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Selection Criteria for Potato (*Solanum tuberosum* L.) Breeding

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Abstract: This research was conducted to determine the relationship among yield and some yield components of potato using correlation and path coefficient analysis. The experiment was carried out eastern of Turkey (Van-Gevaş ecological conditions) in 2001 and 2002. In this study, 21 potato cultivars were used. The experimental design was a randomized block with three replications. Positive and significant relationships were found among tuber yield and plant height, number of stems per hill, number of tubers per hill, tuber weight, tuber yield per hill, percentage of medium size and big tubers, dry matter content and starch content of the tubers. A negative and significant relationship was determined between tuber yield and percentage of small tubers, negative and a non-significant relationship was determined between the tuber yield and the specific gravity. According to the path coefficient analysis, there were strong positive direct effects of tuber yield per hill, dry matter content and number of tuber per hill on tuber yield, p.c : 0.7928, 0.1646 and p.c: 0.1518, respectively.

Key words: Potatoes, path coefficient, correlation, yield, yield components

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important crops in Turkey and is grown in 200,000 ha^{-1} area with 5,250,000 tons of production[1]. The main objective of growing potato is to get a high yield with a good quality. Because genotypic and environmental factors determine yield and quality in plants, the primary breeding criteria should focus on genotypic factors. Because of its major role in human nutrition, it is essential in potato breeding programs. to know the relationships between yield and its components

Yield is a complex character associated with many interrelated components. Generally, correlation coefficients show the degree of linear of relationships among characteristics and relation between these characteristics. However, a path coefficient analysis is needed to clarify relationships between characteristics because correlation coefficients only describe relationships in a simple manner[2]. Path coefficient analysis separates direct effects from the indirect effects through other related characters by partitioning the correlation coefficient[3]. Path coefficient analysis is used when we want to determine the amount of direct and indirect effects of the causal component on the response component[4]. Maity and Chatterzee[5], Yıldırım *et al.*[6] determined the direct and indirect effects of various plant characteristics on yield and yield components using path coefficient analysis in various potato traits and established yield components which should be primarily examined in potatoes breeding programs. Yıldırım *et al.*[6] indicated that the tuber width, number of stems per hill and plant height have significant direct effects on the tuber yield. Günel *et al.*[7] indicated that the vegetation period and percentage of big tubers have highly positive significant correlations with tuber yield per unit of area.

As in previous studies, plant breeders found well-qualified varieties or certain characteristics using path analysis at the terminal selection stages. In this study, relationships among yield and yield components were examined to determine the association of tuber yield with its components and with some developmental traits.

MATERIALS AND METHODS

This study was carried out in irrigated conditions between 2001 and 2002 at the Van-Gevaş ecological conditions (38°18′ N, 43°07′ E, 14.6°C mean temperature, average rainfall 378.4 mm). Some soil properties related to research location are summarized in Table 1.

The experiment included 21 potato cultivars. The field experiment was established in a Randomized Block Design with three replications. Each plot (2.4 x 3.2 = 7.68 m^2) was planted using a 60 x 40 cm row spacing (32 hills per plot) in the early days of May in both years. Phosphorous (100 kg P ha^{-1} as triple-super-phosphate (42%)) and

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Table 1: Some physical and chemical properties of soil in the experimental sites

Depth (0-40 cm)	Texture	pH	Organic matter (%)	N (mg/100 g)	Phosphorus (ppm)	Salt (%)	Lime (%)
2001	Sandy-loamy-clay	7.75	1.00	0.070	7.50	0.078	22
2002	Sandy-loamy-clay	7.73	1.20	0.085	7.15	0.085	20

nitrogen (120 kg N ha^{-1} as ammonium sulphate (21%)) fertilizers were applied to each plot (half of the nitrogen fertilizer was applied at the sowing and the other half six week after emergence). Irrigation and hoeing were supplied when necessary. Each investigated characters were examined in the randomly selected mid-rows of plots. Tuber yield (kg ha^{-1}), plant height (cm), number of stems per hill, number of tubers per hill, average tuber weight (g), tuber yield per hill (kg), percentage of small, medium and big tubers (%), dry matter content (%), specific gravity (g cm^{-3}) and starch content (%) were investigated in this study.

Phenotypic correlations between the examined traits were calculated in the usual manner and path coefficient analysis was carried out according to the method of Dewey and Lu[8]. The path coefficient is a standardized partial-regression coefficient. It separates the direct and indirect effects of a correlation coefficient.

RESULTS AND DISCUSSION

Results of Table 2 showed that the lowest CV was obtained for specific gravity (g cm^{-3}) as 5.9%, the highest CV was obtained for the percentage of small tubers (31.0%) and the percentage of big tubers (27.4%).

Positive significant relationships were found between tuber yield and plant height (r= 0.241**), number of stems per hill (r= 0.275**), number of tuber per hill (r= 0.634**), average tuber weight (r= 0.644**), tuber yield per hill (r= 0.939**), percentage of medium tuber (r= 0.121*), percentage of big tuber (r= 0.316**), dry matter content (r= 0.218*) and starch content (r= 0.187*) (Table 3). A negative and significant relationship was found between tuber yield and percentage of small tubers (r= -0.430**). The relationship between tuber yield and specific gravity was negative (r= -0.088) but not significant.

Tuber yield per hill had the greatest direct effect on tuber yield per unit of area (p.c.= 0.7928). Its indirect effects on tuber yield were positive through number of tubers per hill, average tuber weight, percentage of medium size tubers, dry matter content and specific gravity, but negative through plant height, number of stems per hill, percentage of small tubers, percentage of big tubers and starch content (Table 4). The main reason for the strong direct effect of the tuber yield per hill was the strong positive correlation (r= 0.939**) of this character with the tuber yield per unit of area.

The second highest direct effect on tuber yield per unit of area was of the evolved from dry matter content (p.c.= 0.1646). While dry matter content had the highest positive indirect effect via tuber yield per hill (p.c= 0.1752), it had the highest negative indirect effect on tuber yield via the starch content (p.c= -0.1553). Number of tuber per hill had the third highest positive direct effect on the tuber yield per unit of area (p.c= 0.1518). Number of tubers per hill had a higher indirect effect on the tuber yield per unit of area via tuber yield per hill (p.c= 0.4897) than its direct effect.

Additionally, the average tuber weight had a positive and high direct effect on the tuber yield per unit of area (p.c= 0.1381). It had a strong indirect effect via the tuber yield per hill (p.c= 0.5367).

Starch content had the highest negative direct effect on tuber yield per unit of area (p.c= -0.1570). It had strong indirect effects on the tuber yield via dry matter content (p.c= 0.1629) and the tuber yield per hill (p.c= 0.1517).

The percentages small and medium size tubers had low positive direct effects on tuber yield per unit of area as p.c= 0.0606 and 0.0040, respectively. However, percentage of small tubers had a very strong negative indirect effect on the tuber yield per unit of area via the tuber yield per hill (p.c= -0.4119).

The correlation between plant height, number of stems per hill, percentage of big tubers, starch content and tuber yield per unit of area were positive and significant (Table 3), but these traits had negative direct effects on tuber yield per unit of area.

The results of the present study indicated that even though the relationships (correlations) among some characters were statistically significant (Table 3), the path coefficient values were found non-significant (Table 4). According to these results; linear relations among characters are insufficient in plant breeding programs as a means for indirect selection.

Similarly, Yıldırım *et al.*[6], found positive and significant correlation between plant height, starch content, stem number per hill, tuber yield per plant and average tuber weight and tuber yield per unit of area. Moreover, Günel *et al.*[7], Çalışkan and Yıldırım[9], Pandiata *et al.*[10] reported positive and significant relationships between tuber yield per hill, percentage of big tubers and tuber yield per unit of area. Günel *et al.*[7] determined negative and significant correlations between percentage of small tubers and tuber yield per unit of area.

Table 2: Minimum, maximum, Mean±SE and CV values

Traits	Minimum	Maximum	Mean±SE	CV (%)
Tuber yield (kg ha^{-1})	1155.00	3530.00	2415.9±47.50	22.1
Plant height (cm)	24.60	67.20	42.2±0.720	19.2
Number of stems per hill	0.70	5.00	3.7±0.050	15.0
Number of tubers per hill	5.60	15.70	9.4±0.170	20.7
Average tuber weight (g)	48.60	101.60	68.7±0.960	15.7
Tuber yield per hill (g)	425.30	978.30	641.0±12.50	21.9
Percentage of small tubers	6.40	38.80	21.4±0.590	31.0
Percentage of medium tubers	21.50	71.90	47.8±0.730	17.3
Percentage of big tubers	10.80	50.50	30.6±0.750	27.4
Dry matter content (%)	15.20	25.00	20.6±0.190	10.3
Specific gravity (g cm^{-3})	1.06	1.80	1.09±0.01	5.9
Starch content (%)	9.70	19.20	14.9±0.180	13.9

Table 3: Correlation coefficients between some characters of potato

Characters	1	2	3	4	5	6	7	8	9	10	11	12
Tuber yield (kg ha^{-1})	1.00											
Plant height (cm)	0.241**	1.00										
Number of stem per hill	0.275**	0.387**	1.00									
Number of tubers per hill	0.634**	0.069	0.286**	1.00								
Average tuber weight (g)	0.644**	0.362**	0.144	0.039	1.00							
Tuber yield per hill (g)	0.939**	0.266**	0.289**	0.618**	0.677**	1.00						
Percentage of small tuber	-0.430**	-0.197	-0.169	-0.285**	-0.338**	-0.520**	1.00					
Percentage of medium tuber	0.121*	-0.111	0.157	0.192*	-0.236*	0.024	-0.294**	1.00				
Percentage of big tuber	0.316**	0.316**	0.052	-0.022	0.503**	0.391**	-0.414**	-0.612**	1.00			
Dry matter content (%)	0.218*	0.105	0.279**	0.216*	0.096	0.221*	-0.279**	-0.329**	-0.154	1.00		
Specific gravity (g/cm^3)	-0.088	-0.104	0.085	-0.071	-0.056	-0.089	0.066	0.065	-0.121	-0.090	1.00	
Starch content (%)	0.187*	0.102	0.291**	0.201*	0.072	0.191*	-0.273**	0.351**	-0.183*	0.990**	0.108	1.00

** Significant at 1%;* Significant at 5%

Table 4: Path analysis showing direct and indirect effects of eleven characters on potatoes yield. Figures in parentheses are direct effect on tuber yield per unit area

	Indirect effects											
Characters	1	2	3	4	5	6	7	8	9	10	11	Correlation value (r)
Plant height (cm)	(-0.0086)	-0.0008	0.0105	0.0500	0.2110	-0.0119	-0.0004	-0.0107	0.0173	0.0006	-0.0160	0.241**
Number of stems per hill	-0.0033	(-0.0022)	0.0434	0.0198	0.2290	-0.0102	0.0006	-0.0018	0.0460	-0.0005	-0.0457	0.275**
Number of tuber per hill	-0.0006	-0.0006	(0.1518)	0.0054	0.4897	-0.0173	0.0008	0.0008	0.0356	0.0004	-0.0316	0.634**
Average tuber weight (g)	-0.0031	-0.0003	0.0060	(0.1381)	0.5367	-0.0205	-0.0009	-0.0171	0.0157	0.0003	-0.0113	0.644**
Tuber yield per hill (g)	-0.0023	-0.0006	0.0938	0.0935	(0.7928)	-0.0315	0.0001	-0.0133	0.0364	0.0005	-0.0300	0.939**
Percentage of small tuber	0.0017	0.0004	-0.0433	-0.0467	-0.4119	(0.0606)	-0.0012	0.0141	-0.0459	-0.0004	0.0429	-0.430**
Percentage of medium tuber	0.0010	-0.0003	0.0291	-0.0326	0.0186	-0.0178	(0.0040)	0.0208	0.0541	-0.0004	-0.0552	0.121*
Percentage of big tuber	-0.0027	-0.0001	-0.0034	0.0694	0.3100	-0.0251	-0.0024	(-0.0340)	-0.0254	0.0007	0.0287	0.316**
Dry matter content (%)	-0.0009	-0.0006	0.0328	0.0132	0.1752	-0.0169	0.0013	0.0052	(0.1646)	-0.0005	-0.1553	0.218*
Specific gravity (g/cm^3)	0.0009	-0.0002	-0.0108	-0.0077	-0.0707	0.0040	0.0003	0.0041	0.0149	(-0.0056)	-0.0169	-0.088
Starch content (%)	-0.0009	-0.0006	0.0305	0.0099	0.1517	-0.0165	0.0014	0.0062	0.1629	-0.0006	(-0.1570)	0.187*

** Significant at 1%;* Significant at 5%

Yıldırım *et al.*[6] reported that number of tuber per hill and tuber weight had positive and high direct effects on the tuber yield per unit of area. These all support the results of our study.

In conclusion, determining the linear relations (correlations) among components affecting the tuber yield is insufficient to indicate selection criteria in potato breeding programs. It is essential that the levels of direct and indirect effects of the causal components are determined.

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