

## ORIGINAL ARTICLE

# Evaluation the Different Varieties of Spring Safflower in Three Irrigation Levels

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### ABSTRACT

Due to the growing demand for edible oils, oilseed crop development is very important. Safflower (*Carthamus tinctorius L*) is a native of Iran oil seed. This crop is compatible with the environmental conditions in the country as well; this is especially true in areas exposed to non-biological stresses such as drought and salinity, but there are no enough studies about this plant. In order to investigate the effects of drought stress on the grain yield, an experiment was conducted split plot and completely accidental blocks plan with two replicates in normal conditions (7irrigation) and two times drought stress ( 6 and 5 irrigation, respectively) by 26 varieties. In this research, we measured and studied the traits like the day number to germination, the day number to stalk appearance, the day number to 50% budding, the day number to 50% flowering, the day number to 100% flowering, the bush height, the number of the boll per bush, the number of the grain per boll, 1000-grain weight, the plant performance and the oil content. The results of the variance analysis showed that there are significant differences between the different irrigation levels regarding the traits, only the 1000 grain weight with 5% possibility and the boll number per bush with 10% possibility. A significant difference was seen between studied varieties regarding the investigated traits which show the genetic diversity of the varieties. According to the results from the comparison of the varieties mean, the least 1000 grain weight belonged to Zaragan2 local variety and the most one was about the foreign variety, Nebraska. According the results of the compression of the varieties mean in the irrigation levels, the plant performance and 1000 grain weight increased with the irrigation time's growth in the production stage. In this research, the varieties with more 1000 grain weight had high plant performance. The plant performance of the safflower different varieties in this experiment were variable in the slope of 13/5 - 20/75g and the most plant performance mean belonged to N51016 and the least one was related to Zaragan4 local. The oil content of varieties had changes from 35/37% in TOMJIK to 25/06% in Kordestan2 local. The genetic diversity between the safflower different varieties is the main factor of oil content changes. The interaction effects of varieties in irrigation levels were not significant for any of the investigated traits, in other words, the varieties and irrigation levels were acted independently on the traits.

**Key words:** safflower, drought stress, grain yield, oil content

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### INTRODUCTION

The major portion of the oil supply is from external sources and regarding the growth of population and per capita consumption of oil in the country, increasing the area under cultivation and production of oilseeds is of utmost importance. Safflower is a native of Iran oil seed that is compatible with the environmental conditions in the country as well; this is especially true in areas exposed to non-biological stresses such as drought and salinity [32]. Despite this plant is Iran native crop and its wild species are found in abundance in Iran [26] but very few studies had done about it and it is not adequately been considered.

Safflower in comparing to the other crops requires less water in a growth period [3]. Kumar [21] compared the safflower planting development potential with sunflower in India and announced that in a definite farm area, the benefit from safflower is more than sunflower. He knows the main result of that, the high tolerance of safflower to the drought. Now, safflower due to drought resistance is a crop in dry land farming areas of the country mountainous parts [4]. Haby, et al [15] announced that excessive irrigation makes vegetative growth, delayed maturity, reduced yield, oil content and protein, because there will not be enough time to complete life cycle and maturity. In general, the required water rate for

safflower irrigation depends on raining rate and distribution in the growth season, the water preserving capacity of the soil, the soil moisture restore, evaporation and transpiration potential in the area, the type of the variety, harvesting time, the fertilizer rate and some other factors is different [35].

Aray and French [11] investigated the effects of the irrigation regimes on the growth, yield and yield components of safflower grain and announced that generally, safflower is a strong water consuming plant in the initiative period of flower sprout formation up to the end of the its flourishing. The soil moisture is so important in the sprout formation of the flower and influences the yield so much. Also, they announced that because safflower has a deep stem, its drought tolerance is in the condition that there is the moisture restore in the soil.

Haby et al [15] conducted one or two irrigation before flowering and said that the initial stalk formation of the flower is enough for desired grain performance. Hang and Ivans in a 2 year old experiment compared safflower with sunflower regarding the water consumption and some other traits and found out that the safflower reaction to the irrigation is so same with the sunflower. Liliang investigations [17] in China verify that the irrigation periods have significant effects on the safflower's bush growth and evolution. Nahavandi Azad [24] announced that if we conduct 3 more irrigation after the safflower planting irrigation, the first one will be 30 – 40 days after the planting, the second one will be in stalk appearance and the third one will be in the grain and flower stage. Abel [2] said that the irrigation should stop 5 days before 95% flowering.

Yazdi Samadi and Abde Mishani [33] investigated the Iranian and foreign lines in Karaj, without irrigation and concluded that the oil content is changed from 16% to 40% and the Iranian lines have high oil content. According to Abel [1,2] the moisture stress reduces the oil content in the ending stages. Luebs, et al [23] believed that the climate different conditions in the grain formation period create a lot differences in the safflower grain oil content and have effects on the oil fatal acids and iodine number. Lee [27,21] announced that one or two irrigation in the relation to the no irrigation do not influence safflower oil content and iodine number.

Han, et al [17] announced that the boll number is a factor that influences safflower yield. This aspect mainly is affected by the genetic factors, the climate conditions, the plant density and the fertilizer rate. However, Erie and French [11] announced that the above mentioned yields come from the grain more weights and the more grain numbers in the boll. Randhaea, et al [29] said that one irrigation before planting and 2 to 5 irrigation after that increase the safflower yield via the grain number per bush. Han, et al [17] reminded that the irrigation periods have significant effects on the safflower yield components.

Davia, et al [9] announced that the inadequate irrigation and the soil moisture shortage are the main factors of the safflower grain yield reduction. Li [22] reported that one or two irrigation after the cultivation increases the yield comparing with the cultivation without irrigation. Haby, et al [15] investigations verified that an irrigation in the initial period of budding causes desired safflower grain yield. In another experiment, the mean yield of the grains with one, two, three and four irrigations were respectively 29%, 44%, 58% and 76% more than irrigation absent safflower yields [17]. Zaman [34] reported that the grain yield with one, two and three irrigation in the different stages of growth is respectively 0/62, 0/81 and 1/11 tons per hectare. Therefore, the yield increases with irrigation time's enhancement. Ganavati [13] announced that the safflower yield is complete in the rainfed condition and one irrigation in the flowering time and two irrigation in the flowering is respectively 0/918, 1/3 and 2/046 tons per hectare.

The aim of this study was to select the superior varieties regarding different traits under the different conditions of drought stress and to investigate the varieties under different conditions of drought stress.

## METHODS AND MATERIALS

This experiment was conducted in Azerbaijan-e-Shargi Agricultural and investigation centre located in 20 km of Tabriz-Azarshahr road as spring cultivation. In this study 26 spring varieties of safflower were investigated in split- plot form with completely random block designs: Bonab L. MIANE.1 ·MARAND L.1 ·MIANE L.2 ·MARAND L.2 ·MARAND L.3 ·LANGARMAHAN L. ·ZARGHAN L.2 ·ZARGHAN L.3 ·ZARGHAN L.4 ·ZARAND.KERMAN 1 ·ZARAND.KERMAN 2 ·KORDESTAN 2 ·ESFAHAN L. ·BROOJERD L. ·NISHABOOR L. ·N974051 ·N51016 ·V-51-242 ·NEBRASKA825 ·A-1 ·TOMJIC ·N.5 ·3151 ·24-1 ۛ D51-361. Three different levels of irrigation mentioned as factor A. In harvest stage, in a3 irrigation level, 7 stage, a2:6 stages, a1: 5 stages were conducted. In a3, the 7 irrigation stages were: after cultivation, germination, the stalk rapid growth, branching, 50% budding, 50% flowering and water grain.

Each experiment was repeated with three main plots and sub-plots within the main plot of 26 × 3 × 2 m were made. Each sub-plot consisted of five rows with a distance of 60 cm and a length of 2 m. In order to establish the number of plants in each sub plot was planted more seed and then Thinning operations

were carried out at the right time and the bush spacing was adjusted on 20cm rows. Sowing depth of 3-2 cm was considered. To improve the nutrition of mountain plants before planting 15 kg urea, 35 kg phosphorus and 15 kg potash were distributed in the field. During the vegetative stage, 10 kg urea and 5/3 kg potash fertilizer was distributed at the farm level. Since the soil pH is in the range 1/8-6/7, there was not considerable risk of salinity in the top soils. During the experimental period, farm management practices, including weed and pest control were based on need. To combat field pests, spraying is carried out in three forms. So that the first time was with Thrips, the second with Desis and the third one was with DinoKarp spraying pesticides. Traits in this study were: the day number to germination, the day number to stalk appearance, the day number to 50% budding, the day number to 50% flowering, the day number to 100% flowering, the bush height, the number of the boll per bush, the number of the grain per boll, 1000-grain weight, the plant performance and the oil content. After making sure of the assumptions of analysis of variance, data analysis and the means were compared by LSD test at 5% probability level 1. Statistical analysis of data was performed using MSTAT-C software.

## RESULTS AND DISCUSSION

### *Variance analysis and comparison of investigated traits mean*

Table1 shows the results of 11 investigated traits variance analysis in 26 spring safflower varieties for two irrigation levels (A) and varieties (B). Between different levels of irrigation, seed weight at 5% level and the number of bolls per plant was significantly lower at 10% probability level; while there was no significant difference observed in other studied traits. Mean squares for traits evaluated as significant figures show 1% possibility rate for the day number to germination, the day number to stalk appearance, the day number to 50% budding, the day number to 50% flowering, the day number to 100% flowering, the bush height, the number of the boll per bush, the number of the grain per boll, 1000-grain weight and the oil content and for the plant yield in 5% possibility shows the genetic diversity between the varieties regarding these traits. Tivari and Namdo [30] evaluated the thorny and thorn less safflower genotypes in India and reported that there is a significant difference between genotypes regarding the yield and yield components and in thorn less genotypes there are more boll per bush, but in thorny genotypes there are more grain per boll and 1000 grain weight. Kazato, et al [8] and Ehsan zade and Mahmoudie [10] studies show that between different varieties of safflower seed yield, there are significant differences. Interactions with a variety of irrigation levels was not significant for any of the parameters studied, in other words, the effectiveness of varieties and irrigation levels on desired traits were independent.

Table 1: The variance analysis of the irrigation levels and variety effects on the safflower measured traits

SOURCE OF VARIANT	df	Mean of square					
		Plant height	No. capitula/plant	No. seeds/capitulum	1000-seed weight	the bush height	oil content
Replication	1	0/776	0/231	321/641	31/870	165/892**	1/154
irrigation levels	2	559/404	121/822*	313/556	318/623*	94/89	1/975
Error1	2	320/045	13/009	72/632	5/916	7/124	1/157
Genotype	25	320/413**	30/576**	214/846**	249/324**	19/629*	25/104**
Genotype* irrigation levels	50	21/777	5/562	15/211	6/458	11/14	0/908
Error2	75	28/155	8/112	15/379	10/155	11/14	1/291
C.V of Genotypes(%)		7/53	18/75	11/98	8/95	19/75	3/89
C.V of irrigation levels(%)		25/4	23/75	26/04	6/83	15/80	3/69

\*and \*\* significant at level 5% and 1%, respectively.

Table1. The variance analysis of the irrigation levels and variety effects on the safflower measured traits

SOURCE OF VARIANT	df	Mean of square				
		days to germination	Days to stem elongation	days to 50% budding	days to 50% flowering	days to 100% flowering
Replication	1	0/231	1/641	0/314	13/564	2/564
irrigation levels	2	0/333	4/949	0/795	12/006	29/237
Error1	2	2/769	2/872	1/641	20/468	20/122
Genotype	25	0/667**	17/516**	53/559**	83/697**	78/183**
Genotype* irrigation levels	50	0/127	0/642	0/502	1/360	1/637
Error2	75	0/176	0/822	0/612	1/553	1/523
C.V of Genotypes(%)		4/50	2/91	1/30	1/60	1/49
C.V of irrigation levels(%)		17/83	5/44	2/13	5/81	5/4

\*and \*\* significant at level 5% and 1%, respectively.

Table (2) indicates comparisons of mean water levels for 26 traits in spring safflower varieties using LSD test. According to this table, the highest seed weight of 15/37 g was a3 and its value at 89/36 mg in a2 and 74/32 mg achieved at a1. In general, the highest grain weight and yield per plant were a3. So, clearly we can observe the effects of irrigation times on the 1000 grain weight enhancement and the plant performance. Erie and French [11] investigated the irrigation regimes in yield and yield components and announced that sufficient irrigation in growth stages increases the yield. In this context, the researchers like Haby, et al [15], Bansal and Katara [5], Li [22], Hang and Evans [18], Katara and Bansal [19], Patel and Patel [27] and Ganavati [13] conducted some researches and showed that irrigation during the different stages of reproductive period increases the grain yield.

Table2. The studied traits mean of 26 spring safflower in 3 irrigation levels

The plant yield	Traits	1000 grain weight	Irrigation levels
15/95		32/74	a1
16/30		36/89	a2
18/44		37/15	a3
2/252		2/052	LSD 5%

a1: the last irrigation in 50% budding

a2: the last irrigation in 50% flowering

a3: water stress free

Zaman [34], Pavar, et al [28], Katole and Mina [20], Halerao, et al [16] and Gajendra [12] verified the high frequency irrigation effects on the yield enhancement. Due to different levels of irrigation water deficit of 50% flowering stage to the next is applied, we can say the traits like the day number to germination, the day number to stalk appearance, the day number to 50% budding and even the day number to 50% flowering don't influence by irrigation different levels and the differences in mean water level are due to the experiment replicates from a2, a1 and a3 irrigation levels. According to Hang and Evans [18] inadequate irrigation causes the height reduction. According to Abel [1] non irrigation condition in the final growth stages reduces the oil content. Luebs, et al [23] focused on the irrigation rate on the oil content. Bansal and Katara [5] announced that the most oil yield is reached with 3 irrigation compared to the low irrigation times. Han, et al [17] mentioned the boll number per bush has effect on safflower yield. Erie and French [11] mentioned the effects of 1000 grain weight and the grain number per boll on the yield enhancement. Bansal and Katara [5] in an experiment investigated the effects of irrigation different levels on the yield components and announced that increasing irrigation frequency on reproductive stage (flowering and grain filling) the number of bolls per plant, number of seeds per boll and seed weight is increased. The results of comparing the genotypes in Table 3 have been inserted. The interaction of genotype and irrigation levels were non-significantly for all the traits, indicating that the reaction was the same genotypes under different irrigation (table1).

Germination period of different cultivars of safflower in this study ranged 9-10/5 day. The highest day number to germination was related to Nebraska and the lowest one was 24-1, Zaragan3, Booroojerd local and Neishaboor local with 9 days. In Iranian varieties, 3151 had the most day number to germination (table3).

Beech and Norman [7] announced that the safflower germination mean period is 10 days. Change range of the traits was the day number from planting to stalk appearance, 29/33- 35/5 days. In the investigated varieties, Neishaboor local and Mianeh local had the longest period from planting to stalk appearance and N51016 had the shortest one (table 3).

The day number from planting to 50% budding was variable: 66/83 days for Zaragan local 2 and 56/67 days for Kerman Zarand 1. After Kerman Zarand1, Kerman Zarand2 and Nebraska reached this stage sooner (table3).

The changes range of the day number was different from planting to 50% flowering: 71/83 – 86/17 days (table3). The foreign varieties, Nebraska and N51016 reached 50% flowering sooner.

The above results indicate that these figures compare with those of other genotypes of safflower have shorter growing periods. In contrast, Zaragan local 2, Zaragan local 4 and Neishaboor local entered this stage after the other germplasms (table3).

The changes range of the day number was different from planting to 100% flowering: 76/5- 91/33. The foreign varieties, Nebraska and N51016 reached 100% flowering sooner. In contrast, Zaragan local 2, Zaragan local 4 and Neishaboor local entered this stage after the other varieties. As we seen there is a definite trend between the day numbers from planting to 50% flowering and the day numbers from planting to 100% flowering.

According to the results from the bush mean height comparison we can see that this trait in safflower different varieties is variable between 52/33 – 82/50. Most dwarf varieties were Nebraska and N51016 and the most long legged were: Neishaboor local and Zaragan local2 (table3).

The boll number per bush changes range in any bush was 9/67 – 19/57 (table3). So that the least one was N51016 and the most one was Zaragan local2.

About the relationship between changes in the number of bolls per plant, number of seeds per boll clear trend is observed. In other words, the varieties with the most boll number per bush had the least grain number per boll. For example, Nebraska had 17/73 boll per bush but the least grain number per boll (17/62). Varieties with the potential to produce 12 to 40 large boll and 30 to 40 seeds per boll are more suitable for mechanized trends [31]. Omidi Tabrizi [25] observed the genetic diversity in spring safflower varieties regarding the boll number bush. The mean study indicates that the relationship between changes in the number of bolls per plant and seed weight has no clear trend, but regarding the change relationship, the increase of boll number per bush enhances the plant yield.

The grain number per boll was variable from 49/47 in N51016 to 17/62 in Nebraska (Table 3). Genetic diversity in populations of endemic spring safflower seeds per boll by Godrati (14) has been confirmed. Significant relationship between the number of seeds per boll and seed weight is not observed. Nebraska had the least grain number per boll (17/62) and the most 1000 grain weight (55/42). Zaragan local 4 has relatively low 1000 grain weight and also low grain number per boll compared with other varieties. The mean study reveals that there is not a clear relationship between the grain numbers per boll with the plant yield.

The 1000 grain weight changes rate was: 26/11 – 55/42g. The least 1000 grain weight belonged to Zaragan local2 and Zaragan local 4 and the most one belonged to Nebraska (table3). Baradaran (6) mentioned to the genetic diversity of safflower different varieties regarding 1000 grain weight. In this research, there were the varieties with more 1000 grain weight and high plant yield.

The safflower different varieties plant yield was 13/5 to 20/57 in this research. The most plant yield belonged to N51016 and the least one belonged to Zaragan local4. Davia [9], Haby, et al [15], Han, et al [17], Yazdi Samadi and Abde Mishani [33], Omidi Tabrizi [25], Godrati [14] and Baradaran [6] observed the genetic diversity of safflower studied varieties regarding the yield.

The changes range of oil content was: 25/06 to 35/37. TOMJIK had the most content and Kordestan local 2 had the least one (table3). The genetic diversity of safflower different varieties is the main reason of oil content variability. These results are compatible with the results of studies by Abel [1], Han, et al [17] and Bansal and Katara [5].

Table3. The mean of studied traits in 26 spring safflower

Number	Variety	Traits		
		The days from planting to 50% budding	The days from planting to stalk appearance	The days from planting to germination
1	Bonab local	64/83	33/00	9/333
2	Mianeh local 1	64/50	35/33	9/167
3	Marand local 1	62/67	30/33	9/333
4	Mianeh local 2	60/50	32/50	9/667
5	Marand local 2	61/67	31/50	9/167
6	Marand local 3	62/17	30/33	9/333
7	Langar Mahan	58/00	30/17	9/167
8	Zaragan local2	66/83	33/00	9/333
9	Zaragan local3	58/33	30/50	9/000
10	Zaragan local4	65/33	34/17	9/167
11	Kerman Zarand1	56/67	29/67	9/333
12	Kerman Zarand2	57/00	30/33	9/167
13	Kordestan local2	59/50	30/33	9/167
14	Isfahan local	59/33	30/50	9/500
15	Booroojerd local	59/17	30/33	9/000
16	Neishaboor local	65/33	35/50	9/000
17	N974051	58/33	30/33	9/333
18	V-51-242	59/00	30/50	9/167
19	N51016	57/00	29/33	9/833
20	NEBRASKA	57/17	29/67	10/17
21	A-1	58/83	29/50	10/00
22	TOMJIK	58/83	30/17	9/167
23	N.5	60/17	30/83	9/000
24	3151	57/50	30/50	10/00
25	D51-361	58/17	30/83	9/167
26	24-1	59/00	30/50	9/000
	LSD1%	1/194	1/383	0/6402



The table3 continued. The mean of studied traits in 26 spring safflower

Number	Varity	Traits		
		The bush height	the days to 100%flowering	The days to 50% flowering
1	Bonab local	77/33	85/33	81/17
2	Mianeh local 1	77/83	87/33	83/33
3	Marand local 1	78/33	82/33	78/00
4	Mianeh local 2	75/83	82/83	78/33
5	Marand local 2	77/00	82/67	78/00
6	Marand local 3	77/83	85/83	80/83
7	Langar Mahan	66/00	81/17	75/33
8	Zaragan local2	78/67	91/33	86/17
9	Zaragan local3	70/33	83/17	78/50
10	Zaragan local4	75/50	89/67	84/67
11	Kerman Zarand1	62/17	79/83	74/17
12	Kerman Zarand2	69/50	82/33	76/00
13	Kordestan local2	62/17	81/33	76/17
14	Isfahan local	75/50	84/33	79/33
15	Booroojerd local	70/00	80/83	76/17
16	Neishaboor local	82/50	90/67	84/50
17	N974051	65/00	81/33	75/50
18	V-51-242	67/67	81/17	76/00
19	N51016	56/67	77/33	72/33
20	NEBRASKA	52/33	76/50	71/83
21	A-1	64/67	80/50	75/17
22	TOMJIK	68/17	80/83	74/33
23	N.5	68/50	82/17	77/17
24	3151	74/67	84/33	79/83
25	D51-361	69/17	82/00	76/00
26	24-1	68/17	81/50	75/83
	LSD1%	8/097	1/883	1/902

The table3 continued. The mean of studied traits in 26 spring safflower

Number	Varity	Traits		
		1000 grain weight (g)	The grain number per boll	The boll number per bush
1	Bonab local	32/09	39/12	12/97
2	Mianeh local 1	27/30	37/35	12/97
3	Marand local 1	34/94	36/20	12/87
4	Mianeh local 2	33/90	30/68	16/93
5	Marand local 2	35/23	44/47	11/30
6	Marand local 3	34/75	33/13	16/73
7	Langar Mahan	36/20	34/52	14/00
8	Zaragan local2	26/11	29/57	19/57
9	Zaragan local3	38/51	32/03	14/50
10	Zaragan local4	26/33	26/88	18/30
11	Kerman Zarand1	38/43	30/10	14/57
12	Kerman Zarand2	37/79	29/10	15/43
13	Kordestan local2	33/54	28/33	16/80
14	Isfahan local	27/60	35/63	17/13
15	Booroojerd local	32/88	33/92	14/37
16	Neishaboor local	39/44	26/77	17/23
17	N974051	43/28	31/05	14/50
18	V-51-242	33/42	34/30	15/87
19	N51016	43/42	49/47	9/667
20	NEBRASKA	55/43	17/62	17/37
21	A-1	45/56	28/63	14/73
22	TOMJIK	34/78	32/23	17/30
23	N.5	37/31	29/17	13/60
24	3151	32/36	32/77	17/33
25	D51-361	29/74	33/78	14/33
26	24-1	35/06	33/98	14/50
	LSD1%	4/863	5/984	4/346

The table3 continued. The mean of studied traits in 26 spring safflower

Number	Varity	Traits	
		The plant performance (g)	Oil content
1	Bonab local	16/15	26/56
2	Mianeh local 1	13/41	27/00
3	Marand local 1	16/08	27/37
4	Mianeh local 2	17/55	28/90
5	Marand local 2	17/49	26/21
6	Marand local 3	18/91	27/48
7	Langar Mahan	17/54	30/28
8	Zaragan local2	15/01	30/38
9	Zaragan local3	17/58	28/29
10	Zaragan local4	13/25	29/73
11	Kerman Zarand1	16/52	29/07
12	Kerman Zarand2	16/91	29/07
13	Kordestan local2	16/11	25/06
14	Isfahan local	16/92	31/29
15	Booroojerd local	15/69	30/27
16	Neishaboor local	17/50	28/62
17	N974051	19/30	30/87
18	V-51-242	17/71	30/22
19	N51016	20/57	29/29
20	NEBRASKA	16/25	30/76
21	A-1	18/88	29/01
22	TOMJIK	19/27	35/37
23	N.5	14/71	27/29
24	3151	18/42	30/52
25	D51-361	14/43	29/57
26	24-1	17/16	30/05
	LSD1%	5/566	1/734

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