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Genetic variability and correlation studies of BARI released Potato varieties in Sylhet Region

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Abstract

The genetic parameters and characters association analysis between yield and yield components of 15 BARI release high yielding potato varieties were studied at RARS, BARI, Akbarpur, Moulvibazar, Bangladesh during the rabi season 2019-2021. The study aimed to confirm the performance of different potato varieties in acidic soil conditions and the selection of the best one suitable for cultivation in the Sylhet region. All the characters showed significant differences among the varieties indicating their wide genetic variation. The maximum tuber weight was produced by BARI Alu-47. The maximum tuber weight per plant and tuber yield (t/ha) was found highest in the variety BARI Alu-47. High estimates of coefficients of variability, heritability, and genetic gain for tuber grade by weight (kg) <28mm, tuber yield, tuber weight per plant, and tuber grade by weight (kg) 28-55mm indicated that these characteristics were largely controlled by additive gene action and that straight selection for them would be effective. Tuber yield per plant had a significant positive correlation with emergence % at 30 DAP, tuber grade by weight (kg) <28mm, and tuber weight per plant at both genotypic and phenotypic levels. These traits could be considered as selection criteria in potato breeding programs. The results indicate that tuber grade by weight (kg) <28mm, tuber weight per plant, and tuber grade by weight (kg) 28-55mm had a high genotypic coefficient of variability, high genetic advance as percentage of mean as well as positive significant correlation with tuber yield per plant. Considering yield and other desirable yield contributing characters, BARI Alu-47 was found suitable for Sylhet region.

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Introduction

Potato (*Solanum tuberosum*) ranked 4th position in the world food production (Hijmans, 2001, FAOSTAT, 2018) and over the years, it is also an important crop for farmers as well as consumers of Bangladesh. It is the 2nd most important crop for the area (0.5283 million ha) and total production (11.3327 million tons) after rice in Bangladesh (DAE, 2018). Potato (*Solanum tuberosum* L.) is the most productive, common item of horticultural crop and has multiple uses (Zaheer and Akhtar, 2016). It is an important vegetable crop in Bangladesh. Its area and production are increasing day by day declaring in 2008, the International Year of Potato, the UN general assembly seeks to focus world attention on the role of potato in defeating hunger and poverty (Hossain *et al.*, 2008). Yield is the result of interactions among several characters which are greatly influenced by environmental factors. Information on the nature and magnitude of variability present in a population owning to genetic and non-genetic causes is an important prerequisite for initiating any systematic breeding program (Mondal, 2003). To feed this ever-growing human of people there is a need to increase productivity. So that, more potatoes can be produced from the same area of land. For a successful breeding program, genetic variability and correlation coefficient analysis plays a vital role. In potato, tuber yield is the cumulative effect of many component characters individually contributing towards yield. Therefore, information on its genetic architecture is essential. This would aid in formulating an efficient breeding program for improving the yield potential via its components (Dixit and Dubey, 1985). Genotypic and phenotypic correlation coefficients tell us the association between and among two or more characters. A significant association suggests that such characters could be improved simultaneously (Hayes *et al.* 1955, Salim *et al.*, 2013).

It is well-established fact that as the number of contributing characters increases, the indirect association becomes more complex and important. Genetic variability, character association pattern, and the direct and indirect effect of the yield contributing characters on yield are very helpful for effective selection in crop improvement (Alam, *et al.*, 2019, Salim *et al* 2013). Under such circumstances, path analysis is an effective tool in assessing the direct and indirect effects of different characters.

A study was, therefore, undertaken on the genetic variabilities, character associations, and path coefficients between tuber yield and its component characters in potato.

In the case of yield potentiality, sustainable productivity, and growing habit, potato plays an important role in crop production in Bangladesh and can meet the food demand during the food crisis. In the Sylhet region, the area under potato cultivation is only 7045 ha which negligible (5.18%) is in the context of the total potato cultivated area of the country. But there is no recommended high yielding variety of potato for cultivation in acidic soil conditions, which is the major bottleneck for potato cultivation in this area. The national average yield of potato is very low (20.77 t/ha) compared to its potential yield, due to lack of quality seeds, climatic constraints, soil characteristics, and the high price of quality seeds (Alam *et al.*, 2020).

BARI has developed near 100 potato varieties, among them; some recent varieties were developed for climate resilience, higher yielder, and less susceptible to insect pests and diseases. These new varieties need to evaluate for their performance under different agro-ecological zones. Therefore, this experiment was conducted to evaluate their yield performance and selection of suitable variety(s) for the Sylhet region.

Material and methods

Experimental site and soil

The experiment was conducted at RARS, BARI, Akbarpur, Moulvibazar, Bangladesh during the rabi season of 2019-21 in the research field. The experimental field was at 24.3095°N, 91.7315°E Longitudes having an elevation of 13.00m from sea level. Soil texture of the experiment field was sandy clay (45-84%), silt (<50%), clay (>20%) and soil p^H 4-4.5.

Plant materials

The genetic materials consist of 15 potato varieties namely- BARI Alu-07, BARI Alu-25, BARI Alu-35, BARI Alu-36, BARI Alu-37, BARI Alu-40, BARI Alu-41, BARI Alu-46, BARI Alu-47, BARI Alu-53, BARI Alu-77, BARI Alu-82, BARI Alu-86, BARI Alu-90, and BARI Alu-91.

Experimental design and management

The experiment was laid out in a Randomized Block Design with three replications. The unit plot size was 4.8m × 2.1m. The whole potato tuber was planted maintaining the spacing of 60cm row to row and 30cm seed to seed. Standard agronomic practices were followed to raise a good crop. TCRC standard fertilizer doses were applied. A routine spray schedule was maintained to control late blight infection. Haulms was pulled after 90 days of planting.

Data collection and analysis

Ten potato plants were selected at random in each replication and observations were recorded for emergence% at 30 DAP, no. of stem/ hill at 60 DAP, plant height (cm) at 60 DAP, tuber grade by weight (kg) <28mm, tuber grade by weight (kg) 28-55mm, tuber grade by weight (kg) >55mm, tuber weight per plant (g) and tuber yield (t/ha). Genotypic and phenotypic coefficient of variation (GCV and PCV), habitability in a broad sense (h2 b), genetic advance as% of the mean (GA%=genetic gain), genotypic (rg), and phenotypic (rp) correlation coefficients were done following the formulae used by Singh and Choudhury (1985). The above calculations were done for all studied characters.

Result and discussion

All the characters showed significant differences among the varieties indicating their wide genetic variation (Table 1).

The performance of different potato varieties is presented in Table 3. Among the studied varieties, BARI Alu-47 showed the highest percentages (96.3%) of emergence at 30 DAP, whereas BARI Alu-77 exhibited the lowest percentage (82.4%) of emergence respectively. The number of stem/hills at 60 DAP was maximum (5.5) in BARI Alu-36, which was statistically identical with BARI Alu-37 (5.1), BARI Alu-41(5.2), and BARI Alu-82 (5.1). BARI Alu-53 was the tallest (72.9cm) and BARI Alu-77 was found as a dwarf (37cm) among the tested varieties.

BARI Alu-47 produced the maximum tuber weight (578g/plant), which showed significantly different from all other varieties and the lowest tuber weight/plant was recorded from the variety BARI Alu-53 (322.7g), BARI Alu-77 (371.7g), BARI Alu-90 (327.7g) and BARI Alu-91 (333g) respectively. The highest yield was recorded from the variety BARI Alu-53 (32.2 t/ha) followed by BARI Alu-37 (26.6 t/ha) and BARI Alu-46 (26.8 t/ha).

As the maximum tuber weight/plant and yield (t/ha) was found highest in BARI Alu-47. In previous research, a field trial with five BARI released potato varieties with a local as the check was conducted in this Sylhet region. They also found a promising yield of potatoes in the drought-prone area of this region (Alam *et al.*, 2020).

Table 1. Analysis of variance for different characters in potato varieties.

Characters	Mean sum of square		
	Replication (r-1) = 2	Genotype (g-1) = 14	Error (r-1)(g-1) = 28
Emergence% at 30 DAP	5.420	96.952**	10.377
No. of stem/ hill at 60 DAP	0.128	1.980**	0.144
Plant height (cm) at 60 DAP	9.183	222.059**	7.646
Tuber grade by weight (kg) <28mm	0.047	8.148**	0.167
Tuber grade by weight (kg) 28-55mm	3.389	39.990**	1.774
Tuber grade by weight (kg) >55mm	3.427	19.547**	2.571
Tuber weight per plant (g)	798.488	15,716.879**	331.655
Tuber yield (t/ha)	2.391	49.215**	1.055

** Denote Significant at 1% level of probability

Table 2. Range, mean and CV (%) of 15 potato varieties.

Parameters	Range		Mean	CV (%)
	Min	Max		
Emergence% at 30 DAP	82.42	99.17	92.47	3.48
No. of stem/ hill at 60 DAP	2.95	5.58	4.58	8.29
Plant height (cm) at 60 DAP	37.08	72.91	52.93	5.22
Tuber grade by weight (kg) <28mm	2.76	7.87	4.15	9.86
Tuber grade by weight (kg) 28-55mm	12.63	27.44	17.47	7.63
Tuber grade by weight (kg) >55mm	4.23	11.95	7.97	20.13
Tuber weight per plant (g)	322.67	578.00	392.31	4.64
Tuber yield (t/ha)	17.98	32.28	21.82	4.71

CV (%) = coefficient of variation

Table 3. Mean performance of different potato varieties for yield and yield contributing characters.

Genotype	Emergence% at 30 DAP	No. of stem/ hill at 60 DAP	Plant height (cm) at 60 DAP	Tuber grade by weight (kg)			Tuber weight per plant (g)	Yield (t/ha)
				<28mm	28-55mm	>55mm		
BARI Alu-07	96.2ab	4.8b	43.1g	2.8c	17.4cd	7.7defg	419.3c	23.3c
BARI Alu-25	98.3ab	5.5a	44.9g	4.4b	16.7de	8.7bcd	390cde	21.2e
BARI Alu-35	84.7de	4.0c	57.3bc	4.0bc	18.1cd	4.9h	341fg	18.9fg
BARI Alu-36	97.5ab	5.5a	57.4bc	5.3b	27.4a	4.2h	365.3ef	20.3ef
BARI Alu-37	94.8ab	5.1ab	52.6de	7.4a	19.5bc	5.4fgh	478.3b	26.6b
BARI Alu-40	93.9abc	3.8c	55.1bcd	3c	17.4cd	11.1ab	385.3de	21.4de
BARI Alu-41	98.6ab	5.2ab	58.1b	4.9b	17.7cd	6.5defgh	414.7cd	23.1cd
BARI Alu-46	94.8ab	2.9d	53.5cde	2.9c	21.6b	8.3cde	481.7b	26.8b
BARI Alu-47	99.1a	3.8c	59.3b	7.8a	13.7gh	5.9efgh	578a	32.2a
BARI Alu-53	84.4de	3.8c	72.9a	2.8c	19c	8.1cdef	322.7g	17.98g
BARI Alu-77	82.4e	4.7b	37h	3.6c	14.6efgh	5.4gh	331.7g	18.4g
BARI Alu-82	89cd	5.1ab	47.5fg	4bc	12.6h	10.7abc	346.7fg	19.3fg
BARI Alu-86	86de	3.5cd	58.3b	2.9c	16.2def	11.9a	369.3ef	20.5ef
BARI Alu-90	93.3bc	5ab	50.2ef	2.7c	14.3fgh	11.8a	327.7g	18.2g
BARI Alu-91	93.6bc	5.1ab	46.2fg	3c	15.1efg	8.2cde	333g	18.5g

Estimates of different statistical and genetic parameters like mean, genotypic and phenotypic variance, genotypic and phenotypic coefficient of variability, heritability (h^2b), and genetic advance as% of the mean (genetic gain) for eight characters under study are presented in Table 4. Analysis of variance showed highly significant F-values for seven characters indicating thereby the presence of variability among the genotypes used in the present study. The maximum genotypic variance was found for tuber weight per plant (5128.41) followed by plant height (cm) at 60 DAP (71.47) and emergence% at 30 DAP (28.86) while the same was minimum for no. of stem per hill at 60 DAP (0.61). The phenotypic variance was also maximum for tuber weight per plant (5460.06) and minimum for no. of stem per hill at 60 DAP (0.76).

Table 4. Estimation of genetic parameters for different characters in potato.

Parameters	σ^2p	σ^2g	σ^2e	PCV	GCV	ECV	Heritability	GA (5%)	GAM
Emergence% at 30 DAP	39.24	28.86	10.38	6.77	5.81	3.48	73.55	9.49	10.26
No. of stem per hill at 60 DAP	0.76	0.61	0.14	18.99	17.08	8.29	80.96	1.45	31.67
Plant height (cm) at 60 DAP	79.12	71.47	7.65	16.80	15.97	5.22	90.34	16.55	31.27
Tuber grade by weight (kg) <28mm	2.83	2.66	0.17	40.56	39.35	9.86	94.09	3.26	78.62
Tuber grade by weight (kg) 28-55mm	14.51	12.74	1.77	21.81	20.44	7.63	87.77	6.89	39.44
Tuber grade by weight (kg) >55mm	8.23	5.66	2.57	36.01	29.86	20.13	68.75	4.06	51.01
Tuber weight per plant (g)	5460.06	5128.41	331.66	18.84	18.25	4.64	93.93	142.97	36.44
Tuber yield (t/ha)	17.11	16.05	1.06	18.95	18.36	4.71	93.83	7.99	36.63

σ^2p: Phenotypic variance PCV: Phenotypic coefficient of variation

GA (5%): Genetic advance σ^2g: Genotypic variance

GCV: Genotypic coefficient of variation GAM: Genetic advance (% of mean)

σ^2e: Environmental variance ECV: Environmental coefficient of variation

Genotypic and phenotypic coefficients of variation were maximum for tuber grade by weight (kg) <28mm (39.35, 40.56) while it was minimum for emergence % at 30 DAP (5.81, 6.77). The high GCV and PCV were also found in Tuber grade by weight (kg) 28-55mm (20.44, 21.81). The PCV was higher than the corresponding GCV for most of the characters denoting environmental factors influencing their expression. Mondal (2003) obtained higher genotypic and phenotypic coefficients of variation for average tuber weight per plant, tuber yield per plant, and tubers number per plant in potato. Abraham *et al.* (2014) observed that the genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients for most of the characters indicating the inherent relationships among the traits in potato. Kamruzzaman *et al.* (2000) observed higher GCV and PCV for the number of flowers, number of fruits, and fruit weight in tomatoes. The heritability ranged from 68.75-94.09. All estimated parameters were observed for high heritability (>60%). The highest heritability was found in tuber grade by weight (kg) <28mm (94.09). The high heritability suggested that selection for these characters is effective, and improvement is made through phenotypic selection. Tuber grade by weight (kg) <28mm (94.09, 78.62), tuber yield (t/ha) (93.83, 36.63), tuber weight per plant (g) (93.93, 36.44) and tuber grade by weight (kg) 28-55mm (87.77, 39.44) had high heritability associated with high genetic advance percent of mean indicates the presence of additive gene effects. Heritability estimates with GA% are more useful in predicting yield under phenotypic selection than heritability alone according to Mondal (2003) in potato. In the present investigation, tuber grade by weight (kg) <28mm, tuber grade by weight (kg) 28-55mm, tuber grade by weight (kg) >55mm, tuber weight per plant (g), and tuber yield had a higher genotypic and phenotypic coefficient of viabilities, high heritability and genetic advance as percentage of mean which indicates that these characters were most vital in the selection for yield improvement. In the majority of the characters, the genetic coefficient of variability was higher than the corresponding phenotypic coefficient of variability (Table 2), suggesting that the character association had not been largely affected by the environment in such cases. Tuber yield showed significant positive correlations with emergence% at 30 DAP (0.615**, 0.562**), tuber grade by weight (kg) <28mm (0.692**, 0.665**) and tuber weight per plant (g) (1.000**, 0.998**) at both genotypic and phenotypic level (Table 5). Similar findings were also reported in potatoes and tomatoes (Alam *et al.*, 2020, Abraham *et al.,* 2014, Asefa and Mohammed. 2016). The findings of Dayal (1972) and Mondal (2003) are in agreement with this result.

Table 5. Genotypic (G) and phenotypic (P) correlations among different pairs of traits for different varieties of potato.

		EP	SPH	PH	TG-1	TG-2	TG-3	TWP
SPH	G	0.426**						
	P	0.225						
PH	G	-0.025	-0.483**					
	P	-0.127	-0.370*					
TG-1	G	0.483**	0.236	0.127				
	P	0.371*	0.224	0.147				
TG-2	G	0.212	0.015	0.377*	0.110			
	P	0.261	-0.021	0.298*	0.066			
TG-3	G	-0.139	-0.217	-0.011	-0.626**	-0.478**		
	P	-0.067	-0.209NS	-0.040	-0.526**	-0.430**		
TWP	G	0.626**	-0.291	0.118	0.692**	0.041	-0.278	
	P	0.572**	-0.251	0.106	0.666**	0.080	-0.260	
TY	G	0.615**	-0.302*	0.127	0.692**	0.042	-0.282	1.000**
	P	0.562**	-0.261	0.11	0.665**	0.080	-0.265	0.998**

EP: emergence% at 30 DAP, SPH: no. of stem per hill at 60 DAP, PH: plant height (cm) at 60 DAP, TG-1: tuber grade by weight (kg) <28mm, TG-2: tuber grade by weight (kg) 28-55mm, TG-3: tuber grade by weight (kg) >55mm, TWP: tuber weight per plant (g) and TY: tuber yield (t/ha)

The correlation study suggested that the important characteristics like emergence% at 30 DAP, tuber grade by weight (kg) <28mm, and tuber weight per plant showed a positive association with tuber yield per plant i.e. increases of emergence % at 30 DAP, tuber grade by weight (kg) <28mm and tuber weight per plant reflect tuber yield increase. These results are in agreement with Alam *et al* 2020 (Alam, *et al*., 2020). On the other hand, positive association with plant height and tuber grade by weight (kg) 28-55mm indicate that vegetative fresh and vigorous plant stature with more tuber produces more yield Similarly, positive and significant correlation were also found between tuber yield and biological yield, plant height and tuber yield, stems per plant and tuber per plant (Abraham *et al*., 2014 Khayatnezhad *et al*., 2011). Thus, the characters plant height and tuber grade by weight (kg) 28-55mm are the important tuber yield attributes to be estimated in the selection criteria for yield improvement.

Conclusion

It may be concluded from the results of the presents study that tuber grade by weight (kg) <28mm, tuber yield, tuber weight per plant, and tuber grade by weight (kg) 28-55mm had high heritability associated with high genetic advance percent of mean, therefore, emphasis should be given on these characters when on goes for improvement of tuber yield of potato. Tuber yield showed significant positive correlations with emergence% at 30 DAP, tuber grade by weight (kg) <28mm, and tuber weight per plant at both genotypic and phenotypic levels. Considering yield and other desirable yield contributing characters, BARI Alu-47 was found suitable for Sylhet region.

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