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Yield Components and Oil Content of Safflower in Eastern Algeria

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ABSTRACT: Safflower (*Carthamus tinctorius* L.) is a member of the family Compositae (Asteraceae), cultivated mainly for its seeds, which is used as a source of edible oil and as birdseed. Traditionally, the crop was grown for its flowers, used for coloring, flavoring foods, making dyes (carthamidin and carthamin), and in medicine. Since Safflower is a drought tolerant crop, the objective of this research was the investigation of the seed yield and oil content of safflower under semi-arid conditions in eastern Algeria.

The results showed that 'SYPRUS' variety gave the highest seeds number per plant (800.17) and seeds yield (420.53 g/m^2). While 'OT-455' variety gave the highest weight of one hundred seeds (4.44 g). Considering the seeds fixed oil (%), 'GILA' variety produced the highest percentage (38.47 %). The research revealed that the most suitable safflower variety, under semi-arid conditions of eastern Algeria was 'SYPRUS' variety which's providing from ICARDA (International Center for Agricultural Research in Dry Areas, Aleppo, Syria). Analyses of variance (ANOVA) showed highly significant differences among the varieties for yield components and oil content. Correlation coefficients between variables (5 traits) are calculated, and the cluster analysis of observations (varieties) is also used to clarify the clustering pattern of genotypes tested.

KEYWORDS: *Carthamus tinctorius* L., yield components, oil seed, drought tolerant, semi-arid areas.

1 INTRODUCTION

Safflower (*Carthamus tinctorius* L.), which is a member of the family Asteraceae (Compositae) , is a multi-purpose plant cultivated since ancient times not only for the dye contained in its flowers, the oil in its achenes, and its medicinal properties, but also for the ornamental value of its colorful inflorescences. In ancient Egypt**,** safflower wreaths or garlands were used at funerals [1].

Most countries in West Asia and North Africa (WANA) have a critical and growing shortage of edible vegetable oils, which are healthier and cheaper than animal fats. The demand for vegetable oils, both from the shift in consumer behavior, and from population growth has been met nearly in total by imports, which drains the countries money reserves [2].

In 2007, world safflower acreage and production were around 725.000 ha and 536.000 tones respectively. The world safflower acreage constitutes less than 0.5% of total area planted with oilseed crops [3].

The objective of this research was the investigation of the seed yield and oil content of different safflower varieties under semi-arid conditions in eastern Algeria.

2 MATERIALS AND METHODS

Nine safflower (*Carthamus tinctorius* L.) varieties ('SYPRUS' from ICARDA and the others from USDA germplasm of Maryland, USA) (Table 1) were cultivated in a split plot design experiment with three replicates. Each plot had 3 rows of 2m length with inter and into row spacing of 50 and 10cm, respectively. The investigation was conducted during the 2007-2008 season (sowing in the last week of December) in the experimental area of the regional station of *INPV* (National Institute of Plant Protection) in Constantine (Elevation: 555.96m, Latitude: 36°20' N, Longitude: 06°38' E).

Table 1: Origins and names of varieties used in the study

N°	Varieties	Origin	Source
1	80/482/3S	USA	USDA germplasm, Maryland, USA
2	FINCH		
3	GILA		
4	KUSUMBA	Pakistan	
5	OLE	USA	
6	OT-455	India	
7	RIO	USA	
8	ROYAL		
9	SYPRUS	Syria	ICARDA, Aleppo, Syria

All agronomic practices were applied on time according to the recommendations except the fertilization witch's not applied. Where, weed control was done mechanically by hoeing the row space in the first week of March.

The climatic data of the region are representing in Table 2 and was obtained from reference [4].

Table 2: Climatic data of experimental area in 2007-2008 season (in growth period)

Months	Precipitation (mm)	Temperature (°C)			Relative humidity (%)
		Low	Average	High	
December	103,20	3,25	6,50	9,37	92,00
January	14,50	1,77	7,38	13,00	80,87
February	11,40	2,28	8,14	14,00	76,33
March	114,00	2,94	9,03	15,13	78,74
April	29,60	5,80	12,98	20,17	68,67
May	71,60	11,32	18,22	25,13	67,23
June	15,00	13,40	21,13	28,87	61,17
July	7,20	18,58	26,63	34,68	51,58

Samples were harvested in the first week of August, where the plant population was 13.3 plants/m^2.

Seeds number per plant, hundred (100) seeds weight and yield of seeds were determined on ten randomized plants/plot. Fixed oil percent in the seeds of the different varieties was determined separately using 5.0g of the seeds with Soxhlet apparatus with petroleum ether (40 – 60 0c).

Finally, the data of yield components and oil content were subjected to statistical analyses using MINITAB for evaluation of variance and correlation between varieties and agronomic components.

3 RESULTS AND DISCUSION

Analysis of variance (ANOVA) revealed significant differences between the nine safflower genotypes for all yield components and oil content (Tables 3 & 4).

Table 3: Yield components and oil content of safflower varieties

Number	Varieties	Number of seeds/plant (NS)	100 seeds Weight (HSW)	Yield of seeds (g/m^2) (YS)	Yield of Oil (% of seeds) (PO)	Yield of Oil (g/m^2) (YO)
1	80/482/3S	575,53	3,98	306,47	26,53	80,29
2	FINCH	388,23	2,91	150,63	36,13	54,57
3	GILA	379,37	3,79	187,92	38,47	72,11
4	KUSUMBA	402,32	3,40	181,67	23,30	42,33
5	OLE	458,23	3,68	224,31	34,60	77,40
6	OT-455	244,49	4,44	144,68	28,87	40,63
7	RIO	378,83	3,69	186,02	35,00	65,93
8	ROYAL	458,67	3,85	235,97	36,60	86,53
9	SYPRUS	800,17	3,94	420,29	27,27	114,56

Table 4 : ANOVA for Yield components (NS, HSW, YS) and oil content (PO, YO) for safflower varieties tested.

Source	SS	MS	F	P
V1(NS)	590251	73781	5.29	0.002**
V2 (HSW)	4.24587	0.53073	20.97	0.000***
V3 (YS)	184898	23112	6.56	0.000***
V4 (PO)	700.35	87.54	6.75	0.000***
V5 (YO)	12913.8	1614.2	3.70	0.010*

, **, *: significant at 0.05, 0.01 and 0.001 level of probability using the F test*

Reference [5] stated that seed yield and oil content are the primarily selection criteria for safflower breeding. The correlation among the all pairs of variables (NS, HSW, YS, PO and YO) are shown in Table 5. The highest positive correlations were obtained between YS with NS (r = 0.976***) and YO (r = 0.866***) (see also Figure 1), and between YO and NS (r = 0.862***).

Table 5: Correlation coefficients between variables (NS, HSW, YS, PO and YO) measured.

	V1(NS)	V2 (HSW)	V3 (YS)	V4 (PO)
V2 (HSW) P	-0,020 0,923 ns			
V3 (YS) P	0,976 0,000***	0,194 0,333 ns		
V4 (PO) P	-0,256 0,198 ns	-0,199 0,320 ns	-0,296 0,134 ns	
V5 (YO) P	0,862 0,000***	0,102 0,613 ns	0,866 0,000***	0,196 0,328 ns

****: significant at 0.001, ns: non significant level of probability using the F test*

PO is negative non-significantly correlated with NS (r = -0.256ns), HSW (r = -0.199ns) and YS (r = -0.296ns). Similar results were observed by [6], who reported that improvement of seed yield in safflower could be decline through oil content and 100-seed weight due to negative association between these traits with seed yield.

It can concluded, that selection for increasing seed yield in safflower may have considerable effect on oil content [6].

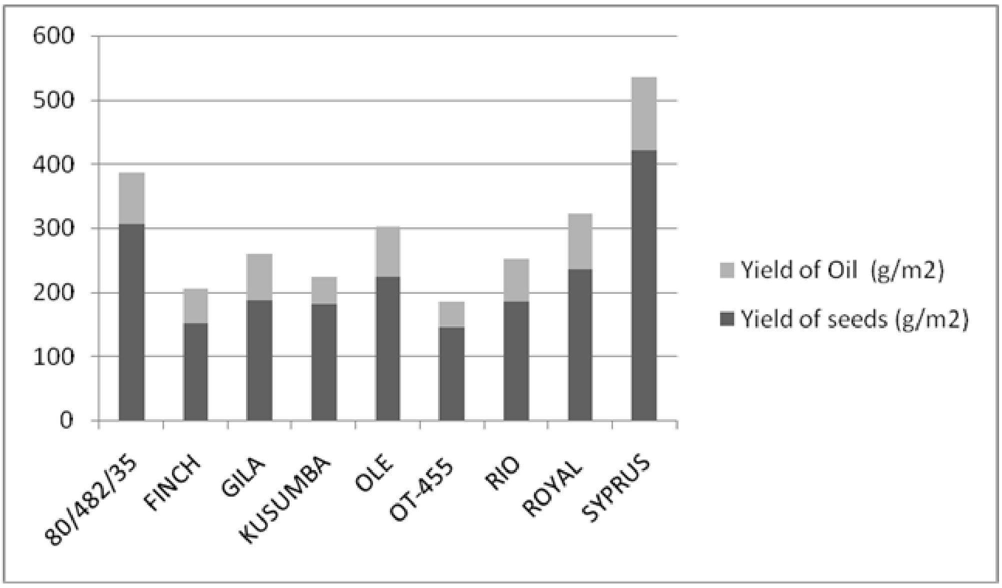

Figure 1: Yield of seeds and oil contents of safflower varieties

The dendrogram (Figure 2) based on 5 variables (NS, HSW, YS, PO, YO) showed four groups of varieties at similarity coefficient of 87.05. The first (I) contains the six USA varieties (1, 2, 3, 5, 7, 8), where, any of the three other groups contains only one variety. At higher coefficient, the first group is divided into 4 sub-groups: 1, 2, (3 & 7) and (5 & 8).

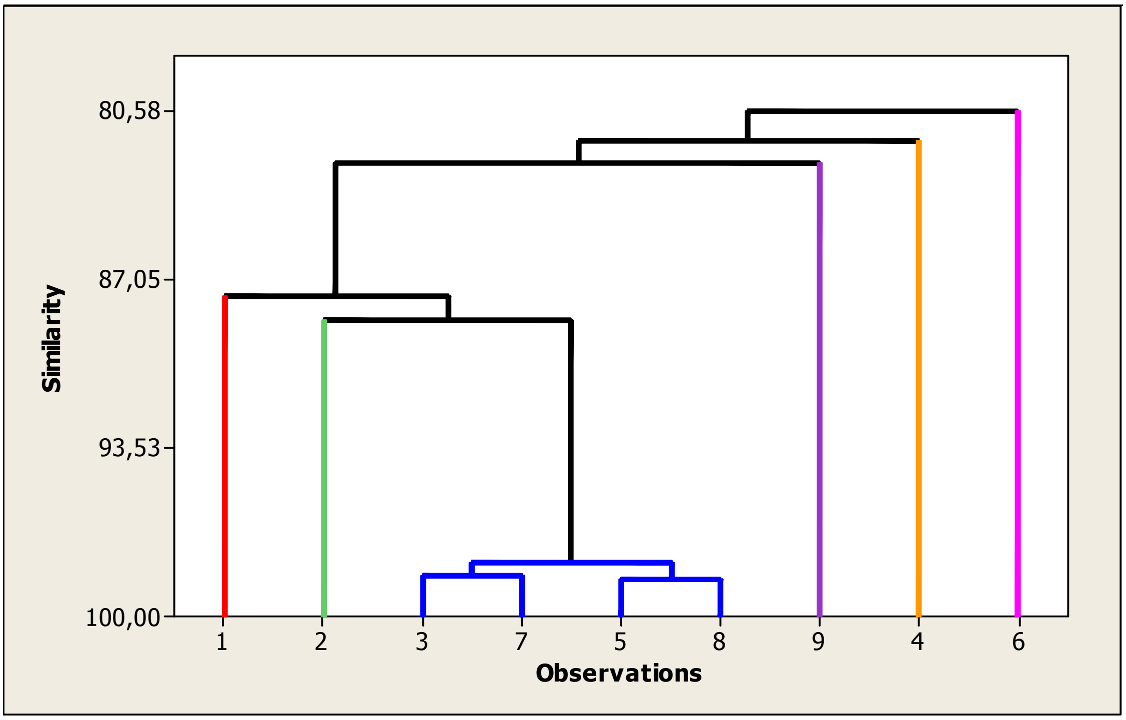

Figure 2 : Cluster analysis (Dendrogram) of safflower varieties (Observations) using 5 variables (NS, HSW, YS, PO, YO)

This shows that there is genetic divergence between the tested genotypes. The clustering pattern indicated that genotypes from different areas were grouped together which can be attributed to free exchange of breeding material or selection. The main factor affecting genetic response was diverse and depended on the area where the material was collected. Reference[7] observed similar results in domestic and foreign safflower germplasm.

The similarity matrix (Figure 3) clarifies the analyses by computing similarity coefficients between any two varieties. The high levels of similarity were recorded between varieties in group (I) (originating in USA). The low levels of similarity were observed between the variety number 1 (from the group I) and the varieties 6, 4 and 9.

Cluster Analysis of Observations (varieties) Squared Pearson Distance, Single Linkage Amalgamation Steps					
Step	**Number of clusters**	**Similarity level**	**Distance level**	**Clusters joined**	
1	**8**	**98,6111**	**0,47329**	**5**	**8**
2	**7**	**98,4132**	**0,54071**	**3**	**7**
3	**6**	**97,9540**	**0,69719**	**3**	**5**
4	**5**	**88,5698**	**3,89493**	**2**	**3**
5	**4**	**87,6964**	**4,19256**	**1**	**2**
6	**3**	**82,5570**	**5,94386**	**1**	**9**
7	**2**	**81,7254**	**6,22721**	**1**	**4**
8	**1**	**80,5781**	**6,61817**	**1**	**6**

Figure 3 : Cluster analysis (Similarity matrix) of safflower varieties (Observations) using 5 variables (NS, HSW, YS, PO, YO)

Hence, selecting parents for hybridization, must receive greater emphasis specialy those varieties falling in the most distant clusters for maximum heterosis since it is expected to produce new recombinants with desired traits. Reference [8] observed similar results in sesame.

4 CONCLUSION

The results obtained in this study indicate that oil seed production can be increased by growing drought tolerant safflower in regions where annual precipitation is not adequate [9], [10], and the introduction of safflower in the Mediterranean type climate will, to a small extent, help in increasing local production of edible oil [11].

From all varieties tested, ‘SYPRUS’ may be recommended as elite genotype for cultivation in semi-arid area of Mediterranean climate as it showed high relative yield performance and oil content.

Since the highest seed yields are expected when all components of seed yield are maximized [12], we concluded that hybridization program is recommended between ‘OT-455’ (the highest weight of one hundred seed variety), ‘SYPRUS’ (the variety which’s presented the highest seeds number per plant and yield of seeds) and ‘GILA’ (the variety which’s presented the highest fixed oil percentage of seeds).

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