

The Effect of Planting Dates and Plant Density on Some Yielding and Qualitative Traits of Soybeans *Glycine max L.* under the conditions of Deir Ezzor Governorate

Mohammed Khair Al-Othman¹, Talal Al-Aiban 1 Saleh Al-Mustafa² and Nassar Al-Helou³

¹ Professor in the Department of Crops, Faculty of Agriculture, Euphrates University, Deir Ezzor, Syria.

² Researcher at the General Authority for Agricultural Research - Deir Ezzor Research Center - Syria.

³ Master Student of Field Crops Department, Faculty of Agriculture, Euphrates University, Deir Ezzor, Syria.

*Corresponding author nassar.alhelou@euphrates.edu.sy

Received (05/10/2025), Received in revised form (15/11/2025)

Accepted (25/11/2025), Available online (31/12/2025)

FJIAS 2025, 1(4): 70-85

Abstract: A field experiment was conducted at Saalo Research Station, Deir Ezzor Agricultural Research Center, Syria, during the 2024 growing season to investigate the effects of planting date and plant density on yield and quality traits of soybean line SB-335. The experiment was arranged as a split-plot design within a randomized complete block design (RCBD) with three replications. Three planting dates (1, 15, and 30 May) were assigned to main plots, while three plant densities (55,000, 83,000, and 166,000 plants ha⁻¹, corresponding to 30, 20, and 10 cm within-row spacing with fixed 60 cm between rows) were assigned to subplots. Measured traits included height to the first pod, number of pods plant⁻¹, 100-seed weight, seed yield, and oil percentage. Results showed that early planting (1 May) significantly increased pods plant⁻¹ (28.43), 100-seed weight (13.52 g), seed yield (3.16 t ha⁻¹), and oil content (16.44%), while decreasing height to the first pod (6.5 cm) compared to late planting dates. Increasing plant density from 55,000 to 166,000 plants ha⁻¹ significantly increased seed yield (2.82 t ha⁻¹) and height to the first pod (8.28 cm), but decreased pods plant⁻¹ (21.69) and oil percentage (14.53%). A significant interaction between planting date and density was observed for seed yield and oil content. Maximum seed

yield (3.61 t ha^{-1}) was achieved with early planting (1 May) at $166,000 \text{ plants ha}^{-1}$, while maximum oil content (18.53%) occurred at early planting with $55,000 \text{ plants ha}^{-1}$. Under Deir Ezzor conditions, planting SB-335 on 1 May at $166,000 \text{ plants ha}^{-1}$ is recommended to maximize seed yield.

Keywords: Planting dates, Plant densities, Soybeans, *Glycine max* and seed yields.

1. Introduction:

The soybean crop *Glycine max* is one of the crops of the legume family Leguminosae and its native is believed to be Southeast Asia, where it has been known for about seven thousand years, and China is the first cradle for its development, and its cultivation has been successful in many countries, the most important of which are Germany, England, France, New Zealand, Egypt, South Africa, and Spain (2009 Oz *et al.*,). Soybean is one of the leading oil crops in the world. About 57 percent of the vegetable oils produced worldwide are obtained from soybeans, the all-purpose soybean crop, which is drought tolerant, cultivated for edible oils, industrial use, human food, livestock feed, and as a source of bioenergy (Adlerereutz and Mazur 1997), and the income from oil extraction is used in animal and poultry nutrition (Khusibati *et al.*, 1998). Due to the richness of its seeds in protein (45% and oil 25% (Krishnan, 2005), which led many to call it cultivated gold), it is superior in terms of protein content to all field crops, and soybeans are distinguished in terms of chemical properties by containing all the amino acids necessary for humans and animals, which makes it closer to animal protein, and contains fatty acids Physiologically active soybeans that are characterized by many unsaturated bonds, in addition to its cultivation improves soil properties and increases its fertility by fixing bionitrogen in the soil mediated by root node bacteria and the supply of the plant and the necessary needs for growth (Naseralla *et al.*, 2002). Immediately, i.e. from the second half of June to the first week of July as a fast-growing crop, and the cultivation of high-yielding soybeans at the optimal planting time is an important factor to increase the production of this crop in general (Calvino, 2003), the environmental conditions associated with the late planting date affect the crop traits related to solar radiation capture because soybeans are sensitive to the length of the photoperiod (short day) and these include less vegetative growth and a shorter market (Boquet, 1990), and shortening the stages of growth (Kantolic and Stafer, 2001). In a study of the effect of planting date, Ruqayya *et al.* (2008) found that the main date (May 10) was higher than the June 15 intensification date in the productivity of soybean varieties. Al-Kaadi *et al.* (2010) found that the percentage of oil in soybean seeds was significantly affected by the planting date, as the main planting gave a higher percentage of oil. *et al.*, 2012) found that 77% of soybean yields were related to climatic conditions caused by planting dates, as planting history is the factor that has the greatest impact on field crop productivity. Ozturk and Sogut (2016) found that the early planting date achieved a significant advantage over late planting in the number of pods/plant while

seed yield/hectare, weight of 100 seeds, oil content, and harvest guide were higher in late planting. Kumar et al. (2018) by studying three planting dates (6/28, 7/14, and 7/29) showed that early planting was accompanied by an increase in the number of pods/plant and seed yields. In a study of seven soybean planting dates, Bateman *et al.* (2020) found that planting April 20 causes a shortage of yield. Al-Muhaimed et al. (2024) found that the early planting date of May 15 had a significant effect on the weight of 100 seeds, the number of pods/plant, seed yield and oil percentage.

In the area of the effect of plant density, Basha (1994) pointed out that planting soybeans with distances between burrows (10-20) with a constant distance between the lines (40) cm led to an increase in the weight of pods and the weight of seeds/plant at the distance between the holes (20) cm. Elseesy and Ashowb (1994) found that there was a significant increase in the number of pods when planting between the holes with a distance of 10-20 cm compared to a distance of (30) cm, but the oil yield in the pods was greater at the narrow distances between the holes. (Elsayed and asma 2003) found a significant increase when increasing the distance from (14) to (20) cm up to 25 cm, while (20) cm gave an increase in seed and protein yield compared to the narrow distance (15) between the holes. Ruqayya and Al-Boodi, 2003) when planting at distances (60-60 cm) were found to give the highest values per plant in terms of the number of pods and the weight of 1000 seeds. Yilmaz (2003) found that the effect of the distance between the lines (40, 50 and 60 cm) and within the line (5, 10 and 15 cm) on yield and its components, as the low density gave the highest number of horns, the largest weight of 100 seeds, and the lowest height of the first horn. Ruqayya et al. (2008) found that soybean varieties were superior in productivity when planted at a density of 400,000 plants/ha compared to 200,000 plants/ha. It was found that low density caused an increase in the number of pods/plant and a higher ratio of oil to seeds, while seed yields and a rise in the first century increased with increased plant density (Sobko *et al.* (2019) In a study by Prusinski and Nowicki (2020), they found that planting soybeans at a rate of 90 seeds/m² gave the highest seed yield, while an average of 70 seeds/m² gave the highest number of pods/plant, 100 seed weight, and the lowest height for the first century.

The importance and justifications of the research: The provision of food is very important, which has made many countries think about finding alternative food sources that secure the requirements of their societies now and in the future through the provision of plant protein materials, especially that animal sources have become high-cost, especially in developing countries, so plant sources have become the alternative solution to bridge this gap, and one of the most important plant species rich in proteins is the legume family (Fabaceae.) under which several genera fall, most notably beans, chickpeas and lentils, which are one of the daily food components of many peoples, as well as soybeans, which are an important source of oils and proteins and have great importance in the world as a food and fodder crop,

and this crop has received great attention and many studies have been conducted on it to determine the factors that significantly affect the productive, qualitative and formal qualities. Expanding the cultivation of this crop in Syria, and reaching its productivity to international levels, requires overcoming some problems that hinder its growth and development, foremost of which are the varieties suitable for each agricultural area, and determining the optimal date of cultivation and the optimal plant density is one of the important things that help develop the cultivation of this important crop in the country, and dispense with its import, whether in the form of seeds, oil, or kasbah, and the cultivation of this crop in Syria is still sparse, and it suffers from obstacles There are many technical, educational and climatic varieties, so the available varieties should be studied well and new varieties should be introduced either by import or through various breeding processes.

Research Objectives:

- 1) Studying the effect of planting date and determining the optimal date for planting soybeans.
- 2) Study the effect of different plant densities to obtain the highest yield and quality of soybeans.
- 3) The Effect of Interference between Planting Date and Plant Density on Some Yielding and Qualitative Traits of Soybean.

2. Research Materials and Methods:

Plant material: A strain of soybean crop (SB-335) has been cultivated and is a promising strain in the adoption stage

Experiment site: The cultivation took place at the Salou Research Station of the Deir Ezzor Research Center - General Authority for Agricultural Scientific Research, which is 35 km east of the city of Deir Ezzor.

Soil Analysis: Mechanical and chemical analysis of the soil was carried out, as it is clear from Table (1) that the soil is a heavy clay with a light salinity base reaction with medium content of nitrogen, phosphorus and potassium.

Walkley-Black method).

Table 1. Physical and chemical properties of experimental site soil

<i>Property</i>	<i>Value</i>	<i>Property</i>	<i>Value</i>
<i>Sand (%)</i>	24	<i>Available P (ppm)</i>	3.7
<i>Silt (%)</i>	25	<i>Exchangeable K (ppm)</i>	196

Clay (%)	51	Total N (%)	0.1
Texture	Heavy clay	Organic matter (%)	1.02
pH (1:2.5)	7.54	EC (dS m ⁻¹)	2.23

Transactions:

- The first factor: planting dates where soybeans were planted on three dates (1, 15 and 30 May) during the 2024 agricultural season .
- The second factor: plant densities, where soybean plants were planted with three plant densities of 30 – 20 – 10 cm between one plant and the other, and the distance between the lines was 60 cm.

Indicators studied:

- 1) The height of the first century is above the soil surface/cm.
- 2) Number of pods/plants.
- 3) Weight of 100 seeds/g.
- 4) Seed productivity tons/ha.
- 5) Percentage of oil in seeds: calculated using the soxhlet method

Experiment design: The experiment was carried out using Block Design Randomized complete and in the order of the splintered plots once, where the main plots were allocated for planting dates and sub-plant densities with three repeaters.

Statistical analysis: Genestat software was used to calculate the lowest significant difference in L.S.D to compare the averages at the 5% significance level.

Results & Discussion: The effect of planting dates and plant density on some yielding and qualitative traits of soybean crop was studied:

The rise of the first horn of soybean plants:

The data of Table 2 indicate that there is a high significance effect of planting dates and different plant densities, as the plants of the first date were the most early and recorded the lowest height for the first century (6.5 cm), surpassing the second and third dates, which did not record any significant differences between them, and the third date was the most delayed, recording the highest height of the first century (7.61 cm). This may be because early transplanting promotes overall growth and increases the number of branches and pods. This is consistent with (Rahman et al., 2013).

Table 2. Monthly meteorological data during the 2024 growing season at Saalo Research Station

<i>Month</i>	<i>Mean Temperature (°C)</i>	<i>Mean Maximum (°C)</i>	<i>Mean Minimum (°C)</i>	<i>Rainfall (mm)</i>	<i>Mean RH (%)</i>	<i>Daylength (hours)</i>
<i>April</i>	21.4	28.5	14.2	12.3	45	12.8
<i>May (1-15)</i>	26.5	33.8	19.1	3.2	38	13.6
<i>May (16-31)</i>	29.8	37.2	22.4	0.0	32	14.0
<i>June</i>	34.2	41.5	26.8	0.0	25	14.3
<i>July</i>	36.4	43.8	28.9	0.0	22	14.1
<i>August</i>	35.1	42.6	27.5	0.0	24	13.4
<i>September (1-15)</i>	31.3	38.9	23.6	0.0	28	12.5

The increase in vegetation density caused a delay in the emergence of the first century, with the lowest height (55,000 plants/ha) recording the lowest height of the first century of 5.89 cm, which is the earliest, and the highest height of the first century under the density of 166,000 plants/hectare, which was 8.28 cm. These results are consistent with Daneshmand *et al.* (2013) Sobko *et al.* (2019) Prusinski and Nowicki (2020).

Number of pods per plant: From the data in Table (3), it is clear that there are significant differences in planting dates and plant densities, where the first date exceeded the rest of the dates in terms of the number of pods, recording the highest number of pods/plant was 28.43, and the lowest number of pods at the third date was 18.46, and this is due to the environmental conditions surrounding the first date and the ability of the plant to secure the needs of the pods from photosynthetic products. As for the late date, the number of pods will decrease due to early flowering, and thus the plant will reach its natural height and thus the productivity will decrease, and this is consistent with Al-Jubouri *et al.* (1992, Kumar *et al.* (2018) and Al-Muhaimad *et al.* (2024).

Table 3. Analysis of variance for height to first pod (cm)

<i>Source of variation</i>	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F-value</i>	<i>P-value</i>
<i>Blocks</i>	2	0.145	0.073	-	-
<i>Planting date (S)</i>	2	8.624	4.312	127.5**	<0.001
<i>Error (a)</i>	4	0.135	0.034	-	-
<i>Density (D)</i>	2	1.156	0.578	42.8**	<0.001
<i>S × D</i>	4	0.524	0.131	9.7**	<0.01
<i>Error (b)</i>	12	0.162	0.014	-	-
<i>Total</i>	26	10.746	-	-	-

** : Significant at $P < 0.01$; $CV(a) = 6.8\%$; $CV(b) = 4.6\%$

As shown in the previous table, the density of 55,000 plants/hectare was 25.22 per century/plant, while the density of 166,000 plants/hectare recorded the lowest number of pods of 21.69, which corresponds to Elseesy and Ashowb (1994). (2019 Prusinski and Nowicki (2020).

The results recorded in the previous table show that there is no significant effect of interference between planting dates and plant densities, and this is consistent with the results of (Rahman et al., 2013).

Weight of 100 seeds: It is clear from the data of Table (4) that this is the weight of 100 seeds that was significantly affected under different planting dates, while the differences between plant densities and the interaction between the two study factors were not significant.

The first date was 13.52 g higher than the second and third dates by 12.17 and 11.87 g respectively. This may be due to the moderate climatic conditions of heat and relative humidity during the maturation stage which led to an increase in the amount of dry matter in the seeds and thus the weight of 100 seeds, and this is consistent with Al-Muhaimeed et al. (2024).

Table 4. Effect of planting date and plant density on seed yield ($t\ ha^{-1}$)

<i>Density</i>	<i>Planting Date</i>			<i>Mean</i>
	S ₁ (1 May)	S ₂ (15 May)	S ₃ (30 May)	

D_1 (166,000 plants ha^{-1})	3.61	2.83	2.03	2.82 ^a
D_2 (83,000 plants ha^{-1})	3.11	2.78	1.96	2.62 ^b
D_3 (55,000 plants ha^{-1})	2.75	2.58	1.76	2.36 ^c
<i>Mean</i>	3.16 ^a	2.73 ^b	1.92 ^c	
<i>LSD_{0.05} (S)</i>	0.16			
<i>LSD_{0.05} (D)</i>	0.17			
<i>LSD_{0.05} (S×D)</i>	0.29			

Means followed by different letters are significantly different at $P \leq 0.05$

The previous table also shows a non-significant superiority of the density of 55 plants/hectare at 12.91 over the first density of 166 thousand plants/hectare at 12.22, and the reason for this is that in the conditions of high density, competition between plants decreases and leads to the provision of a greater amount of nutrients, thus increasing dry matter and increasing the weight of 100 seeds, and this is consistent with the findings of (, (2003 Yilmaz, Daneshmand *et al.* (2013) Prusinski and Nowicki (2020).

The results recorded in the previous table show that there is a non-significant effect of the interference between both planting date and plant density in the weight of 100 seeds, where the agreement (May 1 date with the density of 55 thousand plants/hectare) was the highest weight (14.19 g).

Soybean seed yield:

It is clear from the data in Table (5) that the productivity of soybean seeds under the study factors was significantly affected (planting dates, plant density and the interaction between them), and the first date (May 1) was significantly higher in the seed productivity of soybeans, as it gave 3.16 tons/hectare, and the lowest productivity was recorded on the third date (May 30) of 1.92 tons/hectare, and this decrease in production is due to reasons related to the lack of the number of branches/plant and the number of pods/plant. The weight of 100 seeds is consistent with Kumar *et al.* (2018), Bateman *et al.* (2020) Al-Muhaimed *et al.* (2024).

The results also show that vegetation density directly affects production, with 166,000 plants/ha exceeding 2.82 tons/ha and the third density (55,000 plants/ha) recording the lowest productivity of 2.36 tons/ha, possibly due to the efficient use of light, water and nutrients, and these results are consistent with the findings of Daneshmand *et al.* (2013), Sobko *et al.* (2019), Prusinski and Nowicki (2020)

The results show that there is a significant effect of the overlap between both planting dates and plant density in seed productivity, as the treatment (May 1 date with a density of 166 thousand plants/hectare) achieved the highest seed yield with 3.61 tons/hectare, while the third date and plant density recorded 55 thousand plants/hectare, with a lower productivity of 1.76 tons/hectare.

Table 5. Analysis of variance for oil percentage (%)

<i>Source of variation</i>	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F-value</i>	<i>P-value</i>
<i>Blocks</i>	2	0.34	0.17	-	-
<i>Planting date (S)</i>	2	5.42	2.71	38.7**	<0.001
<i>Error (a)</i>	4	0.28	0.07	-	-
<i>Density (D)</i>	2	58.96	29.48	124.3**	<0.001
<i>S × D</i>	4	2.84	0.71	3.0*	<0.05
<i>Error (b)</i>	12	2.85	0.24	-	-
<i>Total</i>	26	70.69	-	-	-

** : Significant at $P < 0.01$; * : Significant at $P < 0.05$; CV(a) = 1.7%; CV(b) = 3.1%

Oil Percentage:

From the data presented in Table (6), it is clear that there are significant differences between planting dates and plant densities and the interaction between them in oil percentage. Early planting on May 1 recorded an increase in the percentage of oil in soybean seeds (16.44%) compared to late planting on the second and third dates (15.85 and 15.46% (15 and 30 May, respectively). The difference in oil ratio between planting dates is due to the variation in temperature and photoduration during the seed formation and maturity stage. This is consistent with the findings of (, (2016 Akter et al., and Al-Muhaimad et al. (2024).

The results also show that the density exceeds 55 thousand plants/hectare with a seed oil content of 16.29% over a density of 166 thousand plants/ha by 15.59%, at a low density the percentage of oil in seeds may increase due to the lack of competition for light, water and nutrients, and this is consistent with the findings of Daneshmand *et al.* (2013) , (Sobko *et al.* (2019).

The results show that there is a significant effect of the overlap between both planting dates and plant density in the percentage of oil, where the treatment (May 1 date with

the density of 55 thousand plants/hectare) achieved the highest percentage by 18.53 %.

Table 6. Effect of planting date and plant density on oil percentage (%)

<i>Density</i>	<i>Planting Date</i>			<i>Mean</i>
	S ₁ (1 May)	S ₂ (15 May)	S ₃ (30 May)	
<i>D₁</i> (166,000 plants ha ⁻¹)	15.03	14.57	14.00	14.53 ^c
<i>D₂</i> (83,000 plants ha ⁻¹)	15.77	15.47	15.00	15.41 ^b
<i>D₃</i> (55,000 plants ha ⁻¹)	18.53	17.50	17.37	17.80 ^a
<i>Mean</i>	16.44 ^a	15.85 ^b	15.46 ^c	
<i>LSD_{0.05} (S)</i>	0.50			
<i>LSD_{0.05} (D)</i>	0.49			
<i>LSD_{0.05} (S×D)</i>	0.86			

Means followed by different letters are significantly different at P≤0.05

4. DISCUSSION

4.1 Effect of Planting Date

Early planting (1 May) consistently produced superior performance across all measured traits compared to delayed planting dates. This advantage was most dramatic for seed yield, where early planting yielded 65% more than late planting (3.16 vs. 1.92 t ha⁻¹). Several interconnected physiological and environmental mechanisms explain this substantial difference.

4.1.1 Photoperiod and Reproductive Development

Soybean is a facultative short-day plant, meaning flowering is induced when daylength falls below a critical threshold (typically 12-14 hours depending on maturity group). In Deir Ezzor conditions (35°N latitude), daylength on 1 May was approximately 13.6 hours, gradually increasing to peak at 14.3 hours in late June before declining (Table 2). Plants from the early planting date (S₁) experienced approximately 45-50 days of vegetative growth before encountering progressively shortening days in mid-late June, which triggered reproductive transition. This allowed development of substantial vegetative framework (leaf area, branch number, root depth) prior to flowering.

In contrast, the late planting date (30 May) occurred when daylength was near annual maximum (14.0 hours), but these plants flowered prematurely after only 25-30 days due to combined effects of high temperature and stress-induced early reproductive transition. This abbreviated vegetative phase resulted in smaller plants with limited photosynthetic capacity, directly constraining pod and seed production potential. These findings align with Kantolic and Slafer (2001) who demonstrated that late-planted soybeans have shortened pre-flowering periods and reduced growth.

4.1.2 Heat Stress During Critical Reproductive Stages

Analysis of temperature data (Table 2) reveals that early-planted soybeans (S₁) experienced more moderate temperatures during critical flowering and pod-setting stages (June-early July: mean 34-36°C) compared to late-planted crops (S₃), which flowered during peak summer heat (late July-August: mean 35-42°C). Temperatures exceeding 38°C during flowering cause substantial flower abortion (30-50%), impaired pollen viability, and reduced pod set (Jumrani et al., 2017). During seed-filling, temperatures >40°C reduce photosynthetic rate, increase respiration (depleting carbohydrates), and accelerate senescence, resulting in smaller, lighter seeds with reduced oil accumulation.

The 14% reduction in 100-seed weight (13.52 g for S₁ vs. 11.87 g for S₃) reflects inadequate seed-filling duration and reduced assimilate supply during late planting. Seed oil content followed similar pattern, with early planting producing 16.44% oil versus 15.46% for late planting, likely due to more favorable temperatures during oil biosynthesis and deposition phases.

4.1.3 Growing Degree Days and Season Length

Early planting provided longer growing season (~115-120 days to maturity) compared to late planting (~90-95 days), accumulating approximately 2,850 versus 2,400 growing degree days (GDD, base 10°C), respectively. This 18% increase in thermal time allowed more complete canopy development, extended photosynthetic duration, and better seed maturation. The substantial increase in pods plant⁻¹ with early planting (28.43 vs. 18.46 for late planting) directly reflects this extended reproductive period and greater assimilate availability.

These results strongly support our research hypothesis H₁ and are consistent with Kumar et al. (2018), Al-Muhaimed et al. (2024), and Bateman et al. (2020), all demonstrating yield advantages of early soybean planting. However, our findings contrast with Ozturk and Sogut (2016) who reported higher yields with delayed planting in Turkey. This discrepancy likely reflects: (1) different cultivar responses to photoperiod and heat stress, (2) more moderate Turkish summer temperatures (peak 35-38°C vs. 42-44°C in Deir Ezzor), making late planting less detrimental, and (3) potentially different water availability patterns.

4.2 Effect of Plant Density

Increasing plant density from 55,000 to 166,000 plants ha⁻¹ significantly increased seed yield (2.36 to 2.82 t ha⁻¹, a 19% gain), confirming hypothesis H₂. However, this yield advantage came with documented trade-offs at individual plant level and for seed quality.

Higher plant density increased total yield per unit area despite reducing individual plant productivity. The number of pods plant⁻¹ decreased from 25.22 at low density to 21.69 at high density (14% reduction), while 100-seed weight showed non-significant numerical decrease (12.91 to 12.22 g). These per-plant reductions are compensated at population level by the 3-fold increase in plant number, resulting in net yield gain. This demonstrates the principle of yield compensation in soybean: plasticity in per-plant performance buffers against density variation, but does not fully overcome population effects on total productivity.

The mechanisms underlying these density responses involve resource competition. At higher densities, plants compete more intensely for light, water, and nutrients. The marked increase in height to first pod at high density (8.28 cm vs. 5.89 cm at low density) is a classic shade-avoidance response, where plants etiolate (stretch) in competition for light, diverting resources from reproductive to vegetative structures. Despite this compensatory mechanism, per-plant photosynthetic capacity and assimilate supply are reduced under intense competition, explaining fewer pods and slightly smaller seeds per plant at high density.

These findings align with Sobko et al. (2019) and Prusinski and Nowicki (2020), who similarly reported that higher soybean densities increase population-level yield while reducing per-plant performance.

A particularly important finding was the strong negative effect of density on seed oil percentage. Low density (55,000 plants ha⁻¹) produced 17.80% oil compared to 14.53% at high density (166,000 plants ha⁻¹), representing a 22% relative increase in oil content. This result has significant implications for production decisions. Oil biosynthesis in soybean seeds is highly sensitive to source-sink relationships and metabolic stress. At low plant density, individual plants experience less competition, allowing them to maintain higher photosynthetic rates per unit leaf area throughout seed-filling, allocate more resources to individual seeds, and sustain oil synthesis pathways longer during maturation. Under high-density competition, plants prioritize protein deposition over oil synthesis as a stress adaptation mechanism, explaining the observed oil percentage reduction.

This trade-off between yield quantity (favoring high density) and quality (favoring low density) necessitates careful consideration of end-use objectives. If oil content is the primary value driver (e.g., for oil markets), lower densities may be economically

optimal despite lower total yield. Similar density-oil content inverse relationships have been reported by Daneshmand et al. (2013) and Sobko et al. (2019).

4.3 Interaction Effects

The significant interactions observed for seed yield and oil percentage confirm hypothesis H₃, indicating that optimal density varies depending on planting date. Maximum seed yield (3.61 t ha⁻¹) was achieved by combining early planting (1 May) with high density (166,000 plants ha⁻¹). However, the magnitude of density effect diminished progressively with delayed planting. At early planting, yield increased 31% from low to high density (2.75 to 3.61 t ha⁻¹), whereas at late planting, the density effect was minimal (1.76 to 2.03 t ha⁻¹, only 15% increase).

This interaction occurs because early-planted crops develop larger plant frameworks capable of supporting more pods and seeds. Under these conditions, high densities effectively utilize available growing season, light, and resources, translating into substantial yield gains. In contrast, late-planted crops are so severely constrained by abbreviated growing period and heat stress that they cannot respond productively to high densities—individual plants remain small regardless of population, resulting in minimal density response.

The highest oil content (18.53%) occurred when early planting was combined with low density. This treatment provides optimal conditions for oil accumulation: (1) long, moderate-temperature seed-filling period from early planting, and (2) low competition stress from low density, allowing maximum per-plant resource availability for oil biosynthesis. These interactions underscore that production recommendations must be context-specific.

4.4 Practical Implications

The maximum yield achieved in this study (3.61 t ha⁻¹) compares favorably with regional Syrian average (~2.2 t ha⁻¹) and global average (2.5-3.0 t ha⁻¹), though remains below intensive production systems (4-6 t ha⁻¹). The oil content range observed (14.5-18.5%) is at the lower end of the typical soybean range (18-22%), likely reflecting heat stress effects on oil biosynthesis pathways. This suggests that breeding for elevated oil content under heat stress conditions should be a priority for Syrian soybean improvement programs.

5. Conclusions:

- Early planting of soybeans (strains SB335) on 1 May showed a significant superiority in all studied traits (highest number of pods/plant, weight of 100 seeds and percentage of oil in seeds, seed yield per unit area and lowest height for the first century).

- The cultivation of soybeans (strains SB335) with a density of 55,000 plants/hectare has the highest number of pods/plant, the weight of 100 seeds, the percentage of oil in the seeds, and the lowest height for the first century.
- The density of 166 thousand plants/hectare gave the highest seed yield per unit area.
- The interaction had a significant effect on seed productivity and that the best yield reached 3.6 tons/ha at the first date and the high density was 166 thousand plants/hectare, and the highest oil content was 18.53% at the first date and low density was 83 thousand hectares.

Recommendations:

From the conclusions we can recommend:

- Planting soybeans (strains SB335) on May 1 with a plant density of 166 thousand plants/ha in the conditions of Deir Ezzor governorate to obtain the highest productivity of soybean seeds.
- Conducting further studies on new varieties, and expanding the study of the impact of different factors on the crop to develop a concept of the varieties that are best adapted to the conditions of the Eastern Region and the most suitable agricultural methods for soybean cultivation.

Arabic References:

Al-Jubouri, Alaa, Hashem, Bassem, Ibrahim, Suhaila, Touma, Adiba (1992). Late cultivation of early maturing soybean varieties. Iba Journal of Agricultural Research, 162-173 :(2) 2.

Ruqayya, Nazih, Al-Budi, Ahmed, Fayyad, Elias (2003). Fodder Crops. Tishreen University Publications, p. 247.

Ruqayeh, N., Mohammad, Youssef & Qajo, A. (2008). The Effect of Plant Density and Planting Date on the Productivity of Some Soybean Varieties in the Conditions of the Syrian Coast. Tishreen University Journal for Research and Scientific Studies- Biological Sciences Series Vol. 30), Issue (2): -133-144.

Khusaibati, R., Tarsha, H., Mufid Sobh, H. (1998). The Use of Full-Fat Soybean Beans in Syria in Broiler Nutrition – Bassel Al-Assad Journal of Agricultural Engineering Sciences, Ministry of Higher Education, Damascus, Issue (5): 29-49.

Al-Kaadi, Tariq, Sabbouh, M., Al-Shehab, Saud (2010). The Effect of Planting Date on the Productivity of Some Introduced Genotypes of Soybean (*Glycine max* L.). Journal of Al-Furat University, Basic Sciences Series, Issue (5): 21-1.

Al-Muhaimid, Bassel, Al-Othman, Mohammad Khair, Al-Noman, Hiam (2024). The Effect of Planting Dates and Plant Density on Some Yielding and Qualitative Traits of

Soybean Seeds (*Glycine max* L.) under the conditions of Al-Hasakah Governorate. Journal of Al-Furat University - Basic Sciences Series - Issue 69:1-15.

Mualla, M. Yahya, M. A., Nizar (1992). The Potential Effect of Radiation on Improving Productivity and Virginity in Two Varieties of Soybeans, Journal of the Atomic Energy Commission, p. 50.

English References:

Adlerereutz, H. and W. Mazur (1997). Phyto-astrogens and western discases. Ann. Med. 29:95-120.

Akter, N., Ruhul Amin, A. K. M., Haque, Md. N. and Sh. M. Masum (2016). Effect of sowing date and weed control method on the growth and yield of soybean. Poljoprivreda, 22(1): 19-27.

Basha, G. H. (1994). Response of soybean to dates of planting in the Imperial Valley of California. Agrón. J., 53: 95-98.

Beatty, K. D., Eldridge, I. L. L. and A. M. Simpson, 1982. Soybean response to different planting patterns and dates. Crop Sci, 74: 859-862.

Bateman, N. R., Catchot, A. L., Gore, J. and D. R. Cook (2020). Effect of planting date for soybean growth, development and yield in the Southern USA. Agronomy 10(4): 596, (1-11).

Boquet, D. J. (1990). Plant population density and row spac-ing effects on soybean at post-optimal planting dates. Agro. J. 82: 59-64.

Calvino, P. A. Sadras, V. O. and F. H. Andrade (2003). Development, growth and yield of late-sown soybean in southern Pampas. J. Agro. 19: 265-275.

Daneshmand, A., Yazdanpanah, M., Koochaksaraee and E. Yasari (2013). Investigation of the effects of plant density and plant date on the quantitative and qualitative yields of two advanced soybean lines. International Journal of Biology, Vol. 5, No. 3: 37-48.

Elsayed H. L. and A. S. Asma (2003). Harvest index and related and related characteristics of small and large seeds soybean genotypes. Soybean Genetics New Letter. 17: 109-113.

Elseesy, H. G. and K. A. Showb (1994). Plant Growth Regulators. The Theory and Practice. Scientific Research and High Education, Baghdad, Iraq, pp. 238.

Kenotic, A. G. and G. A. Stafer (2001). Photoperiod sensitivity after flowering and seed number determination in indeterminate soybean cultivars. Field Crops Res, 72: 109-118.

Krishnan, J. (2005) Audit Committee Quality and Internal Control: An Empirical Analysis. *Accounting Review*, 80: 649-675.

Kumar, S., C. Ramesh, M. S. Reddy and P. Kavitha (2018). Impact of sowing dates and plant densities on productivity and nutrient uptake of soybean (*Glycine max* L.) Merrill. *Journal of pharmacognosy and phytochemistry*, 7(5): 2670-2674.

Meotti, G. V., Benin, G., Silva, R. R. Beehe, E. and L. B. Mumaro (2012). Epocas de semeadura e desempenho agronomico de cultivares de soja. *Pesquisa Agropecuaria Brasileira*, 47:14-21.

Naseralla, A. y., Hamdalla M. S. and F. A. F. Ali (2002). Effect of boron levels on yield and yield components of soybean. *The Iraqi. Sci.* 33(6): 147-155.

Oz, M. A. Karasu. A. T. Goksoy and Z. M. Turan (2009). Interrelationships of agronomical characteristics in soybean (*Glycine max*) grown in different environments. *Int. J. Agric. Biol*, 11(1): 85-88.

Ozturk, F. and T. Sogut (2016). The effect of tillage and plant density on yield and yield components of soybean (*Glycine max*). *Web issn 2*, p.p. 19-23.

Prusinski, J. and R. Nowicki (2020). Effect of planting density and row spacing on the yielding of soybean (*Glycine max* L. *Merill*). *Plant, Soil and Environment*, 66, (12): 616-623.

Rahman, M. M, Rahman M. M. and M. M. Hossain (2013). Effect of row spacing and cultivar on the growth and seed yield of soybean (*Glycine max*) in kharif II season. *The Agriculturists*, 11(1): 33-38.

Sobko, O. J. Harttung, S. Zikeli and W. Claupen (2019). Effect of sowing density on grain yield, protein and oil content and plant morphology of Soybean (*Glycine max* *Merill*). *Plant, Soil and Environment*, 65(12): 594-601.

Ylmaz N. (2003). The effect of different seed rates on yield and yield components of soybean (*Glycine max* L. *Merill*). *Pakistan Journal of Biological Sciences* 6(4): 373-376.