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Effect of Adding Sulfur and Organic Fertilizer on Growth and Yield of Onions (*Allium Cepa* L.) Under Different Plant Densities

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Abstract

A field experiment was conducted in the Amiriyat al-Fallujah district of the Anbar governorate to know the effect of the combination of sulfur and organic fertilizer on the growth and yield of onion, (a local red type), under different plant densities. The experiment included two factors, first: a combination of fertilizing with decomposing Cow's manure (20 tons.ha-1) and sulfur (50 kg.ha-1), and this factor was distributed as follows (T0: fertilizer recommendation (NPK 100-100-120 kg.ha-1 It is considered a control). T1: cow waste + half of the chemical fertilizer recommendation and T2: fertilizer recommendation + sulfur addition and T3: Cow's manure + half of the fertilizer recommendation + sulfur addition and T4: double the recommendation of cow manure (40 t.ha-1 + half of the fertilizer recommendation + adding sulfur). The second factor: planting distances (S1:10×10, S2:10×15, and S3:10×20) cm. The distance between plants was fixed 10 cm and the dimensions changed between one line and another. The study was carried out as a factorial experiment with the randomized complete block design (RCBD). The results showed clear significant differences for the two study factors in characteristics of vegetative growth, yield, and the content of total soluble solids, as the T4S3 treatment exceeded by giving it the highest number of tubular blades, leaf area and the highest percentage of sulfur in the leaves, which was positively reflected on the plant yield and percentage the total soluble solids amounted to (16.57 blades.plant-1, 15.97 dm², 1.70%, 0.64%, 104.50 g, 15.83%), respectively, The treatment of planting distances S1 achieved significant differences in the total yield (90.39 tons.ha-1 and 8.91 kg) respectively compared to plants of treatment S3, which achieved (74.29 tons.ha-1 and 5.39 kg).

Keywords: Onion, Organic fertilizer, Sulfur fertilizer.

1. Introduction

Onion (*Allium cepa* L.) belongs to the Alliaceae family. It is considered one of the most important vegetable crops in the world for its high nutritional value and versatility [1], as it contains large amounts of vitamins, proteins, iron, and calcium. From medical importance, it contains quercetin, which is an anti-oxidant and anti-cancer [2].

Onions are among the crops that need large amounts of nutrients during their growth period. Chemical fertilizers are one of the main factors that contribute to the growth and production of onions, as onion plants consume large quantities of the major elements nitrogen, phosphorous and potassium, which are among the major nutrients needed by the onion plant in large quantities, and a deficiency of any of them causes a decrease in the growth and yield of the plant [3].

Sulfur is one of the main elements for plant growth and is the fourth element after N, P and K. It is important for the formation of amino acids, proteins, oils, vitamins and some enzymes, and enters the composition of the protoplasm of cells [4]. Sulfur plays a vital role in the biosynthesis of some amino acids as well as contributes to the formation of chlorophyll, and it is one of the necessary elements to encourage vegetative growth, increase yield and improve quality [5].

Despite the importance of chemical fertilizers in improving the growth and yield of plants, their high economic cost and the damage that these fertilizers cause to human life and the environment have prompted us to think of using organic sources as alternatives to chemical fertilizers that improve soil properties and help increase the activity of microorganisms and provide the nutrients he needs The plant during its growth period and from these sources the Cow's manure, sheep, poultry and others [6]. Plant densities are one of the important factors that affected in growth and productivity of onions, as it is possible to obtain a balanced vegetative growth, the best size of the onion, and the highest yield per unit area if the plants grow at an ideal density [7].

The study aims to: Knowing the effect of ground addition of sulfur, organic fertilization and plant density in improving the growth and yield of onions with the best quality.



2. Materials and Methods

A field experiment was carried out in the Amiriyat al-Fallujah district of Anbar Governorate in the agricultural season 2020-2021 to find out the effect of ground addition of sulfur, organic fertilization and plant densities on the growth, yield and quality of onions of the local red type. The study was carried out as a field experiment in a randomized complete block design (RCBD) with three replications. The field was divided into 3 replicates, each replicate containing 15 experimental units (1.2 m²). A sample of field soil was taken before planting at a depth of (20 cm) and analyzed (Table 1). The seeds were planted on 1/10/2020 in rectangular plates with an area of (1.5 m x 1 m) in sandy soil, in lines with a depth of 0.5 cm and a distance of 5 cm between one line and other, and after the seedlings reached the appropriate size 3 - 4 true leaves Then, transferred to the field on (1/12/2020). All service operations recommended by [8] were carried out from planting seedlings until the crop matured.

The study included two factors:

The first: fertilization and the following combinations:

T0: The complete chemical fertilizer recommendation (NPK) 120-100-100 kg.ha⁻¹ [9] and considered as a comparison treatment.

T1: Cow's manure(20 t.ha⁻¹) + half of the chemical fertilizer recommendation

T2: chemical Fertilizer recommendation + adding sulfur 50 kg.ha⁻¹.

T3: Cow's manure(20 tons.ha⁻¹) + half of the chemical fertilizer recommendation + adding sulfur 50 kg.ha⁻¹.

T4: double the recommendation of cow manure + half of the chemical fertilizer recommendation + adding sulfur 50 kg.ha⁻¹.

The second: planting distances includes the following:

S1: (10 x 10) cm, the distance between plants is 10 cm, and between agriculture lines 10 cm.

S2:(10x 15 cm). The distance between plants is 10 cm and between agriculture lines 15 cm.

10): S3 x 20 cm. The distance between the plants is 10 cm and between agriculture lines 20 cm.

The results were statistically analyzed according to the (Genstat) program and the averages were compared according to the LSD test at a probability level of 0.05 [10].

Table 1. Physical and chemical properties of field soil at a depth of 20 cm.

Electrical connectivity E.C	pH	Ready Nitrogen	ready-made phosphorous	ready-made potassium	silt	clay	sand	soil texture
ds.m ⁻¹ 3.08	7.93	42.61 mg.kg ⁻¹	26.73 mg.kg ⁻¹	152.42 g.kg ⁻¹ m	457 g.kg ⁻¹	245 g.kg ⁻¹	193 g.kg ⁻¹	clay loam

The studied characteristics:

- Vegetative growth traits: A sample of five randomly selected plants was taken and the following traits were estimated.
 1. The number of tubular blades (blade. Plant⁻¹).
 2. Plant leaf area (dm²): using the equation for the tubular blades of onions, as mentioned by [11].

Leaf area = (-93.1) + (1.83 x leaf length) + (38.6 x leaf circumference at a distance of 25% from its base)

3. The percentage of sulfur in the leaves: according to the method mentioned in [12].

- Traits of the yield:

1. Yield per plant (gm): as an average weight of ten onions, chosen randomly from each experimental unit.
2. Experimental unit yield (kg): from multiplying the number of plants in the experimental unit by the yield of one plant.
3. Total yield (tons.ha⁻¹): using the following equation:

$$\text{The total yield of onions ton.ha}^{-1} = (2 \text{ m } 10000 \times \text{experimental unit yield}) / (2 \text{ m}) \text{ experimental unit area}$$

4. Percentage of total soluble solids in bulbs (T.S.S.): using the hand refract meter [13].

3. Results and Discussion

Table 2. Effect of adding sulfur and organic fertilization on the number of tubular blades and leaf area of onion under different plant densities.

Fertilization	Number of tubular blades (blade.plant ⁻¹)				Leaf area (dm ²)			
	Planting distances S				Planting distances S			
T	S1	S2	S3	Average T	S1	S2	S3	Average T
T0	10.00	11.53	14.87	12.13	10.80	11.06	12.80	11.55
T1	8.56	10.77	12.77	10.70	9.83	10.53	13.63	11.33
T2	11.40	13.46	13.60	12.82	10.87	12.67	12.90	12.15
T3	12.40	13.57	14.80	13.59	11.77	12.93	14.17	12.96
T4	13.80	14.67	16.57	15.01	13.17	14.17	15.97	14.43
Average	11.23	12.80	14.52		11.29	12.27	13.89	
LSD S			1.62				0.99	
LSD T			2.09	0.05			1.28	0.05
LSD S×T			N.S				N.S	

The results of Table (2) showed the superiority of T4S3 treatment by giving it the highest number of tubular blades and leaf area of the plant, which amounted to 16.57 blades.plant⁻¹ and 15.97 dm² respectively, compared to plants of treatment T1S1, which amounted to 8.56 blades.plant⁻¹ and 9.83 dm² respectively. This is attributed to the role of organic fertilization, which improves the physical, chemical and biological properties of the soil by increasing the soil's ability to retain moisture, increase its porosity and increase the activity of microorganisms, as well as preparing the soil with nutrients [14], as well as to the role of sulfur in increasing the availability of nutrients in the soil by decreasing the soil pH value and thus increasing its uptake by plants [15]. The large planting distances (low plant densities) increase the number of tubes and increase the leaf area because there is no competition or crowding between plants for growth requirements such as water, food and light, so the plants grow well to give good vegetative growth characteristics [16].

Table 3. Effect of adding sulfur and organic fertilization on the percentage of sulfur in the leaves onion type under different plant densities.

Fertilization	% of sulfur S in leaves			Average T
	Planting distances S			
T	S1	S2	S3	
T0	0.43	0.39	0.46	0.43
T1	0.36	0.43	0.41	0.40
T2	0.52	0.49	0.51	0.50
T3	0.51	0.52	0.53	0.52
T4	0.53	0.53	0.64	0.57
Average S	0.47	0.47	0.51	
LSD S			0.01	
LSD T			0.01	0.05
LSD S×T			0.02	

The results of Table (3) showed the superiority of T4S3 treatment by giving it the highest percentage of elemental sulfur in the leaves, which amounted to 0.64%, sequentially, compared to T1S1-treated plants, which gave 1.06% and 0.36%, respectively. The reason for the superiority of T4S3 treatment plants by giving them the highest rate in the percentage of sulfur in the leaves is attributed to the role of organic fertilization, which increases the readiness of nutrients in the soil solution and increases the plant's ability to absorb them, thus increasing this element in the plant [17]. In addition to the role of sulfur fertilization, which leads to an increase in its quantity in the soil and improvement of soil properties by decreasing the soil pH and thus increasing the readiness of nutrients in it and their absorption by the plant and increasing their concentration inside the leaves [18]. The cultivation distances also play an important role in increasing the concentration of these elements inside the leaves by reducing plant densities (large agricultural distances), which make the plant grow well

without competition and crowding over the growth requirements, the most important of which are the nutrients and increase its readiness within the tissues of the plant [19].

Table 4. Effect of adding sulfur and organic fertilization on plant yield (gm) and experimental unit yield (kg) of onion under different plant densities.

Fertilization T	The yield of one plant (gm)				The yield of the experimental unit (kg)			
	Planting distances			Average T	Planting distances			Average T
	S1	S2	S3		S1	S2	S3	
T0	71.27	76.47	83.20	76.98	8.93	6.97	4.87	6.92
T1	70.27	76.20	79.57	75.34	8.07	6.83	4.73	6.54
T2	73.70	73.77	90.60	79.36	8.83	6.67	5.43	6.98
T3	76.93	77.80	93.87	82.87	9.23	6.97	5.67	7.29
T4	80.87	86.33	104.50	90.57	9.50	7.57	6.27	7.78
Average S	74.61	78.11	90.35		8.91	7.00	5.39	
LSD S			1.40				0.83	
LSD T			1.81	0.05			N.S	0.05
LSD S×T			3.13				N.S	

The results of Table (4) indicated the superiority of treatment T4S3 by giving it the highest rate of yield per plant amounted to 104.50 gm compared to treatment plants T1S1 which amounted to 70.27 gm. Whereas, treatment T4S1 achieved a higher yield for the experimental unit, which amounted to 9.50 kg, compared to treatment T1S3, which amounted to 4.73 kg. The reason for this is attributed to the role of organic fertilization in increasing the readiness of nutrients inside the plant and increasing their concentration in the vegetative total as previously mentioned in the characteristics of vegetative growth and thus increasing the process of photosynthesis and the transfer of the products of this process to the storage places (bulbs), which are considered a sink for these elements. The reason for the advantage of the treatment of large agricultural distances S3 in the yield of one plant is that reducing the number of plants per unit area provides a greater opportunity for plants to absorb the largest amount of nutrients, in addition to the absence of damages from field competition for water, elements and light [20]. These factors combined led to the advantage of the plants of this treatment in giving the largest yield to the plant, these results agreed with [21]. Moreover, the reason for the advantage of the treatment of the few distances S1 is due to the doubling of the number of plants per unit area, and thus the increase in the amount of yield, which in turn reflected positively on the total yield [10].

Table 5. Effect of adding sulfur and organic fertilization on the total yield (tons.ha⁻¹) and the percentage of total soluble solids (TSS) (%) of onion under different plant densities.

Fertilization T	The total yield (ton.ha ⁻¹)				The percentage of total dissolved solids (%)			
	Planting distances S			Average T	Planting distances S			Average T
	S1	S2	S3		S1	S2	S3	
T0	83.20	76.80	72.57	77.52	10.80	12.63	12.80	12.08
T1	79.73	76.33	68.97	75.01	9.83	10.53	13.63	11.33
T2	90.63	73.77	73.60	79.33	12.90	13.23	13.80	13.31
T3	93.87	78.03	76.90	82.93	13.17	14.30	15.43	14.30
T4	104.50	84.30	79.43	89.41	14.17	14.63	15.83	14.88
Average S	90.39	77.85	74.29		12.17	13.07	14.30	
LSD S			0.52				0.73	
LSD T			0.66	0.05			0.95	0.05
LSD S×T			1.15				N.S	

Table 5 showed the advantage of treatment T4S1 by giving the highest rate of total yield amounted to 104.50 tons.ha⁻¹ compared to plants treated T1S3 which gave 68.97 tons.ha⁻¹. Also, treatment T4S3 was advantageous by giving the highest rate of percentage of total soluble solids in bulbs (TSS) reached 15.83% compared to treatment plants T1S1. The reason for the advantage of the organic fertilizer factor and the addition of sulfur in the total yield and the percentage of total dissolved solids (TSS) is due to the role of organic fertilization, which increases the readiness of nutrients and thus increases their concentration inside the plant and the transfer of metabolic products to storage places in addition to the role of the sulfur element, which works to increase the amount of total soluble solids through its primary role in the synthesis of some amino acids and thus increase the proteins inside the bulbs, which increases the number of dry substances inside the bulbs and reduces the amount of water in them, and this increases the storage capacity of the bulbs and increases its variability [1]. On the other hand, the increase in plant densities caused an increase in the total yield, by increasing the number of plants per unit

area to double, which was reflected in that positively increase the yield compared to the large distances where the number of plants is up to half compared to the high density, which reflects negatively on the yield. The reason for the increase in the percentage of total soluble solids in the bulbs of plants treated S3 is that reducing agricultural distances (low densities) leads to reduce competition for nutrients as well as plant growth in a good way and increase nutrients within the plant tissues and their transfer to their storage places (bulbs). These results agreed with what was mentioned [15].

Recommendation

From what was presented so far, we can recommend increasing the fertilization with elemental sulfur using quantities higher than 50 kg.ha⁻¹, and reducing the use of chemical fertilizers and replacing them with organic fertilizers because they caused an increase in the growth and yield of onions and improved quality, and reducing the agricultural distances between plants and between lines increased the density plants per unit area without causing competition damages and this reflected positively on yield and quality. Therefore, the distance S1 (10 x 10 cm) can be adopted as the best distance to achieve an increase in yield and quality. We recommend studying fewer distances than that.

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