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Yield and Yield Components of Safflower (*Carthamus tinctorius* L.) As Affected by Varieties and Different Sowing Dates

Shaee Adeeb Ghareeb[1]

Shaee.gharib@univsul.edu.iq

[1]Department Biotechnology and Crop Science College of Agricultural Engineering Sciences, University of Sulaimani, Sulaimanyah, Iraq.

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Abstract

This present scientific research was conducted in the Qlyasan, which is located in the governorate of Sulaimani in the northeast of Iraq.The experimentation was conducted over two distinct growing seasons.; Winter of 2022-2023 and Spring of 2023, this study aimed to assess the outcome of planting dates on growth, yield, and oil content of different varieties of safflower. The experimental setup followed a (CRBD) design, with three replicates employed during the winter season, for robustness and reliability. the sowing dates were (December 1st, December 15th, and December 31st). while in the spring season, three sowing dates (April 1st, April 15th, and May 1st). Three varieties namely (Gilla, Iden, and Al-Shamia) were planted. The characteristics studied in this research included the height of the plants, No.of primary branches/plant, No.of heads /plant, No.of seeds/head, 1000-seed weight, seed yield (kg ha^{-1}), and content of oil (%). The results indicated that variation in sowing dates had a significant impact on all traits of safflower varieties. The highest seed yield was observed from (December 1st and April 1st) sowing dates (1831.77,1562.22 kg ha^{-1}) during seasons individually, and the lowest seed yield was recorded for the latest sowing dates (December 31st and May 1st). The highest oil content was reached (30.15 and 27.18%) obtained by sowing on December 31st, and April 1st respectively. The Gilla variety surpassed and outperformed in seed yield (2610.50 and 2302.33 kg ha-^{1}) in both seasons respectively, and the AL-Shamia variety produced the highest oil percentage in both seasons at (30.15,23.39%).

Key words: Safflower, Sowing Date, Variety, Seed Yield, Oil.

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Correspondence Author: Shaee Adeeb Ghareeb. Shaee.gharib@univsul.edu.iq

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Introduction

Safflower (Carthamus tinctorius L., Asteraceae) is an annual oil crop well known for its drought tolerance and climate conditions (Li and Mundel, 1996). It seeds rich in valuable oil crops. It contains 25-45% oil, and the seeds have high-quality vegetable oil that contains linoleic (ω-6) and oleic (ω-9) fatty acids, (Culpan and Arslan, 2022). Several key factors influence both seed quality and growth characteristics in safflower. These factors include cultivar selection, environmental conditions, and the agronomic practices employed during cultivation. Koutroubas, S. D. et al. (2009). Among the various agronomic factors influencing the growth and yield of crops, the timing of sowing significantly shapes outcomes. Identifying the optimal sowing date emerges as a paramount factor crucial for maximizing safflower productivity. Koutroubas, S.D et al. (2009), Yau, S.K., 2007, Mir, B., et al. (2011). The time of sowing of sufflower seeds is considered as an important factor in deciding about the management of production, specifically in countries that have challenging environmental constraints such as significant varying in temperature in the region. (Emami et al., 2011). The selection of cultivars is a pivotal aspect of managing cropping systems, gaining even greater significance, especially about sowing dates for optimal crop production. (Soleymani et al.,2011). The characteristics of safflower, both in the field and in terms of quality, are significantly influenced by the surrounding environment and the methods of cultivation. Studies have shown that when it comes to safflower, the best time to plant and the choice of cultivars can change based on the specific ecological conditions in play. (Daltalab et al.,2013). Identifying optimal growth conditions and cultivation practices is essential to developing safflower varieties that excel in both yield and quality. Therefore, this study was primarily designed to evaluate the influence of planting dates on growth, yield, and quality parameters in various safflower cultivars.

Materials and methods

This present scientific research was conducted in the Qlyasan, which was located in the governorate of Sulaimani in the northeast of Iraq, on the border with Iran. Qlyasan is the Research Station of the Department of Biotechnology and Crop Science, College of Agricultural Engineering Sciences, University of Sulaimani, located at (Latitude: 35° 34′ 17″ N, Longitude: 45° 22′ 00″ E, and altitude of 757 masL), 2 km northwest of Sulaimani city. “Garmin, GPS map 60 Cx.”.

This experiment was performed at two growing seasons; the Winter of 2022-2023 and the Spring of 2023 This study employed a randomized complete block design with three replicates to investigate the influence of sowing dates on growth parameters, yield, and oil content in various safflower cultivars. In the winter season, the sowing dates will be (December 1st, December 15th, and December 31st) while in the spring season, three sowing dates (April 1st, April 15th, and May 1st), while the three varieties (Gilla, Iden, and Al-shamia) will be used in two seasons. The experimental units were (1 m × 1.20 m). the soil was ploughed using mould board plough as a primary tillage and cultivated as a secondary tillage. Drip irrigation was used as an irrigation method. 2-3 seeds will be planted in each bed, and it will be thinned to one plant two weeks after germination. Five plants from each plot were randomly chosen to measure things like their growth, yield, and quality characteristics. These characters were plant height in centimeters, number of primary branches/plants, number of heads/plants, number of seeds/heads, 1000 seed weight in grams, seed yield (kg ha-1), and content of oil in percentage. Manual harvesting occurred in both seasons when the plants reached full maturity. A Digital Soxhlet instrument was used for measured oil content %, with n-hexane solvent (BDH, UK), [9].

Table 1: Physicochemical properties of the soil samples from the study site.

Physicochemical Properties			
Physical properties	Sand	87	(g kg^{-1})
	Silt	435	
	Clay	458	
	Texture	Silty Clay	
	pH	7.59	
	ECe	490	(µS cm^{-1})
Chemical properties	O.M.	22.4	(g kg^{-1})
	$CaCO_3$	304.3	

Table 2: Monthly mean values of temperature and rainfall for Qlyasan[1] location in (2022-2023)

Month	Average Temperature (CO)		Rainfall (mm)	
2022	Max	Min	Max	Min
December	18.5	1	143.8	117.4
2023	Max	Min	Max	Min
January	14.5	-0.4	1147.8	17.2
February	21.7	-2	323.6	290.6
March	24.4	2.4	565.8	324.2
April	27.1	4.6	6702	565.8
May	33.6	11.6	718.8	679.2
June	41	18.9	0.4	0
July	44.2	25	0	0
August	45.3	23.9	0.2	0

1-Unit of Meteorology of College of Agricultural Engineering Sciences, University of Sulaimani.

Results and Discussion

Plant height

Upon scrutinizing sowing dates, it is evident that plants from the first sowing date in both planting seasons attained the greatest plant height, registering values of (142.53 and 68.83cm), respectively. In contrast, the shortest plant height was observed in plants sown on the last planting dates in both seasons, as detailed in Table (3). [10, 11,12] concurred that plant height experiences significant reductions with the postponement of the sowing date. The results of this experiment underscore the influence of planting date shifts on various plant characteristics. The timing of planting can affect plant growth and height, influenced by variations in environmental conditions such as ambient temperature, photoperiod length, and soil moisture content during the growing season.

[13] affirmed that delayed planting significantly reduces plant height, attributing this effect to increased temperature and photoperiod length, which shorten the vegetative period and consequently stunt growth and plant height. Noteworthy is the observation that Gilla variety in the winter season and AL-Shamia variety in the spring season exhibited the highest plant height, as presented in Table (4). Numerous studies, including those by [14,15] have reported significant variations in safflower plant height based on environmental conditions, variety, planting density, and seed rates.

Number of branches per plant

The examination of the number of branches per plant, as presented in Table (3), indicates that plants sown on December 1st in the winter season and those planted on April 1st in the spring season exhibited the highest count of branches. This reduction in the number of branches during delayed planting can be attributed to the shortened growing season, leading to insufficient time for the development of primary branch sprouts, consequently influencing the overall branch count [16]. Therefore, it can be deduced that delayed planting causes a decrease in the number of branches, aligning with the findings [17, 18].

Notably, the Gilla variety demonstrated the highest number of primary branches in both seasons, with values of (24.30 and 20.83) branches respectively. This variation can be attributed to the genetic potential inherent in different cultivars. The interaction analysis between planting dates and varieties, as presented in Tables (5 and 6), further confirms that Gilla varieties sown on December 1st surpassed other planting dates and varieties in both seasons.

Head number per plant

The quantity of capitula per plant holds significance as a pivotal yield-contributing factor in evaluating safflower crop seed yield. Emphasizing its importance, [19] highlighted that head number serves as a direct selection criterion influencing seed yield. The present study corroborates this, revealing that the highest number of capitula per plant was achieved on the first planting date in both seasons, with values of (35.49 and 21.77) as presented in Tables (3), respectively.

Regarding sowing dates, there was a notable and statistically significant decrease in head number as sowing was delayed. This reduction can be attributed to the abbreviated vegetation period associated with late sowing. In the context of variety × sowing date interactions, the Gilla variety consistently exhibited the highest head number, particularly when sown on the 1st date, in both seasons (40.40,25.86), Table (5 and 6). [20,21] reported that head number was significantly affected by delayed planting dates. [12,17] these results confirm our study results.

Number of seeds per head

Varieties and sowing dates had significant effects on number of seeds per head Tables (3 and 4), and variety × sowing date interactions had significant effects on the same trials Tables (5 and 6). According to the results of the research, the maximum value was (23.25,19.87seeds) acquired by first sowing dates at both seasons respectively, while the minimum values were (23.25,19.87seeds) acquired by sowing on last dates of both seasons. The maximum seed per head (44.78,41.17seeds) was recorded by variety Gilla at both seasons, and minimum seed per head was recorded by variety Iden (38.27,34.36seeds) at both seasons. As the sowing date was delayed the number of seeds per head decreased. [12] found that delaying the sowing date resulted in a reduction in head diameter and subsequently a decrease in the number of seeds per head. [22] recommended that early sowing in favorable environmental conditions notably enhances the seed count per head. [23] stressed that late sowing may lead to a decline in the number of seeds per head in safflower.

1000 seed weight

As shown in Table (3), that there were significant differences among planting date in relation to the 1000-seed weight (g) at both seasons. The highest value was gained by early sowing dates (41.89 and 37.22g) at both seasons respectively. Gilla variety recorded the highest 1000 seed weight (59.23 and 51.40g) at both seasons respectively Table (4). Hundred-seed weight were decreased as sowing date were delayed at both seasons, because late planting gave a very short time for both vegetative and generative duration, the 1000- seed weight, of all varieties were lower after late planting dates, this result in agreements with [24,25].

Seed yield

The paramount economic parameter for assessing treatment superiority over others is seed yield. As delineated in Table (3), the outcomes reveal that early planting dates yielded the highest seed quantities, with (1831.78kg ha^{-1}) in the winter season (1583.7 kg ha^{-1}) during the spring season. Conversely, delays in planting dates led to a reduction in yield. These findings align with the works of [17,26,27], all of whom reported that the early sowing date resulted in the highest safflower seed yield. Moreover, a delay in sowing date correlated with diminished seed yield. The decline in yield during late sowing dates can be attributed to reductions in one or more components, such as heads number per plant, seeds number per head, 1000-seed weight, and a reduction in the length of the growth period due to accelerated maturation time [18].

The increase in yield can be attributed to the presence of a greater number of primary branches and an extended growing season associated with the first planting date. This resulted in higher dry matter accumulation, enhanced translocation of photosynthetic products to flowers, a higher pollination rate, and subsequent head formation. Additionally, according to Table (4), the Gilla variety demonstrated superior seed yield, reaching (2610.50 and 2302.33 kg ha^{-1}) in both the spring and winter seasons, respectively.

Table (7) in general all characteristic in winter season recorded maximum value compared to spring season.

Oil content (%)

The oil content stands as a pivotal factor significantly influencing the quality of safflower seeds within the agricultural context. As shown in Table (3), there were significant differences among sowing dates in the content of oil obtained at both seasons. The highest content of oil was (30.15 and 27.18%) obtained by sowing on December 31th at winter season and April 1st at spring season respectively. this result in conformity with [25,28].

The data in winter season the late planting (December 31th) were characterized by highest oil content compared to the other sowing dates at the same seasons Table (3), in contrast, in spring season revealed that seeds of early planting April 1st were characterized by recording the highest oil percentage compared to the other sowing dates at the same seasons. The outcomes observed during the winter season align with [13] who demonstrated a 2.3% increase in seed oil for every 12-day delay in cultivation. Conversely, findings from the spring season diverge from those reported by [29], indicating that May 19th as a sowing date exhibited superior recognition for oil content in comparison to the April 18th sowing date. From the results of this experiment we can concluded that in winter season the last sowing date gave the highest oil percentage compared to the other planting dates at both seasons.

The temperature at this planting date December 31th lower than the other temperature planting dates Table (2). Oil content was reduced due to increasing temperature. [30] indicated that increasing the temperature by I 'C lead to decrease oil content by I .7 %. The result is agreement with [31] who recommended that the best sowing time was winter season in terms of oil content. But the result not in agreement with [17]. [32] reported that oil % was not affected by planting date. AL-Shamia variety in both seasons produced the highest oil percentage (30.15,23.39%) respectively, Table (4), The observed distinctions can be attributed to the inherent genetic potential of the safflower varieties, coupled with variations in the responsiveness of certain cultivars during the seed-filling stage (from flowering to maturity) to temperature fluctuations recorded across different planting dates, as documented by [33]. Corroborating these findings, [34] also reported in previous studies that the oil content is notably influenced by the specific variety under consideration. The recorded oil content values in this investigation closely align with those previously documented [35,36,37,38,39] nevertheless, it is noteworthy that the oil content values obtained for the safflower varieties in this study were notably lower than the 61.50% reported by [40]. As indicated by [41], the oil percentage varies from medium to

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high (20-45%) depending on the specific variety and prevailing environmental condition .

Table 3: The effect of planting date on some traits of safflower plant in both seasons:

Planting dates	Plant height (cm)	No. of branch /plant	No. of head/plant	No. of seed/head	1000 seed weight(g)	Seed yield (kg-ha)	Oil content%
Winter season							
1-Dec	142.53	16.87	35.49	32.76	41.89	1831.78	28.40
15-Dec	133.32	14.14	28.98	28.95	37.44	1608.78	28.99
31-Dec	120.32	12.24	23.17	23.26	32.75	1193.33	30.16
LSD (p≤0.05)	1.93	0.67	1.26	1.47	1.13	95.93	0.25
Spring season							
1-April	68.83	13.80	21.77	29.62	37.23	1562.22	27.18
15-April	65.34	13.26	19.57	23.99	33.55	1288.22	26.43
1-May	57.68	9.99	16.79	19.88	28.08	902.56	23.40
LSD (p≤0.05)	1.43	0.68	1.05	1.95	1.00	74.61	0.72

Table 4: The effect of Varieties on some traits of safflower plant in both seasons:

Varieties	Plant height (cm)	No. of branch /plant	No. of head/plant	No. of seed/head	1000 Seed weight(g)	Seed yield (kg-ha)	Oil content%
Winter season							
Gilla	211.47	24.30	50.13	44.79	59.24	2610.50	43.11
Iden	184.30	19.23	39.15	38.28	53.85	2074.67	40.22
Al-Shamia	198.50	21.35	42.17	44.39	55.04	2265.67	48.00
LSD (p≤0.05)	1.93	0.67	1.26	1.47	1.13	95.93	0.25
Spring season							
Gilla	88.53	20.84	35.63	41.17	51.41	2302.33	37.19
Iden	96.65	16.33	23.76	34.36	46.85	1527.83	36.03
Al-Shamia	102.60	18.41	27.82	34.70	50.04	1799.33	42.29
LSD (p≤0.05)	1.43	0.68	1.05	1.95	1.00	74.61	0.72

Table 7: Effect of Seasons on the studied characters:

Seasons	Plant height (cm)	No. of branch /plant	No. of head/plant	No. of seed/head	1000 seed weight(g)	Seed yield (kg-ha)	Oil content%
Winter Season	132.06	14.42	29.21	28.32	37.36	1544.63	29.18
Spring Season	63.95	12.35	19.38	24.50	32.95	1251.00	25.67
LSD (p≤0.05)	189.10	5.74	27.29	10.62	12.24	815.25	9.76

Table 5: The effect of interaction between planting date and varieties on some safflower traits in winter season

Winter Season		Plant height (cm)	No. of branch /plant	No. of head/plant	No. of seed/head	1000 seed weight(g)	Seed yield (kg-ha)	Oil content%
1-Dec	Gilla	151.27	18.60	40.40	36.24	43.15	2097.67	27.73
	Iden	134.23	15.52	31.44	28.98	40.60	1615.00	25.94
	AlShamia	142.10	16.49	34.62	33.08	41.94	1782.67	31.53
15-Dec	Gilla	143.93	15.37	31.47	30.24	39.26	1872.33	28.51
	Iden	122.53	12.29	27.10	25.92	35.66	1438.67	26.68
	AlShamia	133.50	14.77	28.36	30.68	37.40	1515.33	31.79
31-Dec	Gilla	127.73	14.63	28.39	23.10	36.07	1251.00	29.98
	Iden	111.83	10.64	19.76	21.66	31.43	1095.67	27.82
	AlShamia	121.40	11.45	21.36	25.01	30.74	1233.33	32.68
LSD (p≤0.05)		n.s	1.17	2.18	2.55	1.96	166.16	0.43

Table 6: The effect of interaction between planting date and varieties on some safflower traits in spring season.

Spring Season		Plant height (cm)	No. of branch /plant	No. of head/plant	No. of seed/head	1000 seed weight(g)	Seed yield (kg-ha)	Oil content%
1-April	Gilla	63.87	14.73	25.86	35.06	39.15	1774.67	26.14
	Iden	68.23	12.48	17.36	25.58	34.60	1362.33	25.09
	AlShamia	74.40	14.20	22.10	28.23	37.94	1549.67	30.32
15-April	Gilla	60.73	15.68	23.18	26.18	35.60	1646.67	25.26
	Iden	65.87	11.14	17.10	23.69	31.66	976.00	24.87
	AlShamia	69.43	12.95	18.44	22.10	33.40	1242.00	29.15
1-May	Gilla	52.47	11.27	22.22	21.11	28.07	1183.33	22.99
	Iden	59.20	9.03	13.06	19.45	27.43	717.33	22.10
	AlShamia	61.37	9.67	15.10	19.07	28.74	807.00	25.11
LSD (p≤0.05)		n.s	1.18	1.82	3.37	1.74	129.23	n.s

Conclusion

The outcomes of this two-season field study underscore the feasibility of cultivating safflower in both winter and spring seasons in Sulaimani, located in the northeast of Iraq. It is evident that planting dates play a crucial role in optimizing safflower productivity. The choice of cultivar significantly influences key growth parameters, yield, and yield components of safflower. Moreover, environmental and climatic conditions exert a discernible impact on yield components and oil content, contingent upon the specific varieties employed.

In summary, early sowing in favorable ecological conditions emerges as a prudent strategy for safflower cultivation. The findings indicate that early planting in both seasons contributes to an increase in seed yield. The highest oil content is observed when sowing is conducted on December 31st in the winter season and April 1st in the spring season. Considering the pivotal role of sowing date in determining both seed and oil content of safflower, it is recommended to initiate sowing as early as feasible, guided by soil temperature considerations, in both seasons.

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تأثير الاصناف و المواعيد زراعية مختلفة علي نمو وحاصل والنوعية لمحصول العصفر(*Carthamstinctoriuu L.*)

شايي أديب غريب[1]
Shaee.gharib@univsul.edu.iq

[1]قسم التكنولوجيا الحياتية وعلم المحاصيل ،كلية علوم الهندسة الزراعية، جامعة السليمانية، السليمانية، العراق.

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الخلاصة

نفذت تجربة حقلية في موسمين في محافظة السليمانية/اقليم كردستان؛ محطة قلياسان البحثية التابعة لكلية علوم هندسة الزراعية – جامعة السليمانية.تم إجراء التجربة على مدى موسمين نمو متميزين. شتاء ٢٠٢٢–٢٠٢٣ وربيع ٢٠٢٣، هدفت هذه التجربة لدراسة تاثير مواعيد الزراعة على حاصل البذور ومحتوى زيت لأصناف مختلفة من العصفر. تم اتباع تصميم التجربة (CRBD) وتم استخدام ثلاث مكررات. خلال فصل الشتاء والمواعيد الزراعة هي (١ كانون الاول، ١٥ كانون الاول، ٣١ كانون الاول). بينما في فصل الربيع ثلاثة مواعيد للزراعة (١ نيسان، ١٥ نيسان، و ١ ايار). تمت زراعة ثلاثة أصناف هي (جيلا، ايدن، الشامية). وشملت الخصائص التي تمت دراستها في هذا البحث ارتفاع النباتات، عدد الفروع الأولية / نبات، عدد الرؤوس / نبات، عدد البذور / رأس، وزن ١٠٠٠ بذرة، محصول البذور (كغم .هكتار$^{-1}$)، و محتوى الزيت (٪). أشارت النتائج إلى أن التباين في مواعيد الزراعة له تأثير معنوي في جميع صفات أصناف العصفر. وقد لوحظ أعلى إنتاجية للبذور في مواعيد الزراعة (١ كانون الاول و ١ نيسان) (١٨٣١,٧٧–١٥٦٢,٢٢ كجم .هكتار$^{-1}$) خلال المواسم على حدة، وسجل أقل إنتاجية للبذور في مواعيد الزراعة الأخيرة (٣١ كانون الاول و ١ نيسان). تم الحصول على أعلى محتوى زيتي (٣٠,١٥ و٢٧,١٨ ٪) تم الحصول عليه بالزراعة في ٣١ كانون الاول ١ نيسان على التوالي. وقد تفوق الصنف جيلا في إنتاجية البذور (٢٦١٠,٥٠ –٢٣٠٢,٣٣ كغم .هكتار$^{-1}$) في كلا الموسمين على التوالي، وأنتج الصنف الشامية أعلى نسبة زيت في كلا الموسمين بنسبة(٪ ٣٠,١٥–٢٣,٣٩).

الكلمات المفتاحية :العصفر، موعيدالزراعة، الاصناف، حاصل البذور، نسبة زيت.