2008) and Gill *et al*. (2000) who reported high heritability. Regarding radiation doses, significantly maximum seed yield per plant (6.67g) was produced at D_1 which was statistically higher than D_2 and D_0 where as lowest seed yield per plant (4.91g) was produced by D_3.

Significant differences were observed for interaction of AUM-18 with AUM-31 and Mung-04. For dose level D_2, genotype AUM-31 (7.05) produced maximum seed yield per plant followed by AUM-18 (6.280g) AUM-19 (4.33g) whereas minimum (4.27g) was observed for Mung-04. There was significant interaction of AUM-18 with all others. At dose level D_1, genotype AUM-18 produced maximum (7.61g) seed yield per plant followed by AUM-31 (7.28g). At dose level D_2 AUM-31 gave maximum yield (7.05g) and minimum (4.30g) was observed for AUM-19 at D_3 (Table 8).

100-seed weight (g)

The genotypes showed sufficient range of variability for

Table 12. Estimation of pooled Genotypic (rg) and Phenotypic (rp) correlation coefficients for various character combinations

Traits		Plant height at first pod maturity	Plant height at 90% pod maturity	Clusters per plant	Branch per plant	Pods per plant	grins per pod	Biological yield	100- seed weight	Seed yield per plant
Emergence rate	R(g)	-0.387	-0.377	0.612	-0.226	-0.416	0.721	0.521	0.542	0.905
	R(p)	-0.388NS	-0.380NS	0.615NS	-0.260NS	-0.413NS	0.709*	0.461	0.481NS	0.886**
Plant height at first pod maturity	R(g)		0.999	-0.468		0.970	-0.888	-0.652	-0.671	-0.762
	R(p)		0.994**	-0.471NS	0.909	0.959**	-0.885**	0.664	-0.630NS	-0.752NS*
Plant height at 90% pod maturity	R(g)			-0.479	0.857**	0.970	-0.887	-0.651	-0.673	-0.752
	R(p)			-0.470NS		0.965**	-0.884**	0.620	-0.641NS	-0.750*
Clusters per plant	R(g)				0.926	-0.678	0.784	0.958	0.979	0.686
	R(p)				0.855**	-0.659*	0.766**	0.858	0.879**	0.653*
Branches per plant	R(g)					0.858**	-0.260NS	0.709*	-0.416	0.664
	R(p)						0.664	0.664	0.809	0.516
Pods per plant	R(g)						-0.934	-0.817	-0.838	-0.765
	R(p)						-0.930**	-0.791	-0.810*	-0.759*
grins per pod	R(g)							0.853	0.863	0.939
	R(p)							0.817**	0.838**	0.935**
Biological yield	r(g)								0.876**	0.970
	R(p)								0.961	0.859**
100- seed weight	R(g)									0.690
	R(p)									0.676*

*= Significant at 5% probability level, **=Highly Significant at 1% probability level
NS=Non Significant

100-seed weight. Mean value for 100-seed weight ranged from 6.32g to 5g. Maximum mean value was observed for AUM-31 followed by AUM-18, whereas minimum 100-seed weight was recorded for Mung-04. Coefficient of variability was 7.32%. Genotypic coefficient of variability and phenotypic coefficient of variability were 8.37% and 8.47%, respectively (Table 11). Heritability estimate was highly (92.52%) with low genetic advance (0.576). The result are in agreement with Arshad *et al.* (2004), Neha *et al.* (2005), Kapoor *et al.* (2005), Parimal and Chakraborti (2005) who reported high heritability. But not agree with Idrees *et al.* (2006) who reported high heritability with high genetic advance.

Significantly highest 100-seed weight (5.51g) was calculated at D_1 where as lowest 100-seed weight (5.03 g) was observed at dose level D_3 in response to different radiation treatments. Non significant differences were observed for interaction of AUM-31 with all others (Table 9). AUM-31 (6.32g) produced maximum100-seed weight followed by AUM-19 and Mung-04 (5.3g) whereas minimum (5.240g) by AUM-18 at D_1. For

For dose level D_2 genotypes AUM-18 (5.2g) produced maximum100-seed weight followed while AUM-19, AUM-31 and Mung-04 have got the same levels (5.31g). There was non significant interaction of AUM-18 with all others. At dose level D_3, genotype AUM-31 (5.33g) produced maximum100-seed weight followed by AUM-19 and Mung-04 (5.225g) whereas minimum (5.1g) was observed for AUM-18. There was non significant interaction of AUM-31 with all others. It is clear from the results that AUM-31 produced maximum100-seed weight at D_1 and D_3 level.

Biological yield (g)

The genotypes showed adequate range of variability for biological yield. Mean value for biological yield per plant ranged from 56.78 g to 92.06 g. Highest mean value was observed for AUM-31 followed by AUM-18 and Mung-04 whereas minimum biological yield per plant was recorded by AUM-19. Coefficient of variability was 4.57%. Genotypic coefficient of variability and phenotypic coefficient of variability were 25.85% and 25.82% respectively (Table 11). Heritability estimate was highly (93.68%) with high genetic advance (4.874). The results are in agreement with Gul *et al*. (2007), Khan and Goyal (2009), Jagadeesan *et al* (2008) and Gill *et al*. (2000) who reported high heritability. As regards radiation doses, significantly maximum biological (90.285g) was obtained at D_1 which was statistically at par with D_2 whereas minimum seed yield per plant (56.07g) was produced by AUM-18 at D_3.

Interaction effect of genotypes and radiation doses on number of biological yield per plant was found highly significant (Table 10). Mean values for biological yield per plant ranged from 60g to 90.6g. The interaction between genotypes and doses for seed yield per plant showed that AUM-31 (92.6g) produced maximum biological yield per plant followed by AUM-18 (89.28g) and Mung-04 (86.23g), where as minimum (56.07g) by AUM-18 at D_3. Significant differences were observed for interaction of AUM-31 with AUM-18 (Table 10). For dose level D_2, genotypes AUM-31 (90.05g) produced maximum biological yield per plant followed by AUM-18 (88.2g) and AUM-19 (67.3g), whereas minimum (60.27g) was observed for Mung-04. There was significant interaction of AUM-31 with all others. At dose level D_3, genotype AUM-31 (77.81g) produced maximum seed yield per plant followed by Mung-04 (77.430g) and AUM-19 (66.32g), whereas minimum (56.7g) was observed for AUM-18. There was significant interaction of AUM-31 with all others. It is clear from the results that AUM-31 produced maximum biological yield at D_2 and D_3 levels.

Correlations

The value of phenotypic and genotypic correlation provides the information about the relationship between the two or more than two independent variables. In plant breeding and genetics through correlation analysis the different traits can be valued. Pooled genotypic and phenotypic correlation coefficients are discussed below and values are given in Table 12.

The results in (Table 12) predict that the phenotypic correlation of emergence rate with plant height at first pod maturity, plant height at 90% pod maturity, pods per plant, Grains per pod is negative and non significant and positive and non significant phenotypic correlation with cluster per plant and 100-seed weight. However highly significant and positive phenotypic correlation was observed with seed yield per plant (0.886). Genotypic correlation ranged for this trait was (0.905 to -0.2263). High genotypic correlation of emergence rate was found with seed yield per plant however low correlation of emergence rate was observed with plant height at 90% pod maturity. The result shows that (Table 12) there exist a strong positive and highly significant phenotypic correlation of plant height at first pod maturity with plant height at 90% pod maturity and pods per plant. However negative and non-significant phenotypic correlation exists with cluster per plant, 100-seed weight and positive non-significant phenotypic correlation with pod length. Negative and highly significant phenotypic correlation was observed with seed per pod. Genotypic correlation range for this trait was (0.948 to- 0.2263). High genotypic correlation of plant height at first pod maturity was found with seed yield per plant however low correlation of plant height at first pod maturity was observed with plant height at 90% pod maturity. The results are agreement with Kumar *et al*. (2004) Tabasum *et al* (2010).

Plant height at 90% pod maturity had positive and highly significant phenotypic correlation with branches per plant, pods per plant and seeds per pod. However it had negative and non significant phenotypic correlations with clusters per plant and positive non significant phenotypic correlation with pod length, negative significant phenotypic correlation with seed yield per plant and 100 seed weight. Genotypic correlation ranged for this trait was (0.948 to -0.2263). High genotypic correlation of plant height at 90% pod maturity was found with seed yield per plant however low correlation of plant height at 90% pod maturity was observed with plant height at 90% pod maturity (Table 12). There exists a negative and significant phenotypic correlation for cluster per plant with pod per plant and seed yield per plant. However positive and highly significant phenotypic correlation was observed with seed per pod and 100-seed weight (Table 12). Genotypic correlation ranged for this trait was (0.97 to -0.887). High genotypic correlation of cluster per plant was found with 100-seed weight however low correlation of cluster per plant was observed with pods per plant. The results are agreed with Sadiq *et al*. (2005). The results given in Table 12 revealed negative and non significant phenotypic correlation of pods per plant with pod length. However it had negative and highly significant phenotypic correlation with seed per pod, negative and significant phenotypic correlation with 100 seed weight and seed yield per plant. Genotypic correlation ranged for this trait was (-0.1766 to -0.765). High genotypic correlation of pods per plant with was found pod length however low correlation of pods per plant was observed with seed yield per plant. The results are agreed with Kumar *et al*. (2004). Table 12 indicated negative and significant phenotypic correlation of branches per plant with cluster per plant, seed per pod and 100-seed weight. However it had positive and highly significant phenotypic correlations with pod per plant. It had negative and non significant phenotypic correlations with pod length and seed yield per plant. Genotypic correlation ranged for this trait was (0.9905 to -0.3872). High genotypic correlation of branches per plant was found with pods per plant however low correlation of branches per plant was observed with pod length. The results are disagreeing with Dhuppe *et al.* (2005). Table 12 revealed positive and highly significant phenotypic correlation of grain per pod with100-seed weight and seed yield per plant. Genotypic correlation ranged for this trait was (0.9388 to 0.863). High genotypic correlation of grain per pod was found with seed yield per plant however low correlation of grain per pod was observed with 100-seed weight. The results are not agreed with Gill *et al*. (2000) and Kumar *et al*. (2003). Table 12 shows that the biological yield has positive and significant phenotypic correlation with grins per pod and yield per plant. Genotypic correlation ranged for this trait was (0.81-0.96). High genotypic correlation of biological yield was found with seed yield per plant however low correlation of biological yield was observed with 100-seed weight. The results presented in Table 12 had positive and significant phenotypic correlation of 100-seed weight with seed yield per plant. Genotypic correlation ranged for 100-seed weight with seed yield per plant was 0.6763. The results are agree with Arshad *et al*. (2004).

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