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Genetic prospective for the improvement of agronomic traits in *Solanum tuberosum* L.

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Abstract

Selection and evaluation of nineteen potato (*Solanum tuberosum* L.) genotypes for yield and yield components by calculating genotypic, phenotypic correlation coefficient, heritability and co-heritability was done at Potato Research Sub-Station Muree. The positive genotypic correlation coefficient was observed for different potato grades, number of eyes/tuber and plant height with yield. The amount of co-heritability and broad sense heritability was maximum for traits, plant height, <35 mm potato grade and 35-55 mm potato grade indicated preponderance of strong genetic expression. Therefore, there was a potential for the concurrent genetic improvement of these traits through selection and breeding in the plant material used in present study.

Key words: Genotypic correlation, co-heritability, heritability, genetic expression.

Introduction

Potato (*Solanum tuberosum* L.) is one of the important crops in developed as well as in the developing countries of world due to its characteristics of staple food and high yielding potential. Therefore, there is bright prospect to promote potato crop as supplementary food in developed and developing countries of the world.

Keeping in view the importance of potato crop, an efficient breeding program and accurate evaluation of different important traits can play a vital role in the success of potato breeders. Due to change in the expression of various traits with the change in the breeding material and environment, it is expected from potato breeders to produce improved cultivars with good quality, high yield and wide range of adaptability. Genetic makeup and environmental factors are influencing the yield and quality of the potato tuber, therefore it is essential to select a balance combination of traits in selection and evaluation of the breeding material. Computation of genotypic, phenotypic correlation, heritability and co-heritability to establish the efficient breeding strategy for the selection of high yielding genotypes can be very important.

A wide variety of agronomic traits are being used for breeding of potato crop. Emergence percent, various potato grades, plant height, number of stems/plant, number of eyes/ tuber and stolon length have been reported and are the most important yield components for increasing tuber yield [1, 11-13]. Gunel *et al*. [8] indicated that plant height, number of stems/plant, stolon length, percentage of big tubers have highly positive significant correlation with tuber yield. They also determined negative and significant correlation between percentage of small tubers (<35 mm) and tuber yield/unit area. Gopal *et al*.[7] studied genotypic correlations of eyes/tuber, number of stems/plant, plant height, potato size grades 35 mm, 35-55 mm, >55 mm and yield.

Improvement in different important traits largely depends on the presence of heritable variations, and heritability is a measure of magnitude of genetic determination of traits and facilitates the selection process [18]. Iqbal and Khan [10] found that the high co-heritability among different agronomic traits and yield resulted in more potato yield. The amount of heritability may range from moderate to high. Bugarcic *et al*. [2] reported varying degree of heritability 96.99% and 83.6% for number of stems per plant and tuber yield, respectively.

The objective of this study was to investigate the association between yield and yield components, heritability and co-heritability for effective selection of elite genetic material.

Materials and Methods

Plant material: A set of nineteen genotypes, i.e. SH-5, SH-10, SH-19, SH-53, SH-63, SH-67, SH-70, SH-80, SH-95, SH-103, SH-113, SH-174, SH-187, SH-216A, SH-240(R), SH-288(R), SH-353(R), Cardinal(R) and Desiree(R) were collected from Potato Research Station Sialkot for selection and evaluation purposes. The present study was conducted at Potato Research Sub-Station Muree, Pakistan. Temperature ranged during the period of study was 17 to 28.5°C with an average rainfall was1800 mm. The experiment was laid out in Randomized Complete Block Design with three replications in 6 x 3 m^2 area each in well drained rocky soil. Four rows for each replication in each block were planted with row x row distance 75 cm and plant x plant distance 20 cm. Recommended (NPK 100:50:50/acre) fertilizer was applied to all the three replications.

Data recording: Data for number of eyes/tuber were recorded before planting of tubers as average number of eyes/tuber. Total 120 seed grade tubers were sown in each replication and 30 tubers in each line/replication. After 15 days of planting emergence % was calculated. Plant height was recorded for main stem from ground level to the tip of the plant. Data for number of stems/ plant was also estimated simultaneously. Stolon length was recorded at harvest. Stolon length was estimated from the part of under ground stem where just under the surface of soil to the attachment with mother tuber; yield was recorded for each variety in each replicate separately in kg/plot. Different potato grades were isolated as percent by passing samples of 100 potatoes through aluminium trays of different diameter >55 mm, 35-55 mm and <35 mm randomly chosen in each variety in each replicate.

Analysis of data: The recorded data were subjected to analysis of variance [21] using MSTAT C software to ascertain existence of variability among the genotypes. Genotypic and phenotypic correlations were computed [14]. Co-heritability and heritability (broad sense) of the traits was estimated by following the methodology given by Burton and Devane [4]. Standard error for the heritability was worked out [19].

Results

Analysis of variance revealed the presence of significant differences ($p \leq 0.001$) among all genotypes for all observed traits (Fig. 1). It showed that there was ample scope for continuing the further analysis of genotypic and phenotypic correlation, heritability and co-heritability.

Present study showed that genotypic correlation was generally higher than phenotypic correlations (Table 1) showed that emergence percent was positive and significantly correlated with 35-55 mm potato grade both at genotypic and phenotypic level, while it was negatively correlated with yield. A linear relationship running along x-axis between emergence % and yield also confirmed that increase in emergence would cause decrease in the yield (Fig. 2). There was positive but non-significant correlation of potato size >55 mm with yield at genotypic level. Fig. 3 also depicts same kind of behavior between these two traits. Results depicted that there was strong negative association between tuber size (35-55 mm) and yield both at genotypic and phenotypic level (Fig. 4). Table 1 also indicates that potato tuber size < 35 mm was positively but non-significantly associated with yield both at genotypic and phenotypic level (Fig. 5). Agronomic traits plant height and number of stems/plant showed positive but non-significant association with yield both at genotypic and phenotypic levels (Table 1, Figs 6 and 7). Number of eyes/tuber showed positive correlation with yield (Fig. 8), while stolon length showed negative association with the yield (Fig. 9).

The data revealed that the magnitude of co-heritability of plant height, number of eyes/tuber and stolon length with yield was maximum, while value of co-heritability of emergence % and potato grade >55 mm was moderately high. Table 2 depicts that lowest value of co-heritability was for potato grade <35 mm with yield. The magnitude of broad sense heritability of traits, i.e. number of eyes/tuber, number of stems/plant, plant height, < 35 mm potato grade, 35-55 mm potato grade and >55 mm potato grade was high (Table 3).

Discussion

Correlation quantifies the strength of association among different traits [10]. Genotypic correlation is the inherent relationship between any two variables [5]. Epistatic effects, presence of linkage and pleotropic effect of gene is the main cause of correlation among the different traits. Environment could be a factor which affect the both associated traits either in same direction or some time in different directions. Genetic and environmental effects combine together and give phenotypic correlation that's why due to dual nature of phenotypic correlation, it is impossible to calculate genotypic correlation from phenotypic correlation [20]. Results indicated that the traits, i.e. potato tuber grade >55 mm, plant height, and number of eyes/tuber are yield components which were contributing to the potato yield positively [3, 6]. The positive association of these traits will increase the selection efficiency and ultimately cause an increase in the tuber yield [8]. The negative association of potato grade 30-55 mm and stolon length with yield indicated that with the increase of these both traits the potato yield will decrease [22]. This negative association among traits could be broken by selecting the plants from populations generated by random mating of different parental line [15].

Improvement of different traits based upon the availability of heritable variation and heritability is a measure of degree of genetic variation in the traits and it can help the selection and evaluation process. High magnitude of co-heritability of plant height, number of eyes/tuber and stolon length with yield indicated that these traits would inherit positively with yield [7, 10, 17]. The very high values of broad sense heritability with the high genetic gain indicated that traits are mostly under the control of additive type of gene action and improvement of these traits could be productive for development of high yielding elite genetic material [2, 16].

Conclusions

The magnitude of correlation coefficient, co-heritability and heritability of >55 mm potato grade, plant height and number of eyes/tuber suggested that these traits are strongly contributing to the potato yield and most effective approach towards the improvement of potato yield was selection directly based upon these traits in the presence of heritable genetic variance.

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Table 1. Genotypic and phenotypic correlation coefficients for yield and yield components.

S.O.V.		Emergence %	Potato grade >55 mm	Potato grade 35-5 mm	Potato grade <35 mm	Plant height (cm)	Number of stems/plant	Number of eyes/tuber	Stolon length/plant	Yield
Emergence	rg		0.107^{NS}	0.622**	-0.589*	-0.238^{NS}	-0.287^{NS}	-0.229^{NS}	0.146^{NS}	-0.200^{NS}
%	rp		0.541**	0.403*	-0.349*	-0.171^{NS}	16.87**	-0.170^{NS}	0.122^{NS}	-1.761^{NS}
Potato grade	rg			-0.046^{NS}	-0.467*	0.155^{NS}	0.211^{NS}	-0.043^{NS}	0.035^{NS}	0.273^{NS}
>55 mm	rp			-0.072^{NS}	-0.460*	0.164^{NS}	0.195^{NS}	-0.051^{NS}	0.052^{NS}	-0.230^{NS}
Potato grade	rg				-0.904*	-0.373^{NS}	$6.68\text{x}10^{-8\ NS}$	-0.183^{NS}	0.086^{NS}	-0.023^{NS}
35-5 mm	rp				-0.797**	0.364*	0.175	-0.171	0.096	-0.301
Potato grade	rg					0.860**	-0.253^{NS}	0.184^{NS}	-0.094^{NS}	0.144^{NS}
<35 mm	rp					0.270^{NS}	-0.242^{NS}	0.170^{NS}	-0.093^{NS}	0.115^{NS}
Plant height	rg						0.059^{NS}	0.450^{NS}	-0.446*	0.314^{NS}
(cm)	rp						0.056^{NS}	0.426*	-0.421*	0.196^{NS}
Number of	rg							0.185^{NS}	-0.138^{NS}	0.047^{NS}
stems/plant	rp							0.192^{NS}	-0.137^{NS}	0.055^{NS}
Number of	rg								0.912**	0.459*
eyes/tuber	rp								-0.636*	0.296^{NS}
Stolon	rg									-0.479*
length/plant	rp									-0.341^{NS}

* Significant ($p \leq 0.05$), ** Highly significant ($p \leq 0.01$), NS Non-significant ($p \leq 0.01$), S.O.V. Source of variability, rg Genotypic correlation, rp Phenotypic correlation.

Table 2. Estimates of co-heritibilities between yield and yield components.

S.O.V.	Emergence %	Potato grade >55 mm	Potato grade 35-55 mm	Potato grade <35 mm	Plant height (cm)	Number of stems/plant	Number of eyes/tuber	Stolon length/plant	Yield
Emergence		0.410	0.934	0.872	0.828	0.743	0.771	0.707	0.562
%		±0.047	±0.501	±0.525	±0.106	±0.094	±0.139	±0.140	±0.135
Potato grade			0.576	0.912	0.831	0.917	0.719	0.591	0.693
>55 mm			±0.072	±0.073	±0.158	±0.142	±0.209	±0.209	±0.202
Potato grade				0.971	0.960	0.931	0.965	0.835	0.417
35-5 mm				±0.117	±0.281	±0.244	±0.364	±0.355	±0.356
Potato grade					0.939	0.951	0.967	0.946	0.160
<35 mm					±0.276	±0.252	±0.372	±0.374	±0.356
Plant height						0.9324	0.935	0.969	0.864
(cm)						±0.1887	±0.269	±0.280	±0.270
Number of							0.823	0.891	0.444
stems/plant							±0.213	±0.219	±0.214
Number of								0.938	0.809
eyes/tuber								±0.213	±0.219
Stolon									0.910
length/plant									±0.215

Table 3. Estimates of broad sense heritability for yield and yield components.

S.O.V.	Genotypic variance (Vg)	Phenotypic variance (Vp)	Error	h^2_{BS} ± SE
Emergence %	77.713	202.99	125.277	0.382±0.428
Potato grade <55 mm	712.175	135.298	847.473	0.840±0.444
Potato grade 35-55mm	3103.053	3245.474	142.421	0.956±0.456
Potato grade >35mm	3885.544	170.035	4055.579	0.958±0.498
Plant height	7311.806	7950.307	638.501	0.919±0.066
Number of stems/plant	29.393	34.313	4.92	0.856±0.085
No. of eyes/tuber	61.982	72.664	10.682	0.852±0.125
Stolon length (cm)	111.581	122.448	10.867	0.911±0.126
Yield (kg)	470.702	1495.684	1024.982	0.314±0.224

h^2_{BS} = Broad sense heritability.

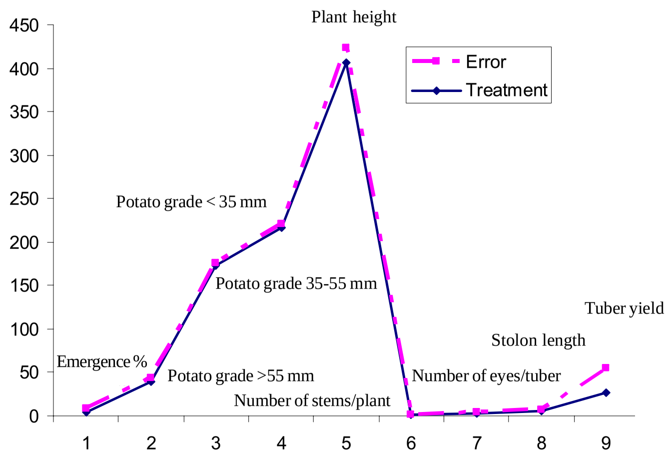

Figure 1. Treatment and error mean square of the yield and yield components.

All treatments were highly significant (**) at p≤0.001.

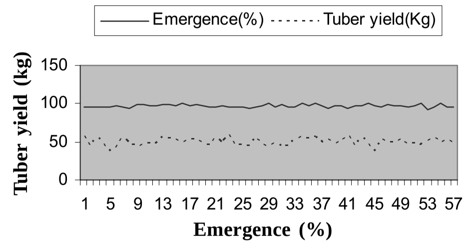

Figure 2. Emergence (%) vs tuber yield (kg).

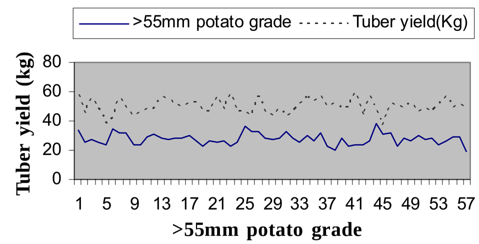

Figure 3. >55mm potato grade vs tuber yield (kg).

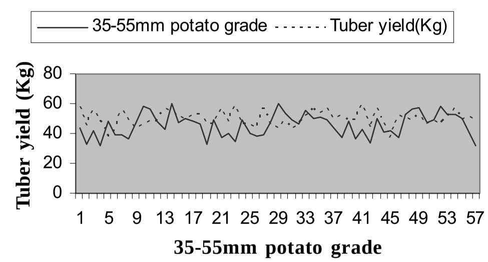

Figure 4. 35-55mm potato grade vs tuber yield (kg).

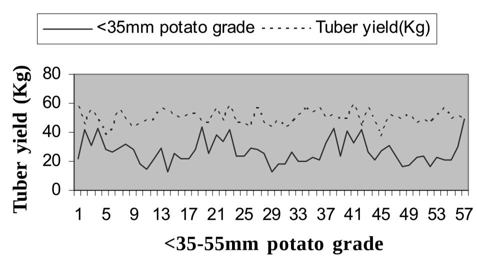

Figure 5. <35mm potato grade vs tuber yield (kg).

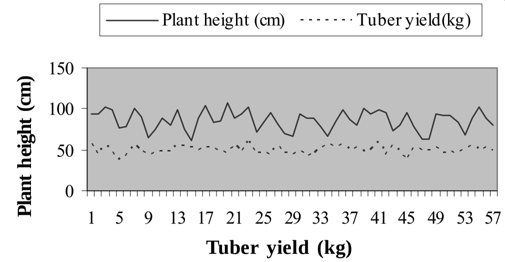

Figure 6. Plant height vs tuber yield.

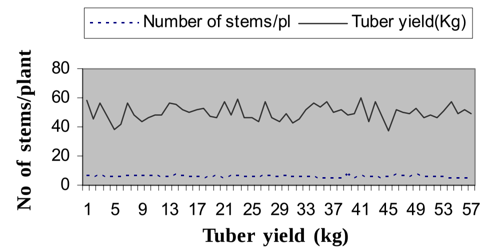

Figure 7. Number of stems/plant vs tuber yield (kg).

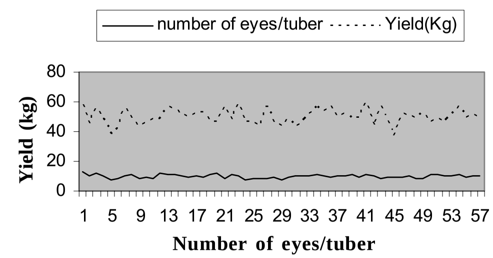

Figure 8. Number of eyes/tuber vs tuber yield (kg).

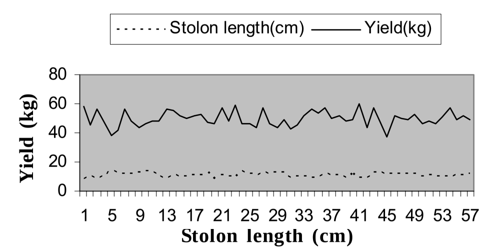

Figure 9. Stolon length (cm) vs tuber yield (kg).