Plant Archives Vol. 25, No. 1, 2025 pp. 2856-2860 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.1.412

CORRELATION AND PATH ANALYSIS OF POTATO GENOTYPES FOR MORPHOPHYSIOLOGICAL TRAITS UNDER INDO-GANGETIC PLAIN

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(Date of Receiving-04-01-2025; Date of Acceptance-22-03-2025)

ABSTRACT

Understanding the interconnections between different agronomic traits is crucial for developing an effective breeding strategy in potato. The current experiment was carried to study the correlation and path analysis in 26 Potato (*Solanum tuberosum* L.) genotypes in a randomized block design with three replications during rabi 2023 under AICRP (Potato) Dholi, Muzaffarpur, Bihar. Correlation coefficient analysis revealed that the traits plant height, number of compound leaves, number of tubers per plant, tuber dry matter and plant emergence showed a positive and significant association with tuber yield per plant. Where traits like harvest index, specific gravity showed positive non-significant association with tuber yield per plant. Path coefficient analysis revealed that number of tubers per plant, number of compound leaves and plant emergence showed high direct positive effect on tuber yield per plant. It can be concluded that, due to the strong positive correlation and direct positive impact of number of tubers per plant, plant emergence and number of compound leaves on tuber yield per plant, these traits are highly suitable for indirect selection in potato breeding programs aimed at increasing tuber yield.

Key words: Selection, Correlation coefficient analysis, Path coefficient analysis.

Introduction

Potato, "*Solanum tuberosum* L.'' is a plant tuber that belongs to the night shade family (Solanacece). The cultivated potatoes were evolved through domestication of wild species that are native to Andean uplands in southern Peru (Hardigan *et al.*, 2017). Potatoes were introduced to India from England via Portuguese tradesmen during the early 17th century (Singh and Rana 2014). Tuberosum and andigena (2n = 2x = 48) are the sub species of *Solanum tuberosum* currently being cultivated. According to N.I. Vavilov, the primary origin of potatoes is the Andes of South America. The formation of tubers requires shortday length, while a long day length reduces tuber formation (Amador *et al.*, 2001). The fruits contain an alkaloid called solanine; hence, they aren't suitable for human Utilization. All potato kinds are grown from a seed called TPS, or botanical seed, which is distinct from the seed tuber (Eggers *et al.*, 2021).A 100-gram fresh tuber consists of 70-80% water and 20-25% dry matter, including 2.8 grams of edible protein, 0.6 grams of total sugars,16.3 grams of starch, 0.5 grams of crude fiber, 0.14 grams of fat, 22.6 grams of carbohydrates, and 25 milligrams of vitamin C (Annegeri and Hiremath, 2022).

Table 2: Estimates of phenotypic coefficient of correlation for twelve yield contributing characters of tuberosum genotypes.

	PH	PE	NSP	NCL	NTP	DTM	HI%	DM	SG	RS	NRS	TWPP
PH	1											
PE	0.1429	1										
NSP	0.1689	-0.0825	1									
NCL	0.439**	0.246 *	-0.016	1								
NTP	0.2354*	-0.0505	-0.1817	0.764**	1							
DTM	0.2115	-0.0486	0.1048	-0.0703	-0.1541	1						
HI	0.3163 **	-0.1227	0.2742 *	0.2346**	0.2297**	-0.1723	1					
DM	-0.1876	-0.1311	-0.1149	-0.3787 **	-0.0052	-0.3074 **	0.3469 **	1				
SG	0.1896	-0.0022	-0.2603 *	0.0724	0.0866	-0.1525	-0.0907	0.0942	1			
RS	-0.191	0.083	-0.2623 *	-0.0906	0.0878	0.0186	-0.3712 **	-0.1773	0.2881 *	1		
NRS	-0.4514 **	0.0854	-0.1297	-0.1909	0.3511 **	-0.2508 *	-0.0861	0.2735 *	-0.0937	0.047	1	
TWPP	0.4391 **	0.2704 *	-0.0214	0.3681 **	0.6493**	-0.006	0.106	0.431**	0.204	0.1223	-0.3198 **	1

PH: Plant height, PE: Plant emergence, NSP: no. of shoots/plant, NCL: no. of compound Leaves/ plant, NTP: no. of tubers /plant, DTM; days to maturity, HI: harvest index, DM: dry matter, SG: specific gravity, RS: reducing sugar, NRS: non reducing sugar, TWPP: tuber weight /plant.

In recent years, the per capita consumption of potatoes has been steadily increasing, highlighting the need to develop high-yielding cultivars with improved storage and processing qualities. This can be achieved through modern crop improvement techniques. Utilizing genetically diverse parents in breeding programs is expected to produce desirable and superior offspring (Bhatt, 1973).

The degree to which two different variables are related with one another is shown by correlation. The selection process is highly influenced by degree of association, which aids in choosing the desired genotypes. The identification of component features for genetically enhancing yield through selection is made easier with the use of correlation coefficient analysis, which typically provides information about the relationships between the many characters under consideration.

It is usually beneficial and wanted to consider yield combined with yield-contributing features for final selection. Therefore, the relationship between yield and its component qualities has been investigated by using phenotypic correlation coefficient.

Due to the fact that correlation studies by themselves cannot clearly link one attribute to another. in order to create a true state of interaction between various features, path coefficient analysis is consequently essential for examining cause and effect interactions. a change in any one of these qualities will affect the entire structure of cause and effects interactions since the dependent trait total tuber yield is linked to several independent constituent traits (indirect). Using a path coefficient analysis with yield as the dependent trait and the other characteristics as independent variables, the phenotypic correlation coefficients of ten characteristics on total tuber yield were split into direct and indirect impacts.

Materials and Methods

The purpose of this study titled " correlation and path analysis in potato under Indo-gangetic plain," was to collect data on the trait correlation, path coefficient analysis of potato germplasm at the farm of Tirhut College of Agriculture, Dholi, Bihar, during Rabi 2023-24. Twenty-six (26) genotypes *i.e.* CP-2298, CP-1424, CP-7701, CP-1157, CP-4242, CP-2150, CP-1544, CP-1215, CP-4404, CP-3433, CP-7183, CP-3168, CP-3593, CP-1214, CP-1162, CP-7783, CP-1735, CP-3426, CP-3674, CP-1596, CP-1329, CP-2354, CP-2148, CP-2132 were used by following RBD design with three replications. On 10^{th} November 2020, the treated tubers were placed on ridges spaced at 60 cm × 20 cm spacing. Each genotype was planted on 2 m long and 1.8 m wide plot consisting five rows which accommodated six plants per row and thirty plants per plot. Earthing up at 30 DAP was performed manually. Splitting the injection of urea into furrows was performed before earthing up. Manual weeding was done at 30 and 45 DAP respectively. The recommended package of practices was followed.

Data for each trait under study were collected from five randomly selected plants in each plot and expressed on a per-plant basis. The average of these five plants was used for statistical analysis. Observation recorded are Plant height (cm), Plant emergence (%), Number of shoots per plant, Number of compound leaves per plant, Number of tubers per plant, Days to maturity, Harvest index (%), Tuber dry matter, Specific gravity of tuber (g/cm^3), Reducing sugar (mg/100g), non-reducing sugar (mg/100g) and Tuber Yield per plant (kg).

Statistical analysis

Al-Jibouri *et al.*, (1958) used a variance and covariance analysis matrix with total variability partitioned into genotypes, replications, and error components to determine the correlation coefficient.

Phenotypic correlation coefficient (r_p):

$$rp(XiXj) = \frac{CoVp(XiXj)}{\sqrt{Vp(Xi)}.Vp(Xj)}$$

$r_p(X_iX_j)$ = phenotypic correlation between i_{th} and j_{th} traits

$CoV_p(X_iX_j)$ = phenotypic covariance between i_{th} and j_{th} traits

$V_p(X_i)$ = phenotypic variance of i_{th}trait

$V_p(X_j)$ = phenotypic variance of j_{th} trait

Following that, the estimated correlation coefficients (r_g and r_p) were compared to a tabulated 'r' value at (n-2) df, as specified by Fisher and Yates (1967). The correlation was considered significant when the computed values were larger than the tabulated values at a significance level of 5%, and non-significant when the reverse result was achieved.

Path coefficient analysis

Dewey and Lu's (1959) approach was used to get the path coefficient. The path coefficient was obtained by simultaneously solving the following equations, which provided the essential relationship between genotypic correlation (r) and path coefficient (P).

$r_{14}= P_{14}+ r_{12}\ P_{24}+ r_{13}\ P_{34}$

$r_{24}= r_{21}\ P_{14} +P_{24} + r_{23}\ P_{34}$

$r_{34}= r_{31}\ P_{14} +P_{32} + r_{24}\ P_{34}$

The genotypic association of character components with yield was represented by r_{14}, r_{34}, and r_{24}, which were all dependent variables. Independent variables (r_{14}, r_{34} and r_{24}) show genotypic correlation across component qualities, whereas $r_{12}\ P_{24}$, $r_{21}\ P_{14}$, $r_{13}\ P_{34}$, $r_{23}\ P_{34}$, $r_{24}\ P_{34}$, and $r_{31}\ P_{14}$ show indirect impacts on yield via other characteristics.

The direct impacts were calculated using the provided formulae.

$P_{14}= C_{11}\ r_{14}+ C_{12}\ r_{24}+ C_{13}\ r_{34}$

$P_{34}= C_{31}\ r_{14} +C_{32}\ r_{32} + C_{24}\ r_{34}$

$P_{24}= C_{21}\ r_{14} +C_{22}\ r_{24} + C_{23}\ r_{34}$

The constants C_{11}, C_{12}, C_{23}, and C_{33} were calculated using the abbreviated Doultittle's technique. Lenka and Mishra (1973) classification was used to classify direct and indirect effects values.

Residual effect: The contribution of residual factor was estimated as

Residual effect(x), $P_{xy} =\sqrt{1-R^2}$

Where, R^2=Coefficient of determination

Result and Discussion

The selection process is highly influenced by degree of association, which aids in choosing the desired genotypes. The identification of component features for genetically enhancing yield through selection is made easier with the use of correlation coefficient analysis.

The traits number of compound leaves (0.6888**), number of tubers per plant (0.6346**), tuber dry matter (0.4268**) and plant emergence (0.2708*) showed a positive and significant association with tuber weight per plant. Positive correlation with reducing sugar (0.1223) and harvest index (0.1036) was noted, albeit without statistical significance. In contrast, the trait exhibited significant and negative correlation with non-reducing sugar (-0.3198**).

Inter correlation among yield components

The trait plant height had a positive and significant relationship with number of compound leaves (0.439*), tuber weight per plant (0.4394**), harvest index (0.3163**) and number of tubers per plant (0.2355*). Similar findings were observed by Bhagowati *et al.*, (2002).

The trait plant emergence had a positive and significant association with tuber weight per plant (0.2704*) and number of compound leaves (0.2463*). Similar findings observed by Panigrahi *et al.*, (2017). Plant emergence showed non-significant and negative association with harvest index (-0.1227), number of shoots per plant (-0.0825), number of tubers per plant (-0.0506), days to maturity (-0.0486) and tuber weight per plant (-0.0022).

The trait harvest index (0.2742*) showed a positive and significant association with number of shoots per plant.

The trait number of compound leaves had a positive and significant relationship with number of tubers per plant (0.7648**), tuber weight per plant (0.3681**), plant emergence (0.2463*) and harvest index (0.2346*). Similar findings observed by Nasiruddin *et al.*, (2014).

The trait number of tubers per plant had a positive and significant association with number of compound leaves (0.7648**), tuber weight per plant (0.6493**), and harvest index (0.2297*). Similar findings were obtained by Luthra (2001)

The trait harvest index had a positive and significant relationship with number of shoots per plant (0.2742*), tuber dry matter (0.3469*), number of compound leaves (0.2346*) and number of tubers per plant (0.2297*). Similar findings were given by Hajam *et al.*, (2019).

The trait reducing sugar had a positive and significant relationship with Specific gravity (0.2881*). There is a positive but non-significant correlation with number of tubers per plant (0.0878), tuber weight per plant (0.1223) and plant emergence (0.083).

Table 2: Estimates of phenotypic path coefficient analysis of total tuber yield with its component traits in potato in tuberosum genotypes (Residual value= 0.402).

	PH	PE	NSP	NCL	NTP	DTM	HI%	DM	SG	RS	NRS	TWPP
PH	**0.1019**	0.0331	0.0163	0.1006	0.0906	0.0065	-0.0189	0.0055	0.0331	-0.0068	0.0775	0.4394 **
PE	0.0146	**0.2319**	-0.008	0.0563	-0.0195	-0.0015	0.0073	0.0017	-0.0004	0.003	-0.0147	0.2708 *
NSP	0.0172	-0.0191	**0.0966**	-0.0039	-0.0699	0.0032	-0.0163	0.0001	-0.0454	-0.0094	0.0223	-0.0247
NCL	0.0448	0.0571	-0.0016	**0.2287**	0.2941	-0.0021	-0.014	0.0229	0.0279	-0.0004	0.0314	0.6888 **
NTP	0.024	-0.0117	-0.0175	0.1749	**0.3846**	-0.0047	-0.0137	0.0259	0.0442	0.0044	0.0242	0.6346 **
DTM	0.0216	-0.0113	0.0101	-0.0161	-0.0592	**0.0306**	0.0103	-0.0095	-0.0266	0.0007	0.043	-0.0064
HI%	0.0322	-0.0285	0.0265	0.0537	0.0883	-0.0053	**-0.0596**	0.0105	-0.0158	-0.0132	0.0148	0.1036
DM%	0.0144	0.0099	0.0002	0.135	0.2563	-0.0075	-0.0161	**0.0389**	0.0103	0.0019	-0.0165	0.4268 **
SG	0.0193	-0.0005	-0.0251	0.0365	0.0975	-0.0047	0.0054	0.0023	**0.1745**	0.0103	0.0161	0.2042
RS	-0.0195	0.0192	-0.0253	-0.0026	0.0478	0.0006	0.0221	0.002	0.0503	**0.0357**	-0.0081	0.1223
NRS	-0.046	0.0198	-0.0125	-0.0418	-0.0542	-0.0077	0.0051	0.0037	-0.0164	0.0017	**-0.1716**	-0.3198 **

PH: Plant height, PE: Plant emergence, NSP: no. of shoots/plant, NCL: no. of compound Leaves/ plant, NTP: no. of tubers /plant, DTM; days to maturity, HI: harvest index, DM: dry matter, SG: specific gravity, RS: reducing sugar, NRS: non reducing sugar, TWPP: tuber weight /plant.

For the trait non reducing sugar genotypic correlation was positive and non-significant for tuber dry matter (0.0963), plant emergence (0.0854) and reducing sugar (0.047). in contrast, the trait exhibited significant and negative correlation with tuber weight per plant (-0.3198**).

Path coefficient analysis of tuberosum genotypes for yield attributing traits

Due to the fact that correlation studies by themselves cannot clearly link one attribute to another. in order to create a true state of interaction between various features, path coefficient analysis is consequently essential for examining cause and effect interactions a change in any one of these qualities will affect the entire structure of cause and effects interactions since the dependent trait total tuber yield is linked to several independent constituent traits (indirect).

Using a path coefficient analysis with yield as the dependent trait and the other characteristics as independent variables, the phenotypic correlation coefficients of ten characteristics on total tuber yield were split into direct and indirect impacts. for phenotypic path coefficients, the computed direct and indirect impacts of a number of variables on total tuber yield are represented the direct and indirect effects of 12 characters on tuber yield is estimated by path coefficient analysis.

The direct effect of plant height was positive with value of 0.1019. this trait showed positive indirect effects through number of compound leaves (0.1006), number of tubers per plant (0.0905), non-reducing sugar (0.0775), plant emergence (0.03314), number of shoots per plant (0.0163), days to maturity (0.00646) and tuber dry matter (0.0055). similar findings given by Hajam *et al.*, (2019). the trait had negative indirect effects on tuber weight per plant via reducing sugar (-0.0068) and harvest index (-0.0189). Similar findings were obtained by Bhagowati *et al.*, (2003). Plant emergence had a positive direct effect on tuber weight per plant (0.23192). The number of shoots per plant had direct effect on tuber weight per plant (0.0966). Number of shoots per plant exerted positive indirect effects on tuber weight per plant through non-reducing sugar (0.02223), plant height (0.0172), days to maturity (0.0032) and tuber dry matter (0.0001) similar findings given by Lamboro *et al.*, (2014). The direct effect of number of compound leaves was positive with value of 0.2287. Results supported by Yildirim *et al.*, (1997). This trait showed positive indirect effects through number of tubers per plant (0.2941), plant emergence (0.0571), plant height (0.0448), non-reducing sugar (0.0314), and tuber dry matter (0.0229).

Number of tubers per plant had a highest positive direct effect on tuber weight per plant (0.3846) similarly identified by Hajam *et al.*, (2019). The indirect effect of this trait was positive *via* number of compound leaves (0.1749, tuber dry matter (0.0259), non-reducing sugar (0.0242), plant height (0.024) and reducing sugar (0.0044). similar findings were obtained by Tripura *et al.*, (2016). The direct effect of days to maturity was positive (0.0306) and exerted positive indirect effects on tuber weight per plant through non-reducing sugar (0.04304), plant height (0.0216), harvest index (0.0103), number of shoots per plant (0.0101) and reducing sugar (0.0007). The direct effect of harvest index was negative with value of -0.05961. this trait showed positive indirect effects through number of tubers per plant (0.08834), number of compound leaves (0.05365), plant height (0.03224), number of shoots per plant (0.02648), tuber dry matter (0.01052).

Tuber dry matter had a positive direct effect on tuber weight per plant (0.0389). the indirect effect of this trait was positive *via* number of tubers per plant (0.2563), number of compound leaves (0.135), plant height (0.0144), plant emergence (0.0099) and number of shoots per plant (0.0002). Similar findings were obtained by Khayatnezhad *et al*., (2011). The Specific gravity had direct effect on tuber weight per plant was positive (0.1745). The direct effect of reducing sugar was positive with value of 0.03566. Non-reducing sugar had a negative direct effect on tuber weight per plant (-0.1716).

Residual effect the phenotypic residual value was 0.402, which indicated that the twelve features under study accounted for 59.8% of the variability and that the remaining 40.2% of the variability was attributed to unidentified causes.

Conclusion

From the correlation and path analysis of different traits in potato, the study revealed key insights into the interrelationships among various traits. The correlation analysis showed that traits like plant height, number of compound leaves per plant, number of tubers per plant, dry matterare showed significant positive influences on yield suggesting these traits may be targeted for selection in breeding programs to enhance productivity (Roy and Singh (2006).

Path analysis further delineates the direct and indirect effects of each trait on yield, offering a more pronounced understanding of how traits interact to influence yield. Traits with high direct effects, such as number of compound leaves per plant, plant emergence and number of tubers per plant, suggest a direct pathway for improving yield, while traits with significant indirect effects indicate potential for yield improvement through secondary pathways. Collectively, these findings support the potential to enhance potato breeding strategies by focusing on traits with strong direct and indirect impacts on yield, helping breeders prioritize traits for selection and cross-breeding in potato improvement programs. This approach provides a foundation for optimizing potato production, enhancing both yield and quality traits in new cultivars under Indo-Gangtic plain.

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