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Relationships among Traits Using Correlation and Path Coefficient Analysis in Safflower (*Carthamus tinctorius* L.) Sown Different Fertilization Levels and Row Spacing

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Abstract: This research was conducted out in 2001 and 2002 at Van, Edremit ecological conditions in east of Turkey. One of the aims of this research was to determine the relationship among yield and some yield components using correlation and path coefficient analysis. In this study Yenice safflower cultivar was sown at three different phosphorus levels (0, 60, 120 kg ha^{-1}), four different nitrogen levels (0, 50, 100 and 150 kg ha^{-1}) and three different row spacing (20, 30 and 40 cm). The experiment was designed split-split plot design with four replications. The first experimental year positive and significant relationships were found among seed yield and plant height (r= 0.385**), number of head per plant (r= 0.160*), percent of oil (r= 0.945**) and oil yield (r= 0.981**). Negative and significant relationship was found between seed yield and percent of protein (r= -0.272**) but negative and non-significant relationship was found between seed yield and 1000-seed weight (r= -0.129). The second year positive and significant relationships were found between seed yield and all investigated characters. According to path coefficient analysis, in the 2001 and 2002 experimental years there were strong positive direct effects of the oil yield on the seed yield , p.c : 1.3305 and p.c: 1.5205, respectively.

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

INTRODUCTION

Safflower has been grown since ancient times (4500 B.C.) in Egypt, Morocco, China and India to obtain Chartamin a dye from the flowers that may be either yellow or red[1]. Safflower is an important crop which is used for oil. India, Ethiopia and Iran are the countries with the longest tradition of safflower growing as an oil plant.

Yield is a complex character associated with many interrelated components. Generally, correlation coefficients show relationships among independent characteristics and the degree of linear relation between these characteristics. However, path analysis is needed to clarify relationships between characteristics deeply because correlation coefficients describe relationships in a simple manner[2]. Path coefficient analysis separates the direct effects from the indirect effects through other related characters by partitioning the correlation coefficient[3]. Yield components and their interrelationships is very important in safflower breeding. Corleto *et al.*[4] reported that the number of heads per plant is the most important character for yield of safflower. Abel and Driscol[5] reported that the number of heads per plant and number of seeds per head were important traits for high yielding on safflowers lines.

Gencer *et al.*[6] stated that seed yield and oil content are the primarily selection criteria for safflower breeding.

Omidi Tabrizi[1] demonstrated that increase of oil yield is primarily associated with increase in seed yield, which was effected by biomass and the number of heads per plant.

Zheng *et al.*[7] stated that, the high-yielding safflower varieties have taller individuals lower branches, more effective heads, fewer ineffective heads, lower weight of seeds, higher average number of heads and longer flowering period.

Taiping *et al.*[8] reported that grain yield of safflower was effected by cultural factors including amount of fertilizer, water, row spacing etc.

In present study Yenice safflower cultivar was shown at three different phosphorus levels, four different nitrogen levels and three different row spacing to determine relationships among yield and yield components using correlation and path coefficient analysis.

MATERIALS AND METHODS

This study was carried out in irrigated conditions between 2001 and 2002 at the Van-Edremit ecological conditions (38°11′N, 42°53′E) in Turkey. Mean temperature of experiment area is 14.6°C, average rainfall 378.4 mm. The study site had sandy-loamy-clay soil. Some soil properties related to research location are summarized in Table 1.

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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 (me/100 g)	Phosphorus (ppm)	Salt (%)	Lime (%)
2001	Sandy-loamy-clay	7.75	1.02	0.072	7.55	0.077	20
2002	Sandy-loamy-clay	7.70	1.18	0.083	7.25	0.078	20

The experiment was designed split-split plot design with four replications. In this study Yenice safflower cultivar was sown at three different phosphorus levels (0, 60, 120 kg ha^{-1}), four different nitrogen levels (0, 50, 100 and 150 kg ha^{-1}) and three different row spacing (20, 30 and 40 cm). Each plot was sown 5 plant lines in the middle of April in both study years. Characters were examined on ten plants randomly selected in the mid- rows of plots. Seed yield (kg ha^{-1}) plant height (cm), number of branches/plant, number of heads/plant, number of seeds/head, 1000-seed weight (g), protein content (%) oil content (%) and oil yield (kg ha^{-1}) were recorded. Phenotypic correlations between examined characters were calculated in the usual manner and path coefficient analysis was carried out according to the method of Dewey and Lu[9]. The path coefficient is known as a standardized partial-regression coefficient and separates the direct and indirect effects of a correlation coefficient. Hence, path analysis plays an important role in determining the degree of relationship between yield and yield components.

RESULTS AND DISCUSSION

Maximum, minimum and mean trait values with their standard errors and C.V levels are summarized in Table 2. The first experiment year while the lowest C.V level was obtained from the protein content as 4.7%, the second year was obtained from 1000-seed weight as 7.2%. The highest C.V level was obtained from the oil yield as 38.9 and 37.1% in 2001 and 2002 experiment years, respectively.

Simple correlation coefficients calculated among examined characteristics are given in Table 3 (2001) and Table 4 (2002). The first experiment year positive significant relationships were found between the seed yield and the plant height (r= 0.385**), the number of heads/plant (r= 0.160*), oil content (r= 0.945**) and oil yield (r= 0.981**). Positive but non-significant relationships were found between the seed yield and no. of branches/plant (r= 0.095) and no. of seeds/plant (r= 0.105). While negative and significant relationship was found between seed yield and protein content (r= -0.272**), negative but non-significant relationship was found between seed yield and 1000-seed weight. The second experiment yield positive and significant relationships were found among seed yield and all of investigated characters (Table 4). Gencer *et al.*[6] found positive and significant relationships between seed yield and no. of heads per plant, no. of seeds per head and oil content. Also the same researcher found negative relationships between seed yield and protein content. Also generally the results of Omidi[1] and Zheng[7] have supported present results.

The direct and indirect effects of these eight examined traits on the seed yield were estimated by path coefficient (Table 5 and 6). The oil yield had the greatest positive direct effect on the seed yield in 2001 and 2002 as p.c = 1. 3305 and p.c= 1.5205, respectively. In the first experiment yield the effects of other factors such as plant height, number of branches per plant, number of heads per plant and number of seeds per heads had positive direct effect on seed yield, but 1000-seed weight, protein content and oil content had negative direct effect on seed yield (Table 5). The second experiment yield while number of heads/plant, number of seeds/head, 1000-seed weight and protein content had positive direct effect on seed yield, plant height, number of branches and oil content had negative direct effect on seed yield (Table 6).

The results of the present study indicated that even though the relationships (correlations) among some characters were statistically significant (Table 3 and 4), the path coefficient values were found non-significant (Table 5 and 6). According to these results; linear relations among examined characters are insufficient in plant breeding programs.

Similarly, Zheng *et al.*[7] found positive and significant correlation between seed yield and the branching height and weight of seed, but these characters had negative direct effect on seed yield. Gencer *et al.*[6] also found positive and significant relationships between seed yield and number of head per plant, number of seeds per head, but these characters had negative direct effect on seed yield. Otherwise Gencer *et al.*[6] found negative and significant relationships between seed yield and plant height and 100-seed weight, but these characters had positive direct effect on seed yield.

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

Table 2: Basic statistics and co-efficient of variation of yield and yield components

	2001				2002			
Parameters	Min.	Max.	Mean±SE	C.V (%)	Min.	Max.	Mean±SE	C.V (%)
Seed yield (kg ha^{-1})	105.3	234.6	166.2±2.78	20.1	72.4	168.6	114.1±1.56	16.4
Plant height (cm)	72.7	112.0	96.0±0.63	7.9	58.6	109.7	86.9±0.91	12.6
No. of branches/plant	4.0	9.2	6.2±0.08	15.6	3.2	6.5	4.5±0.05	14.2
No. of heads/plant	11.3	20.9	15.2±0.17	13.4	6.2	12.0	8.8±0.09	12.5
No. of seeds/head	24.0	37.1	28.7±0.29	12.4	17.4	37.2	26.7±0.30	13.8
1000-seed weight (g)	33.0	45.4	39.9±0.20	6.3	33.1	43.8	36.4±0.21	7.2
Protein content (%)	13.7	18.1	16.3±0.06	4.7	13.0	28.8	19.1±0.28	18.2
Oil content (%)	16.3	37.7	27.0±0.44	19.6	15.2	43.3	25.3±0.43	20.4
Oil yield (kg ha^{-1})	17.5	88.5	46.6±1.51	38.9	11.0	72.8	29.7±0.92	37.1

Table 3: Correlation coefficients among the characteristics of safflower in 2001

Parameters	1	2	3	4	5	6	7	8	9
Seed yield (kg ha^{-1})	1.000								
Plant height (cm)	0.385**	1.000							
No. of branches/plant	0.095	0.108	1.000						
No. of heads/plant	0.160*	0.270**	0.397**	1.000					
No. of seeds/head	0.105	0.165*	0.072	0.111	1.000				
1000-seed weight (g)	-0.129	-0.358**	-0.058	-0.049	-0.133	1.000			
Protein content (%)	-0.272**	-0.153	0.099	-0.093	-0.112	0.129	1.000		
Oil content (%)	0.945**	0.365**	0.122	0.115	0.071	-0.098	-0.075	1.000	
Oil yield (kg ha^{-1})	0.981**	0.373**	0.107	0.139	0.079	-0.108	-0.161*	0.983**	1.00

* p<0.05 ** p<0.01

Table 4: Correlation coefficients among the characteristics of safflower 2002

Parameters	1	2	3	4	5	6	7	8	9
Seed yield (kg ha^{-1})	1.000								
Plant height (cm)	0.410**	1.000							
No. of branches/plant	0.560**	0.609**	1.000						
No. of heads/plant	0.616**	0.613**	0.844**	1.000					
No. of seeds/head	0.524**	0.462**	0.510**	0.494**	1.000				
1000-seed weight (g)	0.173*	0.066	0.153	0.212**	0.137	1.000			
Protein content (%)	0.874**	0.438**	0.542**	0.555**	0.444**	0.105	1.000		
Oil content (%)	0.893**	0.408**	0.548**	0.576**	0.437**	0.083	0.784**	1.000	
Oil yield (kg ha^{-1})	0.945**	0.405**	0.558**	0.600**	0.472**	0.105	0.847**	0.974**	1.00

*p<0.05 ** p<0.01

Table 5: Path analysis showing direct and indirect effects of safflower yield 2001

	Indirect effects								
Parameters	1	2	3	4	5	6	7	8	Korr. (r)
Plant height (cm)	(0.0051)	0.0001	0.0019	0.0024	0.0023	0.0125	-0.1363	0.4966	0.385**
No. of branches/plant	0.0006	(0.0012)	0.0028	0.0010	0.0004	-0.0082	-0.0457	0.1429	0.095
No. of heads/plant	0.0014	0.0005	(0.0071)	0.0016	0.0003	0.0076	-0.0428	0.1846	0.160*
No. of seeds/head	0.0008	0.0001	0.0008	(0.0143)	0.0009	0.0092	-0.0267	0.1057	0.105
1000-seed weight (g)	-0.0018	-0.0001	-0.0003	-0.0019	(-0.0064)	-0.0106	0.0367	-0.1443	-0.129
Protein content (%)	-0.0008	0.0001	-0.0007	-0.0016	-0.0008	(-0.0820)	0.0279	-0.2137	0.272**
Oil content (%)	0.0019	0.0002	0.0008	0.0010	0.0006	0.0061	(-0.3735)	1.3080	0.945**
Oil yield (kg ha^{-1})	0.0019	0.0001	0.0010	0.0011	0.0007	0.0132	-0.3672	(1.3305)	0.981**
R^2	0.9795								

*p<0.05 **p<0.01; Figures in parentheses are direct effect on seed yield per unit area

Table 6: Path analysis showing direct and indirect effects of seven characters on safflower yield in 2002

	Indirect effects								
Parameters	1	2	3	4	5	6	7	8	Korr. (r)
Plant height (cm)	(-0.0002)	-0.0100	0.0248	0.0279	0.0031	0.0597	-0.3094	0.6157	0.410**
No. of branches/plant	-0.0013	(-0.0164)	0.0341	0.0308	0.0073	0.0740	-0.4160	0.8481	0.560**
No. of heads/plant	-0.0013	-0.0139	(0.0404)	0.0290	0.0101	0.0758	-0.4373	0.9120	0.616**
No. of seeds/head	-0.0010	-0.0084	0.0199	(0.0603)	0.0066	0.0606	-0.3312	0.7176	0.524**
1000-seed weight (g)	-0.0001	-0.0025	0.0085	0.0083	(0.0478)	0.0143	-0.0629	0.1600	0.173*
Protein content (%)	-0.0010	-0.0089	0.0224	0.0268	0.0050	(0.1365)	-0.5949	1.2876	0.874**
Oil content (%)	-0.0009	-0.0090	0.0233	0.0263	0.0040	0.1070	(-0.7587)	1.4805	0.893**
Oil yield (kg ha^{-1})	-0.0009	-0.0092	0.0242	0.0285	0.0050	0.1156	-0.7387	(1.5205)	0.945**
R^2	0.9212								

*p<0.05 **p<0.01; Figures in parentheses are direct effect on seed yield per unit area

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