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Study of Phenology, Harvest Index, Yield, Yield Components and Oil Contentof Different Cultivars of Rain-Fed Safflower

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Abstract: To study phenology, harvest index, yield, yield components and oil content of different safflower rain-fed cultivars, an experiment was carried out in Zanjan Rain-fed Farming Research Station during 2006-7. Seventeen safflower cultivars supplied by Maraqeh Rain-fed Farming Research Station were evaluated in a completely Randomized Block Design with three replications. Variance analysis of phenological and morphological traits, yield and yield components showed that safflower cultivars had significant differences on the probability level of 1% regarding days to branching, days to flowering, branch no per plant, grain no per boll and thousand-seed weight and they had significant differences on the probability level of 5% regarding days to boll-bearing, harvest index and oil yield. But no significant differences were observed regarding days to germination, days to Rosset termination, boll no per plant and oil content. The cultivar PI-537598 had the highest grain and oil yield (800 and 236.8 kg ha^{-1} in average, respectively) and Isfahan variety had the lowest ones (345.4 and 108 kg ha^{-1} in average, respectively). The shorter the vegetative period was, the longer the reproductive period was due to sooner flowering and so the higher the yield was.

Key words: Cultivar · Rain-fed safflower · Yield · Oil content

INTRODUCTION

The cultivars studied in this research were the results of previous observation and replicated studies conducted in rain-fed farming research stations including Zanjan, Kermanshah, Ardabil, Kordestan, Lorestan and Maraqeh and the superiority of some of these cultivars has been observed in the studies carried out in farming fields too. The first report from Sararood station, Kermanshah showed that the best cultivar had the yield of 703 kg ha^{-1} in spring rain-fed culture [1]. In Kordestan station, the cultivars CW-74 and PI-537598 had the highest yields (513.8 and 504.3 kg/ha, respectively) [2]. In a study on 20 safflower cultivars in spring rain-fed culture, Poordad [3] found that the cultivars PI-537598, PI-250537 and SYRIAN had the highest yields. In a study on 16 safflower cultivars under spring culture in Koohdasht, the cultivars SYRIAN, CW-4440 and PI-537598 were found to have the highest yields (918.5, 892.6 and 874 kg ha^{-1}, respectively) [1]. In another study, CYPRUS (790 kg ha^{-1}) and LESAF (340 kg ha^{-1}) had the highest and lowest yield among 24 cultivars, respectively [4]. In another study on 22 spring safflower cultivars under rain-fed culture in Kermanshah, Akhtar *et al.* [4] reported the yield of PI-250537 as 471 kg ha^{-1} and that of LESAF as 756 kg ha^{-1}. The mean yield of cultivars was 550 kg ha^{-1} under the precipitation of 303 mm and 588 kg ha^{-1} under the precipitation of 426 mm. Mündel *et al.* [5] suggested that grain yield of safflower is affected by grain no per boll and branch no per plant. Therefore, they recommended selecting for these traits in order for selecting for high-grain yield cultivars. They also recommended selecting early-maturity semi-dwarf cultivars with high thousand-grain weight and moderate grain no per boll for rain-fed culture.

Fathi *et al.* [6] found that grain and oil yield and grain no per boll increased as the interplant spacing increased. In their study, Cassato *et al.* [7] showed that boll no per

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plant is the most important yield component in safflower. In a study on 121 safflower genotypes, Bagheri *et al.* [8] indicated that single plant yield had significant positive correlation with days to flowering, plant height, thousand-grain weight and single boll grain weight. Path analysis shows that boll no per plant is the most effective trait on single-plant yield. In a study on 18 safflower cultivars, Khider [9] reported that grain yield had significant positive relation with grain no per boll, boll width and oil content. Bensalah *et al.* [10] reported that there was a significant relation between the first flowering branch and yield. There was a high correlation between yield and grain no per boll too. Boll no per plant, biologic yield and protein content had significant positive correlations with grain yield too [11]. The effect of seed strength on final yield has been confirmed by many researchers such as Robrets and Osei-Bonsu [12] and Pieta filho and Ellis [13]. Qasemi-e Golozari *et al.* [14] found that ground coverage, grain no. and grain yield were better in the plants resulting from powerful seeds that in plants resulting from weak seeds. Also grain yield per unit area of plants resulting from weak seeds is 30-40% less than those resulting from powerful seeds. Qarineh *et al.* [15] found that grain yield is significantly affected by cultivar. Elias [16] found that seed deterioration partly decreases final yield by affecting seedling emergence rate. Seed weakness mostly affects yield in two ways: firstly, grown seedling percentage declines and hence plant density decrease to under-optimum levels; and secondly, the growth rate of these plants may be slower than those of plants coming out of strong seeds [17, 18, 12]. Yield decline due to weaker and lower seedlings is deteriorated by pests and diseases in different cultivars and even if there is an optimum plant no per unit area, its disorder distribution may decrease yield [14].

MATERIALS AND METHODS

The study was carried out in Do-tappeh rain-fed farming research station in Zanjan Province during 2006-2007 (alt. 1887 m.; Long. 35°48' E.; Lat. 36°07' N.). Mean minimum, average and maximum absolute temperature in a seven-year period from 1999 to 2005 has been reported as-20, 11.2 and 37°C respectively and mean annual precipitation was 395.5 mm. Field soil texture was silt-loom-clay including 40% clay, 46% silt and 14% sand. The cultivars were selected from observatory researches which had been conducted in rain-fed farming research stations of Kermanshah, Maraqeh, Kordestan, Zanjan, Ardabil, Gonbad, Ilam and Lorestan, while the superiority of some cultivars had been proved in on-farm researches [3]. The foreign cultivars used in the study were as following: PI-537598, SYRIAN, PI-537636, CW-4404, LESAF, CYPRUS, CW-74, KINO-76, S-541, PI-250536, PI-250537, HARTMAN, GILA, PI-537636-S, PI-198290 and DINCER. They are spin, early-maturity, dwarf with thousand-grain weight of 33-40 g, mean grain yield of 500-900 kg ha^{-1} and oil content of 28-32%. In addition, Isfahan indigenous variety had been entered due to its vast cultivated area in the region. It is late-maturity, spinless with oil content of 31-33%, thousand-grain weight of 34-36 g and resistant to root rot [3]. The seeds were procured from Agricultural Research Station of Zanjan Province and the study during which 17 safflower cultivars were evaluated, was carried out in the form a Completely Randomized Block Design with three replications. Each block included 17 plots (7×2.1 m^2) with 7 rows with interspacing of 30 cm. Plants were 10 cm apart from each other as Research Station had recommended. All seeds were disinfected prior to planting by Benomyl (2:1000). Then they were planted 2 cm apart from each other at the depth of 4 cm on March 19, 2006. After emergence, they were thinned leaving 10 cm between them.

To phenologically study from planting to harvesting, the traits days to 50% emergence, days to Rosset period, days to branching initiation, days to boll-bearing initiation and days to 50% flowering were recorded. To determine yield components, branch no per plant, boll no per plant, grain no per boll and grain weight were measured and recorded. To measure grain yield and its components, oil yield, plant height and to record qualitative traits of cultivars, the plants were harvested by sickle after removing the effects of surface margin of 1.5 m^2. Then, 20 plants were randomly chosen and their traits were measured. Afterwards, the samples were put in plastic bag to avoid moisture loss and were transferred to laboratory for evaluating their qualities. Bolls were immediately removed and their dry weights were measured. To find the harvest index, 10 plants were randomly selected from each plot and were put in oven (75°C) for 48 hours with all their straws [19]. Then the samples were separately weighed and their biological yields were determined. Next, the grains were separated from straw and grain yields of all 10 plants were measured. Harvest index was determined as following:

$$\text{Harvest index} = (\text{economical yield}/\text{biological yield}) \times 100$$

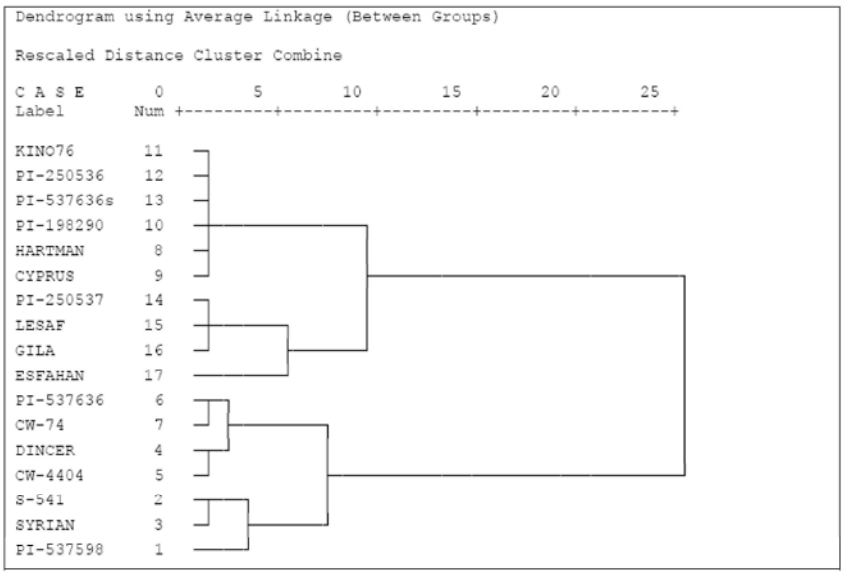

Fig. 1: Clustering 17 rain-fed safflower cultivars for grain yield

The variance analysis of the data gathered at final harvest was carried out by software MS-TATC and SAS based on a completely randomized block design and their means comparison was carried out by Duncan Test. To reduce the extent of data for better study, cluster analysis was used by the software SPSS. Among different cluster analysis methods, between-groups linkage was used considering coefficient and low serials (Figure 1).

RESULTS AND DISCUSSION

Days to Emergence: Variance analysis showed that there was no significant difference among cultivars regarding days to emergence (Table 1). For simple and better comparison, cultivars were clustered regarding grain yield and all cultivars were divided into five groups including very high-, high-, fair-, low- and very low-yield. Means comparison (Table 2) shows that all cultivars were germinated during 18.3-20 days after planting with no significant difference. Therefore, their aforementioned differences in seed quality and strength variation are caused by their genetic structure and environment and initial seed quality KI did not adversely affect the studied cultivars. The observed differences in grain yield, oil, yield components and so on were brought about by factors other than initial seed quality. Deckard [20] reported that the genotypes which had had higher grain yield in comparisons of Seed Supply and Breeding Institute had lower deterioration and higher germination rate than those with lower grain yield. These results indicate that the observed differences in the yields of genotypes were not merely due to genetic differences but seed deterioration level was a factor too, because as studies show, the more the seed deterioration level was, the lower their yield would be in farm. The required GDD for the germination of rain-fed safflower cultivars was 83.8 heat units in this study.

Days to Rosset Termination: Variance analysis (Table 1) shows that there were no significant differences among cultivars regarding days to Rosset termination (RT). All safflower cultivars passed their Rosset period with no significant differences in 77-70 days after planting after receiving a GDD of about 548.5 boll units and commenced their branching period. Means comparison (Table 2) shows that very high-yield cultivars had lower days to RT than very low-yield cultivars. Therefore, the cultivars which finish their Rosset period sooner and enter into the other growth stages will seemingly have higher yields.

Days to Auxiliary Branching: According to variance analysis, safflower cultivars had significant differences on the probability level of 1% regarding days to auxiliary branching (Table 1). It shows that with warming and receiving optimum heat, genetic talents of cultivars are exhibited from this stage on. On the basis of means comparison (Table 2), the group of low-yield cultivars had the highest days to auxiliary branching (for example, it was 105 days for Isfahan indigenous variety after

Table 1: Summary of variance analysis of some traits in different safflower cultivars

		Means of squares				
Source of variation	D.F.	Days to emergence	Days to Rosset termination	Days to branching	Days to boll-bearing initiation	Days to flowering initiation
Replication	2	2.01^{ns}	10.05*	32.4ns	10.6^{ns}	2.4^{ns}
Cultivar	16	0.75^{ns}	1.4ns	40.75**	10.08*	25.4**
Error	32	1.06	2.3	15.8	4.6	1.61
Variation coefficient (%)	-	5.5	1.43	4.06	2.04	1.03

n.s. = non-significant; * and ** = significant on the probability levels of 1 and 5%, respectively.

Table 2: Means comparison of some traits in 17 rain-fed safflower cultivars

Grouping	Cultivar	Days to emergence	Days to Rosset termination	Days to branching	Days to boll-bearing initiation	Days to flowering initiation
Very high yield	PI-537598	18.6 A	77.0 A	92.0 D	104.3 ABC	121.0 C
	S-541	18.0 A	77.0 A	94.3 CD	107.0 A	122.0 BC
	Syrian	19.33 A	77.0 A	94.2 CD	101.0 C	121 C
High yield	Dincer	18.3 A	78.0 A	96.6 BCD	102.0 BC	123.0 BC
	CW-4404	18.6 A	78.0 A	94.0 CD	103.3 ABC	121 C
	PI-537636	19.00 A	77.0 A	96.3 VCD	105.6 AB	121 C
	CW-74	18.3 A	77.0 A	93.0 D	105.6 AB	124 B
Fair yield	Hartman	19 A	77.0 A	98.3 A..D	103.3 ABC	122 BC
	Cyprus	20.0 A	78.0 A	101.0 ABC	105.6 AB	124 B
	PI-198290	18.3 A	78.0 A	98.3 A..D	104.3 ABC	124 B
	KINO-76	18.3 A	77.0 A	98.3 A..D	107.0 A	124.0 B
	PI-250536	18.3 A	79.0 A	99.0 A..D	104.3 ABC	121 C
		18.6 A	79.0 A	101.6 ABC	104.6 ABC	124 B
Low yield	PI-250537	18.6 A	78.0 A	96.3 BCD	105.6 AB	122 BC
	Lesaf	19.0 A	78.0 A	101.0 ABC	107.0 A	124 B
	Gila	18.3 A	78.0 A	103.0 AB	107.0 A	124 B
Very low yield	Isfahan	19.3 A	78.0 A	105.0 AB	107.0 A	133.3 A

Note: In each column, the means have same letters did not show significant difference on the probability level of 5%

receiving 956 heat units) and the group of very high-yield cultivars had the lowest one (for example, it was 92 days for PI-537598 after receiving 780.4 heat units). It is clear that the cultivars with very high, high and even fair yield have lower days to auxiliary branching than cultivars with low and very low yield.

Days to Boll-bearing and Flowering: Variance analysis showed that cultivars had significant differences on the probability level of 5% regarding days to boll-bearing (Table 1). According to means comparison (Table 2), low- and very low-yield cultivars e.g. LESAF, GILA and Isfahan variety had higher days to boll-bearing (in average 107 days after planting) than others. The received GDDs for low-yield cultivars were about 989.5 heat units. Variance analysis resulted that there were significant differences among cultivars on the probability level of 5% regarding days to flowering (Table 1). As it is clear, 18 cultivars had no significant difference regarding days to RT but with warming and receiving effective heat, significant differences had appeared regarding other traits. The lowest GDD required by cultivars to enter this stage was 1229.25 heat units for high- and very high-yield ones. Isfahan variety with very low yield received a GDD of 1448.3 heat units. Table 2 shows cultivar grouping in five groups in terms of very high, high, fair, low and very low yield. As shown, mean days of Isfahan variety to flowering (with very low yield) started 12 days later than such very high-yield cultivars as PI-537598 and SYRIAN. Therefore, it seems that a reason for high yield in this group is early termination of vegetative growth and early initiation of reproductive growth and fast development.

Grain Yield per Unit Area: Table 3 shows the results of grain yield variance analysis. According to these results, there were significant differences among cultivars on the probability level of 5% regarding this trait. The results of means comparison (Table 4) as well as clustering of the cultivars regarding grain yield (Figure 1) indicates that 17 safflower cultivars can be divided into five groups: the cultivars PI-537598, S-541 and SYRIAN (with grain

Table 3: Summary of variance analysis of some traits in 17 safflower rain-fed cultivars

		Means of squares				
Source of variation	D.F.	Grain yield	Boll no./plant	Branch no./plant	Grain no./boll	1000-seed weight
Replication	2	187142.2	3.8^{ns}	0.84^{ns}	10.43^{ns}	0.18^{ns}
Cultivar	16	45601.6*	2.15^{ns}	1.08**	21.06**	15.26**
Error	32	31737.0	1.88	42.0	8.53	0.27
Variation coefficient (%)	-	25.9	19.05	18.60	13.8	1.58

n.s. = non-significant; * and ** = significant on the probability levels of 1 and 5%, respectively

Table 4: Means comparison of some traits in 17 safflower rain-fed cultivars

Grouping	Cultivar	Grain yield	Boll no./plant	Branch no./plant	Grain no./boll	1000-seedweight
Very high yield	PI-537598	800.0 A	12 AB	4.0 AB	21.3 BC	33.7 C
	S-541	733.5 AB	10.3 AB	3.0 BC	19.0 BC	33.6 C
	Syrian	728.5 AB	12.6 A	5.0 A	31.6 A	33.29 CD
High yield	Dincer	693.5 ABC	11.3 AB	3.3 BC	21.0 BC	40.5 A
	CW-4404	663.5 ABC	10.6 AB	4.0 AB	20.3 BC	33.4 CD
	PI-537636	632.1 ABC	8.6 AB	4.0 AB	22.0 BC	32.5 D
	CW-74	622.0 ABC	11.1 AB	4.0 AB	21.6 BC	33.26 CD
Fair yield	Hartman	574.6 ABC	10.6 AB	3.3 BC	20.6 BC	33.4 CD
	Cyprus	556.3 ABC	10.1 AB	4.0 AB	24.3 AB	32.4 DE
	PI-198290	538.0 ABC	10.2 AB	3.6 BC	29.0 A	33.1 CD
	KINO-76	527.0 ABC	11 AB	3.0 BC	21.0 BC	31.1 F
	PI-250536	526.3 ABC	9.8 AB	3.6 BC	18.3 C	35.07 B
		521.3 ABC	10.8 AB	3 BC	18.0 C	34.06 C
Low yield	PI-250537	449.6 ABC	9.6 AB	3.0 BC	18.3 C	31.5 EF
	Lesaf	444.2 BC	9.9 AB	3.0 BC	18.6 BC	33.09 CD
	Gila	426.7 BC	10.3 AB	3.0 BC	22.0 BC	32.4 DE
Very low yield	Isfahan	345.4 C	10.7 AB	2.6 C	20.0 BC	29.3 G

Note: In each column, the means have same letters did not show significant difference on the probability level of 5%

yields of 800, 733.5 and 728.5 kg ha^{-1}, respectively) in group of very high-yield cultivars, the cultivars DINCER, CW-4404, PI-537636 and CW-74 (with grain yields of 693.5, 663.5, 632.1 and 622 kg ha^{-1}, respectively) in group of high-yield cultivars, the cultivars HARTMAN, CYPRUS, PI-198290, KINO-76, PI-250536 and PI-537636-S (with grain yields of 574.6, 556.3, 538, 527, 526.3 and 521.3 kg ha^{-1}, respectively) in group of fair-yield cultivars, the cultivars PI-250537, LESAF and GILA (with grain yields of 449.6, 444.3 and 426.7 kg ha^{-1}, respectively) in group of low-yield cultivars and Isfahan indigenous variety (with grain yield of 345.4 kg ha^{-1}) in group of very low-yield cultivars.

The results of Iranian research stations show the superiority of the cultivars PI-537598, CW-74 [2], PI-537598 and SYRIAN [3]. In a study on 16 spring safflower cultivars in Koohdasht, it was shown that the cultivars SYRIAN, CW-4404 and PI-537598 with grain yields of 918.5, 892.6 and 874 kg ha^{-1} had the highest grain yields [1]. The comparison of the results of this study with the results of other studies carried out in other stations proves the higher yield potential of these cultivars in different regions of Iran. Akhtar *et al.* [4] reported that under rain-fed farming conditions in Kermanshah, CYPRUS and LESAF had the highest (790 kg ha^{-1}) and lowest (340 kg ha^{-1}) grain yields, respectively. Combined analysis of the studied cultivars in different regions such as Zanjan, Maraqeh, Kermanshah, Sanandaj, Koohdasht, Ardabil and Qonbad showed that the cultivar PI-537598 had the highest grain yield (872.8 kg ha^{-1}) [1]. On-farm study of safflower cultivars in three regions of Kermanshah Province showed that Isfahan variety had the lowest grain yield and SYRIAN had the highest one [3]. Some traits effective on high- and low-yield cultivars are discussed later.

Boll Number per Plant: Variance analysis showed that there were no significant differences among cultivars regarding boll no. per plant (Table 3). Combined analysis of the studies carried out in research stations of cold regions in Iran showed no significant differences among cultivars regarding this trait [1]. Consequently, it seems that the variation in grain and oil yield among cultivars was brought about by variation in such traits as branch no. per plant, grain no. per head, thousand-grain weight and harvest index as well as the effects of different

Table 5: Summary of variance analysis of some traits in 17 safflower rain-fed cultivars

		Means of squares		
Source of variation	D.F.	Harvest index	Oil yield/ha	Oil content (%)
Replication	2	62.5**	19477.7**	3.2ns
Cultivar	16	17.97*	3699.08*	2.45ns
Error	32	11.03	2781.7	1.95
Variation coefficient (%)	-	11.82	22.99	4.7

n.s. = non-significant; * and **= significant on the probability levels of 1 and 5%, respectively

phenological stages such as branching, boll-bearing, flowering and maturity. Means comparison of groups with different yields (Table 4) shows that although the difference of cultivars in boll no. per plant was not significant, very high-yield cultivars such as PI-537598 and SYRIAN and high-yield ones such as DINCER had higher boll no. per plant than low-yield cultivars such as Isfahan variety in total.

Primary Branch Number per Plant: Variance analysis shows that there was a significant difference among cultivars regarding primary branch no. per plant on the probability level of 1% (Table 3). Means comparison (Table 4) shows that SYRIAN had the highest and Isfahan variety had the lowest primary branch no. per plant (5 and 2.6 branches per plant, respectively). Considering means comparison of groups with different yields, it can be said that very high-yield groups such as SYRIAN and high-yield ones have much higher branch no. than low- and very low-yield groups like Isfahan variety. Research shows that there is a direct relationship between auxiliary branch no. and yield [21].

Grain Number per Boll: Variance analysis (Table 3) indicates that there was a significant difference among different safflower cultivars regarding grain no. per boll at the probability level of 1%. According to means comparison (Table 4) grain no. per boll in very high-yield cultivars like SYRIAN and fair-yield ones like PI-198290 is significantly higher which is a proof of their higher grain yield potential. The cultivar PI-537636-S had the lowest grain no. per boll. Therefore, higher grain no. per boll of two cultivars with high and fair yield shows their positive effect on yield but under rain-fed with low plant density; boll grain no. per unit area could not provide the yield resulting from optimum plant density in all cultivars.

Thousand-grain Weight: Variance analysis shows that there was a significant difference among different cultivars regarding thousand-grain weight on the probability level of 1% (Table 3). According to means comparison (Table 4), the cultivar DINCER had the highest thousand-grain weight (40.5 g) and Isfahan variety had the lowest one (29.3 g). Table 4 shows the mean thousand-grain weight of groups with different yields according which high- and very high-yield cultivars like DINCER and SYRIAN had better performance regarding thousand-grain weight than very low-yield group including Isfahan variety.

Harvest Index: Variance analysis of harvest index (Table 5) shows that there were significant differences among cultivars regarding harvest index on the probability level of 5%. According to means comparison, PI-537598 had the highest and Isfahan variety had the lowest harvest index (32 and 23.1%, respectively) (Table 6). Higher yield and harvest index of PI-537598 indicates better partitioning of photosynthetic substance to economic yield which can be considered as a good trait in breeding high-yield cultivars. Harvest index is most important in breeding crops because as a positive trait, it can be transferred from cultivars with high harvest index but low production potential to cultivars with surpassing agronomical traits but low harvest index [5]. Table 6 includes means comparison of harvest index in different yield groups, according which the less the harvest index is, the less the grain and oil yield will be. In a study on spring safflower, Chaudhary [22] reported a correlation between grain yield and harvest index. The similarity of harvest index variation pattern to grain and oil yield and branch no. per plant variation pattern as well as partly to boll no. per plant variation pattern shows that dwarf branchy safflower cultivars produce higher economic yield than such cultivars as Isfahan variety and have better harvest index (Table 6).

Table 6: Means comparison of some traits in 17 safflower rain-fed cultivars

Grouping	Cultivar	Grain yield	Oil yield/ha	Oil content (%)
Very high yield	PI-537598	32.0 A	236.8 A	29.27 AB
	S-541	31.0 AB	217.4 AB	29.48 AB
	Syrian	30.4 AB	212.5 ABC	28.86 AB
High yield	Dincer	30.16 AB	193.2 ABC	28.01 B
	CW-4404	30.03 AB	200.2 ABC	30.34 AB
	PI-537636	27.3 ABC	154.3 ABC	29.33 AB
	CW-74	28.6 ABC	191.2 ABC	30.9 A
Fair yield	Hartman	28.9 ABC	165.5 ABC	29.03 AB
	Cyprus	17.8 ABC	168.4 ABC	30.58 AB
	PI-198290	29.3 ABC	153.1 ABC	28.29 AB
	KINO-76	27.3 ABC	151.4 ABC	28.83 AB
	PI-250536	29.2 ABC	186.3 ABC	29.54 AB
		27.1 ABC	154.6 ABC	29.78 AB
Low yield	PI-250537	25.3 BC	137.4 ABC	30.74 AB
	Lesaf	24.9 BC	132.5 ABC	29.71 AB
	Gila	24.8 BC	129.8 BC	30.33 AB
Very low yield	Isfahan	23.1 C	108.8 C	31.16 A

Note: In each column, the means have same letters did not show significant difference on the probability level of 5%

Oil Yield: Variance analysis shows significant differences among cultivars regarding oil yield on the probability level of 5% (Table 5). According to means comparison (Table 6) and cluster analysis (Figure 1), 17 safflower cultivars can be divided into five following groups:

- Very high oil yield cultivars including PI-537598, S-541 and SYRIAN with oil yields of 236.8, 217.4 and 212.5 kg ha^{-1}, respectively;
- High oil yield cultivars including DINCER, CW-4404, PI-537636 and CW-74 with oil yields of 193.2, 200.2, 186.3 and 191.2 kg ha^{-1}, respectively;
- Fair oil yield cultivars including HARTMAN, CYPRUS, PI-198290, KINI-76, PI-250536 and PI-537636-S with oil yields of 165.5, 168.4, 153. 1, 151.4, 186.3 and 154.6 kg ha^{-1}, respectively;
- Low oil yield cultivars including LESAF, GILA and PI-250537 with oil yields of 132.5, 129.8 and 137.4 kg ha^{-1}, respectively;
- Very low oil yield cultivars including Isfahan variety with oil yield of 108.0 kg ha^{-1}.

The comparison of grain yield clustering (Figure 1) shows that these two traits stand in the same group regarding variation pattern and cultivars with high oil yield have high grain yield too and vice versa. The superiority of PI-537598 with mean yield of 275 kg ha^{-1} has been proved in different research stations in Iranian cold regions [1].

Grain Oil Content: Variance analysis (Table 5) showed no significant differences among cultivars regarding grain oil content. However, Isfahan variety and DINCER (with oil content of 31.16 and 28.01%, respectively) had the lowest and highest oil contents and other cultivars stood between them with no significant differences (Table 6).

CONCLUSION

According to variance analysis of phenological and morphological traits, yield and yield components, there were significant differences among cultivars regarding days to branching initiation, days to flowering initiation, branch no./plant, grain no./boll and thousand-grain weight on the probability level of 1% and there were significant differences among cultivars regarding days to boll-bearing initiation, harvest index, oil content and oil yield on the probability level of 5%. But there were no significant differences regarding days to germination, days to RT, boll no. per plant. According to cluster analysis, all 17 cultivars were divided into five groups regarding grain yield including very high, high, fair, low and very low yield and all traits were compared on the basis of this grouping. The results showed that PI-537598 had the highest grain and oil yield (800 and 236.8 kg ha^{-1} in average, respectively) and Isfahan variety had the lowest ones (345.4 and 108 kg ha^{-1} in average, respectively). It is concluded from the effective phenological stages on grain and oil yield and branching, boll-bearing and flowering speedup that the shorter the duration of vegetative growth is, the longer the duration of reproductive stage will be due to early flowering and the higher the yield will be.

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