SciMedCentral

International Journal of Plant Biology & Research

Research Article

Variability, Heritability and Genetic Advance of Quantitative Traits in Sugar Beet (*Beta vulgaris* L.) by Effect of Mutation

R. K. Ganapati[1]*, R. Rani[2], K. M. R. Karim[1], R. K. Roy [3], M. M. Rahman[1] and M. R.Alam[1]

[1]*Breeding Division, Bangladesh Sugarcane Research Institute, Bangladesh*
[2]*Department of Zoology, B M College, Bangladesh*
[3]*Biotechnology Division, Bangladesh Rice Research Institute, Bangladesh*

***Corresponding author**

R. K. Ganapati, Breeding Division, Bangladesh Sugarcane Research Institute, Ishwardi, Pabna, Bangladesh. E-mail: rkganapati@hotmail.com

Submitted: 02 June 2015

Accepted: 07 October 2015

Published: 09 October 2015

ISSN: 2333-6668

Keywords

- *Beta vulgaris* L
- Quantitative trait
- Variability
- Genetic advance
- Brix percent

Abstract

Variation in genetic constituent leads to increasing phenotypic expression of the quantitative characters of individuals. This variation is induced by mutation and the variability was evaluated on the quantitative traits such as, days to germination, percent germination, root length, brix percent and yield of sugarbeet mutant at M1 generation by the effect of radiation. The results were showed higher genetic variability, heritability, genetic advance with significant uplift in yield and the related ones. Hence selection is effective considering these traits from a gamma ray irradiated population. The gamma rays irradiation induced addition-deletion in DNA pairs and also reshuffle chromosomal component. The results were showed significant enhancement in yield and related traits. It indicates that improvement in quantitative traits would be possible through gamma rays irradiation.

INTRODUCTION

Sugar beet (*Beta vulgaris*L.) is grown worldwide and produces one-third of the world's sugar supply [1]. Tropical sugar beet is now a prospective sugar crop in tropical area and being extended in agriculture of Bangladesh. Being a short durated one it will make space smoothly in farmer's field without a competition of other sugar crops specially sugarcane. The productivity of sugar beet is 60tha^{-1} [2]. The systematic collection of sugar beet 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 [3] and the genetic base of the present day collection remains poor [4] due to lack of variability owing to its autogamaous nature. The creation of variability is difficult through hybridization as the congenial environment is not available in here [5]. Besides the major constraints in achieving higher yield of sugarbeet is absence of suitable ideo types for different cropping system, poor harvest index and susceptibility to disease [5]. Therefore, genetic variability is the basic requirement for making progress in crop breeding [6]. The objective of this study, using gamma rays on sugar beet was to create genetic variability to which improve the quantitative traits and to evaluate the genetic variation.

MATERIALS AND METHODS

Plant materials

Eleven hybrid varieties of Sugarbeet were chosen for the study to evaluate the genetic variation on quantitative characters in M1 generation. The seeds were collected from Sugarbeet Pilot Project, Bangladesh Sugarcane Research Institute, Bangladesh.

Mutagen employed

Gamma rays the physical mutagen were used on seeds to induce the genotypic variation. The seeds were irradiated at Bangladesh Atomic Energy Commission (BAEC), Savar, Bangladesh and the source of gamma rays was labeled Cobalt (60^{o}C).

Mutagenic treatment

Three sets eleven genotypes each of one hundred well matured, non-dormant seeds were taken for irradiation. The sets of seeds were packed in paper cover for irradiation and treated with 2kR, 3 kR and 4 kR of gamma rays. Healthy, well-matured, non-dormant, untreated seeds were used as control.

Experimental design

The irradiated and non-irradiated seeds were grown for a year (2013-2014) at the Breeding field, Division of Breeding, Bangladesh Sugarcane Research Institute, Ishwardi, Bangladesh.

Statistical analysis

Analysis of variance (Annova for RBD) was used to analyze yield and its component traits calculated using the software Statistix 10. The variance observed among the replication was exclusively non-heritable and hence treated as environmental variance. The variance of M1 populations was partitioned into heritable and non-heritable components by Mather and Jinks [7]. Genotypic and phenotypic coefficient of variation (GCV & PCV) was computed using the formula [8] and categorization of variation was done by the method [9]. Heritability (h2) was computed [10] and classified [11]. Genetic advance was estimated adopting the suggested method [12]. The significance was assessed at the 5% and 1% probability level, unless otherwise stated.

RESULTS

Mean performance of Quantitative traits

At different intensity of gamma rays, a gradual increase of mean values was observed up to optimal dose when compared to control in M1 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.

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 3 kR gamma rays for days to germination (4.76±2.660; N-5.30±0.703), percent germination (80.67±0.767; N-77.48±0.176), root length (24.64±0.962; N -18.67±4.624), brix percent (19.46±12.755; N-19.39±1.450), yield (t/ha) (57.79±7.670; N-56.58±2.654). The mean performance was significantly different from control.

Genotypic and phenotypic coefficient of variation of quantitative traits (GCV &PCV)

Breeder success 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.

The phenotypic and genotypic coefficient of variation expressed in terms of per cent were comparatively high at 3 kR of gamma rays for for days to germination (39.38; 41.98), percent germination (30.30; 30.45), root length (51.74; 143.69), brix percent (08.76; 09.66), yield(t/ha) (31.48; 33.19). The GCV and PCV values were statistically significant atP-0.05 and P-0.01 level, which positively correlated with their mean values of quantitative traits (Table 1).

Heritability, (h_2), genetic advance (GA%) as percent of mean of quantitative traits

A wide 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, 3 kR of gamma rays revealed highest values of heritability with genetic advance as percent of mean for days to germination (0.88; 271.81), percent germination (0.99; 15.33), brix percent (0.82; 31.42) and yield (t/ha) (0.90; 21.72) except root length.

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

Table 1: Phenotypic growth habit (Quantitative traits) mean values of different dose of gamma rays and control in M1 generation.

Quant. Trait	non-irradiated	2kR	3 kR	4 kR
Days to germination	05.30±0.703	04.81±1.890	04.76±2.660	05.15±0.719
Germination	77.48±0.176	73.73±1.48	80.67±0.767	72.79±1.410
Root Length	18.67±4.624	17.32±3.879	24.64 ± 0.962	18.05±0.540
Brix Percent	19.39±1.450	19.36±5.197	19.46±12.755	18.30±1.392
Yield	56.58±2.654	47.36±2.595	57.79±7.670	45.03±1.443

Table 2: Phenotypic and genotypic coefficient variation of quantitative traits of sugar beet induced by gamma rays in M1 generation.

Quant. Trait	non-irradiated		2kR		3 kR		4 kR	
	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV
Days to Germination	19.89	24.39	29.02	32.07	39.38	41.98	25.35	33.69
Germination	26.84	26.99	22.93	23.08	30.30	30.45	30.24	30.38
Root Length	23.57	23.88	19.52	20.13	51.74	143.69	16.30	18.87
Brix Percent	6.14	7.72	07.90	09.49	08.76	09.66	07.71	13.51
Yield	27.78	29.46	14.71	19.51	31.48	33.19	15.38	19.59

Table 3: Heritability (h2) and genetic advance as % of mean of quantitative traits of sugar beet induced by gamma rays in M1generation.

Quant. Trait	non-irradiated		2 kR		3 kR		4kR	
	h2	GA%	h2	GA%	h2	GA%	h2	GA%
Days to Germination	0.66	156.60	0.82	221.85	0.88	271.81	0.57	174.76
Germination	0.99	13.73	0.99	12.19	0.99	15.33	0.99	15.52
Root Length	0.97	53.24	0.94	51.73	0.13	36.08	0.75	42.83
Brix Percent	0.63	23.47	0.69	27.27	0.82	31.42	0.33	23.61
Yield	0.89	18.63	0.57	14.48	0.90	21.72	0.62	15.90

yield 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 root length were recorded in radish [15]. 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 M2 generation of Chick pea [16]. 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 M2 generation [17]. 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 M1 generation of cowpea [18].

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

The estimates of range, phenotypic and genotypic coefficient of variation for all the quantitative traits was presented in table 2. The GCV and PCV expressed in terms of percent points were comparatively high at 3 kR gamma rays for days to maturity, percent germination, root length, brix percent and yield. This closer magnitude suggested that greater role of variability due to the induction of gamma rays at genetic level. The GCV and PCV were high at all the quantitative traits including yield in sorghum bicolor and these characters having possessedbetter potential for crop improvement [19]. 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., plant height, root length, root diameter showed high degree of GCV recorded in radish [20]which 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 [19]. The study revealed high heritability with high genetic advance as percent of mean in all the quantitative traits except root length at 3 kR of gamma rays ion M1 generation. High heritability accompanied with high genetic advance indicates preponderance of additive gene action in such cases selection may be effective [19]. It indicated that predominance of additive gene action. Similarly results observed on heritability estimates for days to germination, root length, plant height, root diameter and harvest index in radish [20]. In case of root length the mean performance is higher at 3 kR radiation compare to control and others having poor heritability and genetic advance indicate that this may be due to dominant gene action or due to epistatic effect, similar results were obtained [21]. This growth and yield traits were significant at 3 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 3kR than 2kR and 4kR of gamma ray treatment. It could be regarded as an indication of additive gene action due to gamma ray treatment [22]. 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 [23].

CONCLUSION

From the 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 except root length. Further study on gene action is needed for recommendation of selection of root length as yield contributing quantitative trait. 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 sugar beet.

REFERENCES

1. Draycott AP. Introduction In: Draycott AP, ed. Sugar Beet. Oxford, UK: Blackwell Publishing Ltd, 2006; 1–8.

2. Islam MS, Ahmad S, Uddin MN, Sattar M A. Evaluation of Tropical Sugar beet (Beta vulgaris L). Genotypes under Bangladesh Condition. Bangladesh J Agril. Res. 2012; 37: 721-728.

3. Roopalakshmi K, Kajjidoni ST, Salimath SM. Effect of irradiation and matting schemes on native of association of yield and its components in black gram. Legume Res. 2003; 4: 288-291.

4. Delannay X, Rodgers DM, Plamer RG. Relative genetic contribution among ancestral lines to North America soybean cultivars. Crop Sci. 1983; 23: 944-949.

5. Deepalakshmi AJ, Anandakumar CK. Creation of genetic variability for different polygenic traits in black gram (Vignamungo(L.) Hepper)

through induced mutagenesis. Legume Res. 2004; 3: 188-192.

6. Appalaswamy A, Reddy GLK. Genetic divergence and heterosis studies of mungbean (Vignaradiata (L.) Wilczek). Legume Res. 2004; 21: 115-118.

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

8. Burton GW. Quantitative inheritance in grasses. Proc Intern Grassland Cong. 1952; 1: 277-283.

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

10. Lush JL. Intrusive collection of regression of offspring on damsasa method of estimating heritability of characters. Proc. Amer. Soc. Animal Prod. 1940; 33: 293-301.

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

12. Johnson HW, Robinson HF, Comstock RE. Estimation of genetic and environmental variability in soybean. Agron J. 1955; 47: 314-318.

13. Borlaug NE. Contributions of conventional plant breeding to food production. Science. 1983; 219: 689-693.

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

15. Ullah MZ, Hasan MJ, Rahman AHMA, Saki AI. Genetic Variability, Character Association and Path Coefficient Analysis in Radish (Raphanussativus L.). The Agriculturists. 2010; 8: 22-27.

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

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

18. Odeigah PGC, Osanyinpeju AO, Myers GO. Induced mutations in cowpea (Vigna unguiculata). Rev Biol Trop. 1998; 3: 579-586.

19. Unche PB, Misal MB, Borgaonkar SB, Godhawale GV, Chavan BD, Sawant DR. Genetic variability studies in sweet sorghum (Sorghum bicolor L.Moench). Intern J Plant Sci. 2008; 1: 16-18.

20. Kumar K. Variability, heritability and genetic advance in raddish (Raphanussativus L.). Intern J Plant Sci. 2008; 1: 211-212.

21. Mohamed MA, Harris PJ, Henderson J. In vitro selection and characterisation of a drought tolerant clone of Tagetes minuta. Plant Sci. 2000; 159: 213-222.

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

23. Anjali B, Krishna TG, Bhatia CR. RAPD Aanalysis of induced mutants of groundnut (Arachis hypogea L.). J Genet. 1997; 76: 201-208.

Cite this article

Ganapati RK, Rani R, Karim KMR, Roy RK, Rahman MM et al. (2015) Variability, Heritability and Genetic Advance of Quantitative Traits in Sugar Beet (Beta vulgaris L.) by Effect of Mutation. Int J Plant Biol Res 3(4): 1046.