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Influence of planting dates and foliar feeding with nano-boron on safflower production and fatty acid quality

Waleed Khalid Shahatha Al-Juheishy

*Corresponding author. Department of Field Crops, College of Agriculture & Forestry, University of Mosul, Mosul, Iraq. E-mail: w.khalid83@uomosul.edu.iq

Abstract

Objective

Improving both yield and oil quality is important for increasing the economic value of safflower under local environmental conditions. Therefore, the aim of the current study was to evaluate the effect of different planting dates and foliar application of nano-boron on seed yield, oil content, and fatty acid composition of safflower (*Carthamus tinctorius* L.).

Materials and methods

A field experiment was conducted during the winter growing season of 2024–2025 at two locations, Raseediyah and Wana. The treatments included three planting dates (20 November, 5 December, and 20 December) and three concentrations of nano-boron foliar spray (0, 2.5, and 5 g L^{-1}). The experiment was performed in a randomized complete block design (RCBD) with three replications at each site. Data were collected for thousand seed weight, seed yield, seed oil percentage, oil yield, and the fatty acid composition of the oil. They were oleic, linoleic, palmitic, and stearic acids. Standard agronomic practices were applied throughout the growing season. Then statistical analysis was carried out to evaluate the main effects and interactions between treatments.

Results

The results showed that planting date had a significant effect on safflower productivity and oil quality. Early planting on 20 November produced the highest values for thousand seed weight, seed yield, seed oil percentage, oil yield, and the proportion of oleic and linoleic acids at both locations. In contrast, later planting dates (5 and 20 December) resulted in higher contents of palmitic and stearic acids in the oil at Raseediyah and Wana. Foliar application of nano-boron significantly improved all measured traits compared with the control treatment. The highest nano-boron concentration (5 g L^{-1}) gave the greatest values for yield components, oil content, oil yield, and all studied fatty acids. A significant interaction was observed between the early planting date (20 November) and the application of 5 g L^{-1} nano-boron, which produced the highest seed yield at both experimental sites.

Conclusions

The study concluded that early planting combined with foliar feeding of nano-boron is an effective practice for improving safflower yield and fatty acid quality. Planting on 20 November with a nano-boron concentration of 5 g L^{-1} is recommended under similar environmental conditions.

Keywords: fatty acids, nano-boron, oil quality, planting dates, yield

Paper Type: Research Paper.

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Introduction

Safflower is considered an important oil crop, both medicinally and economically, due to its edible oil content, which ranges from 20-40% in the seeds. It is considered one of the healthiest vegetable oils, based on its antioxidant content, unsaturated fats (oleic and linoleic), and high protein content. The seeds and flower petals also comprise substances with wide medical uses. In addition, the dyes extracted from the petals, carthamin and carthamidin, are used to dye clothing and foods (Laftah and Alabdulla, 2022). It has also recently received important attention as an animal feed (Landau *et al.,* 2004). Food and Agriculture Organization of United Nations (FAO) notes that safflower is still grown in relatively small regions when compared to other oilseed crops (Al-Juheishy, 2024). The leading producers of safflower are India, the United States, Mexico, and China (Rowland, 1993). India stands as the top safflower producer globally, responsible for 46% of the total output (421,000 tons), primarily utilizing it for oil extraction (Esendal, 2001). Mexico is the second largest producer, producing it primarily for oil production for domestic consumption and export (Bassil and Kaffka, 2002). Safflower is grown in temperate regions within arid and semi-arid environments around world (McPherson *et al.,* 2004). The Middle East is considered the original home of this crop, with evidence indicating that Iran is one of its centers of origin (Zareie *et al.,* 2013; Khalili *et al.,* 2014). One of oilseed crops that can withstand drought best is safflower, which may generate large amounts of seeds even in semi-arid conditions. Its good salinity tolerance is an important attribute, especially with the continued expansion of salt-affected agricultural areas worldwide (Weiss, 2000). Safflower's significance has made a thorough investigation into its growth and production needs imperative. It has been observed that the planting date plays a significant role in raising crop quality and output. Since environmental factors during crop's growth and development phase greatly influence the height of plant, seed yield and its components, length of growing season, oil yield, and fatty acid composition, decision regarding when to sow is made by ensuring a variety of favorable conditions that impact plant productivity (Adugna and Labuschagne, 2003). Nanotechnology has been used in recent years in many fields such as agriculture, chemistry, medicine, etc., as it is environmentally friendly and reduces environmental pollution due to its use in small doses. Nanofertilizers are effective and efficient alternatives to traditional fertilizers. Numerous investigations have found that tiny size of nanomaterials makes it easier for the surface mass ratio of particles to increase. This causes a significant amount of nutritional ions to be absorbed and released gradually over time. Therefore, fertilizer nano-formulations guarantee crops appropriate nutrition throughout growth phase, which ultimately results in increased agricultural output (Monreal *et al.,* 2016). The creation of nucleic acids (DNA and RNA), lignin, cellulose, proteins, ion absorption, enzyme activity, and glucose transport all depend on nano-boron, a vital micronutrient. It enhances pollen tube growth as well. B concentration in plant tissues is positively correlated with both percentage of unfertilized flowers and total number of blooms (Wimmer and Eichert, 2013). The results of Samancı and Kaynak (2003) in their study, which used different planting dates during the spring season (25/4, 5/5, 15/5/1998), revealed that the early planting date (25/4) was importantly superior in seed yield and seed oil percentage, while there were no significant variations between sowing dates for oleic and linoleic acids. Mirshekari *et al.,* (2013) noticed significant variations between sowing dates in their study of three planting dates during the spring season (19/4, 5/5, 20/5/2009) in seed oil percent, oil yield, palmitic and stearic acids. Weight of a thousand seeds, seed yield, percentage of oil in seeds, and oil yield all significantly improved with early date (1/12), according to the results of Ghareeb (2024) experiment, which employed 3 sowing dates (1/12, 15/12, and 31/12/2022). Bahadori et al. (2025) demonstrated in his study of 3 sowing dates (6/12, 26/12, 15/1/2019) that the first date (December 6) important ly outperformed the first date in terms of thousand seed weight, seed yield, seed oil percent, and oil yield. In his investigation of several nano-boron treatments, Goudar (2017) revealed that spraying sunflowers with a 0.2% nano-boron concentration important ly increased the number of seeds, seed yield, seed oil percent, and oil yield. According to their investigation of nano-boron treatments on sunflowers, Vadlamudi *et al.,* (2022) said that the 0.2% treatment performed noticeably better than the 0.2% treatment in terms of seed yield and seed oil percentage. Al-kakayie and Al-Juhayshi (2024) observed notable variations in thousand seed weight, seed yield, seed oil %, seed yield, oleic and linoleic acids among the three nano-boron treatments (0, 1, 2, and 3 g/L) he studied on sunflower crops. The study sought to determine the best planting date for safflower, the right amount of nano-boron, and the quantity and quality of fatty acids.

Materials and methods

A field experiment was conducted during the winter growing season of 2024-2025 at two locations, Raseediyah and Wana. It was performed to study the effects of planting dates and foliar application of nano-boron on safflower productivity and fatty acid quality. The experiment was arranged as a factorial experiment using a randomized complete block design (RCBD) with three replications. Two factors were studied. The first factor consisted of three planting dates (20 November, 5 December, and 20 December). The second factor included three nano-boron concentrations (0, 2.5, and 5 g L^{-1}). The total number of experimental units was 27 (3 × 3 × 3). Each experimental unit consisted of four rows, each 2 m long. The distance between rows was 50 cm, and plants were spaced 30 cm apart within the rows. Data were collected from plants grown in the two middle rows to avoid border effects. The distance between experimental units was 1 m, and the distance between blocks was 1.5 m. Before planting, the field was prepared by perpendicular plowing using a disc plow, followed by leveling and soil preparation. Sowing was carried out on 20 October 2024. After seedling emergence, thinning was performed two weeks after planting, leaving one plant per hole. Weed control and hoeing were carried out as required during the growing season. Fatty acid composition was determined using a fat esterification method according to the AOAC (1995) procedure. Methanolic potassium hydroxide was prepared by dissolving 11.2 g of potassium hydroxide in 100 mL of methanol. For esterification, 1 g of oil sample was mixed with 5 mL of hexane and 8 mL of methanolic potassium hydroxide. The mixture was shaken vigorously for 30 seconds and then allowed to separate into two layers. The upper hexane layer, containing fatty acid methyl esters, was collected and injected into the gas chromatograph. Fatty acid analysis was performed using a Shimadzu GC-2010 gas chromatograph equipped with a flame ionization detector (FID) and a ZB-1 capillary column (30 m × 0.25 mm). The injector temperature was set at 280°C, the detector temperature at 340°C, and the column temperature was programmed from 100 to 300°C at a rate of 10°C min^{-1}. The carrier gas pressure was maintained at 100 kPa. Statistical analysis was performed using analysis of variance (ANOVA) with the Statistical Analysis System (SAS, 2005). Mean comparisons were conducted using Duncan's multiple range test at 1% and 5% probability levels.

Results and discussion

Thousand-seed weight: The results presented in Table 1 show that planting dates had a significant effect on thousand-seed weight at both Rashidiya and Wana sites. The early planting date (20 November) produced the highest thousand-seed weight. It reached 43.42 g at Rashidiya and 43.73 g at Wana. While the late planting date (20 December) resulted in the lowest values (41.23 and 41.65 g, respectively). This improvement under early planting may be attributed to a longer growth period. As it enhanced photosynthetic activity and allowed greater translocation and accumulation of assimilates in the seeds during the seed-filling stage. These results are in agreement with those reported by Ghareeb (2024) and Bahadori et al. (2025). According to Table 2, nano-boron application significantly affected thousand-seed weight at both sites. The highest values were obtained with the 6 g L^{-1} nano-boron treatment (43.71 and 44.14 g). Whereas, the control treatment (0 g L^{-1}) recorded the lowest values. This response may be related to the role of boron in improving nutrient transport, pollen viability, and seed development during the reproductive stage. Similar findings were reported by Goudar (2017), Goudar et al. (2018) and Al-kakayie and Al-Juhayshi (2024). The interaction between planting dates and nano-boron treatments had no significant effect on thousand-seed weight, as shown in Table 3.

Seed yield: As shown in Table 1, seed yield was significantly influenced by planting date at both experimental locations. The highest seed yield was recorded for the 20 November planting date (1101.23 and 1106.59 kg ha^{-1} at Rashidiya and Wana, respectively). Whereas, the lowest yield was observed with the 20 December planting date. The superiority of early planting may be associated with its positive effect on thousand-seed weight and favorable climatic conditions during flowering and seed filling. These findings are consistent with Ghareeb (2024) and Bahadori et al. (2025). Nano-boron foliar application also had a significant effect on seed yield (Table 2). The 6 g L^{-1} treatment produced the highest seed yield at both sites. While, the control treatment resulted in the lowest values. This increase in yield may be attributed to improved nutrient uptake, enhanced photosynthetic efficiency, and better seed filling. These results agree with those reported by Goudar (2017), Goudar et al. (2018), Vadlamudi et al. (2022), and Al-kakayie and Al-Juhayshi (2024). A significant interaction between planting dates and nano-boron treatments was observed (Table 3). Where, the combination of 20 November planting and 6 g L^{-1} nano-boron produced the highest seed yield at both sites.

Table 1. Effect of planting dates on yield components, oil content, oil yield, and fatty acid composition of safflower at Rashidiya and Wana sites

Planting date	Thousand-seed weight (g)	Seed yield (kg ha⁻¹)	Oil content (%)	Oil yield (kg ha⁻¹)	Oleic acid (%)	Linoleic acid (%)	Palmitic acid (%)	Stearic acid (%)
Rashidiya site								
20 Nov	43.42 a	1101.23 a	30.93 a	341.22 a	14.64 a	68.88 a	9.64 b	6.15 b
5 Dec	42.43 b	1079.54 b	28.99 b	313.46 b	16.05 a	70.18 a	11.53 a	7.66 a
20 Dec	41.23 c	1059.65 c	27.85 c	295.43 c	15.57 a	69.67 a	10.81 a	7.06 a
Wana site								
20 Nov	43.73 a	1106.59 a	30.70 a	340.23 a	15.55 a	69.65 a	10.76 b	6.83 b
5 Dec	42.73 b	1085.76 b	29.46 b	320.40 b	16.49 a	70.41 a	11.29 ab	7.81 a
20 Dec	41.65 c	1063.57 c	28.32 c	301.54 c	17.06 a	71.35 a	12.01 a	8.49 a

Note: Values followed by different letters within the same column and site are significantly different at $P \leq 0.05$ according to Duncan's multiple range test.

Table 2. Effect of nano-boron foliar application on yield components, oil content, oil yield, and fatty acid composition of safflower at Rashidiya and Wana sites

Nano-boron (g L⁻¹)	Thousand-seed weight (g)	Seed yield (kg ha⁻¹)	Oil content (%)	Oil yield (kg ha⁻¹)	Oleic acid (%)	Linoleic acid (%)	Palmitic acid (%)	Stearic acid (%)
Rashidiya site								
0.0	41.15 c	1025.11 c	27.91 b	286.23 c	11.75 c	66.40 c	7.84 c	3.74 c
2.5	42.22 b	1076.56 b	29.65 a	319.55 b	15.42 b	69.67 b	10.51 b	6.91 b
5.0	43.71 a	1138.75 a	30.21 a	344.34 a	19.09 a	72.66 a	13.63 a	10.22 a
Wana site								
0.0	41.35 c	1030.73 c	28.10 b	289.77 c	11.93 c	66.96 c	8.11 c	4.03 c
2.5	42.62 b	1101.93 b	29.82 a	328.91 b	16.40 b	70.67 b	11.41 b	7.70 b
5.0	44.14 a	1123.25 a	30.56 a	343.49 a	20.77 a	73.78 a	14.53 a	11.41 a

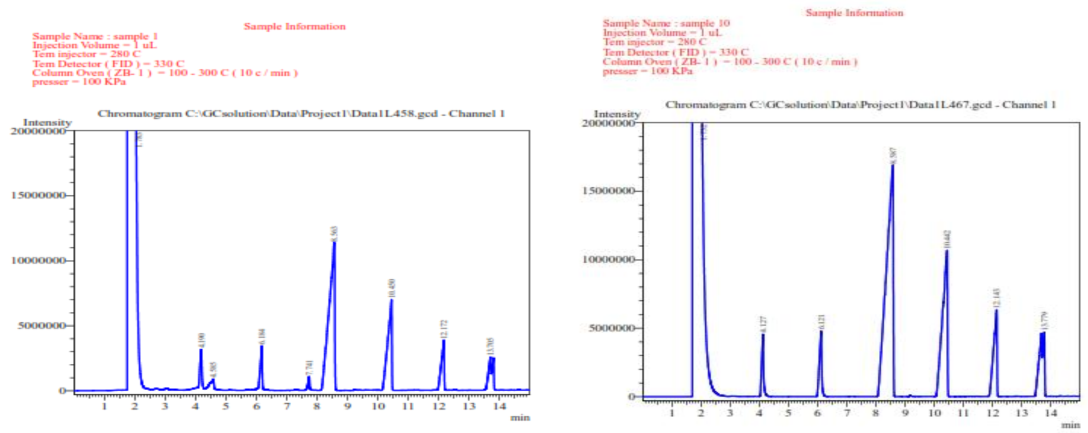
Note: Values followed by different letters within the same column and site differ significantly at $P \leq 0.05$.

Table 3. Interaction effect of planting dates and nano-boron treatments on yield components, oil content, oil yield, and fatty acid composition of safflower at Rashidiya and Wana sites

Planting date	Nano-boron (g/L)	Thousand-seed weight (g)	Seed yield (kg ha⁻¹)	Oil content (%)	Oil yield (kg ha⁻¹)	Oleic acid (%)	Linoleic acid (%)	Palmitic acid (%)	Stearic acid (%)
Rashidiya site									
20/11	0	41.76	1037.33 g	29.35	304.45	11.50	66.10	7.44	3.60
20/11	3	43.01	1100.90 d	31.66	348.60	14.56	68.89	9.25	5.65
20/11	6	45.50	1165.46 a	31.80	370.61	17.88	71.65	12.25	9.20
5/12	0	41.58	1027.56 h	27.43	281.91	11.77	66.32	7.98	3.74
5/12	3	42.33	1075.20 e	29.50	317.18	16.05	70.55	11.65	8.11
5/12	6	43.38	1135.86 b	30.05	341.18	20.33	73.69	14.98	11.14
20/12	0	40.11	1010.43 i	26.95	272.31	12.00	66.80	8.12	3.89
20/12	3	41.33	1053.60 f	27.80	292.33	15.65	69.58	10.65	6.98
20/12	6	42.26	1135.86 c	28.80	292.89	19.08	72.65	13.66	10.32
Wana site									
20/11	0	41.90	1045.36 f	29.11	304.37	11.74	66.50	7.98	3.85
20/11	3	43.51	1128.80 b	31.05	350.49	15.12	69.80	10.65	6.65
20/11	6	43.51	1145.61 a	31.93	365.83	19.80	72.65	13.65	10.00
5/12	0	41.78	1031.55 g	27.80	286.76	11.95	66.89	8.12	4.00
5/12	3	41.61	1101.85 d	30.01	330.73	16.88	70.66	11.25	7.80
5/12	6	42.63	1123.88 c	30.58	343.72	20.65	73.69	14.50	11.65
20/12	0	41.95	1015.30 h	27.40	278.19	12.10	67.49	8.25	4.25
20/12	3	40.55	1075.16 e	28.41	305.52	17.22	71.56	12.35	8.66
20/12	6	41.71	1100.25 d	29.16	320.91	21.88	75.00	15.44	12.58

Note: Means followed by different letters indicate significant differences at $P \leq 0.05$ according to Duncan's multiple range test.

Fatty acid composition: Planting dates did not significantly affect oleic and linoleic acid contents (Table 1). It agrees with the findings of Samancı and Kaynak (2003). However, nano-boron application significantly increased oleic and linoleic acid contents (Table 2). They likely due to improved photosynthesis and fatty acid biosynthesis, as reported by Al-kakayie and Al-Juhayshi (2024). In contrast, palmitic and stearic acids were significantly higher under later planting dates. They possibly due to higher temperatures during seed filling that favor saturated fatty acid accumulation. This observation agrees with Mirshekari et al. (2013). Nano-boron treatments significantly increased palmitic and stearic acids. While, the interaction effects were not significant (Table 3).



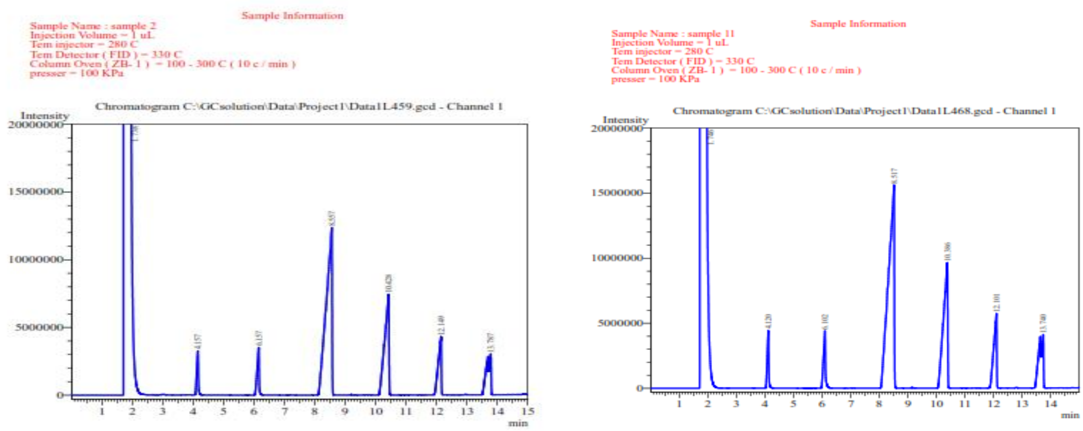
Peak Table - Channel 1

Peak#	Ret.Time	Area	Area%	Height	Name
1	1.783	3945705510	92.9556	89236320	
2	4.190	12778278	0.3010	2940195	
3	4.585	6746417	0.1589	786909	
4	6.184	15052588	0.3546	3321526	
5	7.741	3898210	0.0918	1020084	
6	8.563	148444128	3.4971	11320841	
7	10.450	63437465	1.4945	6939446	
8	12.172	24480958	0.5767	3831595	
9	13.705	24178651	0.5696	2486915	
Total		4244722205	100.0000	21883831	

Peak Table - Channel 1

Peak#	Ret.Time	Area	Area%	Height	Name
1	1.732	4880109866	89.8656	78440226	
2	4.127	20271427	0.3733	4506250	
3	6.121	26454874	0.4872	4735474	
4	8.587	273112203	5.0293	16717819	
5	10.442	124563876	2.2938	10609991	
6	12.143	51667498	0.9514	6297456	
7	13.779	54276983	0.9995	4649727	
Total		5430456727	100.0000	25956943	

Figure 1. Fatty acids curve at planting date of 20/11 with nano-boron treatment of 0 g/L for sites of Rashidiya (1) and Wana (10)



Peak Table - Channel 1

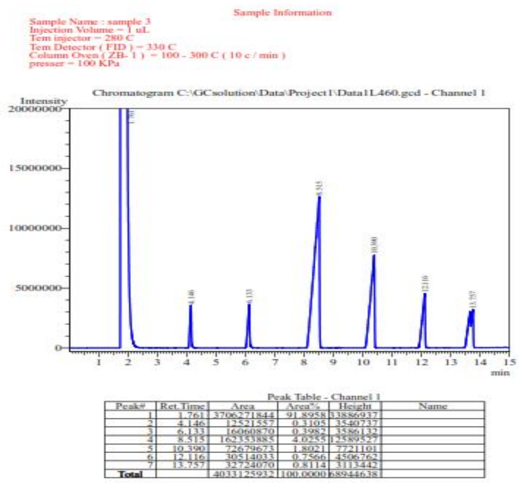
Peak#	Ret.Time	Area	Area%	Height	Name
1	1.738	3719100897	92.0132	27474537	
2	4.157	11986035	0.2965	3145340	
3	6.157	15555214	0.3848	3442129	
4	8.557	162375670	4.0173	12298742	
5	10.428	72474382	1.7931	7375552	
6	12.149	29676317	0.7342	4272125	
7	13.787	30754441	0.7609	3002524	
Total		4041922956	100.0000	61010949	

Peak Table - Channel 1

Peak#	Ret.Time	Area	Area%	Height	Name
1	1.746	3842188780	89.7134	44825796	
2	4.120	16410586	0.3832	4336771	
3	6.102	21447181	0.5008	4389278	
4	8.517	218188719	5.0946	15605523	
5	10.386	99167980	2.3155	9585282	
6	12.101	41187871	0.9617	5663506	
7	13.740	44144905	1.0308	4071858	
Total		4282736022	100.0000	88478014	

Figure 2. Fatty acids curve at planting date of 20/11 with nano-boron treatment of 2.5 g/L for sites of Rashidiya (2) and Wana (11)

Gas chromatographic analysis of fatty acids: Gas chromatography (GC) analysis was used to identify and quantify oleic, linoleic, palmitic, and stearic acids in safflower oil samples from both Rashidiya and Wana sites. The chromatograms corresponding to different planting dates and nano-boron treatments are presented in Figures 1–9. They clearly illustrate variations in fatty acid profiles under different treatments.



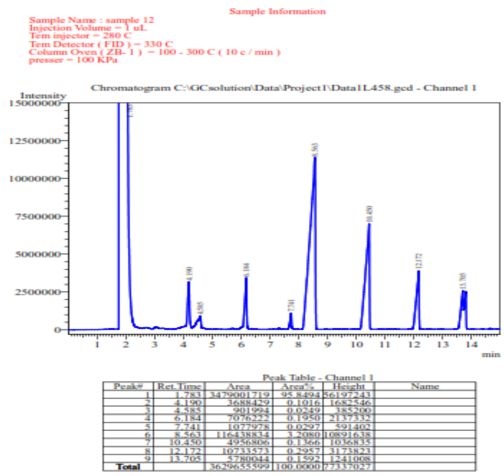
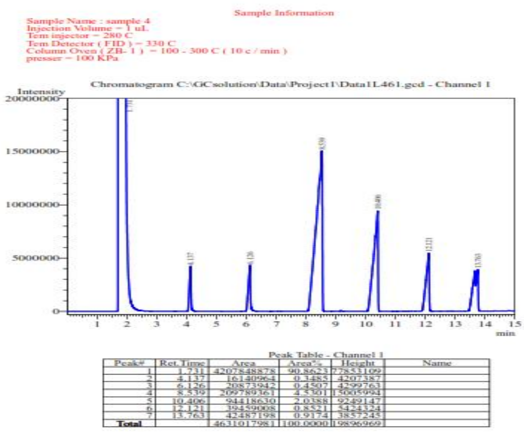


Figure 3. Fatty acids curve at planting date of 20/11 with nano-boron treatment of 5 g/L for sites of Rashidiya (3) and Wana (12)



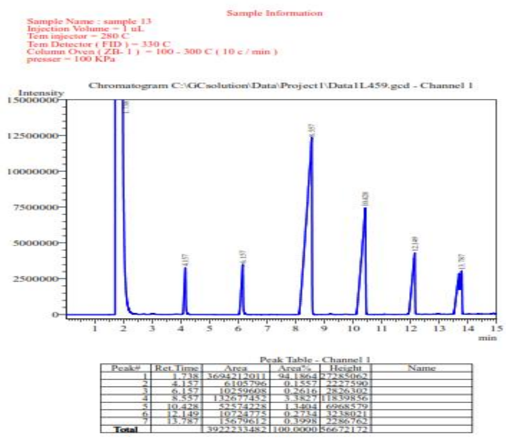
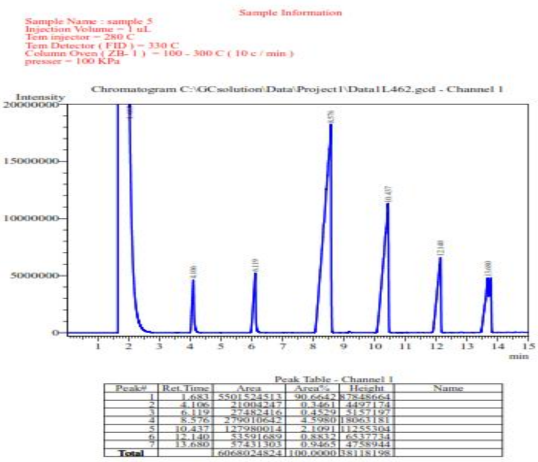


Figure 4. Fatty acids curve at planting date of 5/12 with nano-boron treatment of 0 g/L for sites of Rashidiya (4) and Wana (13)



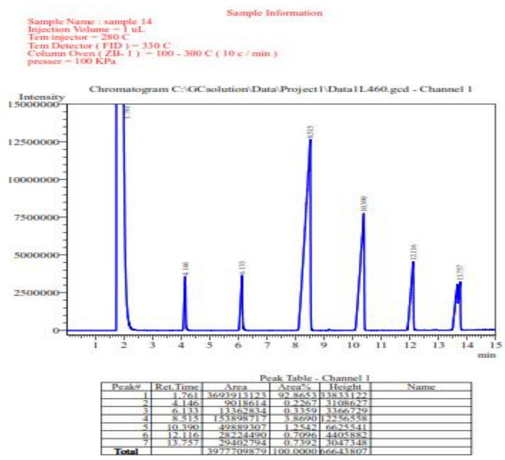
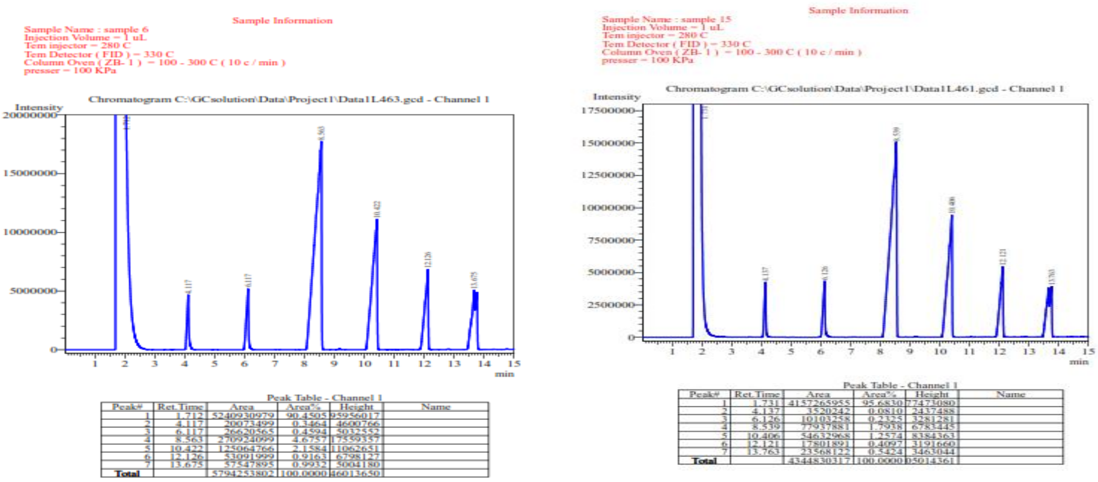


Figure 5. Fatty acids curve at planting date of 5/12 with nano-boron treatment of 2.5 g/L for sites of Rashidiya (5) and Wana (14)



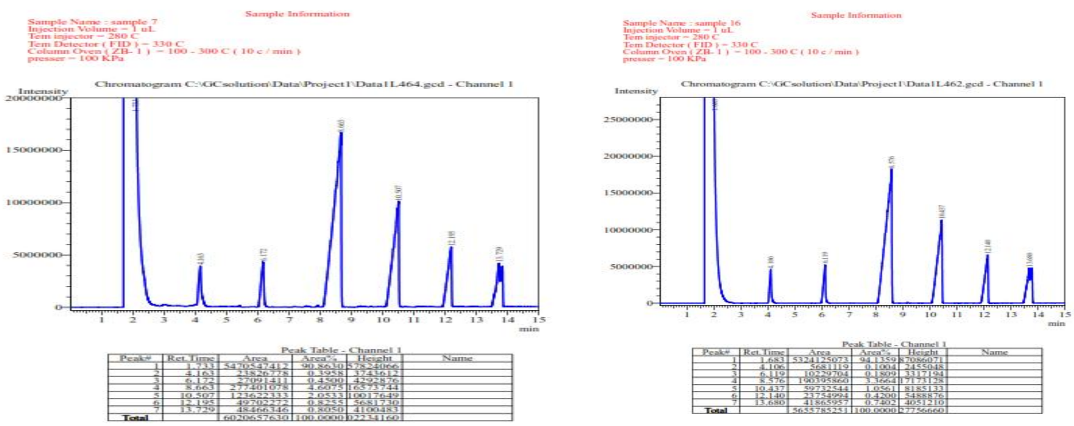
Peak Table - Channel 1

Peak#	Ret.Time	Area	Area%	Height	Name
1	1.712	52409309979	90.4505	95956017	
2	4.117	200734999	0.3464	4600766	
3	6.117	266205655	0.4594	5032552	
4	8.563	2709240099	4.6757	17559357	
5	10.422	1250647666	2.1584	11062651	
6	12.126	530919999	0.9163	6798127	
7	13.675	575478955	0.9932	5004180	
Total		57942538002	100.0000	46013650	

Peak Table - Channel 1

Peak#	Ret.Time	Area	Area%	Height	Name
1	1.731	41572659555	95.6830	77473080	
2	4.137	35202422	0.0810	2437488	
3	6.126	101032588	0.2325	3281281	
4	8.539	779378881	1.7938	6783445	
5	10.406	546329688	1.2574	8384363	
6	12.121	178018911	0.4097	3191660	
7	13.763	235681222	0.5424	3463044	
Total		43448303317	100.0000	05014361	

Figure 6: Fatty acids curve at planting date of 5/12 with nano-boron treatment of 5 g/L for sites of Rashidiya (6) and Wana (15)



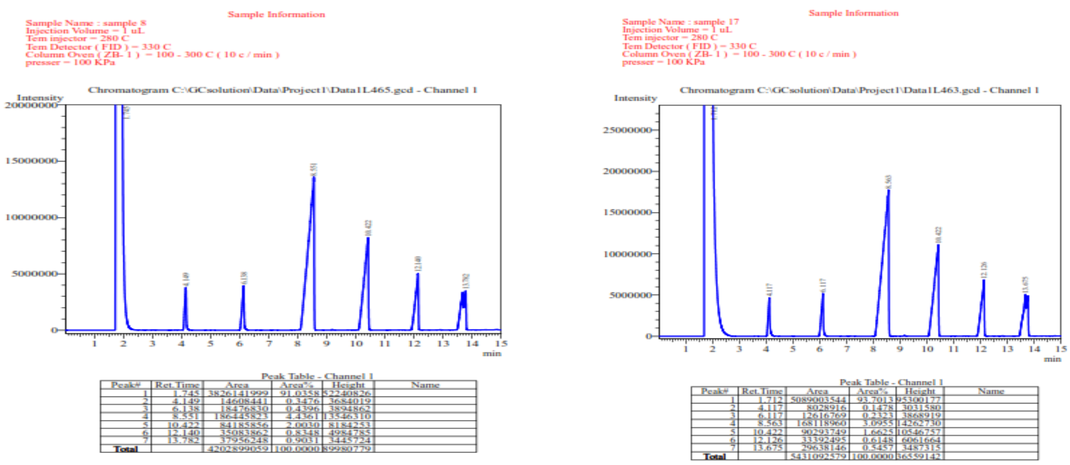
Peak Table - Channel 1

Peak#	Ret.Time	Area	Area%	Height	Name
1	1.733	54705474112	90.8630	578240066	
2	4.163	238267778	0.3958	3743612	
3	6.172	270914111	0.4500	4292876	
4	8.663	2774010778	4.6075	16573744	
5	10.507	1236223333	2.0533	100176449	
6	12.195	497022772	0.8255	5681730	
7	13.729	484663346	0.8050	4100483	
Total		60206576330	100.0000	02234160	

Peak Table - Channel 1

Peak#	Ret.Time	Area	Area%	Height	Name
1	1.683	53241250073	94.1359	87086071	
2	4.106	56811119	0.1004	2455048	
3	6.119	102297704	0.1809	3317194	
4	8.576	1903958860	3.3664	17173128	
5	10.437	597325444	1.0561	8185133	
6	12.140	237549994	0.4200	5488876	
7	13.680	418659957	0.7402	4051210	
Total		56557852251	100.0000	27756660	

Figure 7. Fatty acids curve at planting date of 20/12 with nano-boron treatment of 0 g/L for sites of Rashidiya (7) and Wana (16)



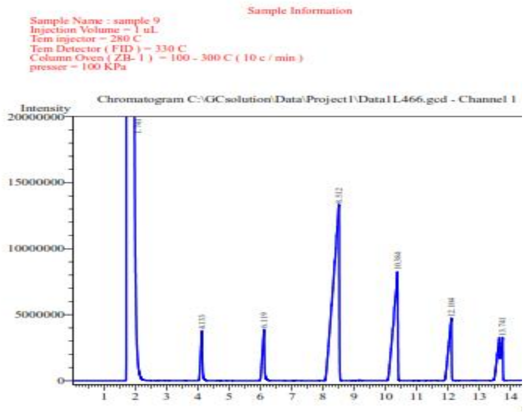
Peak Table - Channel 1

Peak#	Ret.Time	Area	Area%	Height	Name
1	1.745	38261419999	91.0358	522408826	
2	4.149	146084441	0.3476	3684019	
3	6.138	184768830	0.4396	3894862	
4	8.551	1864458823	4.4361	13546310	
5	10.422	841858856	2.0030	8184253	
6	12.140	350838862	0.8348	4984785	
7	13.782	379562248	0.9031	3445724	
Total		42028990059	100.0000	89980779	

Peak Table - Channel 1

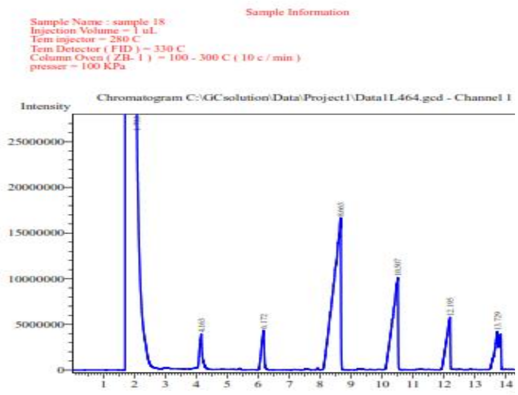
Peak#	Ret.Time	Area	Area%	Height	Name
1	1.712	50890003544	93.7013	953000177	
2	4.117	80289916	0.1478	3031580	
3	6.117	126167769	0.2323	3868919	
4	8.563	1681118960	3.0955	14262730	
5	10.422	902937749	1.6625	10546757	
6	12.126	333924995	0.6148	6061664	
7	13.675	296381146	0.5457	3487315	
Total		54310925579	100.0000	36559142	

Figure 8. Fatty acids curve at planting date of 20/12 with nano-boron treatment of 2.5 g/L for sites of Rashidiya (8) and Wana (17)



Peak Table - Channel 1

Peak#	Ret.Time	Area	Area%	Height	Name
1	1.741	4013027166	91.9609	30022910	
2	4.133	14563570	0.3337	3731927	
3	6.119	17980844	0.4120	3814330	
4	8.512	177159668	4.0597	13279051	
5	10.384	77590613	1.7780	8220224	
6	12.104	31212974	0.7153	4577366	
7	13.741	32307610	0.7403	3231206	
Total		4363842445	100.0000	66877014	



Peak Table - Channel 1

Peak#	Ret.Time	Area	Area%	Height	Name
1	1.733	5327237390	94.2793	57502093	
2	4.163	9438529	0.1670	2514146	
3	6.172	17618629	0.3118	3656547	
4	8.663	165494864	2.9289	14810256	
5	10.507	66943682	1.1847	9169902	
6	12.195	24671428	0.4366	4957152	
7	13.729	39077674	0.6916	3708192	
Total		5650482196	100.0000	96318288	

Figure 9. Fatty acids curve at planting date of 20/12 with nano-boron treatment of 5 g/L for sites of Rashidiya (9) and Wana (18)

Conclusion: This study showed that planting safflower on 20 November improved seed weight, seed yield, seed oil percentage, oil yield, and the contents of oleic and linoleic acids in comparison with later planting dates. Early planting provided better growth conditions. These conditions helped increase photosynthesis and oil formation in the seeds. Foliar application of nano-boron at 6 g L^{-1} also had a positive effect on all measured traits. This treatment increased thousand-seed weight, seed yield, seed oil percentage, and oil yield. It also improved oil quality by increasing oleic, linoleic, palmitic, and stearic acids. In general, planting safflower on 20 November combined with foliar spraying of 6 g L^{-1} nano-boron can be recommended to achieve higher yield and better oil quality under the conditions of this study.

Author contributions

All activities were performed by B. A. R. M. O. The final document was examined, debated, and approved by the author.

Data availability statement

The corresponding author can provide data supporting this study's conclusions upon reasonable request.

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Ethical approval

Not applicable.

Conflict of Interest

The author affirm that they have no financial conflicts of interest or competing interests in this study.

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انجمن بیوتکنولوژی ایران
مجله بیوتکنولوژی کشاورزی
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دانشگاه شهید باهنر کرمان

تأثیر تاریخ‌های کاشت و تغذیه برگی با نانوبور بر عملکرد گلرنگ و کیفیت اسیدهای چرب

ولید خالد شحاته الجهیشی

گروه زراعت، دانشکده کشاورزی و جنگلداری، دانشگاه موصل، موصل، عراق. ایمیل: w.khalid83@uomosul.edu.iq

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چکیده

هدف: بهبود هم‌زمان عملکرد و کیفیت روغن برای افزایش ارزش اقتصادی گلرنگ تحت شرایط محیطی محلی اهمیت زیادی دارد. ازاین‌رو، هدف از مطالعه حاضر بررسی اثر تاریخ‌های مختلف کاشت و محلول‌پاشی برگی نانوبور بر عملکرد بذر، درصد روغن و ترکیب اسیدهای چرب گلرنگ (*Carthamus tinctorius* L.) بود.

مواد و روش‌ها: این آزمایش مزرعه‌ای در فصل رشد زمستانه ۲۰۲۵-۲۰۲۴ در دو منطقه رصیدیه و وانه اجرا شد. تیمارها شامل سه تاریخ کاشت (۲۰ نوامبر، ۵ دسامبر و ۲۰ دسامبر) و سه غلظت محلول‌پاشی برگی نانوبور (۰، ۲٫۵ و ۵ گرم در لیتر) بودند. آزمایش به‌صورت طرح بلوک‌های کامل تصادفی (RCBD) با سه تکرار در هر محل انجام گرفت. داده‌ها شامل وزن هزار دانه، عملکرد بذر، درصد روغن بذر، عملکرد روغن و ترکیب اسیدهای چرب روغن شامل اسیدهای اولئیک، لینولئیک، پالمیتیک و استئاریک جمع‌آوری شدند. عملیات زراعی متداول در طول فصل رشد اعمال شد و سپس تجزیه و تحلیل آماری برای ارزیابی اثرات اصلی و متقابل تیمارها انجام گرفت.

نتایج: نتایج نشان داد که تاریخ کاشت تأثیر معنی‌داری بر بهره‌وری و کیفیت روغن گلرنگ دارد. کاشت زودهنگام در تاریخ ۲۰ نوامبر در هر دو منطقه بیشترین مقادیر وزن هزار دانه، عملکرد بذر، درصد روغن بذر، عملکرد روغن و درصد اسیدهای اولئیک و لینولئیک را به همراه داشت. در مقابل، تاریخ‌های کاشت دیرتر (۵ و ۲۰ دسامبر) باعث افزایش محتوای اسیدهای پالمیتیک و استئاریک روغن در هر دو منطقه رصیدیه و وانه شدند. محلول‌پاشی برگی نانوبور به‌طور معنی‌داری تمام صفات اندازه‌گیری‌شده را نسبت به تیمار شاهد بهبود داد. بالاترین غلظت نانوبور (۵ گرم در لیتر) بیشترین مقادیر اجزای عملکرد، درصد روغن، عملکرد روغن و تمامی اسیدهای چرب مورد بررسی را ایجاد کرد. همچنین، اثر متقابل معنی‌داری بین تاریخ کاشت زودهنگام (۲۰ نوامبر) و مصرف ۵ گرم در لیتر نانوبور مشاهده شد که بیشترین عملکرد بذر را در هر دو محل آزمایش به دست داد.

نتیجه‌گیری: این مطالعه نشان داد که کاشت زودهنگام همراه با تغذیه برگی نانوبور روشی مؤثر برای بهبود عملکرد گلرنگ و کیفیت اسیدهای چرب آن است. بر اساس نتایج، کاشت در تاریخ ۲۰ نوامبر همراه با مصرف نانوبور به غلظت ۵ گرم در لیتر تحت شرایط محیطی مشابه توصیه می‌شود.

کلمات کلیدی: اسیدهای چرب، تاریخ کاشت، عملکرد، کیفیت روغن، نانوبور

نوع مقاله: پژوهشی

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