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Response of Sunflower (*Helianthus annuus* L. *cv* Shumoos) to foliar spray of ethephon and plant densities

Mohammed Altefat Abbas and Hayder Abdul Hussain Mohsen Almughir

Department of Field Crop Sciences, College of Agriculture, Al-Muthanna University, Iraq.

Email: agrcr.grad.mohamed2122@mu.edu.iq

Email: haider_amm3@mu.edu.iq

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Abstract:

A field experiment was carried out during the spring season of 2023 in Al-Muthanna Governorate, located at longitude 31.586 and latitude 45.131, to determine the study of different plant densities and ethephon spraying with their interaction on the yield and size of sunflower seeds (Shamus variety). The experiment was implemented using a randomized complete block design (R.C.B.D) according to a split plot design and with three replications. The main plots included four levels of ethephon (0, 600, 1200, and 1800) ppm, which has the symbols E0, E1, E2 and E3 respectively. The Sub Plot included four planting distances (20, 30, 40, and 50) cm among plants, which were symbolized as D1, D2, D3, and D4, respectively. The results showed a significant effect among plant densities among plants, the low density D4 was the highest mean in seeds number per disk (1632.26 seeds disk^{-1}), the individual yield (131.30 tons ha^{-1}), 1000 seeds weight (79.10 gm), and seed length (16.64 mm). The levels of ethephon differed significantly in different traits, The E3 level gave the highest mean for the individual yield (102.04 tons ha^{-1}) and 1000 seeds weight (68.48 grams), while E1 level gave the lowest mean for the individual yield (93.67 tons ha^{-1}), and 1000 seeds weight (61.49 gm), while there was no significant effect of the interaction between the two study factors for all traits.

Keywords: plant density, ethephon spraying, yield, seed size, sunflower (*Helianthus annuus* L.), (cv. Shumoos)

Introduction:

Sunflower non-oil *Helianthus annuus* L. is an important economic crop in the world, it has a high ability to withstand environmental conditions, belonging to the Compositae family. The original homeland of the sunflower is North and Central America. Its seeds are eaten by humans after being roasted, palatable and of high nutritional value. It contains proteins 16-18% and carbohydrates 5-7%, in addition to its content of elements such as iron, phosphorus, calcium, potassium, vitamins, and fiber [1]

The number of plants per unit area is one of the important factors in field management, it determines the form of the relationship between vegetative cover and seed yield per unit area. One of the reasons for the decrease in the area cultivated with sunflower crops in Iraq, it is the lack of outlets for receiving the crop by the state with regard to oily varieties and the lack of experience or knowledge of the high monetary value of low-oil varieties, which were used after roasting as cherries, provided that the seeds of this variety are large and plump, leads to an increase in its value and demand, showed great interest in using plant growth regulators to control crop growth, used a group of compounds called growth inhibitors, including ethephon [2]

Ethephon is a commonly used growth regulator on plants, its effect depends on the stage of plant growth and the timing of spraying, it works to release ethylene in plant tissues, therefore, it inhibits auxin in the stem, leads to a reduction in leg elongation [3]

The current study aims to demonstrate the effect of plant density and spraying with Althephon on the yield and seed size of the sunflower (Shamos variety) (*Helianthus annuus* L.).

Materials and Methods

The field trial was conducted in the spring of 2023 in the province of Muthana, located at 31.586 E longitude and 45.131 latitude, to study the effects of different plant densities and ethephon sprays and their interactions on the yield and size of sunflower seeds (variety Shumoos).

The experiment was conducted using a randomized complete block design (R.C.B.D) with three replications based on a split-plot design. The land was plowed, leveled, graded, and divided into experimental units according to the type of construction used. The experimental unit area (4 × 3 m), each experimental unit has 4 furrows, 4 m long, and the distance between the furrows is 75 cm. The experimental units were 1 m apart, and the blocks were 1 m apart. Samples were then randomly sampled from different locations in the experimental site at a depth of 30 cm, dried, ground, and then sieved through a special sieve. Sieve through a 2mm diameter sieve and mix evenly. Representative samples were collected before planting and subjected to physical and chemical analysis. The results are shown in Table (1).

Table (1) Physical and chemical analyzes of the soil used in the experiment.

Items		Value	Unit
pH		7.43	---
EC		2.36	ds m^{-1}
Organic Matter		0.51	gm kg^{-1} soil
Available Nitrogen		16.3	mg kg^{-1} soil
Available Phosphorus		14.8	mg kg^{-1} soil
Soil properties	Sand	6.55	gm kg^{-1} soil
	Clay	60.11	gm kg^{-1} soil
	Silt	33.37	gm kg^{-1} soil
Tex.		Clay loam	

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The land was planted in the spring season on 1/3/2023 with seeds of the Shumoos variety. Sow the seeds in holes 5 cm deep, 2-3 seeds per hole. The experimental plot was fertilized using the fertilization method, using urea fertilizer (46% N) as the nitrogen source, and the fertilizer was applied in two batches, the first batch after germination, and the second batch at the early stage of flower bud formation. Use heavy superphosphate (46% P2O5) as phosphorus source [4]. The field was irrigated after planting, then thinning was performed after emergence at the stage of 2-4 true leaves, leave only one plant in the hole, the process of serving the crop, including irrigation, hoeing, and manual weeding, was also carried out many times during the growing season. Irrigation was done according to the plant's need, and harvesting began Signs of full maturity occur when the underside of the disk turns yellow and the outer bracts begin to take on a brown color.

The experiment included studying the effect of the following factors:

The first factor:(note your desing split plot main plot represent the first factor) Plant density: Four densities (D) were used between plants (66666, 44444, 33333 and 26666), which are designated as D1, D2, D3 and D4, respectively.

The spraying ethephon: Using four levels of ethephon (0, 600, 1200 and 1800 ppm) and their symbols are E0, E1, E2, and E3, respectively.

Studied traits

Ten plants were randomly selected from the middle furrows for the purpose of calculating the following characteristics:

Seeds number in the disk (seed $disk^{-1}$): The seeds contained in the disk were counted after manually sorting them, which includes full seeds and empty seeds.

Individual plant yield (gm $plant^{-1}$): It was calculated by weighing the ten plant seeds harvested from each experimental unit, then an average was extracted after adjusting the weight based on 8% humidity.

1000 seeds weight (gm): It was calculated as 1000 seeds weight harvested from each experimental unit

and then the weight was adjusted based on a humidity of 8% (Al-Sahuki, 1994)

Seed length (mm): It was calculated using the Vernier caliper (Al-Sahuki *et al*., 1996).

Statistical analysis:

Data were analyzed using GenStat analysis software according to the design used in the experiment. Average values are calculated according to L.S.D. Comparison of. Tested at probability level 0.05 [7]

Results and discussion

Total seeds number in the disc (seed disc^{-1}):

Table (2) shows that planting at low plant density D4, significantly superior to other plant densities, by giving it the highest mean (1632.26 seeds disk^{-1}), compared to the densities D2 and D3, which were given 1363.22 and 1504.08 seeds disk^{-1}, respectively, compared to the high plant density, D1 recorded the lowest mean (1241.77 seeds disk^{-1}). The reason for the increase in the number of seeds in the flower disk may be due to the large distances, due to the lack of competition among plants for available growth factors, especially light during the flowering stage, leads, as a result, to an increase in the production of photosynthesis products, investing it towards increasing vegetative growth and raising the efficiency of the photosynthesis process, increasing its metabolites transferred to new sites of emergence during the reproductive stage of the plant, led to an increase in the efficiency of pollen grains and an increase in flower setting, which had a positive impact on preparing the emerging seeds with their requirements for processed food necessary for their sustainability, reflected in an increase in the number of seeds in the pink disc. This result agreed with the findings of [8].

By examining the table, it can be observed that the total amount of seeds in the tablet had no noteworthy impact on the levels of ethephon, as well as on the two examined factors.

Table (2) The effect of plant densities, levels of ethephon, and their interaction on the total seeds number in the disk (seed disk^{-1}).

Planting distances	Ethephon levels (E)				Mean
	E0	E1	E2	E3	

(D)					
D1	1227.73	1238.67	1234.20	1266.47	1241.77
D2	1402.13	1361.27	1324.70	1364.77	1363.22
D3	1464.27	1541.73	1540.53	1469.77	1504.08
D4	1602.63	1681.73	1612.73	1631.93	1632.26
Mean	1424.19	1455.85	1428.04	1433.23	
L.S.D	D	E	D×E		
0.05	55.152	N.S	N.S		

Individual plant yield (gm^{-1} plant):

Table (3) showed that there was an increase in individual plant yield with a decrease in plant density among plants, the low density D4 gave the highest mean (131.30 gm plant^{-1}), with a significant difference from the densities D2 and D3, which were given an average of 86.65 and 109.50 gm plant^{-1}, respectively, compared to density D1, which gave the lowest mean (64.96 gm plant^{-1}). The reason for the increase in the yield of an individual plant is the low plant density, there is no competition between parts of a single plant and between plants for the needs necessary for growth, leads to an increase in the amount of light that the plant receives, reflected in an increase in the efficiency of photosynthesis, an increase in the efficiency of transport of manufactured materials, and an increase in the accumulation of dry matter in the plant, led to an increase in the weight of 1000 seeds, and this leads to an increase in the yield of the individual plant. Consistent with [9].

Table (3) shows that there were significant differences between ethephon levels, The E3 level gave the highest mean (102.04 gm plant^{-1}), compared to level E1, which gave the lowest mean (93.67 gm plant^{-1}). This may be due to the increase in individual plant yield at the level of ethephon E3, to increase the number of leaves, leaf area, the efficiency of nutrient transfer, and increase the dry matter in the plant, led to an increase in the 1000 seeds weight, therefore, it led to an increase in the weight of the individual outcome, while there was no significant effect of the interaction between the two study factors on the individual plant yield trait.

Table (3) The effect of plant densities, levels of ethephon, and their interaction on individual plant yield (gm plant^{-1}).

Planting distances (D)	Ethephon levels (E)				Mean
	E0	**E1**	**E2**	**E3**	
D1	65.42	60.90	64.59	68.92	64.96
D2	85.91	82.32	87.51	90.86	86.65
D3	103.74	106.88	113.90	113.49	109.50
D4	129.21	124.57	136.55	134.88	131.30
Mean	96.07	93.67	100.64	102.04	

L.S.D	D	E	D×E
0.05	3.343	4.134	N.S

1000 seeds weight of (gm):

Table (4) The data shows a significant impact on the weight of 1000 seeds based on plant densities. The lowest density (D4) had the highest mean weight (79.10 gm), while D3 had a mean of 71.40 gm. D2 had a lower mean of 62.24 gm, compared to the highest density (D1) which had the lowest mean at 49.75 gm. This increase in weight at low plant density can be explained by the ample supply of resources available to each individual plant. With less competition, the plant is able to efficiently use metabolic materials and increase the rate of photosynthesis. This results in a higher amount of nutrients obtained by each plant, which is reflected in the larger leaf area per plant. This, in turn, leads to a more successful distribution of metabolites to a greater number of seeds, ultimately increasing the weight of 1000 seeds. These findings align with previous studies by [10] , [11] and [9]

The results in the same table also indicate that there is a significant effect when spraying with ethephon on the 1000 seeds weight, the high ethephon level, E3, gave the highest mean (68.48 gm), while the E1 level gave the lowest mean (61.49 gm). The reason for the increase in the 1000 seeds weight at the E3 level is attributed to the increase in the number of leaves and leaf area, leads to an increase in the availability of nutrients, which is reflected in an increase in the 1000 seeds weight, from the same table it is clear that the interaction effect between the two study factors was not significant for the 1000 seeds weight.

Table (4) The effect of plant densities, levels of ethephon, and their interaction on 1000 seeds weight (gm).

Planting distances (D)	Ethephon levels (E)				Mean
	E0	E1	E2	E3	
D1	51.64	47.28	48.53	51.57	49.75
D2	60.67	58.78	64.21	65.29	62.24
D3	69.31	67.81	72.81	75.67	71.40
D4	80.50	72.10	82.40	81.40	79.10
Mean	65.53	61.49	66.99	68.48	
L.S.D	D	E	D×E		
0.05	2.977	3.714	N.S		

Seed length (mm):

Table (5) indicates that there is a significant effect between plant densities on seed length, while ethephon levels and the interaction between the two study factors did not

have any significant effect on seed length. Low plant density significantly outperformed D4, it gave the highest mean (16.64 mm), superior to the densities D2 and D3, which gave us an average of 15.52 4.90 mm, respectively, compared to the high density D1, which gave the lowest mean (14.36 mm). The reason for the increase may be due to the lack of competition between plants at low plant density for nutrients, reducing the percentage of shading between plants, which led to an increase in the transfer of carbon metabolism inputs from the source to the downstream and their accumulation in the seed, it agrees with [12].

Table (5) The effect of plant densities, levels of ethephon, and their interaction on seed length (mm).

Planting distances (D)	Ethephon levels (E)				Mean
	E0	E1	E2	E3	
D1	14.03	14.00	14.37	15.03	14.36
D2	14.63	14.60	15.17	15.20	14.90
D3	15.30	15.27	15.63	15.87	15.52
D4	16.70	16.87	16.47	16.53	16.64
Mean	15.17	15.18	15.41	15.66	
L.S.D	D	E	D×E		
0.05	0.535	N.S	N.S		

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