# SEED YIEID AND OIL CONTENT OF SAFFLOWER AS AFFECTED BY GENOTYPES AND SOWING DATES

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## ABSTRACT

**The experiment was conducted at two locations; Grdarasha and Sumail of Erbil and Duhok governorates respectively, in Kurdistan region, during spring season 2013 and winter season 2013-2014 to study the effect of sowing dates on seed yield and oil content of safflower genotypes. A split-plot arrangement in a randomized complete block design was used with three replicates; sowing dates were assigned to main plots and genotypes to sub-plots. The results revealed that the first sowing date of spring (April 11$^{th}$ ) and winter (Noveber 13 $^{th}$) seasons produced the highest seed yield 1277.6 and 1583.7 kg ha$^{-1}$ in spring season and 2676.5 and 1904.2 kg ha$^{-1}$ in winter season at Grdarasha and Sumail locations respectively. In winter season; Rabee 500 genotype at Grdarasha location and Aurduny genotype at Sumail location surpassed other genotypes in seed yield (2246.7 and 1636.2 kg ha$^{-1}$). In spring season; seeds of early date (April 11$^{th}$) and Aurduny genotype were characterized by recording the highest oil percentage (30.28 and 29.58%) at Grdarasha location and (31.81 and 31.77%) at Sumail location respectively. In contrast, in winter season the fourth sowing date and G2018 genotypes seeds were characterized by the highest oil percentage (28.62 and 29.13%) at Grdarasha location and (29.11 and 28.14%) at Sumail location.**

**Keywords: seed yield, oil yield, spring seeding, winter seeding.**



# حاصل البذور ومحتوى الزيت للعصفر بتأثير التراكيب الوراثية ومواعيد الزراعة

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## المستخلص

**اجريت التجربه في موقعين؛ كردەرەشه وسميل التابعين لمحافظتي اربيل ودهوك على التوالي /اقليم كردستان خلال الموسم الربيعي 2013 والموسم الشتوي 2013 –2014 لدراسه تاثير مواعيد الزراعة على حاصل البذور ومحتوى زيت التراكيب الوراثية لمحصول العصفر. استخدم ترتيب الالواح المنشقه في تصميم القطاعات الكامله المعشاه وبثلاثة مكررات، خصصت مواعيد الزراعة الى الالواح الرئيسية والتراكيب الوراثية الى الالواح الثانوية. أظهرت النتائج بان الموعد الاول للموسمي الربيعى والشتوى انتجت أعلى حاصل البذور (1277,6 و1583,7 كغم. هـ$^{-1}$) في الموسم الربيعي و(2676,5 و1904,2 كغم. هـ$^{-1}$) في الموسم الشتوي للموقعين كردەرەشه وسميل على التتابع. في الموسم الشتوي؛ تفوق التركيب الوراثي ربيع 500 للموقع كردەرەشه واردني للموقع سميل على بقية التراكيب الوراثية في حاصل البذور (22,46,7 و1636,2 كغم. هـ$^{-1}$). في الموسم الربيعي؛ حصلت أعلى نسبة للزيت (29.58%) للموقع كردوشه على نقيض ذلك، في الموسم الشتوي؛ إتسمت بذور الموعد الرابع والتركيب الوراثي G2018 بأعلى نسبة زيت (28,62 و29,13٪ ) للموقع كردەرەشه و(29,11 و28,14٪ ) للموقع سميل.**

**كلمات مفتاحية : حاصل البذور، حاصل الزيت، زراعة ربيعية وشتوية.**

## INTRODUCTION

Safflower (*Carthamus tinctorius* L., Asteraceae) is one of the most valuable oil crops, and the by product meal after oil extraction is used for animal feed, since it is rich in protein., Growth traits of safflower and seeds yield are affected by various factors such as genotype, environment and agronomic practices. Among the agronomic practices affecting yield is sowing date, which is associated with changing day length and temperature. The choice of the appropriate sowing date is one of the key points in crop management to obtain high yield quantity and quality. Several studies in safflower revealed that seed yield and oil content were affected by sowing dates (spring or winter) and cultivars. Moghanlou et al. (12) found that sowing on May 8$^{th}$ produced the highest seed yield (5144 kg ha$^{-1}$ ), while Badri et al. (2) showed that sowing on March 16$^{th}$ produced the highest seed yield (1558.7 kg ha$^{-1}$). The results of Emami et al. (6) and Mohamadzadeh et al. (14) reported that sowing dates on November 5$^{th}$ and December 6$^{th}$ at iran produced the highest seed yield (1877.7 and 1225.0 kg ha$^{-1}$) respectively. Sowing date can be a major factor that affects oil content at the time of seed development (15). Khoulenjani et al. (9) showed that May 19$^{th}$ recognized better because of oil content compared to April 18$^{th}$ sowing date. There is little informations about spring and winter sowing dates of the crop, especially under climatic conditions of Kurdistan region environment, The objective of was this study to evaluate the effects of sowing dates on yield and oil content of three safflower genotypes.

## MATERIALS AND METHODS

The experiment was carried out at two locations at Kurdistan region; Grdarasha, the Research Station of College of Agriculture-University of Salahaddin (Latitude 36° 07' N, and Longitude 44° 01' E, 411 masl), which is located 5 km south of Erbil governorate. Sumail, farm of Faculty of Agriculture - University of Duhok (Latitude 36° 84' N, and Longitude 40° 01' E, 411 583 masl), which is located 15 km west of Duhok governorate. This experiment was performed at two growing seasons; spring 2013 and winter of 2013-2014 to evaluate the effect of sowing dates on growth, yield and quality of safflower genotypes. The soil samples were taken at 0-30 cm depth and their chemical and physical properties were analyzed as shown in table 1.

**Table1. Some chemical and physical properties at two locations (Grdarasha[1] and Sumail[2])**

| Location | PSD | | | Soil texture | pH | EC (ds m$^{-1}$) | O.M (g kg$^{-1}$) | Total N (g kg$^{-1}$) | P (mg kg$^{-1}$) soil | Soluble Cations K$^{+}$ (m mole L$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Clay (%) | Silt (%) | Sand (%) | | | | | | | |
| Grdarasha | 45.0 | 42.5 | 12.5 | Silt clay | 7.42 | 0.2 | 10.9 | 0.18 | 3.75 | 0.10 |
| Sumail | 48.8 | 46.4 | 4.8 | Silt clay | 7.97 | 0.3 | 15.0 | 1.12 | 4.01 | o.14 |

**1-The soil properties tests were conducted at the Directorate of Agriculture Research Center, Ankawa /Erbil**
**2- The soil properties tests were conducted at the Laboratory of Soil and Water Science Department, Faculty of Agriculture-University of Duhok .**

**Table 2. Monthly mean values of temperature and rainfall for both experimental locations (Grdarasha[1] and Sumail[2]) in 2013- 2014**

| Months | C)°Average temperature ( | | | | Rainfall (mm) | |
|---|---|---|---|---|---|---|
| 2013 | Grdarasha | | Sumail | | Grdarasha | Sumail |
| | Min. | Max | Min | Max | | |
| April | 12.72 | 27.40 | 10.90 | 25.32 | 14.5 | 26.8 |
| May | 18.51 | 33.32 | 15.90 | 31.92 | 31.2 | 21.4 |
| June | 22.83 | 39.63 | 18.60 | 38.19 | 0.0 | 0.0 |
| July | 25.81 | 43.16 | 20.30 | 41.88 | 0.0 | 0.0 |
| August | 25.50 | 42.62 | 21.00 | 41.68 | 0.0 | 0.0 |
| September | 20.34 | 37.09 | 15.50 | 35.48 | 0.0 | 0.0 |
| October | 18.60 | 31.08 | 11.60 | 28.14 | 12.2 | 0.0 |
| November | 12.15 | 22.51 | 9.87 | 21.04 | 21.3 | 64.4 |
| December | 4.31 | 14.02 | 1.0 | 11.81 | 82.3 | 61.5 |
| 2014 | | | | | | |
| January | 1.9 | 18.0 | 2.55 | 13.94 | 47.8 | 171.8 |
| February | -0.9 | 25.0 | 2.95 | 16.45 | 6.9 | 7.6 |
| March | 5.5 | 27.2 | 7.87 | 19.95 | 85.1 | 151.4 |
| April | 3.7 | 36.0 | 10.78 | 26.48 | 11.7 | 18.7 |
| May | 14.3 | 39.3 | 16.16 | 33.34 | 0.5 | 6.4 |

**1-Agricultaral Meteorology of Erbil Governorate, prepared by Erbil General Directorate of Agriculture**
**2- Meteorological Station. Faculty of Agriculture -University of Duhok**

The experimental design was randomized complete block with split-plot arrangement of treatments with three replicates. In spring season, four sowing dates (April 11$^{th}$, April 25$^{th}$, May 9$^{th}$ and May 23$^{th}$) at Grdarasha/Erbil governorate and four sowing dates (April 11$^{th}$, April 25$^{th}$, May 11$^{th}$ and May 25$^{th}$) at Sumail/Duhok governorate, while at winter season, the sowing dates were (November 13$^{th}$, November 27$^{th}$, December 18$^{th}$ and December 31$^{th}$) at Grdarasha/Erbil and (November 23$^{th}$, December 2$^{nd}$, December 24$^{th}$ and January 8$^{th}$) at Sumail/Duhok, these dates were applied as main plots, while the three genotypes (Rabee 500, Aurduny and G2018) represented as sub-plots which are used in two seasons and two locations. The experimental unit was (3 m × 3.6 m) The genotypes seeds werw seeded in furrows, with 90cm between furrows and 25 cm with furrows, plant population 44444 plant ha$^{-1}$ . Nitrogen fertilizer was applied at a rate of 120 N kg ha$^{-1}$ in the form of urea (46% N) at three intervals; the first at sowing date, the second at flowered buds formation and the third at flowering stage. $P_2O_5$ was applied at sowing date by rate of 80 kg ha$^{-1}$ in form of triple superphosphate (46% $P_2O_5$). Data were recorded when 50% of plants had opened flowers to determine the number of days from sowing to flowering and the data of 80% of heads in a plot had brown color to determine the number of days from sowing to maturity. Plant height, number of primary branches per plant and number of heads per plant were calculated as an average of five harvested plants per plot. Seed yield was obtained by harvesting plants samples from the mid furrow. Oil was extracted from safflower seeds using Soxhlet apparatus by hexane extract and oil percentage was estimated according to Association of Official Analytical Chemists (1). Analysis of variance was done to obtain data of each season and location and combined analysis of split-plot arrangement in a randomized complete block design at two locations were compared by using Statistical Analysis System (16). Duncan's multiple range tests was used to determine the differences among means (4).

## RESULT AND DISCUSSION

**Number of days from flowering to maturity:** In spring season; planting dates, genotypes and their interaction combination had significant effect on number of days which the plant needed from onset of flowering to maturity stage excluding planting dates at Sumail location (Tables 3 and 4). Plants of second date at Grdarasha location took 38.44 days from flowering to maturity, while the fourth date; elapsed 19.33 days. This variation may be due to the differences in temperature which influencing on plants growth and development to reach maturity starting from flowering. It is noticed also that the G2018 genotype (which did not differ statistically from Aurduny genotype) at Grdarasha location and resemble Aurduny genotype and Rabee 500 genotype at Sumail location (Table 3). The longest periods were 41.00 and 22.00 day by G2018 and Rabee 500 genotypes when were planted on April 25$^{th}$ at Grdarasha location and May 25$^{th}$ at Sumail location for the same genotypes respectively (Table 4). In winter season; planting dates, genotypes and their interaction had significant effect on this trait (Tables 5 and 6). Plants of the first date (November 13$^{th}$ and November 23$^{th}$) at both locations elapsed 36.89 and 37.67 day from flowering to maturity respectively, followed by Rabee 500 genotype at Sumail location needed more duration between flowering and maturity (35.25 days), also the longest periods were scored by Rabee 500 genotype when planted on November 13$^{th}$ and 23$^{th}$ at both locations respectively. Tables 3 and 5 indicated that the highest number of days from onset of flowering to maturity took at Grdarasha location in spring season reaching 30.03 days, while at Sumail location took the shortest days (19.33). In contrast to winter season, the longest days at Sumail location was 34.53 days that was attributed to weather variation between seasons and between locations (Table 2).

**Plant height**

It is showed that plants of first sowing date in the two seasons at both locations attained the highest plant height, while the shortest was for plants planted in last sowing date (Tables 3 and 5), that is due to penetration and distribution of sunlight more efficiently at the plant base in last date, leading to auxins breakdown and resulted in increasing of stalk thickness and shortened plants internodes (14).

These results were in agreement with Mirzakhani et al. (11) who claimed that plant height reduced significantly at the late planting date. Likewise, plants of Aurduny genotype produced the highest length (which did not differ statistically from G2018 genotype) at Grdarasha location in winter season, compared to Rabee 500 genotype plants (Table 5). The results were coincided with those of Soleymani et al. (19) who reported that such variation between cultivars.

**Number of primary branches per plant** The results in Table 3 revealed that plants planted in April 11$^{th}$ at both locations produced the highest number of primary branches comparing with the un other dates at both locations. However, plants planted at first date produced highest primary branches than the rest of dates at both locations (Table 5). Such reduction in branches number was due to shortened of growing season which led to shortage of assigned duration to promote the sprouts of primary branches, consequently number of branches (10). The Rabee 500 genotype at Grdarasha location and G2018 genotype at Sumail location produced the highest number of primary branches (17.50 and 11.94) respectively, such variation attributed to genetically potential of cultivars. Number of primary branches at Grdarasha location surpassed Sumail location in two seasons (Tables 3 and 5).

**Number of heads per plant**

The number of heads / plant produced from (table3 and 4) early sowing at locations and both seasons; this increase was wrrelated with plants height and number of primary branches increasing which has adverse effect on number of heads per plant. Rabee 500 genotype's plants planted at both locations in winter season produced the highest number of heads (78.80 and 36.00) respectively. The highest number of heads per plant at Grdarasha location was 65.10, but the least number of heads was 27.4 at Sumail location (Table 5).

**Number of seeds per head**

Data of table 3 revealed that planting at April, 11$^{th}$ produced the highest number of seeds per head (28.87 and 28.72) for both locations, respectively in comparison to the fourth date. Aurduny genotype recorded the highest number seeds per head (37.56 and 27.36) at both locations respectively (Table 5).

**Seed weight**

The results in Tables 3 and 5 revealed in consisting in100-seed weight, as the highest values were recorded by early planting dates in spring and winter seasons at both locations. These results are in harmony with (6).

**Seed yield**

The results in the Tables 3 and 5 indicate that planting in the first date produced the highest seed yield (1277.6 and 1583.7 kg ha$^{-1}$) in spring season and (2676.5 and 1904.2 kg ha$^{-1}$) in winter season at both locations respectively, while lateness in planting dates caused reduction in yield by (57.4 and 56.9%) in first season and (54.8 and 41.9%) in second season at both locations respectively,. These results are in agreement with (8 and 18) they found that the highest seed yield of safflower was obtained in the early sowing date (2000 kg ha$^{-1}$), moreover, they observed that 9-18 day delaying in sowing date, decreased seed yield by 510-850 kg ha$^{-1}$, these result contradict to those of Mohamadzadeh et al. (13) who reported that the highest seed yield was obtained at December 6$^{th}$. The declination of yield in late sowing dates is due to reduction in one or more of its components such as heads number/plant, seeds number/head and 100-seed weight and also to the reduction in length of growth period through acceleration of maturation time (20) The reasons of yield increment is due to existence more number of primary branches and longer growing season of first date, this resulted in higher dry matter accumulation, better translocation of photosynthetic products to flower, more pollination rate and then heads formation. Also it is found from table 5 that Rabee 500 genotype at Grdarasha location and Aurduny genotype at Sumail location surpassed in seed yield (2246.7 and 1636.2 kg ha$^{-1}$) the rest genotypes. It is obvious clear from tables (3) and (5) that Grdarasha location superior to Sumail location, this may be due to the increment of stem length, number of primary branches, number of heads, seeds of head and 100-seed weight which resulted in greater seed yield at Grdarasha location, also due to climatically conditions, soil chemical and

physical properties differences between both locations (Tables 1 and 2).

**Oil content (%)**

The data in spring season revealed that seeds of early planting (April 11th) were characterized by recording the highest oil percentage (30.28 %) and (31.81%) at both locations respectively, (Table 3), in contrast, in winter season the fourth date seeds were characterized by highest oil content (28.62%) at Grdarasha location and (29.11%) at Sumail location (Table 5). This declination in oil percentage of fourth date in spring season and first date in winter season could be attributed temperature rising during seed-filling (Table 2) at both locations respectively, which accompanied with growing and formation of seed (7). The results of spring season contradict with the results of Khoulenjani et al. (9) who showed that May 19th sowing date was well recognized for oil content compared with April 18th sowing date. The results of winter season are in harmony with Bagheri (3), who showed that the seed oil increased by 2.3% per a 12 day delay in cultivation. Aurduny genotype in spring season and G2018 genotype in winter season produced the highest oil percentage (Tables 3 and 5), this is due to genetically potential, in addition to the variation in response of some genotypes at seed-filling stage (flowering-maturity) to temperature recorded at different planting dates (17). The highest oil percentage (31.18%) was recorded at Sumail location in spring season comparing to the second location, while the second season had non-significant between locations effect on oil percentage (Tables 3 and 5). The results is not in agreement with COSGE et al. (5), who recommended that the best sowing time was winter season in terms of oil content. From the results of this experiment we can concluded that in spring season the sowing date April 11th at both locations gave the highest seed yield and oil percentage, while in winter season, the highest seed yield obtain at sowing date November 13th and 23th and the highest oil percentage on December 31th and January 8th and the highest seed yield for Rabee 500 genotype and G2018 genotype at both locations respectively. Grdarasha location in two seasons was recognized by its high yield, while Sumail location by its high oil content in spring season.

**Table 3.The effect of planting date and genotypes on some traits of safflower for both locations in spring season 2013**

| Location | Planting date | Flowering to Maturity (days) | Plant height (cm) | No. of primary branches/plant | No. of heads/plant | No. of seeds/head | 100-seed weight | Seed yield (kg ha$^{-1}$) | Oil content (%) |
|---|---|---|---|---|---|---|---|---|---|
| Grdarasha | April 11 | 33.89b | 69.81a | 13.89a | 56.00a | 28.87a | 6.00a | 1277.6a | 30.28a |
| | April 25 | 38.44a | 61.00b | 12.40b | 52.72a | 27.33a | 6.13a | 849.3b | 29.63b |
| | May 9 | 28.44c | 53.06c | 12.44b | 51.28ab | 19.30b | 6.12a | 811.2b | 29.10c |
| | May 25 | 19.33d | 49.78c | 12.39b | 42.92b | 13.94b | 5.10b | 544.6c | 28.31d |
| Sumail | April 11 | 19.33 | 88.14a | 16.34a | 57.33a | 28.72a | 3.41a | 1583.7a | 31.81a |
| | April 25 | 19.22 | 76.54b | 12.37b | 52.16a | 26.30a | 3.66a | 116.3b | 30.00c |
| | May 11 | 19.33 | 54.50c | 5.28c | 43.92b | 16.48b | 3.53a | 683.8c | 31.00bc |
| | May 25 | 19.44 | 47.14d | 3.53c | 46.08a | 13.69b | 3.04b | 683.4c | 31.12b |
| **Location** | **Genotypes** | **Flowering to Maturity (days)** | **Plant height (cm)** | **No. of primary branches/plant** | **No. of heads/plant** | **No. of seeds/head** | **100-seed weight** | **Seed yield (kg ha$^{-1}$)** | **Oil content (%)** |
| Grdarasha | Rabee 500 | 28.92b | 59.92 | 12.93 | 51.86 | 22.98 | 6.23 | 956.5 | 28.99b |
| | Aurduny | 30.25a | 56.57 | 12.63 | 50.54 | 23.85 | 6.09 | 812.9 | 29.58a |
| | G2018 | 30.91a | 58.75 | 12.79 | 49.79 | 20.23 | 5.80 | 839.6 | 29.42a |
| Sumail | Rabee 500 | 20.67b | 68.12 | 10.15 | 50.56 | 22.38 | 3.46 | 922.2 | 31.15b |
| | Aurduny | 19.08b | 65.51 | 9.51 | 51.53 | 21.94 | 3.30 | 1053.3 | 31.77a |
| | G2018 | 18.28b | 66.13 | 10.73 | 47.53 | 19.58 | 3.33 | 1075.1 | 30.64c |
| Means of locations | Grdarasha | 30.03a | 58.41 | 12.78a | 50.73 | 22.35 | 6.04a | 1870.7a | 29.33b |
| | Sumail | 19.33b | 66.58 | 10.13b | 49.87 | 21.30 | 3.36b | 1016.8b | 31.18a |

**Values designed a different letters within columns indicates significantly differences according to Duncan's multiple rang test**

**Table 4. The effect of interaction between planting date and genotype on some safflower traits for both locations in spring season 2013**

| Location | Planting date | Genotypes | Flowering to Maturity (days) | Plant height (cm) | No. of primary branches/plant | No. of heads/plant | No. of seeds/head | 100-seed weight | Seed yield (kg ha$^{-1}$) | Oil content (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Grdarasha | April 11 | Rabee500 | 34.67b | 73.33a | 11.87 | 40.77b | 32.00ab | 5.53 | 773.5bc | 28.90cde |
| | | Aurduny | 33.67b | 70.00ab | 13.00 | 40.00ab | 23.23a-d | 5.83 | 807.3bc | 29.27c |
| | | G2018 | 33.33b | 66.00abc | 12.33 | 40.00b | 28.25abc | 5.73 | 967bc | 32.67a |
| | April 25 | Rabee500 | 34.67b | 60.00cde | 12.67 | 51.33ab | 33.26a | 6.50 | 1568.6a | 31.53b |
| | | Aurduny | 39.67a | 60.67cd | 11.67 | 45.50ab | 27.27a-d | 5.93 | 1127ab | 29.10cd |
| | | G2018 | 41.00a | 62.33bcd | 12.83 | 61.33ab | 24.47a-d | 5.93 | 1137.1a | 28.27ef |
| | May 9 | Rabee500 | 27.33d | 55.17de | 14.00 | 51.00ab | 19.03cde | 6.21 | 905.2bc | 27.93f |
| | | Aurduny | 27.67d | 50.83df | 13.50 | 54.50ab | 21.97bcd | 6.83 | 751.8bc | 31.63b |
| | | G2018 | 30.33c | 53.17def | 14.17 | 40.33ab | 16.90def | 5.90 | 766.5bc | 27.73f |
| | May25 | Rabee500 | 19.00e | 51.17ef | 13.17 | 64.33a | 7.60f | 6.60 | 590.5bc | 27.60fe |
| | | Aurduny | 20.00e | 44.67f | 12.33 | 54.16ab | 22.93a-d | 5.77 | 565.5c | 28.33def |
| | | G2018 | 19.00e | 53.50def | 11.83 | 49.50ab | 11.30ef | 5.63 | 477.7c | 29.10cde |
| Sumail | April 11 | Rabee500 | 18. 67cd | 90.43a | 17.57a | 50.10b | 31.33a | 3.67a | 1448.8abc | 31.63b |
| | | Aurduny | 20.67ab | 87.10a | 15.23ab | 51.23ab | 32.37a | 3.10bcd | 1590.9ab | 32.40b |
| | | G2018 | 18.67cd | 86.90a | 16.23ab | 55.13ab | 22.67abc | 2.87d | 1711.3a | 31.40c |
| | April 25 | Rabee500 | 20.67ab | 77.20b | 15.43ab | 53.57ab | 27.77ab | 3.53a | 1016.3cde | 31.33c |
| | | Aurduny | 19.00bcd | 77.43b | 14.33b | 65.57a | 28.33ab | 3.70a | 1236.9bcd | 31.37c |
| | | G2018 | 18.00cd | 75.00b | 16.33ab | 52.87ab | 22.90abc | 3.73a | 1095.8cde | 29.70d |
| | May 11 | Rabee500 | 21.33a | 46.67e | 4.8cd | 47.67b | 17.90bcd | 3.33a-d | 537.6f | 32.00bc |
| | | Aurduny | 19.33bc | 45.83e | 4.57cd | 44.00b | 18.71cd | 3.43abc | 679.5ef | 28.53e |
| | | G2018 | 17.33d | 48.93de | 6.47c | 40.10b | 15.83cd | 3.83a | 833.2def | 32.47b |
| | May25 | Rabee500 | 22.00a | 58.17c | 2.86d | 50.90ab | 12.70cd | 3.30a-d | 686.0ef | 29.63d |
| | | Aurduny | 17.33d | 51.67de | 3.90cd | 45.33b | 11.47d | 2.96cd | 705.6ef | 34.73a |
| | | G2018 | 19.00bcd | 53.67cd | 3.90cd | 42.00b | 16.90cd | 2.87d | 659.9ef | 29.00ed |

**Values designed a different letters within columns indicates significantly differences according to Duncan's multiple rang test**

**Table 5. The effect of planting date and genotypes on some traits of safflower for both locations in winter season 2013-2014**

| Location | Planting date | Flowering to Maturity (days) | Plant height (cm) | No. of primary branches/plant | No. of heads/plant | No. of seeds/head | 100-seed weight | Seed yield (kg $ha^{-1}$) | Oil content (%) |
|---|---|---|---|---|---|---|---|---|---|
| Grdarasha | November13 | 36.89a | 145.07a | 18.22a | 92.41a | 36.53 | 8.24a | 2676.5a | 25.12c |
| | November27 | 29.33b | 136.50b | 15.34ab | 64.89b | 34.81 | 8.22a | 2132.9b | 27.52b |
| | December18 | 26.89d | 119.91c | 14.57ab | 43.82c | 30.80 | 7.79a | 1209.1c | 27.97b |
| | December31 | 24.00c | 114.07c | 13.34b | 59.29bc | 32.31 | 6.97b | 1307.0c | 28.62a |
| Sumail | November23 | 37.67a | 121.63a | 13.52a | 33.55a | 23.93 | 4.63a | 1904.2a | 24.18c |
| | December2 | 33.33b | 110.81b | 10.59b | 28.33a | 23.78 | 4.62a | 1171.3b | 27.10b |
| | December24 | 33.67b | 101.59c | 10.63b | 27.78a | 23.52 | 4.57a | 1189.5b | 29.02a |
| | January8 | 33.44b | 95.29d | 9.33b | 18.88b | 20.19 | 4.02b | 1106.4b | 29.11a |
| **Location** | **Genotypes** | **Flowering to Maturity (days)** | **Plant height (cm)** | **No. of primary branches/plant** | **No. of heads/plant** | **No. of seeds/head** | **100-seed weight** | **Seed yield (kg $ha^{-1}$)** | **Oil content (%)** |
| Grdarasha | Rabee500 | 27.50 | 120.66b | 17.50a | 78.80a | 34.16ab | 7.47 | 2246.7a | 27.38b |
| | Aurduny | 28.08 | 131.88a | 14.83ab | 61.33b | 37.56a | 7.99 | 1612.0b | 25.33c |
| | G2018 | 27.75 | 134.28a | 14.13b | 55.18b | 29.13b | 7.96 | 1635.4b | 29.13a |
| Sumail | Rabee500 | 35.25a | 107.11 | 9.97b | 36.00a | 21.28b | 4.37 | 1283.9b | 26.38c |
| | Aurduny | 34.58ab | 107.06 | 11.14ab | 24.28b | 27.36a | 4.04 | 1636.2a | 27.58b |
| | G2018 | 33.75b | 107.83 | 11.94a | 21.88b | 19.92b | 4.60 | 1308.4b | 28.14a |
| Means of locations | Grdarasha | 27.78b | 128.94a | 15.37a | 65.10a | 33.61a | 7.81a | 1831.4a | 27.35 |
| | Sumail | 34.53a | 107.34b | 11.01b | 27.38b | 22.85b | 4.34b | 1342.8b | 27.30 |

**Values designed a different letters within columns indicates significantly differences according to Duncan's multiple rang test-**

**Table 6. The effect of interaction between planting date and genotype on some safflower traits for both locations in winter season 2013-2014**

| Location | Planting date | Genotypes | Flowering to Maturity (days) | Plant height (cm) | No. of primary branches/plant | No. of heads/plant | No. of seeds/head | 100-seed weight | Seed yield (kg ha$^{-1}$) | Oil content (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Grdarasha | November13 | Rabee500 | 41.67a | 135.23bcd | 20.90a | 127.33a | 35.37ab | 7.53abc | 3580.0a | 26.63c |
| | | Aurduny | 34.67b | 149.47ab | 16.77abc | 69.90bc | 43.13a | 8.67a | 1893.8cd | 25.60cd |
| | | G2018 | 34.33b | 150.40a | 17.00ab | 80.00b | 31.00ab | 8.53a | 2555.7bc | 31.67a |
| | November27 | Rabee500 | 29.33d | 126.80cde | 16.77abc | 75.10b | 34.73ab | 8.00abc | 2746.3b | 28.07b |
| | | Aurduny | 31.33c | 139.47abc | 16.23abc | 63.77bc | 39.43ab | 8.43ab | 1879.5cd | 25.50bc |
| | | G2018 | 27.33e | 143.23ab | 13.03bc | 55.80bcd | 30.27ab | 8.23abc | 1772.8de | 32.30a |
| | December18 | Rabee500 | 18.67g | 112.23ef | 15.70abc | 56.33bcd | 26.73b | 7.47abc | 1407.9de | 28.13b |
| | | Aurduny | 20.33g | 123.13de | 11.30c | 36.90d | 37.90ab | 7.97abc | 1127.4e | 26.37c |
| | | G2018 | 23.67f | 124.37de | 13.03bc | 38.33d | 27.77b | 7.93abc | 1092.1e | 28.07b |
| | December31 | Rabee500 | 20.33g | 108.87f | 15.23bc | 56.43bcd | 39.80ab | 6.87c | 1252.5ed | 26.67c |
| | | Aurduny | 26.00e | 115.33ef | 15.00bc | 74.77b | 29.77ab | 6.90bc | 1547.5ed | 23.87e |
| | | G2018 | 25.67e | 119.10ef | 13.46bc | 46.67cd | 27.37b | 7.13abc | 1121.0e | 24.83de |
| Sumail | November23 | Rabee500 | 38.67a | 123.22a | 12.45abc | 29.11ab | 18.11d | 4.62ab | 1833.4abc | 23.4og |
| | | Aurduny | 37.67a | 124.77a | 12.33abc | 27.11ab | 32.00a | 4.17bcd | 1976.0a | 24.63f |
| | | G2018 | 36.67a | 116.90ab | 15.78a | 27.11ab | 21.67bc | 5.10a | 1903.1ab | 24.50f |
| | December2 | Rabee500 | 33.33bc | 108.49bc | 7.89d | 51.56a | 24.00bcd | 4.68ab | 1117.6bcd | 27.50d |
| | | Aurduny | 33.33bc | 105.33bc | 11.11bcd | 24.33ab | 27.11abc | 4.50ab | 1379.5a-d | 26.57e |
| | | G2018 | 33.33bc | 118.67a | 12.78ab | 24.78ab | 20.22cd | 4.69ab | 1016.9d | 27.23de |
| | December24 | Rabee500 | 34.33bc | 100.67cd | 10.67bcd | 42.00ab | 22.00cd | 4.12bcd | 1409.8a-d | 30.73b |
| | | Aurduny | 34.00bc | 107.67bc | 13.22ab | 29.22ab | 30.00ab | 3.69d | 929.0d | 26.73e |
| | | G2018 | 32.67bc | 96.45de | 8.00d | 13.78b | 18.55d | 4.41bc | 1229.7a-d | 29.60c |
| | January8 | Rabee500 | 34.67b | 96.11de | 8.89cd | 21.33ab | 21.00gd | 4.05bcd | 774.8d | 24.13f |
| | | Aurduny | 33.33bc | 90.44e | 7.89d | 16.44ab | 20.34cd | 3.30cd | 1460.4a-d | 31.97a |
| | | G2018 | 32.33c | 99.32cde | 11.21bcd | 21.87ab | 19.22d | 4.20bcd | 1083.9cd | 31.23b |

**Values designed a different letters within columns indicates significantly differences according to Duncan's multiple range test**

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