QUANTITATIVE VARIABILITY, HERITABILITY AND GENETIC ADVANCE IN BLACK GRAM BY EFFECT OF MUTATION IN FIELD TRAIL

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SUMMARY

Genetic variation has led to an increasing the quantitative traits of crops. The variability on genome is induced by mutation, which enhances the productivity. We evaluated variability on quantitative characters such as, plant height, number of branches/plant, number of leaves/plant, number of fruit clusters/plant, number of pods/plant, number of seeds/pod, yield/plant and 100 seed weight of black gram in M2 generation by the effect of mutation by gamma rays. The results were showed high genetic variability, heritability and genetic advance with significant enhancement (P 0.05 and P 0.01) in growth and yield traits. Hence selection is effective for these traits could be possible through gamma rays. The speculation of effects of gamma rays on genome is that irradiation, induced addition, deletion in DNA pairs and also attributed large chromosomal rearrangement. The result were showed significant enhancement in yield and related traits. It indicates that improvement in quantitative traits would be possible through gamma rays.

1. Introduction

Black gram (*Vigna mungo* (L.) Hepper) is an important pulse crop occupying unique position in Indian agriculture. It is under cultivation in India is about 3.25 million hectares and an annual production is 1.45 million tons. National productivity of black gram is alarmingly remaining around 500 kg/ha [1]. The systematic collection of black gram is displayed inadequate variability for biotic and abiotic genes. It is possible that genes for high productivity could have been lost due to overriding role of natural selection [2] and the genetic base of the present day collection remains poor [3] due to lack of variability owing to its autogamaous nature. The creation of variability is difficult through hybridization due to its high self-pollination and flower drop [4]. Besides the major constrains in achieving higher yield of black gram is absence of suitable ideotypes for different cropping system, poor harvest index and susceptibility to disease [5]. In order to

improve yield and other polygenetic characters, mutation breeding can be effectively utilized [4]. Therefore, genetic variability is the basic requirement for making progress in crop breeding [6]. The objective of this study, using gamma rays on black gram was to create genetic variability to which improve the quantitative traits and to evaluate the genetic variation.

2. Materials and methods

Plant material

One variety of black gram (variety vamban-1) was chosen for the study to evaluate the genetic variation on quantitative characters in M_2 generation. The seeds were collected from Vamban, Tamilnadu, India.

Mutagen employed

One of the physical mutagen namely gamma rays were used to induce the genotypic variation on seeds. The seeds were irradiated at Sugarcane Breeding Institute (ICAR), Coimbatore, India and the source of gamma rays was labeled Cobalt (60Co).

Mutagenic treatment

Ten sets of three hundred well matured, non-dormancy seeds were taken for irradiation. The sets of seeds were packed in paper cover for irradiation and treated with 20, 40, 60, 80,100 and 120 kR of gamma rays. Healthy, well-matured, non-dormant, untreated seeds were used as control.

Experimental design

The irradiated and control seeds were grown for a year (2003-2004) at the Breeding field, Department of Botany, Annamalai University, Annamalainagar, TN, India.

M1 generation

The irradiated seeds along with control (untreated) were planted in a randomized complete block design (RBD) with three replications for treatment in 2003. The plots consisted of seven rows including control at 20 cm spacing, 4 m long and 1.5 m wide. The field was fertilized with organic fertilizer. Along with all the cultural practices such as irrigation, weeding and protection measures were taken throughout the growth period.

Harvest of M_1 and M_2 generation

At maturity (60th day) triplicates (30 plants/plot for each dose) of all doses with control plants were separately harvested and the following parameters were duly analyzed.

Eight traits associated with control were measured for each treatment, plant height, number of branches/plant, number of leaves/plant, number of fruit clusters/plant, number of pods/plant, number of seeds/pod, yield/plant (g), and 100 seed weight (g) The bulked seeds collected form each dose/control were saved and raised to M_2 generation were grown in suitable season for RBD with three replications. At maturity all the parameters were measured as M_1 generation.

Statistical analysis

Analysis of variance (Annova for RBD) was to use to analyze yield and its component traits calculated using the software NPRCSTAT, developed in National Pulse Research Center, Vamban, Pudukottai, TN, India. The variance observed among the replication was exclusively non-heritable and hence treated as environmental variance. The variance of M2 populations was partitioned into heritable and non-heritable components [7]. Phenotypic and genotypic coefficient of variation (PCV & GCV) was computed using the formula adopted by Burton [8] and categorized of the range of variation was done as proposed by Sivasubramanian and Madhavamenon [9]. Heritability (h2) was computed using the formula according to Lush [10] and it was classified according to

Robinson [11]. Genetic advance was estimated adopted the method suggested by Johnson et al [12]. The significance was assessed at the 5% and 1% probability level, unless otherwise stated.

3. Results

Quantitative traits mean performance

Among the different dose of gamma rays, a gradual increase of mean values was observed up to optimal dose when compared to control in M2 generation. Beyond the optimal dose of mutagen showed decreasing of mean values of quantitative traits (Table 1). Variability analysis showed an increase all the traits.

Table 1. Phenotypic growth habit (Quantitative traits) mean values of different dose of gamma rays and control in M_2 generation

Quantitative traits	Control	40 kR	60 kR	80 kR
Plant height	50.38±4.54	51.89±4.59	54.37±3.22	49.81±3.82
No. of branches/plant	4.21±0.14	4.38±0.38	4.74±0.37	3.24±0.24
No. of leaves/plant	26.13±2.18	27.74±2.41	28.56±1.77	24.91±1.81
No. of clusters/plant	14.87±0.88	15.96±0.64	17.67±1.12	12.91±0.79
No. of pods/plant	28.29±2.87	29.42±1.87	32.71±2.88	30.28±1.96
No. of seeds/pod	8.42±0.81	8.62±0.58	9.01±0.36	8.22±0.66
Seed yield/plant (g)	7.59±0.08	7.82±0.05	8.35±0.09	6.45±0.07
100 seed weight (g)	4.834±0.41	4.952±0.36	5.111±0.46	4.638±0.28

SE 0.9843   SED 1.6121   (P= 0.05) 0.3722   (P=0.01) 0.4898

Mean performance of growth habit and yield traits

The analysis of variance (ANOVA) revealed the significance degree among the treatment and control. The wide range of variation was recorded at 60 kR gamma rays for plant height (54.37±3.22; C-50.38±4.54), number of branches/plant (4.74±0.37; C-4.21±0.14), number of leaves/plant (28.56±1.77; C-26.13±2.18), number of fruit clusters/plant (17.67±1.12; c-14.87±0.88), number of

pods/plant (32.71±2.88; C-28.29±2.87), number of seed/pod (9.01±0.36; C- 8.42±0.18), yield/plant (8.35±0.09; C-7.59±0.08) and 100 seed weight (5.111±0.46; C- 4.834±0.41). The mean performance was significantly different from control. The significant values were P-0.05 and P-0.01.

Phenotypic and genotypic coefficient of variation of quantitative traits (PCV & GCV)

The success of breeder in selecting genotypes possessing higher yield and growth traits depends largely on the existence and exploitation of genetic variability of the fullest extent. The estimates of range, phenotypic and genotypic coefficient of variability was presented in Table 2.

Table 2. Phenotypic and genotypic coefficient variation of quantitative traits of black gram induced by gamma rays in M_2 generation

Quantitative traits	40 kR		60 kR		80 kR	
	PCV	GCV	PCV	GCV	PCV	GCV
Plant height	19.67	19.21	31.69	30.67	14.28	12.46
No. of branches/plant	20.69	20.18	27.15	23.36	19.73	18.16
No. of leaves/plant	19.69	17.55	30.82	30.12	18.66	16.22
No. of clusters/plant	12.33	10.69	38.69	36.71	19.71	15.85
No. of pods/plant	20.44	19.26	36.69	38.15	32.17	30.92
No. of seeds/pod	19.46	18.38	24.44	20.66	17.31	15.57
Seed yield/plant	18.24	16.89	25.66	24.68	14.11	17.39
100 seed weight	21.66	20.15	22.50	20.42	19.16	17.16

The phenotypic and genotypic coefficient of variation expressed in terms of per cent were comparatively high at 60 kR of gamma rays for plant height (31.69; 30.67), branches/plant (27.15; 23.36), leaves/plant (30.82; 30.12), cluster/plant (38.69; 36.71), pods/plant (39.69; 38.15), seeds/pod (24.44; 20.66), yield/plant (25.66; 24.68) and 100 seed weight (22.50; 20.42). The PCV and GCV values were significant atP-0.05 and P-0.01 level, which positively correlated with their mean values of quantitative traits (Table 1).

Heritability, (h2), genetic advance (GA%) as percent of mean of quantitative traits

The wide range of variability was exhibited by heritability and genetic advance as percent of mean. The heritability and GA as percent of mean were high almost all dose of gamma ray treatment (Table 3). However, 60 kR of gamma rays revealed highest values of heritability with genetic advance as percent of mean for plant height (89.16; 60.20), branches/plant (76.61; 74.05), leaves/plant (35.11; 37.88), cluster/plant (86.16; 37.69), pods/plant (95.31; 31.58), seeds/pod (53.76; 50.16), yield/plant (75.45; 66.82) and 100 seed weight (77.19; 84.52).

Table 3. Heritability (h2) and genetic advance as % of mean of quantitative traits of black gram induced by gamma rays in M_2 generation

Quantitative traits	40 kR		60 kR		80 kR	
	h²	GA %	h²	GA %	h²	GA %
Plant height	24.54	48.80	89.16	60.20	62.30	43.27
No. of branches/plant	25.39	36.98	76.61	74.05	52.32	62.22
No. of leaves/plant	16.33	17.77	35.11	37.88	26.28	22.66
No. of clusters/plant	29.39	33.58	86.16	37.69	30.13	32.99
No. of pods/plant	76.23	29.52	95.31	31.58	71.56	22.91
No. of seeds/pod	40.16	38.63	53.76	50.16	29.77	27.00
Seed yield/plant	26.37	15.25	75.45	66.82	40.21	14.12
100 seed weight	22.38	49.47	77.19	84.52	52.26	46.14

4. Discussion

Effect of gamma rays on quantitative mean performance

Plant breeding along with advances in agronomic and production practices, has played a major role in the advances grain yield per hectare over the past 50 years [13]. The wider range of variation was observed for all the quantitative traits (Table 1). It suggested the presence of enough variation for these characters to exploit the variability. Similar variation was recorded in barley for plant height, number of kernels per spike and spike length [14]. The highest mean values for plant height and branches per plant were recorded in chilli [15]. Plant height has been shown to be an important trait for predicting the competitive ability of wheat cultivars [16-17]. The study shown plant height and other growth traits increased than control plant due to effect of mutagen on genome may induce genetic variability. Improved quantitative traits namely plant height, number of branches/plant, 100 seed weight and plant yield with effect of EMS and gamma rays in M_2 generation of Chick pea [18]. Positive shift than control in plant height, number of branches/plant, number of clusters/plant, number of pods/plant and number of seeds/pod with effect of gamma rays in M_2 generation [19]. Quantitative traits such as plant height, peduncles/plant, pods/plant, 1000 seed weight and seeds/pod were increased than control with effect of EMS and gamma rays recorded in M2 generation of cowpea. [20].

Effect of gamma rays on Phenotypic and genotypic coefficient variation (PCV and GCV)

The estimates of range, phenotypic and genotypic coefficient of variation for all the quantitative traits was presented in table-2. The PCV and GCV expressed in terms of percent points were comparatively high at 60 kR gamma rays for plant height, branches/plant, leaves/plant, clusters/plant, pods/plant, seeds/pod, yield/plant (g) and 100 seed weight (g). This closer magnitude suggested that greater role of variability due to the induction of gamma rays at genetic level. The PCV and GCV were high at all the quantitative traits including yield in sorghum bicolor and these characters having possessed

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better potential for crop improvement [21]. The maximum GCV was present for the grain yield/plant indicates that simple selection for yield may be advantageous as compared to its components under study. Several characters viz., number of pods/plant, number of seeds/pod and 100 grain weight showed high degree of GCV recorded in pea [22] it is agreed with present study and providing sufficient scope to bring an important in these characters through phenotypic selection.

Effect of gamma rays on heritability and genetic advance as percent of mean (h2 and GA %)

The estimate of heritability acts as a predictive instrument in expressing the reliability of phenotypic values. Therefore, it helps the plant breeders to make selection for a particular character when heritability is high in magnitude [21]. The study revealed high heritability with high genetic advance as percent of mean in all the quantitative traits at 60 kR of gamma rays ion M_2 generation. High heritability accompanied with high genetic advance indicates preponderance of additive gene action in such cases selection may be effective [21]. High heritability for plant height, seed cotton yield /plant, number of bills/plant, number of sympodia/plant and average boll weight recorded in F_3 generation of cotton [23]. It indicated that predominance of additive gene action. Similarly results observed on heritability estimates for number of seeds/pod, days to flowering, yield/plant, 100 grain weight, number of pods/plant and harvest index in pea [22]. This growth and yield traits were significant at 60 kR of gamma ray treatment when compared to control and other dose. The variability analysis such as phenotypic and genotypic coefficient of variation, heritability and genetic advance showed at 60 kR than 40 and 80 kR of gamma ray treatment. It could be regarded as an indication of additive gene action due to gamma ray treatment [24]. Gamma rays induced addition and deletion of base pairs of DNA mutation in black gram mutants when compared to parent [5]. This could be attributed to large chromosomal rearrangement due to radiation [25].

Conclusion

From the present investigation it is evident that the wide range of variability for different traits coupled with high heritability and high genetic advance for important yield traits hence selection is effective for these traits. Hence, gamma ray played a pivotal role in crop breeding through mutation. This stability of genetic variability should be analyzed next generation and genes for important traits should be cloned and used in transgenic technique of black gram.

Acknowledgement

References

1. Pawar, S.E. 2001. Impact of mutant varieties of black gram in releasing important productivity. Mut. Breed. Newsl., 45: 7-9.

2. Roopalakshmi, K., Kajjidoni, S.T. and S.M. Salimath, 2003. Effect of irradiation and matting schemes on native of association of seed yield and its components in black gram. Legume Res., 4: 288-291.

3. Delannay, X., D.M. Rodgers and R.G. Plamer, 1983. Relative genetic contribution among ancestral lines to North America soybean cultivars. Crop Sci., 23: 944-949.

4. Deepalakshmi, A.J., and C.K. Anandakumar, 2004. Creation of genetic variability for different polygenic traits in black gram (*Vigna*

mungo (L.) Hepper) through induced mutagenesis. Legume Res., 3: 188-192.

5. Souframanien, J. and T. Goplalakrishnan, 2004. A comparative analysis of genetic diversity of black gram genotype using RAPD and ISSR markers. Theor. Appl. Genet., 109: 1687-1693.

6. Appalaswamy, A. and G.L.K. Reddy, 2004. Genetic divergence and heterosis studies of mungbean (*Vigna radiata* (L.) Wilczek). Legume Res., 21: 115-118.

7. Mather, K., and J.L. Jinks, 1971. Biomaterial genetics. Chapman and Hall Ltd. London.

8. Burton, G.W., 1952. Quantitative inheritance in grasses. proc Intern Grassland Cong. 1: 277-283.

9. Sivasubramanian, S. and P. Madhavamenon, 1978. Genotypic and phenotypic variability in rice. Madras Agric. J., 60: 1093-1096.

10. Lush, J.L., 1940. Intrusive collection of regression of offspring on dams asa method of estimating heritability of characters. Proc. Amer. Soc. Animal Prod., 33: 293-301.

11. Robinson, H.F., 1966. Quantitative genetics in relation to breeding of the centennial of mendalism. Indian J. Genet., 26: 171-187.

12. Johnson, H.W., H.F. Robinson, and R.E. Comstock, 1955. Estimation of genetic and environmental variability in soybean. Agron. J., 47: 314-318.

13. Borlaug, N.E., 1983. Contributions of conventional plant breeding to food production. Science., 219: 689-693.

14. Oritz, R., S.F. Mohamad, S.F. Madsen, J. Weibull, and J.L. Christiansen, 2001. Assessment of phenotypic variation in winter barley. Acta Agric. Scandinavia., Soil and Plant Sci., 51: 151-159.

15. Yadwad, A., O. Sridevi, and P.M. Salimath, 2008. Genetic variability in segregating progenies of chilli (*Capsicum annum* L.). Intern. J. Plant Sci., 3: 206-210.

16. Balyon, R.S., R.K. Mali, R.S. Panwar, and S. Singh, 1991. Competitive ability of winter wheat cultivars with wild oat (*Avena ludoviciana*). Weed Sci., 39: 154-158.

17. Wicks, G., P.T. Nordquist, P.S. Baensiger, R.N. Klein, R.H. Hammons, and J.E. Watkins, 2004. Winter wheat cultivar characteristics affect annual weed suppression. Weed Technol., 18: 988-998.

18. Wani, A. and M. Anis, 2004. Spectrum and frequency of chlorophyll mutation induced by gamma rays and EMS in *Cicer arietinum* L. J. Cytol. Genet., 5: 143-147.

19. Koteswara Rao Y., N. Sree Rama Reddy and D. Subramanyam, 1983. Effect of induced mutagenesis on polygenic variability in green gram. The Andhra Agric. J., 3: 200-202.

20. Odeigah P.G.C., A.O. Osanyinpeju and G.O. Myers, 1998. Induced mutations in cowpea (*Vigna unguiculata*). Rev. Biol. Trop. 3: 579-586.

21. Unche, P.B., M.B. Misal, S.B. Borgaonkar, G.V.Godhawale, B.D. Chavan and D.R. Sawant, 2008. Genetic variability studies in sweet sorghum (*Sorghum bicolor* L. Moench). Intern. J. Plant Sci., 1: 16-18.

22. Kumar, K., 2008. Variability, heritability and genetic advance in pea. (*Pisum sativum* L.). Intern. J. Plant Sci., 1: 211-212.

23. Kalpande, H.V., S.D. Bhale, V.V. Kale, J.D. Deshmukh, V.K. Gite and S.S. Kakde, 2008. Genetic variability and correlation studies in F_2 generation of cotton (*Gossypium hirsutum* L.). Intern. J. Plant Sci., 1: 94-97.

24. Sreelathakumary, I. and L. Rajamony, 2004. Variability, heritability and genetic advance in chilli (*Capsicum annum* L.). J. Trop. Agric., 2: 35-37.

25. Anjali B., T.G. Krishna and C.R. Bhatia, 1997. RAPD Aanalysis of induced mutants of groundnut (*Arachis hypogea* L.). J. Genet., 76: 201-208.