Journal of Medicinal and Industrial Plant Sciences (2025) 3 (3): 102- 116
ISSN: 2959 – 121X
DOI: https://doi.org/10.32894/MEDIP.25.3.3.8

Effect of autumn planting date and density on growth, yield and quality of maize seed

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ABSTRACT

A field experiment was conducted at the Research Station of the Field Crops Department at the College of Agriculture, Tikrit University, during autumn season of 2024. The aim was to determine the best autumn planting dates and plant density, and their impact on growth, yield, and quality of maize seeds. The study included two factors: three planting dates (1/8, 15/8, and 1/9) and three plant densities (83,333, 71,428, and 62,500 plant ha^{-1}). The field study was implemented according to a randomized complete block design (RCBD) with three replicates. Results showed that second planting date outperformed all studied traits. Lowest planting density was superior in leaf chlorophyll content, stem diameter, protein and oil content. While 71428 plant ha^{-1} was superior in leaf area, ear length, number of rows per ear, and number of seeds per row. The high planting density was superior in plant height, and seed yield.

KEYWORDS: Planting date; Planting density; Maize.

Received: 10/08/2025; **Accepted**: 30/08/2025; **Available online:** 30/09/2025

تأثير موعد الزراعة الخريفية وكثافتها على نمو وإنتاجية وجودة الذرة الصفراء

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الملخص

أُجريت تجربة حقلية في محطة أبحاث قسم المحاصيل الحقلية بكلية الزراعة، جامعة تكريت، خلال الموسم الخريفي لعام 2024. وكان الهدف تحديد أفضل موعد زراعة خريفية وكثافة نباتية، وتأثيرها على نمو وإنتاجية وجودة بذور الذرة الصفراء. وشملت الدراسة عاملين: ثلاثة مواعيد زراعة (8/1، 8/15، و9/1) وثلاث كثافات نباتية (83,333، 71,428، و62,500 نبات هـ$^{-1}$). ونُفذت الدراسة الحقلية وفقًا لتصميم القطاعات الكاملة العشوائية بثلاث مكررات. أظهرت النتائج تفوق موعد الزراعة الثاني في جميع الصفات المدروسة. تفوقت أقل كثافة زراعة في محتوى الكلوروفيل في الأوراق، وقطر الساق، ومحتوى البروتين والزيت. بينما تفوقت الكثافة (71428 نبات هـ$^{-1}$) في مساحة الورقة، وطول العرنوص، وعدد الصفوف في العرنوص، وعدد البذور في الصف. وتفوقت الكثافة العالية في ارتفاع النبات، وإنتاجية البذور.

الكلمات المفتاحية: موعد الزراعة؛ كثافة الزراعة؛ الذرة.

INTRODUCTION

Maize *Zea mays* L. is a major cereal crop of high economic importance and widely cultivated throughout the world (Ranum et al, 2014). It is described as the "miracle" and "queen of crops" due to its high productivity and remarkable adaptability to diverse environmental conditions compared to other grass crops (Subbarama and Subramania, 2010). Its importance lies in multiple food and industrial uses, as its grains are a rich source of carbohydrates (81%), protein (10.6%), oil (4.6%), and ash (2%), in addition to containing important vitamins such as E, B1, and B2. The stems and leaves are also used in paper industry. Despite the strategic importance of maize, the area planted with it in Iraq remains limited. The autumn crop production was estimated at about 1.2 tons ha^{-1}, which is significantly lower than the global average of 5.5 tons ha^{-1} (FAO, 2024). The area planted with the crop in Iraq amounted to more than 76,000 hectare, with an average production of 3,416 tons ha^{-1}.

The large gap between the local and global average production is attributed to the poor utilization of production inputs, particularly the appropriate plant density and optimal planting date. Plant density is one of the important factors affecting maize growth and yield, given the varying competitiveness of plants at varying density levels. It is essential to achieve balanced growth by adopting an optimal plant density that enables plants to efficiently utilize nutrients and water, make the best use of light, and ensure optimal growth, along with other environmental factors necessary for growth (Gobeze et al., 2012). Adherence to the ideal planting date is also one of the most important factors affecting maize productivity. Early planting may expose plants to low temperatures during the early stages of growth, while delayed planting exposes plants during the flowering stage to high temperatures, which causes poor pollination and fertilization, weakens the grain filling process, and consequently reduces the overall yield (Bruns and Abbas, 2006).

MATERIALS AND METHODS

Agricultural processes, Design and Site.

This experiment was conducted during autumn season of 2024 at the Agricultural Research and Experiment Station affiliated with the College of Agriculture, Tikrit University, at longitude 42.30° East and latitude 34.31° North. Sara variety seeds were used in this study, and the land was plowed twice with a disc plow to prepare the land and carry out the levelling and amendments.The experiment was implemented according to a Randomized Complete Block Design (RCBD) with three replicates, bringing the total number of experimental units to 27 and each experimental unit was 3 x 2 m. Treatments were randomly distributed among the experimental units within each replicate. Each experimental unit consisted of several rows (lines) 3 meters long, according to the plant density levels used in the study. The distance between holes was fixed at 20 cm, and planting was carried out accordingly. To reduce overlap between replicates, each replicate was separated from the other by a 1.5-meter-wide trench.

Table 1. Soil physical and chemical parameters

Parameter	Value	Unit
pH	7.67	____
E.C	2.6	dc m^{-1}
N	1.5	mg kg^{-1}
P	0.088	mg kg^{-1}
K	90.04	mg kg^{-1}
sand	548	g kg^{-1}
silt	252	g kg^{-1}
clay	194	g kg^{-1}
Soil texture		Sandy silty clay

Table 2. Means of some monthly meteorological data.

Month	Max temp C°	Min temp C°
August	45.3	22.97
September	44.2	19.5
October	31.3	14.9
November	25.2	13.2
December	21.3	12.3
January	19.4	11.9

Study Factors and characteristics.

The study included two factors: three planting dates (First: August 1st, Second: August 15th and Third: September 1st) and three planting densities (Firs: 83,333, Second: 71,428 and Third: 62,500 plant ha^{-1}). Characteristics were plant height (cm) , leaf Area (cm^2 $plant^{-1}$), stem diameter (cm), leaf chlorophyll content (Spad), ear length (cm), number of rows per ear (row ear^{-1}), number of seeds per row (seed row^{-1}), seed yield (ton ha^{-1}), protein and oil content (%).

Experimental procedures.

Protein content (%):

Protein percentage was estimated according to the A.A.C.C. (1998) method, using an Inframatic device manufactured by Perten and located at the General Company for Grain Processing. This device relies on near-infrared (NIR) reflectance technology, as described by Gomez et al. (2010). The analysis was conducted by taking 15 grams of the previously prepared flour sample and placing it in a small, cubic-shaped container inside the device. The device was then switched on, giving results within a few minutes. When using a new sample, the container was cleaned with a special brush before switching on again.

Oil Content (%)

Oil content was determined according to the official method approved by the American Oil Association (A.O.A.C., 1990), using a Soxhlet extraction device. The extraction process was conducted in the laboratory of the Field Crops Department, College of Agriculture, Tikrit University. For analytical purposes, 5 grams of dry, ground samples were taken from the seeds of each treatment and placed in a Soxhlet device, using hexane as the solvent for the extraction process. After evaporation to remove the solvent, the resulting oil samples were weighed to calculate their oil content. The oil content was calculated using the following equation:

Oil Percentage = Weight of sample before extraction - Weight of sample after extraction / Weight of sample before extraction × 100.

Statistical Analysis

The statistical analysis of the data was conducted using a randomized complete block design (RCBD) in a factorial experiment, as stated by Al-Rawi and Khalaf Allah (2000). The significant differences between the means were then compared using Duncan's multiple range test at a significance level of 0.05. The statistical analysis was conducted using the SAS program.

RESULTS AND DISCUSSION

Plant height (cm):

Results shown in Table (3) indicated that the second planting date (August 15th) significantly outperformed the other planting date in plant height and recorded the highest mean (281.37 cm). However, third planting date (September st1) gave the lowest mean (241.30 cm). This superiority is attributed to the high relative humidity and moderate temperatures during the growing period, which provided plants with a better opportunity to continue vegetative growth, thus increasing plant height. These results are consistent with the findings of (Al-Jabouri and Anwar 2009). With regard to planting density, the first planting date (83,333 plant ha^{-1}) achieved the highest mean (271.65 cm), while the third planting date (62,500 plants ha^{1}) recorded the lowest mean (253.21 cm). This is likely due to increased competition among plants for growth requirements, especially light, which leads to elongation of the stem internodes in search of light, thus increasing plant height, as indicated by (Al-Othman 2009) and (Al-Qaisi 2024). Regarding the interaction between planting date and planting density, the interaction between second planting date (15/8) and the first planting density (83,333 plant ha^{1}) showed the highest mean (290.14 cm). Hence, the interaction between the third planting date (September st1) and the third planting density (62,500 plants ha^{1}) recorded the lowest mean (230.87 cm).

Table 3. Effect of autumn planting dates and planting density on plant height (cm)

planting density	planting date			plant density means
	First	Second	Third	
First	54.272 a	290.14 a	252.27 a	271.65 a
Second	259.75 a	282.55 a	239.77 a	260.69 b
Third	257.34 a	271.43 a	230.87 a	253.21 c
planting date mean	263.21 b	281.37 a	241.30 c	

At 5% of DMRT, means with the same litters for each factor and interaction do not differ significantly

Leaf Area (cm²)

Results in Table (4) showed significant differences in leaf area depending on planting date and planting density. Second planting date (August 15th) outperformed in recording the highest leaf area (471.95 cm²), while the third planting date (September 1st) recorded the lowest mean (447.15 cm²). This superiority is attributed to the plants being exposed to favourable environmental conditions, such as moderate temperatures and sufficient light hours, which stimulate photosynthesis and enhance leaf growth and size by improving the efficiency of nutrient absorption from the soil. Regarding plant density, the second planting date (71.428 plant ha^{-1}) showed significant superiority in recording the highest mean of leaf area (493.00 cm²), while the first planting density (83,333 plant ha^{1}) recorded the lowest mean (443.62 cm²). This can be explained by the fact that increased leaf area is an indicator of improved cell division activity and increased cell number, which enhances dry matter production in the plant. Conversely, increasing the number of plants per unit area leads to intense competition for environmental resources such as water, light, and nutrients, especially as the plant ages. This competition intensifies during the flowering stage, a critical stage that directly affects the quantity and quality of seeds produced. These results are consistent with those reported by Al-Khazaali et al. (2013), Al-Qaisi (2024), and Muhammad and Al-Muhammadi (2012), who indicated significant differences in leaf area depending on plant density. Regarding the interaction between planting date and planting density, the interaction between second planting date and the second planting density recorded the highest mean of leaf area, reaching 517.32 cm², while the interaction between the third planting date and the first planting density gave the lowest average, reaching 427.54 cm².

Table 4. Effect of autumn planting dates and planting density on leaf area (cm²)

planting density	**planting date**			**plant density means**
	First	**Second**	**Third**	
First	455.67 ab	447.65 b	427.54 ab	443.62 ab
Second	477.45 a	517.32 a	484.23a	493.00 a
Third	460.78 ab	450.89 b	429.68 ab	447. 12ab
planting date mean	ab464.63	471.95 a	447.15 ab	

Stem Diameter (cm)

Increasing stem diameter is an indicator of the growth of xylem and phloem tissues, which are responsible for transporting water and nutrients from the roots to the rest of the plant. This positively impacts the efficiency of photosynthesis and the distribution of its products to storage organs, contributing to improved seed quality. The results shown in Table (5) indicated significant differences due to differences in planting dates and planting densities. The second planting date (August 15th) recorded the highest mean of stem diameter (2.43 cm). However, third planting date (September 1st) recorded the lowest mean (2.21 cm). This superiority of the second planting date is attributed to favourable environmental conditions, such as moderate temperatures, high relative humidity, and long light periods. These conditions contribute to enhancing root system growth and increasing its activity in absorbing water and nutrients. This is reflected in the growth of the vegetative system and its ability to perform photosynthesis efficiently, thus accumulating dry matter in the stem and increasing its diameter. These results are consistent with what Abdullah (2001) reported. Regarding planting density, third density (62,500 plant ha¹) recorded the highest stem diameter of (2.59 cm), while the first density (83,333 plant ha¹) recorded the lowest mean of (2.18 cm). This is attributed to the fact that increased plant density leads to intense competition among plants for environmental resources, particularly light, which prompts plants to grow vertically in search of light at the expense of lateral growth, thus reducing stem diameter. These explanations were supported by Al-Othman (2009). Regarding the interaction between planting date and planting density, the interaction between second planting date and third planting density showed the highest mean of stem diameter (2.69 cm), while the interaction between third planting date and first density recorded the lowest mean (2.09 cm).

Table 5. Effect of autumn planting dates and planting density on stem diameter (cm).

planting density	**planting date**			**plant density means**
	First	**Second**	**Third**	
First	455.67 ab	447.65 b	427.54 ab	443.62 ab
Second	477.45 a	517.32 a	484.23a	493.00 a
Third	460.78 ab	450.89 b	429.68 ab	447. 12ab
planting date mean	464.63 ab	471.95 a	447.15 ab	

Leaf Chlorophyll Content (spad)

Results in Table (6) indicated that second planting date (August 15th) was superior in terms of chlorophyll content and recorded the highest mean of (54.82 spad), while third planting date (September 1st) recorded the lowest mean of (48.61 spad). This superiority is attributed to the favourable environmental conditions during the growth period, such as moderate temperatures, reduced shading, and minimal competition between plants, which contributed to enhancing photosynthesis and increasing chlorophyll concentration in the leaves.

Regarding planting density, the results showed that third planting density (62,500 plant ha¹) was superior in recording the highest mean of chlorophyll content (58.89 spad), compared to the first planting density (83,333 plant ha¹), which recorded the lowest mean (48.29 spad). This is likely due to the better availability of essential growth resources, such as light, water, and nutrients, at lower density. This, in addition to the increased number of leaves and leaf area, led to improved leaf chlorophyll content. Regarding the interaction between planting date and planting density, the interaction between second planting date and third planting density recorded the highest mean of chlorophyll content (59.45 spad), surpassing the interaction between the first planting date and the first planting density, which recorded the lowest mean (48.11spad).

Table 6. Effect of autumn planting dates and planting density on chlorophyll content (spad).

planting density	planting date			plant density means
	First	**Second**	**Third**	
First	48.11b	48.14b	48.61 b	.4829 b
Second	55.30a	56.87b	48,66 a	56.08 a
Third	58.33 a	59.45 a	,4832 b	58.89 a
planting date mean	53.91a	.5482a	.4861 b	

Ear Length (cm)

The results in Table (7) indicate a significant effect of planting date on ear length. The second planting date (August 15th) yielded the highest mean for the trait, reaching (21.67 cm), compared to third planting date (September 1st), which recorded the lowest mean for the trait, reaching (21.28 cm). This may be due to moderate temperatures, long light hours, and high relative humidity, which prompted plants to extend the vegetative growth period and allow sufficient time for the ear to develop and grow. Meanwhile, other planting dates had higher temperatures, longer light hours, and lower relative humidity, which led to reduced ear length. This contrasts with the results of (Namakka et al., 2008). Results in the same table showed that planting density had a significant effect on ear length. The second density (71,428 plant ha¹) achieved the highest length of (22.78 cm), while the first density (83,333 plant ha¹) recorded the lowest length of (20.48 cm). This superiority is attributed to reduced shading during the early stages of ear formation, in addition to the reduced intensity of competition between plants for light and photosynthetic products, which allows plants to invest more dry matter in ear growth and development. Chouelet (2000) indicated that ear length is significantly affected by plant density, as it tends to decrease at high densities due to intense competition. Regarding the interaction between planting date and plant density, the interaction between the second planting date and the second density recorded the highest average ear length of (23.12 cm), while the interaction between third planting date and first density produced the lowest mean of (20.43 cm).

Table 7. Effect of autumn planting dates and planting density on ear length (cm).

planting density	planting date			plant density means
	First	Second	Third	
First	20.46 g	20.55 g	20.43 g	.2048 c
Second	22.69 b	23.12 a	22.53 c	22.78 a
Third	20.92 e	21.34 d	20.89 f	21.05 b
planting date mean	21.36 b	21.67 a	.2128 c	

Number of rows per ear (row ear^{-1})

The results in Table (8) indicated a significant effect of planting date on the number of rows on the ear. Second planting date (August 15th) yielded the highest mean for the trait, reaching 16.63 rows per ear, while first planting date (August 1st) recorded the lowest mean for the trait, reaching 16.33 rows per ear. This may be due to the availability of suitable environmental conditions for growth, such as suitable temperatures that help improve the pollination and fertilization process, leading to the formation of a greater number of rows on the ear, and the availability of relative humidity and nutrients in the soil, which enhances vegetative and floral growth. The results of Table (6) showed that planting density had a significant effect on the number of rows per ear, as the second agricultural density (71,428 plant ha^{1}) was superior in giving the highest average for the trait, reaching 16.82 rows per ear, while the first density (83,333 plant ha^{1}) recorded the lowest average, reaching 16.09 rows. This superiority is attributed to the suitability of plant density, which led to reducing competition between plants for environmental resources such as light, water, and nutrients. These conditions contributed to enhancing the efficiency of photosynthesis and increasing the uptake of nutrients by the roots, which positively impacted the growth of leaf area and dry matter production, thus increasing the transfer of photosynthetic products from leaves to the ears. This helped create a greater number of rows in the ear (Williams et al., 1968; Abdul and Al-Sahuki, 2008). Previous studies (Gozubenli et al., 2010; Kazem and Abdul Nabi, 2014; and Faqira and Al-Shaabi, 2015) indicated significant differences in the number of rows per ear when practicing different plant densities, which is consistent with the results of this study. As plant density increased, leaf area and the number of leaves per plant decreased due to increased competition, which reduced the transfer of photosynthetic materials to the ear and, consequently, negatively impacted the number of rows. As for the interaction between planting date and planting density, an interaction was recorded between the second planting date and the second planting density had the highest mean of 17.09 rows, while the interaction between first planting date and the first planting density (83,333 plant ha^{1}) produced the lowest mean of 16.05 rows.

Table 8. Effect of autumn planting dates and planting density on the number of rows per ear (row ear^{-1}).

planting density	planting date			plant density means
	First	**Second**	**Third**	
First	16.05 e	16.12 e	16.09 e	16.09 c
Second	16.58 bc	17.09 a	16.78 b	16.82 a
Third	16.36 d	16.68 cd	16.38 d	16.47 b
planting date mean	16.33 b	16.63 a	16.42 b	

Number of seeds per row (seed row^{-1})

The results of Table (9) showed significant differences in the number of grains per row depending on the planting dates. The second date (15/8) yielded the highest average for the trait, reaching 40.32 seeds per row^{1}, while the first date (1/8) recorded the lowest average, reaching 39.84 seeds per row^{1}. This superiority is attributed to favorable climatic conditions, particularly temperatures during the flowering period, which contributed to improving the efficiency of the pollination and fertilization processes, thus increasing the fertility rate. This positively impacted the main components of the crop, including the number of grains per row. These results support the findings of Al-Ramadan (1999) and Al-Hadidi (2007). Regarding plant density, the second density (71,428 plants/ha^{1}) achieved the highest average of 40.85 seeds/row^{1}, while the first density (83,333 plants/ha^{1}) recorded the lowest average of 39.56 seeds/row^{1}. This is attributed to reduced competition among plants for environmental factors, allowing each plant to obtain greater amounts of light, water, and nutrients, increasing photosynthetic efficiency (Williams et al., 1968), and improving the efficiency of root absorption, which enhanced the accumulation of dry matter and its transfer from the sources (leaves) to the outlets (ears), thus increasing the rate of grain formation within a single row. As for the interaction between planting date and plant density, the interaction between the second planting date (15/8) and the second planting density (71,428 plant ha^{1}) recorded the highest average number of grains per row, amounting to 41.72 seeds per row^{1}, while the interaction between the first planting date (1/8) and the first planting density (83,333 plant ha^{1}) produced the lowest average, amounting to 39.49 seeds per row^{1}.

Table 9. Effect of autumn planting dates and planting density on the number of seeds per row (seed row^{-1}).

planting density	planting date			plant density means
	First	Second	Third	
First	39.59 e	39.61 e	39.49 e	39.56 c
Second	40.33 c	41.72 a	40.50 b	40.85 a
Third	39.61 e	39.63 e	39.87 d	39.70 b
planting date mean	39.84 c	40.32 a	39.95 b	

Seed Yield (ton ha^{-1})

The results of Table (10) showed a significant superiority for the second planting date (August 15th) in seed yield and recorded the highest mean (11.066-ton ha^{-1}), compared to the first planting date (August 1st) and third planting date, which recorded the lowest means of (10.258 and 10.246 ton ha^{-1}), respectively. This superiority is attributed to the availability of favourable environmental conditions during the flowering period, particularly moderate temperatures and high relative humidity, which helped improving the efficiency of the pollination and fertilization processes. These conditions positively impacted the physiological characteristics of the plant, leading to enhanced growth and increased total production. These results are consistent with what was reported by Aziz and Muhammad (2012). Regarding planting density, the first density (83,333 plant ha^{1}) showed a significant superiority and recorded the highest mean of seed yield (11.433 ton ha^{-1}), while means for second (71,428) and third (62,500) densities reached 10.675 and 9.461 ton ha^{1}, respectively. This superiority at high density is attributed to the increased number of plants per unit area, which led to a higher seed yield, despite the possibility of a lower yield per plant. These results are consistent with those reported by Arif et al. (2010), Rafiq et al. (2010), Dahmardeh (2011), and Fanadzo et al. (2010), who indicated that increasing planting density contributes to increasing seed yield per unit area. Regarding the interaction between planting date and plant density, the interaction between the second planting date and the first planting density recorded the highest seed yield rate of 12.062 tons ha^{-1}, while the lowest seed yield was 9.107 tons ha^{-1} from the interaction between first planting date and third planting density.

Table 10. Effect of autumn planting dates and planting density on seed yield (ton ha^{-1}).

planting density	planting date			plant density means
	First	**Second**	**Third**	
First	11.510 b	12.062 a	10.727 cd	11.433 a
Second	10.163 e	11.313 c	10.550 de	10.675 b
Third	9.101 h	9.822 fg	9.460 g	9.461 c
planting date mean	10.258 b	11.066 a	10.246 b	

Protein content (%).

The results of Table (11) indicated that second planting date (August 15th) was superior in seed protein content and recorded the highest mean of (9.84 %), significantly outperforming the other planting dates. Meanwhile, the first planting date (August 1st) yielded the lowest protein content of (8.78 %). This increase in protein content is attributed to the high temperatures during the grain filling period, which stimulated the rapid transfer of nitrogen from vegetative tissues to the grains, thus increasing their protein content. These results are consistent with what Al-Hadidi (2007) indicated. As for planting density, third planting density (62,500 plant ha^1) significantly outperformed in protein content and gave (9.66 %), while the first planting density (83,333 plant ha^1) yielded the lowest mean of (9.06%). This is attributed to reduced competition between plants at low density, which provided them with a better opportunity to utilize environmental resources such as nutrients, water, and light. This helped increase photosynthetic efficiency and enhance the formation and conversion of amino acids within the plant, thus increasing protein deposition in seeds. These results are consistent with the findings of Gomaa et al. (2014) and Shafey El and Zen el Dein (2016). Regarding the interaction between planting date and planting density, the interaction between second planting date and the third planting density recorded the highest protein percentage rate of 10.54%, while the lowest rate was 8.43% from the interaction between first planting date and first planting density.

Table 11. Effect of autumn planting dates and planting density on protein content (%).

planting density	planting date			plant density means
	First	Second	Third	
First	8.43 f	9.59 cd	9.17 d	9.06 c
Second	8.58 d	10.09 b	9.18 d	9.28 b
Third	9.34 d	10. 54 a	9.97 c	9.66 a
planting date mean	8.78 c	9.84 a	9.44 b	

Oil Content (%).

The results of Table (12) showed that second planting date (August 15th) significantly outperformed seed oil content and recorded the highest mean of (9.23%). Hence, first planting date (August 1st) recorded the lowest mean of (8.47%). This superiority is attributed to lower temperatures during seed filling stage, which led to a reduction in plant respiration rates and, consequently, increased carbohydrate accumulation, which are subsequently converted into fatty acids stored in the seed embryo (Liu et al., 2021). Third planting density (62,500 plant ha^{1}) significantly outperformed the first planting density (83,333 plant ha^{1}) and recorded the highest oil content of (9.20%), compared to the first planting density (83,333 plant ha^{1}), which recorded the lowest content of (8.47%). This is attributed to the optimal distribution of plants within a unit area at low density, which contributed to reducing competition between plants for essential environmental resources such as light, ventilation, and nutrients. This helped increase the total leaf area of plants, which led to improved photosynthetic efficiency and increased dry matter accumulation, which positively impacted the formation of fatty acids that make up the oil. These results are consistent with those reported by Al-Khazaali et al. (2013) and Al-Qaisi (2024). Interaction between second planting date and third planting density showed the highest oil content of (9.57%), while the interaction between first planting date and first planting density recorded the lowest rate of 8.11%.

Table 12. Effect of autumn planting dates and planting density on oil content (%).

planting density	planting date			plant density means
	First	Second	Third	
First	8.11 e	8.92 c	8.37 d	8.47 c
Second	8.42 d	9.19 b	8.91 c	8.84 b
Third	8.89 cd	9.57 a	9.14 bc	9.20 a
planting date mean	8.47 c	9.23 a	8.81 b	

CONCLUSION

The study results showed that the autumn planting date had a significant effect on most of the studied traits. The planting date (August 15th) yielded the best results in terms of growth, yield, and seed quality, confirming its suitability for autumn planting in the study area. It was found that a moderate plant density (71,428 plant ha^{-1}) improved many quantitative and qualitative traits, achieving a good balance between yield and quality in production. The interaction between planting date and plant density showed a significant effect on some traits, indicating the importance of balancing these two factors to achieve an optimal corn crop. It can be argued that choosing the appropriate planting date with a moderate plant density is a key factor in increasing production efficiency and improving seed quality in autumn maize planting.

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