RESEARCH ARTICLE

CORRELATION AND PATH ANALYSIS IN POTATO UNDER TEMPERATE CONDITIONS

Muzamil A. Hajam*[1], Tariq A. Bhat, Asif. M. Rather[-1], S. H. Khan[1], M. Ahmad Ganie[1] and M. Shafi[3]

[1]Division of Vegetable Science, [2]Division of fruit Science, Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, Jammu and Kashmir, 190001
[3]Division of GPB, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, Jammu and Kashmir, 190001
Division of Vegetable Science, SKUAST-K, Shalimar Campus, Srinagar, Jammu and Kashmir

Received-05.01.2019, Revised-27.01.2019

Abstract: Understanding interrelationships among various agronomic traits is vital to plan an effective breeding program in potato (*Solanum Tuberosum* L.). This study was undertaken in SKUAST-K to determine associations among yield and yield related traits in the crop plant so as to identify the major traits of importance. A replicated field experiment was carried out using thirty eight potato genotypes selected at random from the germplasm collection of diverse origin. Observations were made on five characters. The highest phenotypic and genotypic coefficients of variability were observed for tuber yield on per plot, hectare and plant basis followed by specific gravity, number of stems per hill, number of tubers per plant and plant height. In general the phenotypic coefficients of variation were slight higher than genotypic coefficients of variation for most of the yield contributing characters which indicates the minor role of environment in the expression of these traits. Correlation coefficients revealed that the tuber yield per plant exhibited significant positive association with number of tubers per plant, average tuber weight, plant height, leaf area, plant spread, number of stems per hill, tuber yield per plot /hectare, specific gravity and dry matter. Path coefficient analysis revealed high direct positive effect on tuber yield via number of tubers per plant, tuber yield per plot, average tuber weight, plant height, leaf area and number of stems per hill revealing their importance in the improvement of this crop.

Keywords: Correlation, Solanum tuberosum, Yield

INTRODUCTION

Potato (*Solanum tuberosum* L.) is most important vegetable crop and is widely grown in india. Yield is an important outcome and has an utmost economic importance which a plant breeder always should keep in mind Yield is an ultimate criterion which a plant breeder has always to keep in view in his attempt to evolve improved cultivars of any crop. However, yield is a polygenic character and highly influenced by environment. Knowledge of the association of quantitative characters specifically for yield and its attributes is of immense practical value to obtain an optimal selection index for yield improvement. The selection of one character will lead to indirect change (s) of other character (s) if the two are correlated. Therefore, the knowledge of phenotypic and genotypic correlation and path analysis is important for a plant breeder. Thus the present study was under taken to study the indirect association of various yield components in order to develop a reliable set of traits for indirect selection.

MATERIALS AND METHODS

Material comprised of thirty eight genotypes maintained at SKUAST-K.The genotypes were characterized for various agro-morphological traits. The experiment was laid in RCBD design with four replications during Rabi 2016- 2017. Each replication was divided into eight blocks with eight genotypes per block. The genotypes were planted in three-rowed plots of 2.4 x 1.2 m at a spacing of 60 x 20 cm.Observations were recorded on five randomly selected plants for each entry per replication.Coefficient of correlation was calculated for all possible combinations of all the characters at genotypic, phenotypic and environmental levels by using the following formula proposed by Miller *et al.* (1958).

$$r\ xixj = \frac{\text{Cov .xixj}}{\sqrt{V(xi)\ V(xj)}}$$

Where, r xixj = coefficient of correlation between characters xi and xj
Cov. xixj = covariance for xi and xj
V (xi) = variance for xi
V (xj) = variance of xj
Genotypic, phenotypic and environmental correlation was computed by substituting corresponding variance and co-variance in the above mentioned formula for all the possible character combinations.
Path coefficient analysis was laid out to show the cause and effect relationship between yield and its components and their partition into direct and indirect effects. This relationship was evolved by Wright (1921) which was later used by Dewey and Lu (1959) and the residual effects were calculated as per procedure given by Singh and Choudhary (1985).

*Corresponding Author

Unexplained variation of the residual effects was obtained from the equation:

$$R = \sqrt{1 - \Sigma dirij}$$

Where, R = residual effect

di = direct effect of the i^{th} character

rij = correlation coefficient between the i^{th} character and j^{th} dependent character.

Direct and indirect effects of different characters on tuber yield per plant were calculated at both genotypic and phenotypic levels.

RESULTS AND DISCUSSION

The Correlation coefficients were determined using variances and co variances to obtain relationship among various characters and their relationship with tuber yield $plant^{-1}$.

The correlation coefficients genotypic (r_g) among the various growth characters of potato genotypes/varieties are presented in Table-1. Correlation coefficients revealed that the economically important trait i.e. tuber yield $plant^{-1}$ exhibited significant positive association with number of stems $hill^{-1}$ ($r_{g=}$ 0.4338), plant height ($r_{g=}$ 0.6889), plant spread ($r_{g=}$ 0.4856), leaf area (r_{g} = 0.4915), number of tubers $plant^{-1}$($r_{g=}$ 0.6474), average tuber weight ($r_{g=}$ 0.5976), tuber yield $plot^{-1}$ ($r_{g=}$ 0.8623), tuber yield $hectare^{-1}$ ($r_{g=}$ 0.8973), specific gravity ($r_{g=}$ 0.4126) and dry matter ($r_{g=}$ 0.4724) at genotypic level. The probable reason for leaf area being positively and significantly correlated with tuber yield could be attributed to more amount of photosynthesis occurring. More photosynthesis, as a result, would account for effective conversion of carbohydrates (reserve material) to economic yield by increasing the number or average weight of tubers. Plants with higher number of stems, spread and height could produce more number of leaves which may lead to accumulation of more photosynthates for tuber development resulting in increased tuber weight and finally tuber yield.The positive and significant correlation of yield with dry matter and specific gravity might be due to the reason that, as dry matter and specific gravity go high, the tuber weight is also high and hence the tuber yield is more. Leaf area was positively and significantly associated with plant spread and yield ha^{-1}; plant height had a positive significant relation with per cent emergence days after planting, plant spread, average tuber weight and yield ha^{-1} and dry matter. Similarly, plant spread exhibited positive and significant correlation with, leaf area, plant height, yield ha^{-1} and dry matter. Specific gravity and dry matter showed positive and significant relation, thereby indicating that the change in one character will lead to simultaneous change in the other. The significant and positive association among the characters suggests the scope for improvement of these traits, which may influence each other and in turn may improve the tuber yield.The present findings are in close agreement with the results of Bhagowati *et al.* (2002) between plant height and leaf numbers, tuber numbers and average tuber weight, primary branch numbers and leaf numbers, tuber numbers and between leaf numbers and average tuber weight; Ozkaynak *et al.* (2003) for yield with plant height, number of tubers $plant^{-1}$ and average tuber weight; Luthra *et al.* (2005) for yield with plant height, number of $tubers^{-1}$, stems $hill^{-1}$, tuber yield $plant^{-1}$ and tuber weight; Dereje and Basavaraja (2005) for tuber yield with plant spread; Pandey *et al.* (2005) for yield and dry matter content; Rasool *et al.* (2007) for yield with number of tubers $plant^{-1}$, average weight $tuber^{-1}$ (tuber size), plant height, diameter of main stem and number of main and secondary stems $plant^{-1}$; Khayatnezhad *et al.* (2011) for tuber yield with number of main stem $plant^{-1}$, plant tuber weight and plant height; Nasiruddin *et al.* (2014) for tuber yield $plant^{-1}$ with plant height, main stem number $plant^{-1}$, canopy size, leaf area $plant^{-1}$ and dry matter; Singh *et al.* (2015) for tuber yield $hectare^{-1}$ with marketable tuber yield ha^{-1}, fresh weight of tubers $plant^{-1}$, number of shoots $plant^{-1}$, number of tuber $plant^{-1}$ and plant emergence per cent . in general, the estimate of genotypic correlation coefficients of yield and yield attributing characters indicating a strong inherent association between various traits under study and the masking effect of environment in the total expression of genotypes or a strong inherent association between various traits under study. Similar findings have also been reported by Ramanjit *et al.* (2001), Roy and Singh (2006) and Ummyiah *et al.* (2013).

TSS ($r_{g=}$ -0. 2303) and vitamin C ($r_{g=}$ -0.0127) exhibited negative and non-significant association with tuber yield $plant^{-1}$. Per cent emergence days after planting ($r_{g=}$0.1283) and days taken to flowering ($r_{g=}$0.1222) showed positive but non-significant association with yield $plant^{-1}$. In addition to this, negative and non significant interrelationship was observed between yield $plant^{-1}$ and vitamin C which was in conformation with the results obtained by Desai and Jaimini (1988) and Ummyiah and Khan (2013). There is a definite metabolic correlation between the content of carbohydrates and the vitamin C present. Every plant requires a specific quantum of energy for performing the metabolic activities for which the energy is provided by carbohydrates and proteins which may be converted to other substrates when the plant system needs it. So, keeping in view the specific amount of energy needed by the plant, the total amount of carbohydrates (i.e. yield) may decrease, if the amount of vitamin C increases. Similar case has been observed in *Brassica* group *(Brassica juncea, Brassica napus* etc.) where a triangular correlation exists between carbohydrates, proteins and oil. If oil content increases, the carbohydrates and proteins automatically decrease.

Table 1. Genotypic correlation coefficients for various yield and quality component traits in potato (*Solanum tuberosum*. L)

S. No.	**Parameters**	**% emergence days after planting**	**Number of stems hill^{-1}**	**Days taken to flowering**	**Plant height (cm)**	**Plant spread (cm)**	**Leaf area(cm^2)**	**Number of tubers plant^{-1}**	**Average tuber weight(g)**	**Tuber yield plant^{-1}(g)**	**Tuber yield plot^{-1}(kg)**	**Tuber yield hectare^{-1} (q)**	**Specific gravity**	**Total soluble solids (^{o}B)**	Vitamin C (mg 100g^{-1})	Dry matter (100g^{-1})
1.	Per cent emergence days after planting	-------	- 0.183	0.1953	0.367*	0.2917	0.1318	0.0275	0.2436	0.1283	0.3126	0.4436*	0.2374	0.0366	0.0339	0.3905*
2.	Number of stems hill^{-1}		--------	0.0478	0.271	0.325	0.2658	0.7899**	0.4881*	0.4338*	0.1358	0.2573	0.0775	0.1541	-0.1782	0.3516*
3.	Days taken to flowering			--------	0.1801	-0.1211	-0.0347	-0.2254	0.2276	0.1222	0.1979	0.1381	-0.0727	-0.1039	-0.1973	0.3608
4.	Plant height (cm)				--------	0.3876*	0.2417	0.2859	0.5761**	0.6889**	0.464**	0.6797**	0.2227	0.0482	-0.1791*	0.4698**
5.	Plant spread (cm)					--------	0.5467**	0.3776	0.3409	0.4856**	0.5976**	0.6107**	0.1907	0.2622	-0.2185	0.0236
6.	Leaf area (cm^2)						--------	0.3163	0.2719	0.4915**	0.5399**	0.6476**	0.0658	0.1031	-0.3212	0.5418**
7.	Number of tubers plant^{-1}							--------	0.037	0.6474**	0.6104**	0.7236**	0.1531	0.228	-0.3421*	0.4551*
8.	Average tuber weight (g)								--------	0.5976**	0.555**	0.608**	0.4044*	-0.1773	-0.5779**	0.0184
9.	Tuber yield plant^{-1}(g)									--------	0.8623**	0.8973**	0.4126*	-0.2302	-0.0127	0.4724*
10.	Tuber yield plot^{-1} (kg)										--------	0.7529**	-0.1805	0.2286	-0.4124**	0.5693*
11.	Tuber yield hectare^{-1}(q)											--------	-0.024	0.2791	-0.3898*	0.3681*
12.	Specific gravity												--------	0.2449	0.2847	0.7853**
13	Total soluble solids (^{o}B)													--------	0.1458	0.396*
14.	Vitamin C (mg 100g^{-1})														--------	0.215
15.	Dry matter (100g^{-1})															--------

** significant at 1%, * significant at 5%

The path coefficient analysis (Table 2) revealed that the traits viz., number of stems hill^{-1}, leaf area, plant height, number of tubers plant^{-1} and average tuber weight showed the positive direct effect on tuber yield plant^{-1}. The number of tubers plant^{-1} exerted highest positive direct effect on tuber yield plant^{-1} followed by yield plot^{-1}, average tuber weight, plant height and leaf area whereas, traits like plant spread and yield hectare^{-1} showed negative direct effect on yield plant^{-1}. Significant positive correlation coefficients of number of stems hill^{-1}, plant height, plant spread, leaf area, number of tubers plant^{-1}, average tuber weight and yield ha^{-1}, strengthened their reliability in the process of selection for improvement in tuber yield.

Positive direct effect on tuber yield had been reported by Patel *et al.* (2002) and Sattar *et al.* (2007) for tuber number and average tuber weight; Ara *et al.* (2009) and Lamboro *et al.* (2014) for number of stems; Khayatnezhad *et al.* (2011) for plant height and tuber weight; and Ummyiah *et al.* (2013) for average tuber weight, number of tubers plant^{-1} and plant height.

Negative direct effects on yield plant^{-1} were reported by Dereje and Basavaraja (2005) for plant spread. It is therefore, suggested that the characters which exhibited highest direct effect on tuber yield should be taken into consideration during selection programme for the improvement of yield in potato. Regarding positive indirect effects on tuber yield plant^{-1}, number of stems hill^{-1} exhibited indirect positive effect via, leaf area, plant height, number of tubers plant^{-1}, average tuber weight and tuber yield hectare^{-1}; plant height via number of stems hill^{-1}, leaf area, number of tubers plant^{-1}, average tuber weight and yield hectare^{-1}; leaf area via number of stems hill^{-1}, plant height, plant spread, number of tubers plant^{-1}, average tuber weight and yield hectare^{-1}; plant spread via number of stems hill^{-1}, leaf area, number of tubers plant^{-1}, average tuber weight and yield hectare^{-1}; number of tubers plant^{-1} via number of stems hill^{-1}, plant height, leaf area, average tuber weight and yield ha^{-1}; average tuber weight via number of stems hill^{-1}, plant height, leaf area, number of tubers plant$^{-1,}$ average tuber weight and and yield hectare^{-1} via number of stems hill^{-1}, plant height, leaf area, number of tubers plant$^{-1,}$ and average tuber weight. Indirect positive effects towards tuber yield through various traits were reported by many workers such as Dereje and Basavaraja (2005); Roy and Singh (2006); Sattar *et al.* (2007); Singh (2008); Ummyiah *et al.* (2013); and Singh *et al.* (2015). This suggested that for selecting genotypes with higher yield the indirect influence of different traits should also be given due weightage alongwith characters which exert direct effects.

The estimate of residual effect reflects the adequacy and appropriateness of the characters chosen for path coefficient analysis. In the present investigation the residual effect was low (0.0493) indicating the adequacy of characters chosen for the study and the characters studied contributed significantly towards tuber yield plant^{-1}.

The above discussion brought out that number of stems hill^{-1}, leaf area, plant height, number of tubers plant^{-1}, average tuber weight and yield ha^{-1} are the primary contributors for tuber yield plant^{-1} in potato and plants can be selected directly for these traits for improvement of tuber yield plant^{-1} to evolve better lines and to increase the production of the crop.

Table 2. Genotypic path analysis showing direct (diagonal) and indirect (off diagonal) effects of different yield parameters on yield in potato (*Solanum tuberosum*. L)

S. N.	Parameters	Number of stems hill^{-1}	Plant height (cm)	Plant spread (cm)	Leaf area (cm^2)	Number of tubers plant^{-1}	Average tuber weight (g)	Tuber yield plot^{-1}(kg)	Tuber yield hectare^{-1} (q)	Genotypic correlation with yield plant^{-1}
1.	Number of stems hill^{-1}	0.024	0.078	-0.030	0.031	0.168	0.081	0.024	0.039	0.433*
2.	Plant height (cm)	0.014	0.231	-0.057	0.083	0.058	0.195	0.043	0.069	0.688**
3.	Plant spread (cm)	0.013	-0.107	-0.126	0.089	0.198	0.251	0.081	0.073	0.485**
4.	Leaf area (cm^2)	0.016	0.029	0.051	0.044	0.083	0.149	0.039	0.057	0.491**
5.	Number of tubers plant^{-1}	0.015	0.055	-0.035	0.031	0.346	0.111	0.041	0.063	0.647**
6.	Average tuber weight (g)	0.008	0.183	-0.051	0.030	0.006	0.317	0.039	0.051	0.597**
7.	Tuber yield plot^{-1}(kg)	0.031	0.165	0.012	0.029	0.135	0.228	0.324	0.027	0.862**
8.	Tuber yield hectare^{-1} (q)	0.018	0.182	-0.098	0.045	0.394	0.237	0.151	-0.116	0.897**

** significant at 1%, * significant at 5% Residual effect: 0.0493

REFERENCES

Ara, T., Haydar, A., Islam, M. A., Azad, M. A. S. and Khokan, E. H. (2009). Path analysis in potato. *Journal of Soil* and *Nature* **3**(2): 20-23.

Bhagowati, R.R., Saikia, M. and Sut, D. (2002). Variability, heritability, genetic advance and character association in True Potato Seed (TPS) populations. *Journal Agricultural Science Society North East India* **15**(1): 119-122.

Dereje, R. and Basavaraja, N. (2005). Correlation and path analysis in potato. (*Solanum tuberosum* L.). *Journal of Indian Potato Association* **32**(3/4): 213-256.
Dereje, R. and Basavaraja, N. (2005). Correlation and path analysis in potato. (*Solanum tuberosum* L.). *Journal of Indian Potato Association* **32**(3/4): 213-256.
Desai, N.C. and Jaimini. S.N. (1998). Correlation and path analysis of some economic characters in potato. *Journal of Indian Potato Association* **25**: 25-29.

Deway, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of crested wheat grass and seed production. *Agronomy Journal* **519**: 515-518.

Khayatnezhad, M., Shahriari, R., Gholamin, R., Jamaati -e- Somarin, S. and Zabihi -e-Mahmoodabad, R. (2011). Correlation and Path Analysis between Yield and Yield Components in Potato (*Solanum tubersum* L.). *Middle-East Journal of Scientific Research* **7**(1): 17-21.

Lamboro, A., Petros, Y. and Andargie, M. (2014). Correlation and path coefficient analysis between yield and yield components in potato (*Solanum tuberosum* L.) *Plant Science Today* **1**(4): 196-200.

Luthra, S. K., Gopal, J. and P. C. (2005). Genetic divergence and its relationship with heterosis in potato. *Potato Journal* **32**(1-2) : 37-42.

Miller, D.A., Williams, J.C., Robinson, H.F. and Compstock, K.B. (1958). Estimation of genotypic variance and covariance in upland cotton. *Agronomy Journal* **50**: 126-131.

Nasiruddin, M., Haydar, F.M.A., Islam, A.K.M.R. and Hossain, M.M. (2014). Study of Genetic Variability and Correlation of Potato (*Solanum tuberosum* L.) genotypes grown in Bangladesh. *Plant Environment Development* **3**(2): 09-13.

Ozkaynak, E., Samanci, B. and Cetin, M.D. (2003). Correlation and path coefficient analysis of yield components in potato (*Solanum tuberosum* L.). *Turkish Journal of Field Crops* **8**(2) 51-56.

Pandey, K.K., Singh, S.V. and Manivel, P. (2005). Genetic variability and causal relationship over seasons in potato. *Crop Research* **29**(2): 277-281.

Patel, P.B., Patel, N.H. and Patel, R.N. (2002). Correlation and path analysis of some economic characters in potato. *Journal of Indian Potato Association* **29**(3/4): 163-164.

Ramanjit, K., Singh, N. and Kler, D.S. (2001). Correlation studies among leaf area index, tuber number, tuber weight, dry matter production and tuber yield in autumn sown potato. *Environment and Ecology* **19**(1): 19-22.

Rasool, A. Z., Mojtaba, F. and Davood, H. P. (2007). Sequential Path Analysis of Yield Components in Potato. *Potato Research* **49**:273–279.

Roy, A. K. and Singh, P. K. (2006). Genetic variability, heritability and genetic advance for yield in potato (*Solanum tuberosum* L.). *International Journal of Plant Sciences* **1**(2): 282-285.
Roy, A. K. and Singh, P. K. (2006). Genetic variability, heritability and genetic advance for yield in potato (*Solanum tuberosum* L.). *International Journal of Plant Sciences* **1**(2): 282-285.
Sattar, M. A., Sultana, N., Hossain, M. M., Rashid, M. H. and Islam, A. K. M. A. (2007). Genetic variability, correlation and path analysis in potato (*Solanum tuberosum* L.). *Bangladesh Journal of Plant Breeding and Genetics* **20**(1): 33-38.

Sattar, M. A., Uddin, M.Z., Islam, M.R., Bhuiyan, M.K.R and Rahman, M. S. (2011). Genetic divergence in potato (*Solanum tuberosum* L.). *Bangladesh Journal of Agricultural Research* **36**(1): 165-172.

Singh, G. (2008). Studies on genetic variability, association and divergence in potato (*Solanum tuberosum* L.). M.sc. (Ag.) Thesis, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.).

Singh, P., Sharma, P. K., Banjara, N.C., Sahu, N. P. and Sharma, R. (2015). Variability, heritability, genetic advance, correlation and path analysis between yield and yield components in potato (*Solanum tuberosum* L.). *Ecology, Environment and Conservation Paper* **21**(2): 1093-1097.
Singh, P., Sharma, P. K., Banjara, N.C., Sahu, N. P. and Sharma, R. (2015). Variability, heritability, genetic advance, correlation and path analysis between yield and yield components in potato (*Solanum tuberosum* L.). *Ecology, Environment and Conservation Paper* **21**(2): 1093-1097.
Singh, R.K. and Chaudhary, B.D. (1985). Biometrical methods in quantitative genetics analysis, Kalyani Publishers, Ludhiyana. 40-163.

Ummyiah, H. M., Khan, S. H., Jabeen, N., Junaif and Hussain, N.K. (2013). Intertrait relationship and path analysis in potato. *Progressive Horticulture* **45**(1): 201-205.

Wright, S. (1921). Correlation and causation. *Journal of Agricultural Research* **20**: 557-585.