Effect of Activating of Salicylic Acid and Foliar Application with Humic Acid on Some Growth and Yield Characteristics of Sunflower (*Helianthus annuus* L.)

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Abstract. A field experiment was carried out in the Al-Jazeera region of Ramadi city, Anbar Governorate, at the autumn season of 2020 in sandy soil to study the effect of stimulating sunflower seeds with four levels of salicylic acid (0, 125, 250, and 375 mL$^{-1}$) and spraying with humic acid (0, 250, and 500 mL$^{-1}$) where the results showed that the concentration of 375 mL$^{-1}$ of salicylic acid recorded the highest average of the characteristics, the number of seeds per disc and the weight of 1000 grains, and the seed yield was (2034.9 seeds, 80.81 g and 164.97 g. plant$^{-1}$) respectively. While the second treatment of spraying with humic acid recorded the highest mean for the characteristics, the number of seeds per disc and the weight of 1000 g, and the seed yield was the highest average (1752.3 seed. disc, 68.43 g and 124.16 g. plant$^{-1}$).

1. Introduction

Sunflower is one of the oil crops in the world, as it is grown for the purpose of obtaining seeds that contain a high oil content of up to 55%, which considered the best oil consumed in the world [1]. As well as the quantity of seeds that are good fodder for farm animals and poultry due to their high protein content of 36%, carbohydrates 22%, oil 6% and other nutrients [2]. Although the great importance of this crop, its productivity per unit area is still low, not exceeding (2.11 ton. ha$^{-1}$), which is a low production compared to the world production, which exceeded (7.5 ton. ha$^{-1}$). The most important reasons for the lack of productivity of the crop is due to the bad environmental conditions, loss of water, and the causes of salinity in Iraqi soils [3]. Therefore, contemporary research has studied these problems and develop appropriate solutions for them, among these solutions are soaking the seeds of sunflower with salicylic acid. Which contributed the speed of germination seeds and improving them more resistant to environmental conditions [4]. As salicylic acid acts to make the plant benefit from the manufacturing, genetic and functional ability to the best level, in addition to be an environmentally harmless substance, it does not have any effect side or negative effect on humans or animals [5,6]. The spray humic acid activates the physiological characteristics of photosynthesis and enzymes and thus reflected on the increase in the growth and production of sunflower. In addition, it helps the plant adapt to difficult conditions such as drought, heat and salinity, increases soil fertility and activates many vital processes of the plant [7]. Therefore, the aim of the standing to investigate the effect of seed priming with different concentration of salicylic acid and the best spraying level of humic acid which gives the highest rate of grain yield and its components.

2. Material and Methods

A field experiment was carried out in Al-Jazirah region, Ramadi city, Anbar Governorate- Iraq, with the aim of activating sunflower seeds with salicylic acid (0, 125, 250, and 375 mL$^{-1}$) symbolized by (S0, S1, S2 and S3), respectively, and foliar application with humic acid using the concentration (0, 250 and 500 mL$^{-1}$) which are symbolized by (H1, H2 and H3) respectively. To improve some growth characteristics, seed yield and its components, some physiological measures, and in three replications, the experiment was carried out on 12 experimental units in one replicator, so that the total number of the experiment was 36 experimental units. As well as soil was fertilized with nitrogen and phosphate fertilizers according to the required recommendations [5]. Then it was divided into experimental units of (3m x 5m). If the distance between the lines is 50 cm, so the number of lines is 6 lines, but if the distance between the lines is 60 cm, the number of lines becomes 5 lines,) and the distance between one plant and another (25 cm) The experimental units were separated from each other by a space (1 m), the
The experiment was planted at 28/7/2020 for the autumn season, using local variety. The plant density was 80,000 plant ha⁻¹. The required fertilizers of nitrogen fertilizer were added in two doses, the first with planting and the second after a month of planting, and phosphate fertilizer was added in one dose before planting and according to the required recommendations [8]. The following characteristics were studied: leaf area, chlorophyll A, number of seeds per disc, weight of 1000 grains, biological yield and seed yield. The data were analyzed statistically according to the system of factorial experiments in the (RCBD). The significant differences were selected according to the test of less significant difference L.S.D at a probability level of 0.05, statistical analysis was using the program Gen Stat [9].

3. Results and Discussion

3.1 Growth indicators

It was evident from the results of Table (1) that the concentration of 375 mL⁻¹ of salicylic acid was higher in the characteristic of the leaf area, as this treatment gave the highest average of (7432 cm² plant⁻¹) compared to the comparison treatment (S0), which recorded the lowest Mean of (3409 cm² plant⁻¹). The results showed significant differences between the averages of the leaf area characteristic of the plant when spraying with humic acid, as the concentration 500 mL⁻¹ was higher by giving it the highest average of (5290 cm² Plant⁻¹) compared to the comparison treatment that recorded the lowest average for this characteristic amounted to (5179 cm² Plant⁻¹). The results of Table (2) showed that the concentration of salicylic acid 375 mL⁻¹ recorded the highest average for the characteristic of chlorophyll A, reaching (25.02 mg⁻¹ wet. weight) compared to the comparison treatment S0, which recorded the lowest average for the characteristic of chlorophyll A was (17.68 mg-¹ wet. weight). While the treatment H2 concentration (500 mL⁻¹) achieved the highest average of a chlorophyll A trait when spraying the plant with humic acid, it reached (22.91 mg⁻¹ wet. weight) compared to the comparison treatment H0, which recorded the lowest rate of chlorophyll A which was (16.36 mg⁻¹ wet. weight) [9].

3.2 Yield and yield its components

Results of (Table 3) showed the superiority of salicylic acid at a concentration of 375 mL⁻¹ as it gave the highest average characteristic of the number of seeds per disc, as this treatment was recorded (2034.9 grain disc⁻¹) compared to the comparison treatment S0, which recorded the lowest rate for this characteristic of (1370.8 grain disc⁻¹). The reason for the difference is due to the difference in its content of hormones that increase the absorption of the nutrient due to it containing more hormones than the concentration that gave the least number [8-9]. As for when spraying the plant with humic acid, it was found that there are significant differences between them, as the H2 concentration (500 mL⁻¹) was recorded by giving it the highest average number of seeds per disc amounted to 1752.3 grain disc⁻¹ compared to the comparison treatment that recorded the lowest rate for this characteristic reached (1675.9 grain disc⁻¹). The reason for this is that the (H2 concentration) caused a change that stimulated photosynthesis, increased the number of live cells, encouraged tissue growth, and thus increased the number of seeds in disc [14,11]. The results of (Table 4) indicated the found of significant differences between the different concentrations of humic acid, as the concentration (500 mL⁻¹) was recorded by giving it the highest average for a 1000-grain weight trait, which reached (58.53 g) compared to the comparison treatment that recorded the lowest average for this trait, reaching (58.53 g). The reason for the increase in this treatment is due to the positive effect of humic acid, which acted on increasing the biological interactions within the plant tissues, which led to an increase in the vegetative growth indicator most of it, especially the leaf area (table 1), and increased its efficiency in intercepting light and its translocation from the leaves and its accumulation in the seeds. These results agreed with [15, 16]. The results of Table (5) showed the biological yield of plants using different concentrations of salicylic acid, as the concentration of S3 (375 mL⁻¹) was recorded by giving it the highest average for this characteristic of (325.34 g. plant⁻¹) compared to the comparison treatment S0, which recorded the lowest average for this trait, which amounted to 213.77 g. plant⁻¹). The superiority of this treatment is due to the physiological effect of salicylic acid on the different growth traits. The results of this trait agree this result of other researchers [8, 17, 18, 19]. (Table 6) indicates the found of significant differences in the seed yield of the plant, where the S3 concentration (375 mL⁻¹) was recorded by giving it the highest seed yield average of the plant, which reached (164.97 g plant⁻¹). Compared to the comparison treatment S0, which gave the lowest average for this trait (70.25 g. plant⁻¹). This increase was a positive result of the role of salicylic acid in increasing some indicators of growth and yield, which were all reflected.
in the increase in seed yield. The results are in agreement with \[10,12\]. As well as (Table 6) showed a significant effect of humic acid, as the concentration of H2 (500 mL\(^{-1}\)) was recorded giving it the highest average of the seed yield characteristic of the plant, which reached (6124.1 g Plant\(^{-1}\)). The reason for the increase in the seed yield of the plant for the sunflower crop was attributed to the positive effect of humic acid, which worked on increasing the growth and development of the crop, which was positively reflected on the metabolic activities and the morphology of the plant \[20\].

Table 1. Effect of activating of salicylic acid and foliar application with humic acid of leaf area cm\(^2\)

| Sal. | Hum. | S0 | S1 | S2 | S3 | mean |
|------|------|----|----|----|----|------|
| H0   | 3339 | 4096 | 6171 | 7108 | 5179 |
| H1   | 3662 | 4032 | 5572 | 7581 | 5212 |
| H2   | 3225 | 4032 | 6297 | 7606 | 5290 |
| mean | 3409 | 4053 | 6013 | 7432 |     |
| LSD=0.05 | H=60.7 | S*H=121.4 | S= 70.1 |

Table 2. Effect of activating of salicylic acid and foliar application with humic acid of chlorophyll A

| Sal. | Hum. | S0 | S1 | S2 | S3 | mean |
|------|------|----|----|----|----|------|
| H0   | 13.33 | 16.72 | 18.82 | 21.86 | 17.68 |
| H1   | 17.39 | 20.71 | 23.99 | 25.98 | 22.02 |
| H2   | 18.36 | 20.99 | 25.05 | 27.22 | 22.91 |
| mean | 16.36 | 19.47 | 22.62 | 25.02 |     |
| LSD=0.05 | H=0.87 | S*H=1.755 | S= 1.01 |

Table 3. Effect of activating of salicylic acid and foliar application with humic acid of No. of seeds per disc

| Sal. | Hum. | S0 | S1 | S2 | S3 | mean |
|------|------|----|----|----|----|------|
| H0   | 1324.2 | 1533.3 | 1796 | 2050.3 | 1675.9 |
| H1   | 1442.3 | 1561.0 | 1834.7 | 2022.7 | 1715.2 |
| H2   | 1346.0 | 1739.3 | 1892.0 | 2031.7 | 1752.3 |
| mean | 1370.8 | 1611.2 | 1840.0 | 2034.9 |     |
| LSD=0.05 | H=10.72 | S*H=21.44 | S=12.38 |

Table 4. Effect of activating of salicylic acid and foliar application with humic acid of weight 1000 seed g.

| Sal. | Hum. | S0 | S1 | S2 | S3 | mean |
|------|------|----|----|----|----|------|
| H0   | 46.57 | 48.54 | 62.43 | 76.58 | 58.53 |
| H1   | 52.49 | 54.26 | 65.37 | 79.29 | 62.85 |
| H2   | 53.29 | 56.18 | 77.68 | 86.57 | 68.43 |
| mean | 50.78 | 52.99 | 68.49 | 80.81 |     |
| LSD=0.05 | H= 0.028 | S*H= 0.056 | S= 0.033 |
Table 5. Effect of activating of salicylic acid and foliar application with humic acid of biological yield g. plant$^{-1}$

| Sal. | Hum. | S0   | S1   | S2   | S3   | mean |
|------|------|------|------|------|------|------|
|      |      | 201.07 | 219.33 | 257.9 | 303.06 | 245.34 |
| H1   |      | 218.18 | 235.21 | 274.35 | 323.44 | 262.29 |
| H2   |      | 222.09 | 254.44 | 312.08 | 349.51 | 284.54 |
| mean |      | 213.77 | 235.65 | 281.44 | 325.34 |       |
| LSD=0.05 | H=3.43 | $S^*H=6.87$ | $S=3.97$ |

Table 6. Effect of activating of salicylic acid and foliar application with humic acid of plant yield g. plant$^{-1}$

| Sal. | Hum. | S0   | S1   | S2   | S3   | mean |
|------|------|------|------|------|------|------|
|      |      | 62.34 | 76.28 | 114.25 | 155.27 | 102.04 |
| H1   |      | 74.89 | 85.23 | 118.34 | 163.27 | 110.43 |
| H2   |      | 73.54 | 98.37 | 148.34 | 176.37 | 124.16 |
| mean |      | 70.25 | 86.62 | 126.97 | 164.97 |       |
| LSD=0.05 | H=0.34 | $S^*H=0.68$ | $S=0.39$ |

4. Conclusion

Through reviewing the previous results, we can conclude that sunflower responds to foliar application in its different stages of growth and that the best concentration of salicylic acid for soaking the seeds was ($375 \text{ mL}^{-1}$) which recorded the highest average for all traits. It was also found that the foliar application with humic acid by treatment ($500 \text{ mL}^{-1}$) which recorded high average for most of the characteristics. This indicates the possibility of using higher concentrations in other studies and different sites.

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