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Study on Genetic Variability and Heterosis in Potato

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Abstract: Genetic variability and heterosis for eight quantitative traits were evaluated in seven parents and ten hybrids. The hybrids were derived from a 5×2 line × tester mating design. In general high component of variation and coefficient of variability were observed for most of the characters. The highest component of variation, coefficient of variability and heritability were noticed in PW, TW 60 and TN 60. Characters those with high genetic variability and genetic advance were considered to be important for selecting the desirable parents. Heterosis was worked out over mid parent, better parent and standard parent. Combinations AU/13, LP/13, PT/13 and LS/13 for PH; combination PT/13 and LP/13 for TN 60 were significant for mid parent, better parent and standard parent heterosis. The best heterotic combinations for TW 60 were LP/13, LS/13 and LSB/13 which recorded 990.28, 1115.28 and 648.61% standard heterosis respectively and can be utilized for hybrid development.

Key words: Genetic variability, heterosis, potato

INTRODUCTION

Potatoes (*Solanum tuberosum* L.) have become an increasingly important crop in Bangladesh. It is most productive, common and multiuse horticultural vegetable crop. It is a short duration crop that produces a large amount of calories in a short period of time[1]. Heterosis can be expressed when the parents of a hybrid have different alleles at a locus and there is some level of dominance among those alleles[2]. There has been extensive debate concerning the relationship between level of dominance and expression of heterosis. Two major hypotheses have been proposed to explain the genetic basis of heterosis: dominance hypothesis[3] and over dominance hypothesis[4,5]. According to the dominance hypothesis; heterosis is caused by complete or partial dominance. In the over dominance hypothesis, the value of the heterozygote is considered superior to the value of either homozygote. This has been proved in traits controlled by single or few genes. Heterozygotes perform a given function, over a range of environments, more efficiently than either homozygotes[5]. Studies on genetic basis of heterosis for polygenic traits in various crops have shown that heterosis is the result of partial to complete dominance, over dominance and epistasis and may be a combination of all these[6]. Heterosis or hybrid vigor is manifested as an improved performance for F_1 hybrid generated by crossing two inbred parents. Moll and Stuber[7] reported that any combination among generally diverse parents could give hybrids vigor over the parents which might be due to favourable dominant genes, over-dominance or epistatic action of genes. Heterosis can be quantitatively defined as an upward deviation of the mid-parent, based on the average of the values of the two parents[8]. Both positive and negative heterosis is useful in crop improvement, depending on the breeding objectives. In general, positive heterosis is desired for yield and negative heterosis for earliness. Heterosis expressed in three ways, depending on the reference, which is used to compare the performance of a hybrid. The three ways are: mid parent, standard variety and better parent heterosis. From the practical point of view, standard heterosis is the most important because it is desired to develop hybrids, which are better than the existing high yielding varieties grown commercially by farmers.

MATERIALS AND METHODS

In the present study, seven parents and their ten hybrids of potato seeds tuber were used. The materials (tubers) were collected from Breeders Seed Production

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Centre, Bangladesh Agricultural Research Institute, Debiganj, Panchagarh. Potato seeds were shown in the field following Randomized Block Design with three replications during October, 2001 in the research field of the Department of Botany in Rajshahi University, Bangladesh. A spacing of 60 and 30 cm between rows and within the rows, respectively was maintained. Each of the crosses and the parents were planted in a single row plots, having 40 seeds/replication. Recommended agronomic practices were followed to raise the crop under irrigated conditions. Observations were recorded for different characters, such as Plant Height (PH), Number of Leaf per plant (NL), number of branches per plant (BN), tuber number at 60 days after planting (TN60), tuber number at 90 days after planting (TN90), tuber weight at 60 days after planting (TW60), tuber weight at 90 days after planting (TW90), Plant Weight (PW). Genotypic Variance (GV), Phenotypic Variance (PV), Environmental Variance (EV), Genotypic Coefficient of Variances (GCV), Phenotypic Coefficient of Variances (PCV), Environmental Coefficient of Variances (ECV) were calculated according to Burton and Devane[9]. Broad sense heritability estimates and genetic gain were calculated by Hanson *et al.*[10] and Johnson *et al.*[11], respectively. The heterosis was calculated in terms of difference of F_1 from Mid Parent (MP), Standard Variety (ST), Better Parents (BP) and was expressed as percentage increase or decrease over to MP, ST and BP. The level of heterosis was tested using student 't' test. Measurement of heterosis is quite simple. It is generally expressed as percent increase or decrease in the performance of a hybrid in comparison with the reference variety or a parent[12].

$$\text{Mid parent heterosis (\%)} = \frac{F_1\text{- Mid parent}}{\text{Mid parent}} \times 100$$

$$\text{Better parent heterosis (\%)} = \frac{F_1\text{- Better parent}}{\text{Better parent}} \times 100$$

$$\text{Standard heterosis (\%)} = \frac{F_1\text{- Check Variety}}{\text{Check Variety}} \times 100$$

RESULTS AND DISCUSSION

The analysis of variance shows (Table 1) that all the genotypes were significantly different for most of the characters except pH, which indicates that a real difference existed among the varieties. Lines were significant for four characters viz., tuber number at 60 days after planting (DAP), tuber weight at 60 DAP, tuber weight at 90 DAP and plant weight. On the other hand testers were significant for two characters viz., tuber number at 60 DAP and tuber weight at 60 DAP. The mean squares due to male versus female was highly significant for TW60, TN 90 and PW, indicating a wide range of variation within the male and female parents. Similarly, mean square values due to parents versus hybrids were significant for NL, BN, TN 90 TW 60, TW 90 and PW, suggesting that there were high heterotic responses for these traits.

In the present study, the highest genotypic variance was found in TW 90 and the highest phenotypic variance was found in TW 60 (Table 2). Large genotypic value is always helpful for effective selection. Phenotypic coefficient of variability was greater than genotypic and environmental coefficient of variability. The highest Genetic Coefficient of Variation (GCV) indicated that the characters were inherited with genetic variability. The equal or nearly genotypic and phenotypic variation for the characters supports this view. In the present study, the difference between genotypic and phenotypic coefficient of variation were higher for TW 60, PH and NB 90 indicates that these characters were greatly influenced by the environment. The narrow difference between the phenotypic and genotypic components of variation for most of the characters revealed that the major portion of the phenotypic variance were genetic in nature. This finding is in agreement with Singh *et al.*[13]. Similar results were also reported by Rahman *et al.*[14], Alam *et al.*[15] and Biswas[16]. High broad sense heritability (H^2b) along with high genetic advance is usually more helpful in predicting the resultant effect for selection of the best individuals than heritability alone[11]. In present study, high heritability for PW, TN 90, TW 90 were associated with high GA, indicating the presence of additive gene effects in controlling these characters. High habitability with high genetic advance suggested that heritability was due to additive gene effect[17]. However, high heritability does not always give high genetic advance[11,18]. Low genetic advance and high heritability were found for yield contributing characters such as, TN 60, TN 90, which indicated that effective selection of this character may likely improve yield[19].

Amongst the characters studied comparatively high genetic coefficient of variation, high heritability value and high genetic advance were recorded for the characters PW, TW 60 and TN 60 which suggests that these characters are under control of additive gene effects.

Heterosis was calculated as percent increase or decrease over mid-parents, corresponding better parent

Table 1: Mean square from the combined analysis of variance for eight characters in seventeen genotypes of potato

Source	df	pH (Cm)	NL	BN	TN 60	TN 90	TW 60 (gm)	TW 90(gm)	PW(gm)
Replication	2	2.303	198.283*	0.608	5.961	24.712	151.257	5.231	563.379**
Genotypes	16	36.315	156.999***	0.728*	17.417***	117.648***	5522.255***	7120.089***	715.857***
Parents	6	51.005	174.441**	0.741	25.072***	262.956***	10867.949***	14469.511***	10058.282***
P Vs C	1	114.853	1057.856***	4.447***	7.412	218.400***	1918.889***	4088.934**	10180.622***
Crosses	9	17.795	45.276	0.306	13.426***	9.581	2358.833***	2557.269***	547.044***
Line	4	17.765	52.398	0.235	18.957***	19.830	1914.791***	1536.615*	534.728**
Tester	1	48.981	26.133	0.133	31.348**	0.626	7384.237***	4.800	38.533
Line ×Tester	4	10.028	42.939	0.420	3.413	1.570	1546.524***	4216.041***	686.487***
Error	32	42.321	48.137	0.330	2.646	11.425	115.586	504.428	99.335

*, **, *** Significant at 5, 1 and 0.1% level, respectively

Table 2: Estimation of genetic parameters of eight characters in seventeen genotypes of potato

Character	GV	PV	EV	GCV	PCV	ECV	Heritability	GA	GA% of mean
PH	2.002	42.321	40.319	4.805	21.565	22.094	4.731	0.634	2.153
NL	36.287	84.425	48.137	15.656	23.880	18.032	42.981	8.136	21.144
NB	0.133	0.463	0.330	13.758	25.697	21.704	28.663	0.402	15.173
TN60	4.924	7.570	2.646	24.495	30.372	17.956	65.045	3.687	40.696
TN 90	35.407	46.833	11.425	45.430	52.248	25.806	75.603	10.658	81.373
TW 60	1696.967	4406.099	2709.132	72.072	116.134	91.064	38.532	52.664	92.139
TW 90	2205.220	2709.648	504.428	33.762	37.424	16.147	81.384	87.270	62.743
PW	1538.841	1638.176	99.335	45.345	46.786	11.521	93.936	78.321	90.535

Table 3: Mid parent heterosis (MPH), standard heterosis (STH) and better parent heterosis (BPH) of ten hybrids for eight characters in potato

Character		LS/67	PT/67	LP/67	LSB/67	AU/67	AU/13	PT/13	LS/13	LP/13	LSB/13
	MPH	11.28**	7.48**	-2.03	-18.79**	-5.79**	33.48**	43.94**	37.61**	12.28**	10.41**
PH	STH	15.94**	8.76**	5.98**	-3.59**	0.4	19.12**	20.72**	19.52**	1.99	11.95**
	BPH	-0.34	-6.51**	-8.9**	-20.39**	-13.7**	23.05**	40.28**	29.87**	1.99	-7.57**
	MPH	-26.18**	-20.15**	-27.71**	-16.75**	-10.83**	-28.74**	-44.47**	-23.32**	-29.59**	-19.1**
NL	STH	-34.02**	-25.34**	-27.63**	-20.55**	-26.71**	-37.44**	-44.98**	-27.17**	-25.57**	-18.26**
	BPH	-34.17**	-25.51**	-27.79**	-20.73**	-26.88**	-43.85**	-50.61**	-34.63**	-33.2**	-26.64**
	MPH	-16.67**	-17.86**	-13.73**	-14.81**	-6.12**	-34.48**	-53.85**	-19.3**	-16.67**	-26.98**
BN	STH	-20.00**	-8.00**	-12.00**	-8.00**	-8.00**	-24.00**	-40.00**	-8.00**	0.00	-8.00**
	BPH	-23.08**	-23.33**	-15.38**	-17.86**	-11.54**	-45.71**	-57.14**	-34.29**	-28.57**	-34.29**
	MPH	35.63**	13.73**	10.53**	35.94**	-18.62**	-35.79**	13.13**	43.94**	6.6**	9.83**
TN 60	STH	-38.54**	-9.38**	-12.5**	-9.38**	-38.54**	-36.46**	16.67**	-1.04**	9.38**	-1.04
	BPH	5.36**	-10.31**	-12.5**	20.83**	-33.71**	-39.6**	10.89**	-5.94**	3.96**	-5.94**
	MPH	-10.5**	-39.68**	-5.88**	58.04**	-10.59**	-30.19**	-43.81**	-21.84**	-8.75**	12.43**
TN 90	STH	-37.58**	-27.39**	-33.76**	-28.03**	-51.59**	-52.87**	-24.84**	-35.03**	-23.57**	-33.76**
	BPH	-36.77**	-63.69**	-33.76**	43.04**	-28.3**	-58.3**	-62.42**	-34.19**	-23.57**	-1.89
	MPH	-68.65**	-65.39**	-67.27**	-54.79**	-85.05**	-60.61**	-47.53**	53.62**	62.49**	-36.21**
TW 60	STH	213.89**	258.33**	240.28**	562.5**	87.5**	279.17**	290.28**	990.28**	1115.28**	648.61**
	BPH	-84.14**	-81.89**	-82.81**	-66.53**	-90.53**	-72.84**	-72.04**	-21.89**	-12.94**	-46.37**
	MPH	-19.62**	1.32**	-47.03**	-40.57**	-26.14**	-40.59**	-35.29**	1.29	-6.79**	-34.86**
TW 90	STH	7.01**	58.41**	-18.41**	4.86**	3.27**	-20.93**	-3.18**	28.04**	37.29**	10.56**
	BPH	-48.56**	-23.85**	-60.78**	-49.6**	-50.36**	-59.37**	-50.24**	-34.2**	-29.44**	-43.18**
	MPH	-43.07**	-26.95**	-35.87**	-50.26**	-42.28**	-40.42**	-42.52**	-27.2**	-14.71**	-64.2**
PW	STH	-2.2	30.51**	15.76**	20.34**	-3.39**	1.69	4.58**	27.46**	56.78**	-12.2**
	BPH	-62.53**	-50**	-55.65**	-53.9**	-62.99**	-62.00**	-60.92**	-52.37**	-41.42**	-67.19**

*, **, *** Significant at 5, 1 and 0.1% level, respectively

and standard parent. Heterosis of F_1 hybrids are presented in Table 3. For each character, the percentage values of the ten hybrids have been compared with mid parent, standard variety and better parent, the relative superiorities being termed as mid parent heterosis, standard heterosis and better parent heterosis. Significant heterosis was obtained in all the three levels for plant height in crosses AU/13, PT/13, LS/13, LP/13. Among ten hybrids PT/13, LP/13 exhibited highly significant positive heterosis for TN 60 in all level of heterosis. This indicated that these crosses could be the good materials for developing high yielding hybrids. In potato tuber number had greater contribution for high tuber yield production. Regarding number of leaf per plant and number of branch per plant, significant negative heterosis was observed in all ten hybrids in all the three levels of heterosis. For tuber weight at 60 days after planting showed all hybrids were positively significant for standard parent heterosis. On the other hand LS/67, PT/67, LSB/67, AU/67, LS/13, LP/13 LSB/13 exhibited highly significant positive heterosis in tuber weight at 90 days after planting for standard parent heterosis. For tuber number at 90 days after planting no positive significant result was obtained at standard parent heterosis. Among ten hybrids PT/67, LP/67, AU/13, PT/13, LS/13, LP/13 showed significant positive heterosis for plant weight at standard parent heterosis level.

The crosses LS/67, AU/67 and LSB/13 had a high heterotic vigour for three characters viz., plant height, tuber weight at 60 days after planting, tuber weight at 90 days after planting; PT/67 and LS/13 were superior for four characters viz., plant height, tuber weight at 60 days after planting, tuber weight at 90 days after planting, plant weight. The high heterotic crosses can be utilized for developing superior hybrid.

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