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CLUSTER ANALYSIS AND ADAPTATION STUDY FOR SAFFLOWER GENOTYPES

R. ADA
Selcuk University, Faculty of Agriculture, Department of Field Crops, Konya, Turkey

Abstract

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This research was conducted in the "Randomized Complete Block Design" with three replications in research field of Agricultural Faculty, Selcuk University, Konya, Turkey. In study, a total of 16 safflower promised lines (A13, A22, A29, A30, C8, C12, E4, E12, F5, G8, G12, H3, J26, J27, Y1-8-14-1), which were collected from Konya natural vegetation, and 5 cultivars (Remzibey, Black Sun1, Black Sun2, KS 06 and KS 07) were evaluated in two growing seasons (2009 and 2010).

According to the results, the highest first branch height, number of branch, number of head and 1000 seed weight were obtained respectively from J27 (31.77 cm), G12 (8.47 cm), G1 (225.58 number plant^{-1}) and A29 (49.25 g) lines.

The highest seed yield, oil content and oil yield were taken from Remzibey cultivar (2048.7 kg ha^{-1}), Black Sun1 (34.41 %) and Black Sun1 (579.3 kg ha^{-1}) cultivars while the lowest values were obtained from C8 (845.6 kg ha^{-1}), A30 (21.79 %) and J27 (200.9 kg ha^{-1}) lines.

Key words: Adaptation, cluster, safflower

Introduction

Traditionally safflower is being grown for flower to extract dyes, which are being used to coloring of foods and textiles (Badiger et al., 2009). However, for the last fifty years, this crop had been primarily cultivated for production of high-quality vegetable oil in semiarid regions in Asia, Australia, Americas and Europe (Yau, 2009). Safflower, which has many usage areas and certain superior characteristics than other oil plants, may play a significant role to complete the vegetable oil shortage if the growers give adequate importance. The most 2 important points why safflower cultivation is not progressing is that; the low seed yield and oil content of present varieties. Currently, safflower plants are grown under non-irrigation owing to it is known as resistant to drought and the yield is exposed less than 1000 kg ha^{-1}. In order to promote safflower-growing areas and to increase production, high quality seed plants with high yield must be identified firstly (Sakir and Basalma, 2005).

Potential yield of safflower seed is about 4 tons ha^{-1} however, the results of some experiments were reported more than 4-5 tons of grain ha^{-1}. A higher yield than 2 tons ha^{-1} is considered as sufficient (Tabrizi et al., 2000).

Safflower seeds contain from 13 to 46 % oil, and approximately 90 % of this oil is composed from unsaturated fatty acids, which are called as oleic, and linoleic acids (Johnson et al., 1999). Due to rapid drying, the oil is being high demanded in paint and emulsion industries (Karakaya et al. 2004). Ogut and Oguz (2006) reported that safflower oil is quite suitable for biodiesel production. Safflower oil cake is also a valuable feed for animals (Weiss, 2000).

The main goal is reach to limits of the plant by breeding researches.

Cluster analysis is a classification method, which is used to arrange a set of cases into clusters. The aim of set clusters such cases within a cluster are more similar to each other and helps to researchers to give summa-

E-mail:rahimada@selcuk.edu.tr

ry information on data. Cluster analysis is commonly used in social, medical and agricultural sciences. This technique is closely related with multivariate variance analysis, logistic regression, as other multivariate analyses. Different procedures are being used to fulfillment of many different functions. In addition, cluster analysis is being used to exposing of similarity and diversity (Gevrekci et al., 2004).

For economic safflower farming, as well as cultural processes, the selection of convenient varieties is also important. Many breeding methods are used for cultivar selection or development of cultivars. One of them is introduction and adaptation work. Based on this, the recognition of the plant characteristics of varieties and seed yield potential must be determined. Thus, the preliminary information would be available about the types, cultivars that are recommended for registration (Copur et al., 2009)

This study was conducted to determine of seed and oil yield component for 21 safflower genotypes and cluster analysis for characterizing of genotypic differences.

Materials and Methods

This study carried out in research field of Faculty of Agriculture, Selcuk University, Konya, Turkey. Average altitude of the research area was 1050 m.

In research area, long period (1991-2008; April-August) total precipitation was 104.0 mm average temperature is 19.0°C. In the years of 2009 and 2010, the amounts of total precipitations were 115.9 and 103.1 mm respectively. Average temperature was 19.5°C and 21.3°C in the first and the second vegetation periods.

The soil was clay loam, with pH 8.03 and containing phosphorous, potassium, iron, zinc, organic matter and $CaCO_3$ contents of 55.9 kg ha^{-1}, 17.9 kg ha^{-1}, 14.74 ppm, 0.32 ppm and 37.6%, 2.25%, respectively. There was not any salinity problem in the research area.

In the study, 16 safflower promised lines in (A13, A22, A29, A30, C8, C12, E4, E12, F5, G8, G12, H3, J26, J27, J29, Y1-8-14-1), which were selected and collected from Konya natural vegetation and breeded by Dr. Rahim ADA, and 5 cultivars (Remzibey, Black Sun1, Black Sun2, KS 06 and KS 07) were evaluated in two growing seasons (2009 and 2010). Pure lines were derived through self-pollination of individual plants of each genotype. Some features of safflower genotypes used in research have been showed in Table 1.

This research was conducted in "Randomized Complete Block Design" with three replications. In the experiments, a total of 40 kg ha^{-1} of P_2O_5 and 30 kg ha^{-1} of nitrogen were applied before sowing and 20 kg ha^{-1} of nitrogen was used as a top dressing during starting of stem elongation. Weeds were controlled by hand.

The experiment was planted on 2th April and 24th March, 2010. Each genotype was sown in plots with 4 rows, 4 m of longitude with spacing 50 cm between rows. Plant harvests were made in August 2009 and 2010. A length of 50 cm on both sides of the rows in each plot was left as border effects.

Samples of each plot were obtained to determination of plant height (cm), first branch height (cm), number of branches per plant, number of head per plant, 1000-seed

Table 1
Some characteristics of the investigated genotypes

	Flower color		Spiny score
	Fresh	Withered	
Remzibey	Yellow	Yellow	5
Black Sun1	Yellow	Yellow	5
Black Sun2	Yellow	Yellow	5
KS06	Yellow	Yellow	5
KS07	Yellow	Orange	2
A13	Yellow	Yellow	5
A22	Yellow	Yellow	3
A29	Yellow	Yellow	4
A30	Yellow	Yellow	3
C8	Yellow	Yellow	4
C12	Yellow	Orange	3
E4	Yellow	Orange	3
E12	Yellow	Orange	3
F5	Orange	Red	2
G8	Orange	Red	3
G12	Orange	Red	4
H3	Yellow	Yellow	4
J26	Orange	Red	2
J27	Yellow	Orange	3
J29	Yellow	Orange	5
Y1-8-14-1	Yellow	Yellow	3

Spiny scale: 1; spineless, 5; much spiny

weight (g), seed yield (kg ha^{-1}), oil content (%) and oil yield (kg ha^{-1}).

Analysis of cluster and variance was performed using "JUMP" computerized statistical program.

Results

The results from analyses of variance over two years for the investigated characteristics were presented in Table 2. Effects of genotype were found statically important for all the parameters, except plant height. Year x Genotype interaction was also significant except for plant height and number of head. In addition, Table 2 is presented with mean values of the 1st year and 2nd year of the investigated characteristics. In this research, plant height, first branch height, number of head and oil content, the differences between two years were found statically ($p<5$ %) significant.

The year x genotype interaction showed significance, at a level of 1% probability for first branch height, 1000 seed weight and oil content, and showed significance at a level of 5 % for number of branch, seed and oil yield.

The highest first branch height, number of branch, number of head and 1000 seed weight were obtained J27 (31.77 cm), G12 (8.47 cm), G1 (225.58 number plant^{-1}) and A29 (49.25 g) lines respectively. Whereas, the lowest values were found on KS07 cultivar (19.74 cm) and H3 (5.12 cm), A13 (12.83 number plant^{-1}) and J29 (30.05 g) lines.

According to mean of two years (Table 3), Remzibey cultivar has the highest seed yield with 2048.7 kg ha^{-1}, while the lowest was obtained from C8 line (845.6 kg ha^{-1}).

In this study, oil content of Year x Genotype interaction were ranged from 21.35% (E4 line; 2010) to 34.75% (Black Sun2 cultivar; 2009). However, in terms of two years, Black Sun1 cultivar has the highest oil content (34.41%), while the lowest value was obtained on A30 line (21.79%).

The highest oil yield was obtained from Black Sun1 cultivar (57.93 kg ha^{-1}) and the lowest was taken from J27 line (20.09 kg ha^{-1}).

According to the results of cluster analysis (Figure 1), the genotypes were diverged in two main groups. Whole of the varieties were in the first main group. The first main group, which was consisted by higher yielded varieties and line, was also diverged in two sub-groups. All the varieties were together in that sub-group except KS 07

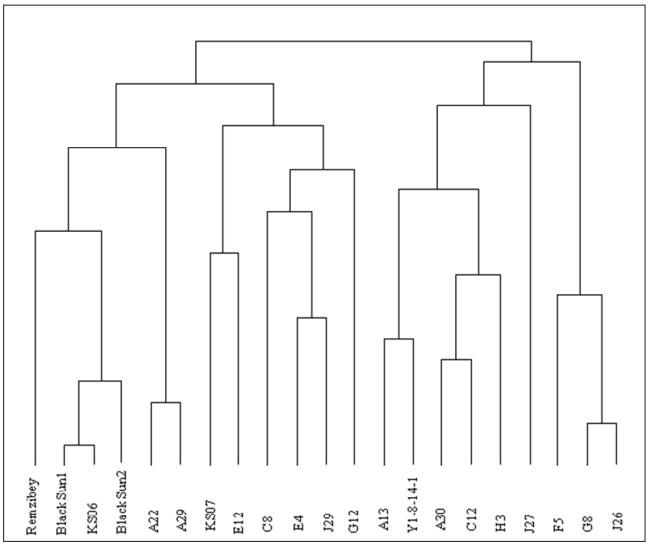

Fig. 1. Dendrogram for 21 safflower genotypes

Table 2
Mean squares in analysis of variance for traits of 21 safflower genotypes (2009-2010)

Source	DF	Plant height	First branch height	Branch number	Head Number	1000 Seed weight	Seed yield	Oil content	Oil yield
Common	125	-	-	-	-	-	-	-	-
Replication	2	533 262	746 006	480 755	98 316	0.58147	790 547	285 006	514 644
Years (A)	1	1085.74*	5758.3*	377 967	4660.69*	491 676	2428.99	34.3413*	103 429
Error (1)	2	189 714	550 523	253 779	583 833	183 966	16349.8	185 098	1213.87
Genotypes (B)	20	983 842	74.5685*	3.70953*	70.5251**	193.599**	5526.51**	91.4109**	707.817**
(AxB)	20	89 617	139.023**	3.4544*	481 697	23.3183**	5244.08*	5.75886**	385.649*
Error (2)	80	71 875	43 437	183 325	29 357	14 004	2613.38	25 281	215 319

** $p < 0,01$, * $p < 0,05$

Table 3
Some values of 21 safflower genotypes

Years	Genotype	Plant height, cm	First branch height, cm	Number of branch	Number of head	1000 Seed weight, g	Seed yield, kgha^{-1}	Oil content, %	Oil yield, kgha^{-1}
	Remzibey	60.53	21.87	8.80	17.63	39.63	2286.80	30.10	688.20
	Black Sun1	67.00	37.33	7.67	7.53	43.50	1438.50	34.34	490.80
	Black Sun2	62.87	38.00	6.20	8.82	43.90	1240.30	34.75	426.90
	KS06	60.63	20.40	9.53	13.89	42.33	1426.00	32.80	464.20
	KS07	54.07	24.07	8.27	20.30	35.23	2083.50	31.33	655.00
	A13	60.73	29.93	6.27	8.13	30.60	1609.90	22.40	361.70
	A22	65.93	26.29	9.03	13.33	53.23	1596.30	26.03	414.20
	A29	65.07	27.67	8.33	7.93	55.10	2247.30	24.45	554.60
	A30	65.70	36.23	6.43	8.65	43.50	1106.90	21.89	241.90
	C8	51.27	23.20	6.80	13.55	38.87	705.30	24.36	174.90
2009	C12	65.00	34.33	5.93	9.85	38.67	1090.70	25.71	279.40
	E4	56.93	25.63	9.40	13.48	39.30	1490.80	26.34	393.50
	E12	62.20	37.73	6.73	10.89	31.47	1114.70	31.15	348.70
	F5	54.93	45.70	5.67	9.20	46.28	907.20	29.29	265.60
	G8	62.27	43.60	7.00	15.37	46.60	1528.80	26.49	404.80
	G12	63.73	35.50	8.47	12.75	37.59	1154.30	25.41	291.80
	H3	61.50	35.50	4.70	9.79	41.20	664.70	24.19	161.00
	J26	65.00	36.00	6.87	13.64	42.90	1102.50	24.71	272.20
	J27	70.90	34.40	7.00	13.22	45.13	851.90	22.59	192.30
	J29	59.27	21.40	9.20	20.00	29.73	1365.10	24.17	343.70
	Y1-8-14-1	62.00	35.09	6.40	11.11	33.30	1374.60	25.21	346.30
	Mean	**61.79**	**31.90**	**7.37**	**12.34**	**40.86**	**1351.70**	**27.03**	**370.10**
	Remzibey	52.40	21.20	5.40	21.20	41.90	1810.60	25.05	445.00
	Black Sun1	51.55	18.43	6.80	27.27	41.70	1960.50	34.47	667.80
	Black Sun2	55.00	18.13	7.07	25.67	44.60	1296.30	33.57	434.70
	KS06	62.07	28.47	5.60	23.13	43.53	1652.90	30.89	512.90
	KS07	55.13	15.40	6.60	27.07	34.70	1232.40	31.77	391.70
	A13	59.87	20.67	5.93	17.53	32.70	1319.30	24.92	327.20
	A22	49.93	18.33	6.07	20.67	41.77	1413.10	26.56	384.20
	A29	46.20	15.13	5.80	18.07	43.40	982.30	24.20	236.90
	A30	57.53	14.87	6.80	24.13	46.03	1429.00	21.69	309.70
	C8	64.83	17.47	6.17	33.27	38.53	985.80	24.95	244.90
2010	C12	66.58	17.13	6.27	26.60	42.93	2022.90	23.37	470.90
	E4	54.37	17.77	6.10	29.60	40.23	1551.50	21.35	330.30
	E12	60.50	14.13	6.13	26.87	31.57	1606.40	31.01	497.90
	F5	46.75	15.47	6.37	21.97	47.37	1797.30	29.15	523.80
	G8	46.60	14.53	6.03	23.22	46.40	742.30	23.04	166.40
	G12	57.33	13.53	8.47	38.40	37.77	1171.60	23.63	279.10
	H3	56.97	21.07	5.53	22.00	42.47	1427.30	23.43	337.60
	J26	49.83	17.23	6.07	19.23	42.72	960.90	24.88	240.20
	J27	68.90	29.13	7.00	21.60	46.38	979.60	21.67	209.50
	J29	57.87	18.64	6.27	26.62	30.37	1645.90	24.78	402.50
	Y1-8-14-1	54.03	19.20	5.23	20.40	32.70	2242.20	21.38	478.80
	Mean	**55.92**	**18.38**	**6.27**	**24.50**	**40.47**	**1439.50**	**25.99**	**375.80**

(continued)

Table 3 (continued)

	Remzibey	56.47	21.54	7.10	19.42	40.77	2048.70	27.58	566.60
	Blacksun 1	59.28	27.88	7.24	17.40	42.60	1699.50	34.41	579.30
	Blacksun 2	58.94	28.07	6.64	17.25	44.25	1268.30	34.16	430.80
	KS06	61.35	24.44	7.57	18.51	42.93	1539.50	31.85	488.60
	KS07	54.60	19.74	7.44	23.69	34.97	1658.00	31.55	523.40
	A13	60.30	25.30	6.10	12.83	31.65	1464.60	23.66	344.50
	A22	57.93	22.31	7.55	17.00	47.50	1504.70	26.30	399.20
	A29	55.64	21.40	7.07	13.00	49.25	1614.80	24.33	395.80
	A30	61.62	25.55	6.62	16.39	44.77	1268.00	21.79	275.80
	C8	58.05	20.34	6.49	23.41	38.70	845.60	24.66	209.90
Mean	C12	65.79	25.73	6.10	18.23	40.80	1556.80	24.54	375.20
	E4	55.65	21.70	7.75	21.54	39.77	1521.20	23.85	361.90
	E12	61.35	25.93	6.43	18.88	31.52	1360.60	31.08	423.30
	F5	50.84	30.59	6.02	15.59	46.83	1352.30	29.22	394.70
	G8	54.44	29.07	6.52	19.30	46.50	1135.60	24.77	285.60
	G12	60.53	24.52	8.47	25.58	37.68	1163.00	24.52	285.50
	H3	59.24	28.29	5.12	15.90	41.84	1046.00	23.81	249.30
	J26	57.42	26.62	6.47	16.44	42.81	1031.70	24.80	256.20
	J27	69.90	31.77	7.00	17.41	45.76	915.80	22.13	200.90
	J29	58.57	20.02	7.74	23.31	30.05	1505.50	24.48	373.10
	Y1-8-14-1	58.02	27.15	5.82	15.76	33.00	1808.40	23.30	412.60
	Mean	**58.85**	**25.14**	**6.82**	**18.42**	**40.66**	**1395.60**	**26.51**	**373.00**

Lsd values: First branch height, genotypes: 7.572, years x genotypes: 14.20; Number of branch, genotypes: 1.556, years x genotypes: 2.20; Number of head, genotypes: 8.524; 1000 seed weight, genotypes: 1.803. years x genotypes: 2.550; Seed yield, genotypes: 77.88, years x genotypes: 83.07; Oil content, genotypes: 2.422, years x genotypes: 3.426; Oil yield, genotypes: 22.35, years x genotypes: 23.84

cultivar. Besides that, the group, which was including the cultivars, was also included with A22 and A 29 lines.

Discussion

The success of safflower entry in new areas is closely depends on the extent of improvement made in yield and oil content. The seed yield of a cultivar might vary with regards of light, water, precipitation, temperature, humidity and competition of nutrients (Vorpsi, 2010).

Plant height, first branch height, number of branches per plant, 1000-seed weight and oil content are the most important characteristics related to seed yield (Patil, 1998; Gupta and Singh, 1997; Choulwar et al., 2005).

Camas et al. (2007) were reported 16.0-72.0 cm for first branch height and Zarei et al. (2011) revealed it varies from 20.0cm to 46.01 cm. The results of this study are in parallel with previous reports.

In different production areas, number of branch varies 4.8-7.7 per plant (Kolsarici and Eda, 1983), 1.2-7.2 per plant (Koc et al., 1997). For 1000 seed weight, Esendal and Tosun (1972) were obtained between 22.40 to 45.10 g.

Characteristics which are correlated with the seed yield might be useful for indirect selection. The using efficiency of the characteristics for selection criteria depend on its heritability and genetic correlation to plant performance (Falconer, 1989).

Seed yield is one of the main goals for specialty of field crops. Thus, plat selections are based on this aim. The previously researches was reported for seed yield that it was differed 1743.0 kg ha^{-1} (Bergman et al., 1987), Muralidharudu and Nagaraj (1990) found 920.0-1050.0 kg ha^{-1} and Kizil et al. (2008) reported 1706.0-3111.0 kg ha^{-1}. Results of this study for seed yield was supported the observations which were put forward by the other researchers.

Oil content of seeds is a quite important for economic trait of safflowers and it considered as one of the most important factors, which is affecting the success of safflower entry in new areas (Vorpsi, 2010). Many factors such as

climatic factors, variety etc. are influenced by the amount of oil in safflower seeds (Esendal and Tosun, 1972).

Uysal et al. (2006), Zhang and Chen (2005), Koutroubas and Papadoska (2005), Gawand et al. (2005) and Arslan and Kucuk (2005) were reported that oil content was varied between 23.70-26.90%, 23.86-40.33%, 26.72-35.78%, 26.3-28.5% and 31.3-36.3% respectively. These results are also supporting present findings.

Significant and positive correlations between yield and oil content, higher oil yield values were observed in the present study. For oil yield, the previous studies were recorded such as 327.4-512.5 kg ha^{-1} (Ozturk et al., 2007), 131.0-547.0 kg ha^{-1} (Esendal and Tosun, 1972). The finding of the present study is in accordance with the other researchers.

It is recommended that in the future of this breeding program, genetically studies should be continued to make a healthy and certain evaluation to relation of dendrogram, which was existed from the cluster analysis.

Conclusion

The study was conducted to determination of high values in oil content and seed yield by evaluating the adaptation ability of some safflower genotypes in Konya, Turkey province. Among the investigated genotypes, it could be recommended that; Remzibey for seed yield, Black Sun1 for oil content, Black Sun1 and Remzibey for oil yield under cultivation in different locations of Konya due to their significantly high seed yield and oil content performance. Different studies, tests and analysis are thought to be needed to determination of the exact characteristics of investigated lines. However, further experimental data are required to support these positive results.

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