Effect of Phosphorus Fertilization and Zinc Spraying on Productivity of Sesame (*Sesamum indicum* L.)

ABSTRACT

The research was carried out during the years 2023/2024 in Ain Al-Bayda Village, Lattakia, Syria to study the effect of phosphorus fertilization and zinc spraying on productivity of sesame by five different levels of phosphorus fertilization (0, 40, 60, 80, 100) kg P_2O/ha, and four concentrations of zinc spraying (0, 30, 60, 90) mg Zn_2SO_4/l.

The experiment was carried out according to a completely randomized plot design with a one-time split plot design and three replicates for each treatment. The main

plots included phosphorus fertilization, while the secondary plots included zinc spraying.
The results showed that the phosphorus fertilization level of 100 kg P_2O_5/ha was significantly superior to all other fertilization levels by the highest average for all traits, as it gave the highest value for number of capsules per plant (92.75 capsules/plant), length of the capsule (2.97 cm), number of seeds per capsule (78.53 seeds/capsule), weight of 1000 seeds (3.98 g) and seed yield (1253.60 kg/ha).
The zinc spray concentration of 90 mg Zn_2SO_4/l gave the highest value for number of capsules per plant (75.27 capsules/plant), weight of 1000 seeds (3.77 g) and seed productivity (1046 kg/ha), while the zinc spray concentration of 60 mg Zn_2SO_4/l gave the highest value for number of seeds per capsule (72.85 seeds/capsule) and length of the capsule (2.68 cm).
The intervention of 100 kg P_2O_5/ha x 90 mg Zn_2SO_4/l achieved the highest value for number of capsules per plant (96.22 capsules/plant), weight of 1000 seeds (4.13 g) and seed productivity (1357.30 kg/ha), while the intervention of 100 kg P_2O_5/ha x 60 mg Zn_2SO_4/l achieved the highest value for the two characteristics of number of seeds per capsule (79.63 seeds/capsule) and length of the capsule (3.03 cm).

Key words: sesame, phosphorus, zinc and fertilization.

1. INTRODUCTION

Sesame is an annual, self- pollinated plant, and is one of the oldest oilseed crops [1], and the species *Sesamum indicum* L. is the most important cultivated sesame species within the ~~sesame~~ family *Pedaliaceae* 2][.

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The cultivated area of sesame globally reached about 10 million hectares, with a productivity of 5.8 million tons/ha. The original homeland of sesame is Ethiopia, then it was transported to India and China [3].

The sesame plant is grown to obtain seeds, which are used in the manufacture of tahini, sweets and pastries. The percentage of oil in the seeds reaches (45-60%), protein (20-25%) and carbohydrates (15%). The product of pressing the seeds after extracting the oil is used in Animal diets [4].

Sesame oil has a long storage period, due to the presence of high levels of antioxidant compounds, including sesamin, sesamolin, and sesamol [5], which have a role in treating arthritis and osteoporosis [6], It inhibits cancer cells [7]. It also contains four main fatty acids: Palmatic, Stearic, Oleic, Linoleic [8]. Sesame oil is used in the formulation of some pharmaceutical products and pesticides [9]. Sesame flowers are used to treat alopecia and cancer, and its leaves are used to treat urinary infections [5].

Ranganatha [10] pointed out that unbalanced use of fertilizers and underutilization of nutrients is the main reason for the low productivity of sesame. Mangaraj *et al* [11] stated that the main factor for increasing crop productivity is improving agricultural management through proper management of nutrients. Improving the growth of many agricultural crops and increasing their productivity depends on proper mineral nutrition for these crops, since plants mainly need macronutrients in addition to micronutrients, in order to ensure the functioning of various biological and physiological processes within plants [12].

Despite the high medicinal and nutritional importance of the sesame crop, the increasing demand for vegetable oils, including sesame oil, and the quest to increase production per unit area, sesame cultivation in the coastal region suffers from many problems, the most important of which is the decline in the area cultivated with it, and the lack of studies on fertilizers and the required quantities, in particular phosphorus fertilization due to its scarcity in the soil of the research area. Therefore, our research aimed to study the effect of phosphorus and zinc on some productive characteristics of sesame plants, and to determine the treatment that gave the best productivity by studying the interaction between levels of phosphorus fertilization and spraying with zinc.

Phosphorus is a major nutrient, as it helps increase vegetative growth and dry matter accumulation [13], and increase root density [14]. Therefore, phosphorus is considered an essential element in determining plant productivity, and its content is usually in the soil. Insufficient for the plant due to its fixation by the soil15] [. Razaq *et al* [16]indicated that the plant needs an element phosphorus in high quantities because it works on: stimulating seed germination, developing roots, strengthening the stem and forming flowers, and it has a role in the synthesis of biomolecules and the formation of high-energy molecules, activating and inhibiting enzymes, and carbohydrate metabolism. Phosphorus is one of the important components of energy-rich compounds, including: (ATP, CTP, GTP, UTP). Phosphorus is necessary for protein synthesis as it is one of the components of nucleic acids. The availability of phosphorus increases the ability of leguminous plants to fix nitrogen.

Zinc contributes to many physiological processes in plants, and is considered one of the essential micronutrients as it participates in activating enzymes that create protein, starch formation, chlorophyll and carbohydrate formation, auxin production, protein stability, necessary for water absorption, helps the plant withstand low temperatures and affects Seed and market maturity rate. Zinc is also an essential component of the following enzymes: Carbonic anhdrolase, Alcohol dehydrogenase, Superoxide dismutase, Carboxy peptidase, Aldolase, RNA polymerase [17].

2. MATERIALS AND METHODS

2.1 Plant materials

Sesame seeds (white variety) were used in the research. The seeds were obtained from the Center for Scientific Agricultural Research, Lattakia, Syria. Its characteristics include: few branches, early maturity, white seeds, and clear, light-colored oil, which makes it desirable by consumers and commercially.

2.2 Location of research implementation:

The research was carried out during the 2023/2024 season, Lattakia, Ain Al-Bayda Village, and in the Laboratories of the Faculty of Agricultural - Field Crops Department and Soil Department - Lattakia University, Syria.

2.3 Soil analysis:

The site's soil was analyzed at the Scientific Agricultural Research Center in the Al-Hanadi region of Lattakia - Syria, shown in Table (1).

Table (1) Chemical and mechanical analysis of the experimental soil

PH	Carbonate % College	matter Organic %	mineral nitrogen ppm	available phosphorus ppm	available potassium ppm	mechanical composition		
						Sand %	Silt %	Clay %
7.9	56	2	7	5	199	25	22	53

The results showed that the site's soil is clayey, with a high content of calcium carbonate, a pH of alkaline, a sufficient content of organic matter, poor in phosphorus and nitrogen, and a moderate content of available potassium.

2.4 Preparing the soil for planting:

Two perpendicular plowing of the site's soil was carried out at a depth of (25-28) cm, then the soil was planned according to the experiment plan, and then the basic NPK fertilizers were added, where potassium was added in the form of potassium sulphate K_2O 51% all at once when preparing the land for planting at a rate of 100 kg K_2O/ha. Nitrogen: it was added in the form of 46% urea after planting in two batches, the first after separation and the second after branching, at a rate of 100 kg N/ha. phosphorus: it was added in the form of 46% triple super phosphate P_2O_5 at once when preparing the land for cultivation, according to five levels (0,40, 60, 80, 100) kg P_2O_5/ha. Zinc: was sprayed in the form of zinc sulphate Zn_2So_4 in two batches, the first at the start of sprouting, and the second twenty days after the first spray, according to four concentrations (0,30, 60, 90) mg Zn_2So_4/l.

2.5 Experiment design:

The research was conducted in a factorial experiment using a randomized complete block design (R.C.B.D.), and these plots were arranged using a split-plot design with three replicates. The main plots were allocated to phosphorus fertilization, and the secondary split plots were allocated to spraying with zinc.

The dimensions of the experimental plot were (2 x 2) m. It contained 4 lines, the distance between the lines was 50 cm, and the distance between plants was 20 cm was left at both ends of the plot without planting 25 cm, and service paths were left between adjacent plots at a distance of 50 cm. Between the three repeater sectors 100 cm. Seeds were planted on 1 May, at a rate of (3-4) seeds per hole. The number of experimental plots was 5 x 4 x 3 = 60 experimental plots, and the agricultural density = 100,000 plants/ha.

2.6 Studied characteristics:

Post-harvest productivity indicators of ten plants from each experimental plot were measured in three replicates and then averages were estimated.

2.6.1 Number of capsules per plant (capsules /plant): The number of capsules per plant was counted for ten plants from each replicate after harvest, then the arithmetic mean of the treatment was estimated.

2.6.2 capsule length (cm): The length of ten capsule of each plant (from the ten selected plants) was measured using the Beaculz device, and their average length, the average of one replicate, and one treatment were calculated.

2.6.3 Number of seeds in the capsule (seeds/capsule): Seeds were counted for ten capsule from each of the ten plants selected from each replicate, the arithmetic mean for one replicate was calculated, and then the average for one treatment was calculated.

2.6.4 1000 seed weight (g): After picking the capsules from the ten plants for each replicate, and separating the seeds from them, the number of 100 seeds for each replicate was counted, weighed with a sensitive balance, then the result was multiplied by 10, then the averages were estimated.

2.6.5 Seed productivity (kg/ha): Each plot was harvested individually, the average of each treatment was calculated from the average of the three replicates (adding the productivity of the ten plants), and then the productivity per hectare was estimated from the productivity of one plot.

2.7 Statistical analysis:

Data were collected and tabulated using the Excel, then statistical analysis was performed using the Gen stat-12 program, calculating the averages, the coefficient of variation (CV%), and the value of the least significant difference (L.S.D.) at the 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Number of capsules per plant (capsules/plant):

3.1.1 Effect of phosphorus fertilization on the average number of capsules (capsules/plant):

The results of Table (2) indicate that there are significant differences between all treatments, as increasing levels of phosphorus fertilization led to a significant increase in the number of capsules on the plant, and the highest average for this trait was achieved at the level of 100 kg/ha, when it reached (92.75 capsules/plant). While the lowest average for the control was (47.28 capsules/plant), This result was consistent with Priyadarshini *et al* [18], as it was found that increasing levels of phosphorus fertilization led to a significant increase in the number of capsules on sesame plants, reaching the highest value at the level of 40 kg P_2O_5/ha (49.80 capsules/plant), superior to lower levels (20, 30) kg/ha and the control, as shown by the results of Ibrahim *et al* [19] when adding several levels of phosphorus fertilization on sesame (0, 30, 60, 90) kg P_2O_5/ha, the level exceeded 90 kg P_2O_5/ha with the highest number of capsules on the plant (67 capsules/plant). Kumar *et al* [20] found that the level of 60 kg/ha exceeded the highest number of capsules (42.36 capsules/plant) when treated with four levels of phosphorus (15, 30, 45, 60) kg/ha on sesame plants. This increase The number of capsules is due to the role of phosphorus in providing the energy that the plant needs in the reproductive stage [21].

3.1.2 Effect of spraying zinc on the average number of capsules (capsules/plant):

The results of Table (2) showed that there were significant differences between most of the treatments, as increasing the levels of spraying with zinc led to a significant increase in the average number of capsules on the plant, and the maximum reached at the spray level of 90 mg/l (75.27 capsules/plant), and the lowest in the control (65.67 capsules/plant), and the differences were not significant between the two spray levels (60 and 90) mg/l. Jahan *et al* [22] showed that increasing levels of zinc fertilization led to an increase in the number of capsules on sesame plants. He used three levels (0, 2.5, 5)% in which the 2.5% level excelled (26.43 capsules/plant), while the lowest average was recorded in the control (22.49 capsules/plant). The differences were not significant between the two levels (0, 5)% as It decreased at the 5% level, and Bakry *et al* [23]showed that increasing levels of foliar spraying with zinc led to an increase in the number of capsules on Plant, as Omodian *et al* [24] found that adding zinc led to an increase in the number of capsules on the plant and this is due to the role of zinc in fertilization and pollen formation [25].

3.1.3 Effect of intervention phosphorus fertilization and spraying zinc on the average number of capsules (capsules/plant):

The intervention (100 kg/ha x 90 mg/l) achieved significant superiority over all other interventions with the highest average for the number of capsules on plant (96.22 capsules/plant), with the exception of the intervention (100 kg/ha x 60 mg/l), which gave (95.22 capsules/plant) and there were no significant differences between them.

Table (2) Effect of phosphorus fertilization and spraying zinc on the number of capsules in sesame:

Phosphorus levels kg P_2O_5/ha	Zinc concentrations mg Zn_2So_4/l				Average effect of phosphorus
	0	30	60	90	
0	41.89	45.56	50	51.67	47.28
40	45.78	58.11	63.44	65	60.33
60	66.33	70.56	75.22	75.11	71.81
80	77.78	85	89	88.33	85.03
100	87.56	92	95.22	96.22	92.75
Average effect of zinc	65.67	70.24	74.58	75.27	
LSD 5 %	zinc×Phosphorus 2.090	zinc 0.992	phosphorus 0.980		
CV %	1.0				

3.2 Length of capsule (cm):

3.2.1 Effect of phosphorus fertilization on the average length of the capsule:

The data presented in Table (3) showed that there were significant differences between all treatments. Increasing the levels of phosphorus fertilization led to a significant increase in the average length of the capsule, and the level of 100 kg/ha was superior to the rest of the levels. The highest value for the trait reached (2.97 cm) and the lowest level showed that there were significant differences between all treatments in the control (2.34 cm). Isa *et al* [26] conducted a study on sesame plants using three levels of phosphorus fertilizer (0, 20, 40) kg P_2O_5/ha and showed an increase in the length of the capsule when phosphorus was added at the level of 20 kg P_2O_5/ha (2.53 cm), then It decreased at the level of 40 kg P_2O_5/ha (2.47 cm) and the lowest value was reached in the control (2.39 cm). Shweta *et al* [27] obtained the highest capsule length (2.62 cm) in sesame plants when fertilizing at the level of 25 kg P/ha compared to the lower levels and the control (0, 15, 20) kg P/ha.

3.2.2 The effect of spraying with zinc on the average length of the capsule:

The results of Table (3) showed that there were significant differences between most of the treatments studied, as increasing levels of spraying with zinc led to a significant increase in the average length of the capsule and the spray level (60 mg/l) was superior to the rest of the levels, and the evidence was the highest average length of the capsule (2.68 cm). then it decreased again at the level of 90 mg/l (2.64 cm) which was significantly equal to the spray level of 30 mg/l, at which the length of the capsule reached (2.64 cm) and The lowest average for this trait was in the control (2.60 cm). Eifediyi *et al* [28] found that increasing zinc levels on sesame plants led to an increase in the length of the capsule, as the highest average length of the capsule reached (3.52 cm) at the level of 15 kg Zn_2So_4/ Compared with the lower levels (5, 10) kg Zn_2So_4/ha and the control, the increase in the length of the capsule when using zinc fertilizer is due to the role of zinc in plant cell division and increasing their size [29].

3.2.3 The effect of the interaction of phosphorus fertilization and zinc spraying on the average length of the capsule:

The intervention (100 kg/ha x 60 mg/l) achieved significant superiority over all other interventions with the highest average for capsule length (3.03 cm).

Table (3) The effect of phosphorus fertilization and spraying with zinc on the length of the capsule in sesame:

Phosphorus levels kg P_2O_5/ha	Zinc concentrations mg Zn_2So_4/l				Average effect of phosphorus
	0	30	60	90	
0	2.31	2.34	2.38	2.34	2.34
40	2.46	2.48	2.51	2.48	2.48
60	2.59	2.62	2.65	2.61	2.62
80	2.75	2.78	2.83	2.78	2.79
100	2.91	2.96	3.03	2.97	2.97
Average effect of zinc	2.60	2.64	2.68	2.64	
LSD 5%	zinc×phosphorus 0.04226		zinc 0.01907	phosphorus 0.02402	
CV %	1.0				

3.3 Number of seeds per capsule (seeds/capsule):

3.3.1 The effect of phosphorus fertilization on the average number of seeds per capsule:

The data in Table (4) showed that there were significant differences between all treatments as increasing the levels of phosphorus fertilization led to a significant increase in the average number of seeds per capsule and the level of 100 kg/ha outperformed the rest of the levels and the highest value for the trait reached (78.53 seeds/capsule) and the lowest in the control (62.87 seeds/capsule). Results of Ibrahim *et al* [19] showed that when several levels of phosphorus fertilizer were added to sesame plants (0, 30, 60, 90) kg P_2O_5/ha, the level exceeded 90 kg P_2O_5/ha with the highest value for the number of seeds per capsule (54 seeds/capsule) and the lowest in the control. Ali *et al* (2014) obtained the highest number of seeds per capsule at the level of 90 kg P_2O_5/ha (62 seeds/capsule) compared to the rest of the levels and the control (0, 30, 60) kg P_2O_5/ha. When Bhavana *et al* [30] studied four levels of phosphorus fertilization on sesame plants (0, 30, 60, 90) kg/ha and they found that increasing fertilization levels led to increase in the average number of seeds per capsule up to the level of 60 kg P_2O_5/ha then it began to decrease, and the highest average number of seeds was obtained at the fertilization level of 60 kg P_2O_5/ha (41.4 seeds/capsule) followed by the level of 90 kg P_2O_5/ha (39.9 seeds/ capsule) The differences were not significant between levels 60 and 90. Shweta *et al* [27] obtained the highest number of seeds per capsule (29.60 seeds/ capsule) in sesame plants when fertilizing at the level of 25 kg P/ha compared to the lower levels and the control (0, 15, 20) kg P/ha and the optimal absorption of nutrients and accumulation of dry matter can be attributed to increased reproduction of plant parts and this is similar to the results on sesame [31].

3.3.2 Effect of spraying with zinc on the average number of seeds per capsule:

The results of Table (4) showed that there were significant differences between all the treatments studied as increasing levels of spraying with zinc led to a significant increase in the average number of seeds/capsule and the spray level (60 mg/l) was superior to the rest of the levels and the control, as the average number of seeds reached (72.85 seeds/capsule), then it decreased again at the spray level of 90 mg/l (71.74) and the differences were not significant between the two spray levels (30, 90) mg/l while the lowest average for this trait was in the control (69.08 seeds/capsule). Jahan *et al* [22] found that increasing levels of zinc fertilization led to an increase in the number of seeds per capsule as three levels (0, 2.5, 5)% ZnO were used and the highest value for the number of seeds was at the 2.5% level (70.68 seeds/capsule), the lowest was for the control (59.23 seeds/capsule) while the 5% level gave an average value between the two levels (0, 2.5)%, as indicated by Bakry *et al* [23] indicated an increase in the number of seeds per capsule as a result of foliar spraying of zinc. This positive role of zinc is due to its role in the process of photosynthesis, the production of chlorophyll and its important role in fertilization and pollen formation.

3.3.3 The effect of overlapping phosphorus fertilization and zinc spraying on the average number of seeds per capsule:

The intervention (100 kg/ha x 60 mg/l) achieved significant superiority over all other interventions with the highest average for the number of seed/capsule (79.63 seeds/capsule), with the exception of the intervention (100 kg/ha x 90 mg/l) which had the number seeds per capsule (79.43 seeds/capsule) and the interaction (100 kg/ha x 30 mg/l) in which the number of seeds per capsule reached (78.56 seeds/capsule) and the differences between them were not significant.

Table (4) The effect of phosphorus fertilization and spraying with zinc on the number of seeds per capsule in sesame:

Phosphorus levels kg P_2O_5/ha	Zinc concentrations mg Zn_2So_4/l				Average effect of phosphorus
	0	30	60	90	
0	60.54	63.01	64.86	63.06	62.87
40	65.20	67.83	69.28	68.09	67.60
60	69.66	71.67	72.81	71.49	71.41
80	73.47	75.81	77.67	76.65	75.90
100	76.51	78.56	79.63	79.43	78.53
Average effect of zinc	69.08	71.38	72.85	71.74	
LSD 5%	zinc×phosphorus 1.805	zinc 0.801	phosphorus 1.072		
CV %	1.5				

3.4 1000 seed weight (g):

3.4.1 The effect of phosphorus **fertilization on the average 1000 seed weight:**

The results of table (5) showed that there were significant differences between the treatments as increasing the levels of phosphorus fertilization led to an increase in the average 1000 seed weight, the value at the level of 100 kg/ha (3.98 g) was superior to the rest of the average for all levels while a lower value was recorded in the control

(3.29 g). The result was consistent with Priyadarshini *et al* [18] as it was found that increasing levels of phosphorus fertilization led to a significant increase in the 1000 seed weight and reached the highest value at the level of 40 kg P_2O_5/ha (3.90 g) superior to the lower levels and the control (0, 20, 30) kg P_2O_5/ha, as shown by the results of Ibrahim *et al* [19] when adding phosphorus fertilizer to sesame plants (0, 30, 60, 90) kg P_2O_5/ha, the level exceeded 90 kg P_2O_5/ha with the highest value for the 1000 seed weight (3.91 g). Ali *et al* [32] also showed that the highest a value for the 1000 seed weight was recorded at the level of 90 kg P_2O_5/ha (4 g) compared to the rest levels (0, 30, 60) kg P_2O_5/ha.

3.4.2 The effect of spraying with zinc on the average 1000 seed weight:

The results of table (5) showed that there were significant differences between all treatments as increasing the levels of spraying with zinc led to a gradual increase in the average 1000 seed weight, it reached the highest value at the spray level of 90 mg/l (3.77 g) and the lowest value at the control (3.48 g). Jahan *et al* [22] found that spraying with zinc led to a significant increase in the 1000 seed weight and was recorded at the level of 2.5 % (3.52 g) is significantly superior to the control while the 5% level gave an average value between the two levels (0, 2.5) %.

3.4.3 The effect of overlapping phosphorus fertilization and spraying with zinc on the average 1000 seed weight:

The intervention (100 kg/ha x 90 mg/l) achieved significant superiority over all other interventions with the highest average 1000 seed weight (4.13 g).

Table (5) Effect of phosphorus fertilization and spraying with zinc on the 1000 seed weight in sesame:

Phosphorus levels kg P_2O_5/ha	Zinc concentrations mg Zn_2So_4/l				Average effect of phosphorus
	0	30	60	90	
0	3.08	3.24	3.39	3.46	3.29
40	3.29	3.37	3.45	3.55	3.42
60	3.50	3.58	3.68	3.75	3.63
80	3.69	3.82	3.92	3.98	3.85
100	3.82	3.91	4.05	4.13	3.98
Average effect of zinc	3.48	3.58	3.70	3.77	
LSD 5%	zinc×phosphorus 0.03351	zinc 0.01656	phosphorus 0.01174		
CV %	0.6				

3.5 Seed yield (kg/ha):

3.5.1 The effect of phosphorus fertilization on the average seed yield:

The results of table (6) indicate that there are significant differences between all treatments as increasing levels of phosphorus fertilization led to a significant increase in the average seed yield reaching the highest value at the 100 kg/ha (1253.60 kg/ha) and the lowest value at the control (627.30 kg/ha) and this is due to the positive effect of phosphorus on various productive traits such as number of capsules, number of seeds per capsule, in addition to, the role of phosphorus in enhancing starch transfer and dry matter production. Ali *et al* [32] found that adding a level of 90 kg P_2O_5/ha to sesame plants it gave the highest value for seed yield (1160 kg/ha) compared to the lower levels and control (0, 30, 60) kg P_2O_5/ha. Kumar *et al* [20] also found that the level of 60 kg/ha was superior to the highest seed yield when treated with four levels of phosphorus (15, 30, 45, 60) kg/ha on sesame plants. Shweta *et al* [27] obtained the highest seed yield (520 kg/ha) in sesame plants when fertilized at the level of 25 kg P/ha compared to the lower levels and the control (0, 15, 20) kg P/ha. This improvement in seed yield when fertilizing with phosphorus is due to the importance of phosphorus in metabolic processes in the plant and its role in the formation of cytokinin which affects the initiation of flowering in the plant [33]. Many researchers have found that fertilizing sesame plants with phosphorus increased seed yield [34].

3.5.2 The effect of spraying with zinc on the average seed yield:

The results of table (6) showed that there were significant differences between all treatments as increasing the levels of spraying with zinc led to a significant increase in the average seed yield reaching a maximum at the spray level of 90 mg/l (1046 kg/ha) and the lowest in the control (763.90 kg/ha). Jahan *et al* [22] found that adding zinc to sesame plants led to significant increase in seed yield as it reached 2.5% (1619 kg/ha) then decreased at 5% (1448 kg/ha) and recorded the lowest value is in the control (1239 kg/ha). Ram *et al* [35] also found that adding zinc sulfate to sesame plants led to an increase in seed yield by 34% and reached (492.90 kg/ha) compared to the control. The results are consistent with Cakmak *et al* [29] as it was found that adding zinc led to an increase in seed yield, this is due to the role that zinc plays in plant resistance to environmental stresses, its role in cell division and regulating membrane function [24]. Movahhedy *et al* [36] reported that spraying zinc on safflower plants led to an increase in seed yield. Nakhzari *et al* [37] also found increase in lentil productivity when plants are sprayed with zinc.

3.5.3 The effect of overlapping phosphorus fertilization and zinc spraying on the average seed yield (kg/ha):

The intervention (100 kg/ha x 90 mg/l) achieved significant superiority over all other interventions with the highest average seed yield trait (1357.30 kg/ha).

Table (6) Effect of phosphorus fertilization and zinc spraying on seed yield in sesame:

Phosphorus levels kg P_2O_5/ha	Zinc concentrations mg Zn_2So_4/l				Average effect of phosphorus
	0	30	60	90	
0	460.80	563.40	720.20	764.70	627.30
40	585	679.70	822.20	860	736.70
60	697	826.70	973.20	1011.30	877.00
80	965	1081	1212.80	1236.70	1123.90
100	1111.70	1214.70	1330.70	1357.30	1253.60
Average effect of zinc	763.90	873.1	1011.82	1046	
LSD 5%	zinc×phosphorus 14.80	zinc 6.78	phosphorus 8.01		
CV %	1.0				

4. CONCLUSIONS

4.1 Increasing the levels of phosphorus fertilization led to an increase in the average of all productive traits studied and achieved at the level of 100 kg P_2O_5/ha the highest average number of capsules per plant (92.75 capsules /plant), length of the capsule (2.97 cm), number of seeds per capsule (78.53 seeds/capsule), weight of 1000 seeds (3.98 g) and seed yield (1253.60 kg/ha).

4.2 Increasing the levels of spraying with zinc led to an increase in the average of some of the productive traits studied, at the level of 90 mg Zn_2So_4/l the highest average number of capsules per plant (75.27 capsules/plant), 1000 seed weight (3.77 g) and seed yield (1046 kg) were achieved, while at the level of 60 mg Zn_2So_4/l it achieved the highest average length of the capsule (2.68 cm) and number of Seeds inside (72.85 seeds/capsule).

4.3 The use of (100 kg P_2O_5/ha x 90 mg Zn_2So_4/l) gave the largest number of capsules per plant, 1000 seed weight and seed yield and led to a significant improvement in the productivity characteristics of the sesame plant.

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5. RECOMMENDATIONS:

Expanding the cultivation of sesame plants (white variety) and fertilizing them at a level of 100 kg P_2O_5/ha (ground fertilization) and spraying zinc at a concentration of 90 mg Zn_2So_4/l (foliar spraying).

To obtain the highest number of capsules on the plant and 1000 seed weight that is an increase in number of capsules and weight of the seeds inside them, which reflects positively on the productivity of the plant and thus obtaining a high yield of sesame seeds.

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