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Vikas Kumar
Department of Vegetable Science, A.N.D.U.A and T. Kumarganj, Ayodhya, Uttar Pradesh, India

DP Mishra
Department of Vegetable Science, A.N.D.U.A and T. Kumarganj, Ayodhya, Uttar Pradesh, India

Vimlesh Kumar
College of Agriculture Campus Azamgarh, A.N.D.U.A and T. Kumarganj, Ayodhya, Uttar Pradesh, India

AK Tiwari
Department of Vegetable Science, A.N.D.U.A and T. Kumarganj, Ayodhya, Uttar Pradesh, India

Corresponding Author:
Vikas Kumar
Department of Vegetable Science, A.N.D.U.A and T. Kumarganj, Ayodhya, Uttar Pradesh, India

Correlation and path coefficient analysis for yield and components traits in different genotypes of potato (*Solanum tuberosum* L.) under Eastern Uttar Pradesh condition

Vikas Kumar, DP Mishra, Vimlesh Kumar and AK Tiwari

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Abstract
The correlation studies conducted in thirty diverse genotypes of potato (*Solanum tuberosum* L.). the analysis of correlation coefficient revealed that the magnitude of genotypic correlation was higher than phenotypic correlation for most of the characters and observed that the weight of ‘B’ grade tubers per hill (g), number of tubers per hill, number of ‘B’ grade tubers per hill, number of ‘C’ grade tubers per hill, weight of ‘C’ grade tubers per hill (g) and number of ‘A’ grade tubers per hill while number of ‘D’ grade tubers per hill and weight of ‘D’ grade tubers per hill (g) were significantly and positively associated with yield of tubers per hill. On the other hand, path analysis studies exhibited that the maximum positive direct effect on yield of tubers per hill was exerted by number of tubers per hill, number of ‘D’ grade tubers per hill, weight of ‘C’ grade tubers per hill (g), number of ‘B’ grade tubers per hill, number of ‘A’ grade tubers per hill, number of leaves per plant, number of eyes per tuber and plant height (cm) at genotypic level. Based upon correlation and path analysis, weight of ‘B’ grade tubers per hill (g), number of tubers per hill, number of ‘B’ grade tubers per hill, number of ‘C’ grade tubers per hill, weight of ‘C’ grade tubers per hill (g) and number of ‘A’ grade tubers per hill while number of ‘D’ grade tubers per hill and weight of ‘D’ grade tubers per hill (g) could be reliable selection parameters for improvement of potato.

Keywords: Correlation, potato, path analysis, yield of tubers per hill, direct effects

Introduction

Potato (*Solanum tuberosum* L.) 2n = 4n = 48 is the most important cash crop belong to family solanaceae. It has been recognized as a 4th major food crop after wheat, rice and maize. It is native of tropical South America region where it grown wild in nature and presents the widest diversity of forms like tuber shape, size, colour, taste etc. It was introduced in India from Europe in early 17th century by Portuguese. The edible part of potato is modified underground stem. It is one of the most efficient food crop which produce more dry matter, dietary fibre, quality protein, minerals, vitamin 'A', 'B' and richest source of energy considered as a balanced and nutritive food. In addition to this, it is utilized in preparation of chips, french fries, shreads, papad etc.

The major potato producing countries in world are, erstwhile USSR, Poland, China, USA, Germany, India, Romania, Netherland, UK, France, and Spain. India contributes 10 to 11 per cent of the world potato production and is the second largest producer at the global level. China has fist rank in potato production sharing 22 per cent of world production. The total cultivated area of potato in India was 1906.97 million hectares with a production 41482.79 million tonnes. Uttar Pradesh is one of the main potato growing states of the country, which produces about 14125.08 million tonnes of potato from an area of 567.66 million hectare (Anonymous, 2011-12) [2].

Potato is a herbaceous annual and stolons are lateral shoots, usually emerged from the most basal nodes below soil level. Typically they are dia geotropic shoots with elongated internodes, hooked at the tip. They have spirally arranged scale leaves. Tubers are developed from the sub-apical region of stolon. However, tuber formation includes two processes, viz., stolon formation and tuberization of the stolon tips. Stolon formation usually begins at the lower nodes and progresses acropetally. The first tuber, in turn, usually develops from the lower stolons and tends to become dominant over those formed latter. Tubers are important as 75 to 85% of the total dry matter produced by the plant is stored in them. Potato tuber is a modified stem with a shortened axis and rather poorly developed leaves. The 'eye' of the potato tuber is a leaf scar with a subtended lateral bud having undeveloped internodes. In part, a number of potato varieties has been recommended by the central and state governments for cultivation in eastern Uttar Pradesh. But no systematic work on the evaluation of existing cultivars has been done so far. The screening of existing genetic variability is pre-requisite to know the nature and magnitude of genetic variation and also the influence of environment in the expression of yield and quality traits. Greater the variability in the initial genetic material better world be the chances of selecting desirable type (Vavilov, 1951) [18]. The genotypic correlation is essential for assessing the real genetic variation in traits of significance. The basic concepts of correlation was put forth by Galton (1889) [8] and elaborated by Fisher (1918) [7] and Wright (1921) [19]. Engledow and Wadham (1923) [5] advocated the physiological basis of yield and correlation between physiological components and yield. Path coefficient is the simple standardized partial regression coefficient, which splits the correlation coefficient into the measures of direct and indirect effects of a set of independent variables on the dependent variable. It helps to find out the direct and indirect effects of yield attribute which are of great importance for crop improvement.

The estimates of correlation coefficients indicate only the inter-relationship of the character but, do not furnish information on the cause and effect relationships. Wright (1921) [19] has devised the analysis of path coefficient to provide effective means of finding out direct and indirect causes of association which permits the critical examination of specific forces acting to produce a given correlation and measures the relative importance of each causal factor. Dewey and Lu (1959) [7] were the first to demonstrate the utility of path coefficient analysis in breeding programme using crested wheat grass progenies.

Due to the mutual association, the development of dependent variable is determined by the degree of direct effect of independent variables and direct effects exerted via other characters, arising inevitably as an integral part of the growth pattern. Under such complex situations, the total correlation is insufficient to explain the real association for an effective and fruitful manipulation of the characters.

Materials and methods

The study was carried out at Main Experiment Station, Department of Vegetable Science, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.) India during *rabi* season of 2011-12. Geographically Narendra Nagar (Kumarganj) falls under humid, sub-tropical climate and is located in between 26.47 ^{0}N latitude and 82.12 ^{0}E longitude at an altitude with 113 meters above the mean sea level. The experimental field was sandy loam in texture with slightly alkaline (pH 8.0) in reaction, low in organic carbon and nitrogen, medium in phosphorus and potassium. The mechanical composition of soil constituted 64.4 per cent sand, 27.8 per cent silt and 11.3 per cent clay. Experiment Station falls under semi-arid region receiving an annual mean precipitation of about 1280 mm. The maximum precipitation is received from July to September. The winter months are usually cool and dry but occasional light showers are also not uncommon. The study comprising thirty genotypes of potato which was collected from C.P.R.I., Shimla. Experiment was laid out in a Randomized Block Design with three replications. Five rows in a plot of 3.0m x 2.0m size with the distance of 60 cm row to row and 20 cm plant to plant was maintained. The tubers of each genotype were sown on 3rd November 2011. The first irrigation was done just after sowing then irrigations were done at 15 days interval during the crop growth period. Data was recorded on Five randomly plants selected in each plot. These plants were tagged and the average value of five plants for each character was used for statistical analysis. The correlation between different characters at genotypic (g), phenotypic (p) and environmental (e) levels were estimated according to Searle (1965) [15]. Path coefficient analysis carried out according to Wright (1921) [19] and as elaborated by Dewey and Lu (1959) [7] by partitioning the genotypic correlation coefficients into direct and indirect effects.

Results and Discussion

Correlation coefficients between yield and its components traits:

The analysis of correlation coefficient (Table 1) revealed that yield of tubers per hill exhibited significant and positive correlation at phenotypic level with number of tubers per hill, number of 'A' grade tubers per hill, number of 'B' grade tubers per hill, weight of 'B' grade tubers per hill (above 51-75 g), number of 'C' grade tubers per hill, weight of 'C' grade tubers (25-50 g), number of 'D' grade tubers per hill and weight of 'D' grade tubers per hill (below 25 g). Challaiah and Kulkarni and Gaur *et al*. also reported similar results in their studies. Among other traits, plant height had negative and significant association with number of eyes per tuber and weight of 'B' grade tubers per hill at phenotypic level. Number of stems per hill showed highly significant and positive correlation with number of leaves per plant and negatively correlated with number of 'D' grade tubers per hill and weight of 'D' grade tubers per hill at phenotypic level. However, this trait had positive and significant correlation with weight of 'A' grade tubers per hill at phenotypic level. Number of leaves per plant showed highly significant and positive correlation with number of stems per hill, weight of 'A' grade tubers per hill and negative correlation with number of 'B' grade tubers per hill, number of 'D' grade tubers per hill and weight of 'D' grade tubers per hill, but significant and positive correlation number of 'A' grade tubers per hill and negative correlation with number of tubers per hill at phenotypic level. Number of tubers per hill showed positive and highly significant association with number of 'B' grade tubers per hill, weight of 'B' grade tubers per hill, weight of 'C' grade tubers per hill, number of 'D' grade tubers per hill, weight of 'D' grade tubers per hill, yield of tubers per hill and significant negative correlation with number of leaves per plant. The estimates of correlation coefficient at phenotypic level revealed that number of eyes per tubers showed significant and negative correlation with plant height. The number of 'A' grade tubers per hill showed positive and highly significant association with weight of 'A' grade tubers per hill, number of 'C' grade tubers per hill and yield of tubers per hill. However, this trait had significant positive correlation with number of leaves per plant. The weight of 'A' grade tubers per hill, showed negative and highly significant phenotypic correlation with number of 'D' grade tubers per hill and weight of 'D' grade tubers per hill and highly significant positive correlation with number of 'A' grade tubers per hill, number of leaves per plant and number of stems per hill. The number of 'B' grade tubers per hill showed positive and highly significant association with number of tubers per hill, weight of 'B' grade tubers per hill, number of 'C' grade tubers per hill, weight of 'C' grade tubers per hill, number of 'D' grade tubers per hill, weight of 'D' grade tubers per hill and yield of tubers per hill and highly significant negative correlation with number of leaves per plant. The weight of 'B' grade tubers per hill showed positive and highly significant association with number of 'C' grade tubers per hill, weight of 'C' grade tubers per hill, number of 'D' grade tubers per hill, weight of 'D' grade tubers per hill yield of tubers per hill, number of 'B' grade tubers per hill and number of tubers per hill. Same findings have been reported by Pinto *et al*. (1982) [13].

The number of 'C' grade tubers per hill showed positive and highly significant correlation with weight of 'C' grade tubers per hill, and yield of tubers per hill number of 'B' grade tubers per hill weight of 'B' grade tubers per hill and number of 'A' grade tubers per hill.

The weight of 'C' grade tubers per hill showed positive and highly significant correlation with weight of 'D' grade tubers per hill, yield of tubers per hill, number of tubers per hill, number of 'B' grade tubers per hill, number of 'C' grade tubers per hill and weight of 'B' grade tubers per hill but significant and positive correlation with number of 'D' grade tubers per hill. The number of 'D' grade tubers per hill exhibited highly significant and positive phenotypic correlation with weight of 'D' grade tubers per hill, number of tubers per hill, number of 'B' grade tubers per hill, weight of 'B' grade tubers per hill but significant and positive correlation with yield of tubers per hill and weight of 'C' grade tubers per hill. The weight of 'D' grade tubers per hill showed significant and positive phenotypic correlation with yield of tubers per hill and highly significant positive correlation with number of tubers per hill, number of 'B' grade tubers per hill, weight of 'B' grade tubers per hill, weight of 'C' grade tubers per hill and number of 'D' grade tubers per hill. Similar results have been reported by Estevez and Sidhu and Pandita (1979) [16], Pandita and sidhu (1980) [10] in their studies.

Path coefficient analysis:

The path coefficient analysis (Table 1) revealed that the highest positive direct effect towards yield of tubers per hill (g) was observed by number of tubers per hill, number of 'D' grade tubers per hill, weight of 'C' grade tubers per hill, number of 'B' grade tubers per hill, number of 'A' grade tubers per hill, number of leaves per plant, number of eyes per tuber and plant height (cm). Almost similar conclusions were drawn by), Pandey *et al*. (2005) [9] and Tuner and Stevens (1959) [17]. However weight of 'D' grade tubers per hill, number of 'C' grade tubers per hill, weight of 'B' grade tubers per hill, weight of 'A' grade tubers per hill, and number of stems per hill had exerted negative direct effect on yield of tubers per hill (g).

The plant height via weight of 'D' grade tubers per hill, number of stems per hill via weight of 'D' grade tubers per hill, number of leaves per plant via weight of 'D' grade tubers per hill, number of tubers per hill via number of 'B' grade tubers per hill, number of eyes per tuber via number of 'D' grade tubers per hill, number of 'A' grade tubers per hill via weight of 'D' grade tubers per hill, weight of 'A' grade tubers per hill via weight of 'D' grade tubers per hill, number of 'B' grade tubers per hill via weight of 'C' grade tubers per hill had exerted maximum positive indirect effects on number of tubers per hill. Similar results have been reported by Ahmad *et al*. (2005) [1], Roy *et al* (2006) [14] and Barik *et al*. (2010) [3]. The weight of 'B' grade tubers per hill via number of tubers per hill, number of 'C' grade tubers per hill via weight of 'C' grade tubers per hill, weight of 'C' grade tubers per hill via number of tubers per hill, number of 'D' grade tubers per hill via number of tubers per hill and weight of 'D' grade tubers per hill via number of tubers per hill, number of eyes per tuber via number of 'D' grade tubers per hill, had also showed maximum positive indirect effects on number of tubers per hill.

However, plant height via number of 'D' grade tubers per hill, number of stems per hill via number of 'D' grade tubers per hill, number of leaves per plant via number of 'D' grade tubers per hill, number of tubers per hill via number of 'C' grade tubers per hill, number of 'A' grade tubers per hill via number of 'D' grade tubers per hill, weight of 'A' grade tubers per hill via number of 'D' grade tubers per hill, number of 'B' grade tubers per hill via number of 'C' grade tubers per hill, weight of 'B' grade tubers per hill via weight of 'D' grade tubers per hill, number of 'C' grade tubers per hill via weight of 'D' grade tubers per hill, weight of 'C' grade tubers per hill via number of 'C' grade tubers per hill, number of 'D' grade tubers per hill via weight of 'D' grade tubers per hill, and weight of 'D' grade tubers per hill via number of 'C' grade tubers per hill had exerted negative indirect effects on yield of tubers per hill.

Table 1: Estimates of correlation coefficient at Phenotypic (P) and genotypic (G) level for yield and its components traits

Traits	Number of stems per hill	Number of leaves per plant	Number of tubers per hill		Number of eyes per tuber	Number of 'A' grade tubers per hill	Weight of 'A' grade tubers per hill (above 75 g)	Number of 'B' grade tubers per hill	Weight of 'B' grade tubers per hill (above 51-75 g)	Number of 'C' grade tubers per hill	Weight of 'C' grade tubers per hill (25-50 g)	Number of 'D' grade tubers per hill	Weight of 'D' grade tubers per hill (below 25 g)	Yield of tubers per hill
Plant height (cm)	P	0.0539	0.2393	-0.1711	-0.3713*	-0.0807	0.0159	-0.2343	-0.3662*	-0.0264	-0.1079	-0.1850	-0.1680	-0.2226
	G	0.0535	0.2991	-0.2042	-0.4666	-0.0900	0.0377	-0.3021	-0.4013	-0.0374	-0.1164	-0.2140	-0.1810	-0.2814
Number of stems per hill	P		0.5274**	-0.2035	0.0118	0.2283	.4064*	-0.1214	-0.1328	0.1609	0.2480	-0.5400**	-0.4810**	0.0356
	G		0.6340	-0.2329	0.0320	0.2718	0.4396	-0.2163	-0.1099	0.1891	0.2973	-0.6130	-0.5710	0.1295
Number of leaves per plant	P			-0.3829*	0.0447	0.3799*	.5426**	-0.4797**	-0.3375	-0.1502	-0.2633	-0.6490**	-0.6490**	-0.1141
	G			-0.4142	0.0357	-0.4033	0.5901	-0.4907	-0.3930	-0.1648	-0.2765	-0.6680	-0.6730	-0.1270
Number of tubers per hill	P				0.2005	0.3287	-0.0476	0.8785**	0.8554**	0.7550	0.5963**	0.7157**	0.6964**	0.7697**
	G				0.2536	0.3788	-0.0409	0.9761	0.9328	0.8201	0.6997	0.7743	0.7508	0.8864

Number of eyes per tuber	P					0.2480	0.2113	0.1501	0.2217	0.2299	0.0507	0.0831	0.0458	0.2530
	G					0.2826	0.2219	0.1807	0.2072	0.2372	0.0709	0.0925	0.0609	0.2718
Number of ‘A’ grade tubers per hill	P						0.773**	0.1924	0.3315	0.4493**	0.0827	-0.2190	-0.2740	0.5937**
	G						0.8592	0.2297	0.3696	0.4832	0.1069	-0.2230	-0.2850	0.6487
Weight of ‘A’ grade tubers per hill (above 75 g)	P							-0.1095	0.0064	0.1563	-0.1129	-0.5090**	-0.5840**	0.3383
	G							-0.1229	0.0249	0.1835	-0.1243	-0.5370	-0.6240	0.3983
Number of ‘B’ grade tubers per hill	P								0.8923**	0.7481**	0.7297**	0.7134**	0.7027**	0.7581**
	G								0.9718	0.7985	0.7732	0.7476	0.7332	0.8895
Weight of ‘B’ grade tubers per hill (above 51-75 g)	P									0.7295**	0.6909**	0.6225**	0.6001**	0.8627**
	G									0.7599	0.7511	0.6478	0.6271	0.9457
Number of ‘C’ grade tubers per hill	P										0.7627**	0.3034	0.3249	0.7454**
	G										0.8041	0.3269	0.3357	0.8344
Weight of ‘C’ grade tubers per hill (25-50 g)	P											0.3808*	0.4606**	0.6487**
	G											0.4069	0.4742	0.7298
Number of ‘D’ grade tubers per hill	P												0.9634**	0.4011*
	G												0.9893	0.4213
Weight of ‘D’ grade tubers per hill (below 25 g)	P													0.3564*
	G													0.3917

*, ** = Significant at P= 0.05 and 0.01 levels, respectively

Table 2: Direct and indirect effects of different characters on yield in potato at genotypic level

Characters	Plant height (cm)	Number of stems per hill	Number of leaves per plant	Number of tubers per hill	Number of eyes per tuber	Number of ‘A’ grade tubers per hill	Weight of ‘A’ grade tubers per hill (above 75 g)	Number of ‘B’ grade tubers per hill	Weight of ‘B’ grade tubers per hill (above 51-75 g)	Number of ‘C’ grade tubers per hill	Weight of ‘C’ grade tubers per hill (25-50 g)	Number of ‘D’ grade tubers per hill	Weight of ‘D’ grade tubers per hill (below 25 g)	Correlation with Yield of tubers per hill
Plant height (cm)	0.0155	-0.0058	0.0222	-0.1465	-0.0159	-0.0328	-0.0045	-0.1206	0.0714	0.0248	-0.1140	-0.4650	0.4898	-0.2814
Number of stem per hill	0.0008	-0.1081	0.0476	-0.1671	0.0011	0.1022	-0.0521	-0.0864	0.0196	-0.1256	0.2910	-0.3340	0.5406	0.1295
Number of leaves per plant	0.0046	-0.0692	0.0743	-0.2972	0.0012	0.1516	-0.0670	-0.1959	0.0699	0.1101	-0.2770	-0.4540	0.8177	-0.1270
Number of tubers per hill	-0.0030	0.0252	-0.0308	0.7175	0.0087	0.1423	0.0049	0.3898	-0.1659	-0.5446	0.1849	0.1849	-0.0270	0.8864
number of eyes per tuber	-0.0070	-0.0035	0.0027	0.1820	0.0341	0.1062	-0.0263	0.0722	-0.0369	-0.1571	0.0694	0.2012	-0.1650	0.2718
Number of ‘A’ grade	-0.0010	-0.0294	0.0230	0.2718	0.0096	0.3758	-0.1019	0.0917	-0.0657	-0.3209	0.1047	-0.4840	0.7689	0.6487

tubers per hills														
Weight of 'A' grade tubers per hill (above 75 g)	0.0006	-0.0475	0.0436	-0.0294	0.0076	0.3229	-0.1186	-0.0491	-0.0044	-0.1219	-0.1217	-0.1690	0.6845	0.3983
Number of B' grade tubers per hill	-0.0050	0.0234	-0.0365	0.7004	0.0062	0.0863	0.0146	0.3993	-0.1728	-0.5303	0.7567	0.6267	-0.9800	0.8895
Weight of 'B' grade tubers per hill (above 51-75 g)	-0.0060	0.0119	-0.0292	0.6693	0.0071	0.1389	-0.0030	0.3881	-0.1779	-0.5047	0.7351	0.4096	-0.6930	0.9457
Number of 'C' grade tubers per hill	-0.0004	-0.0204	-0.0123	0.5884	0.0081	0.1816	-0.0218	0.3188	-0.1352	-0.6641	0.7871	0.7112	-0.9060	0.8344
Weight of 'C' grade tubers per hill (25-50 g)	-0.0020	-0.0321	-0.0205	0.5021	0.0024	0.0402	-0.0147	0.3087	-0.1336	-0.5341	0.4788	0.3854	-0.2800	0.7298
Number of 'D' grade tubers per hill	-0.0030	0.0663	-0.0496	0.5556	0.0032	-0.5837	0.0637	0.2985	-0.1152	-0.2171	0.3983	0.6759	-0.6710	0.4213
Weight of 'D' grade tubers per hill (below 25 g)	-0.0030	0.0617	-0.0500	0.5387	0.0021	-0.107	0.0740	0.2928	-0.1115	-0.2229	0.4641	0.1527	-0.7000	0.3917

Residual effect=0.4395

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