Effect distribution of plants and combination of fertilization (N.P.K) on some of growth, yield and its component of safflower. (*Carthamus tinctorius* L.)

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Abstract

A field experiment was conducted at AL-Diwaniyah city during the 2019-2020 winter seasons, to study the effect of the fertilizer combination of NPK and the distribution of plants on some growth, yield and yield components of safflower (*Carthamus tinctorius* L.) to determine the most appropriate amount of fertilizer combination and plant distance between plants. The experiment was arranged in split plot design based on RCBD, with three replications. Main plot included four levels of fertilizer combination (F1, F2, F3, and F4), and sub plot included five plant distances as follows (D1, D2, D3, D4, and D5). The results showed a significant effect of the fertilizer combination. The treatment F4 gave the highest mean in plant height was 151.50 cm, seed yield per 118.6 g, total seed yield 4.89 tons. h⁻¹, biological yield 15.15 tons. h⁻¹ while for day to 75% flowering the treatment of F1 which was 153.95 day. As for the plants distribution, the treatment D1 which gave the highest mean in plant height was 157.00 cm, total seed yield 5.56 tons. h⁻¹ and biological yield 19.94 ton.h⁻¹, the treatment D5 gave highest mean of seed yield per plant was 145.70 g. For the interaction between the treatment, the combination of (F4×D5) showed significant differences for day to 75% flowering and seeds yield per plant which were (148.97 day, 186.30 ton.h⁻¹) respectively, and the combination of (F3×D1) showed a highest mean for the total yield and biological yield which was (6.21 and 22.04 ton.h⁻¹).

Key words: safflower, fertilizer combination, plant distance and their interaction.

1. Introduction

Safflower plant *Carthamus tinctorius* L. is one of the oil crops of the *Brassicaceae* family, and it is important economically and medicinally because its oil is suitable for human use. The percentage of oil is about (35-50%) [9]. The oil is widely used because it is a dry oil because of high iodine number, which ranges between 140-152, and it contains a high percentage of essential unsaturated fatty acids and Linoleic acid constitutes about 75% [1], and works to reduce the proportion of cholesterol in the blood and prevents hardening of the arteries. In addition, oil and colored flowers are used in various industries such as making soaps, inks, dyes, etc., and the remaining cake is rich with protein 40% and 19.8% carbohydrates, so it is used in animal feed [2]. Conducting the fertilization process is very important for field crops to prepare the crop nutrients in addition to improving soil properties. Providing an adequate amount of nitrogen is to obtain optimum growth and thus produce the highest possible high-quality yield and that when at optimum fertilization levels it leads to the highest yield. Nitrogen fertilization increases the growth parameters, which is reflected in the vegetative growth and thus increases the grain yield and yield components. Phosphorous has an important role for plants, and it is involved in the synthesis of nucleic acids (DNA, RNA) and enzymatic reactions, including the synthesis of enzymes needed for various energy reactions (ATP, ADP) and in building the accompaniments of NADP and NAD enzymes that have an important role in oxidation and reduction in respiration, photosynthesis and the representation of acids fatty. Preparing crops with sufficient amounts of potassium has an important role in the performance of the crop and also increases ability to tolerance stresses, especially drought and frost. [3]. Potassium has an important role in activating important enzymes in process of photosynthesis and building carbohydrates, fats and protein within plants [4]. The distribution of plants is one of the most important field practices because it had a great impact on the performance of plants and through the yield per unit area can be increased, as planting with optimum plant density is one of the most important factors that help increase the chance of fertilization, thus increase yield seeds per plants. In addition to important role for limiting competition in growth factors for light, water and nutrients, where plant density effects on interception of light by plants And to achieve the maximum possible use of
light, which determines the ability of plants to produce dry matter during the period of vegetative growth and the consequent effect on the transfer of those materials to the seed in the later stages of the crop life (fruition growth). In addition, determining the appropriate plant density is of great relevance in competition for water and nutrients in the soil as it affects growth of root system (root system density) and its extension and the consequent increase in its efficiency through increasing the sites of water and nutrient uptake, and all this plays importance role in reducing from the state of competition between the inter plants and the antra plant, both of which are important in determining the efficiency of the plant to produce dry matter, to achieve the maximum possible yield. This study was conducted to determine the best way to distribute plants to obtain optimum density of safflower crop, best compost rate of NPK, and increase yield of seeds per plant, oil and protein contents.

2. Materials and methods

A field experiment was conducted at the Nuri Forest station of the Diwaniyah Agriculture Directorate, during the autumn season (2019-2020), the experiment was arranged in split plot design based on RCBD [5], with three replications. The seeds variety used in experiment was (Gilla) obtained from general Authority for Agriculture Research/ ministry of Agriculture/ Iraq, with main plot included four levels of fertilization combination (N0, P0, K0) (N140, P80, K40) (N160, P100, K60) (N180, P120, K80). Kg.h⁻¹, which is represented by (F1, F2, F3, and F4) respectively, the fertilizer was applied in two time, first time with growing seeds and second time with flowering stage. Sub plot included five plant distances as follows (30 × 30, 40 × 40, 50 × 50, 60 × 60 and 70 × 70 cm) represented by (D1 and D2, D3, D4, and D5 respectively. The seeds were sowing at 20 November 2019 and rate of 4 seeds per hole after two weeks of emergence reduced number of plant per hole to one plant. The midline plant each treatment were harvested in order to determine the seed yield at the end of cropping season and after physiological maturity of plants, this was carried out in 19 June 2020 of each treatments.

2.1. Soil properties

To determine some of the physical and chemical properties according to the methods given by [6] analyzing soil was done in facilities of soil and water Department laboratories, college of agriculture, Al-muthanna University, Table 1.

Table 1. Some physical and chemical properties of the experiment soil.

| Soil properties | results | units   |
|-----------------|---------|---------|
| Ec.             | 3.7     | Ds.m⁻¹  |
| PH              | 7.3     | -       |
| OM              | 0.18    | %       |
| N               | 14.52   | mg.kg⁻¹ |
| K               | 1.25    | mg.kg⁻¹ |
| P               | 10.75   | mg.kg⁻¹ |
| Sandy           | 15.5    | %       |
| Silt            | 35.5    | %       |
| Clay            | 49      | %       |
| Soil texture    | Clay silt loma |

2.2. The studied traits: Ten random plants were selected from the intermediate lines to calculate the following characteristics.

2.3. Days to 75% Flowering: After the appearance of the first flowering, up to 75% of the plants in the experimental unit.

2.4. Plant height (cm): - The plant height was measured before harvesting started from the soil surface to the highest plant height after flowering.

2.5. Seeds yield per plant (g): Calculate from the dispersion of the seeds of five plants 5 and divide them by the number of plants.

2.6. Total yield (tons h⁻¹): Extract from the product of multiplying the average seed yield per plant (g) x number of plants per hectare.

2.7. Biological yield (tons h⁻¹): The weight of the whole plant (stem, leaves, and heads): The whole plant was weighed before the process of removing the heads of the five harvested plants, then they were air-dried and then cut into small pieces and placed in bags and perforated for the purpose of removing moisture. Then it was dried by an electric oven at a temperature of
65 m for 48 hours until the weight stabilized and until the weight was stable and after adjusting it to 12.5% humidity, then the five plants was weighed to extract the average biological weight [7].

3. Results and discussion:

3.1. Days to 75% flowering

The results of Table (2) show that there was a significant effect of the fertilizer combination, as, the fertilizer combination F1 gave the highest mean of days, which was 153.95 days, while the combination F4 gave the lowest mean of days, which was 151.11 days. An effective role in these processes of photosynthesis and encourage cell division and expansion, which was the number of days required with the F1 comparison treatment. The regulation of the absorption of elements, In addition to the regulatory role of potassium in the process of transporting nutrients to all parts of the plant, especially fruits and seeds, [8]. The results in Table (2) indicated a significant effect on the effect of planting distances, as distance D5 gave the lowest average number of days from planting, which was 151.44 days, while distance D1 gave the highest average number of days to 75% flowering, as it was 155.62 days. This is may be due to increase in planting distances between the lines that increasing the movement of air and the penetration of sunlight to the plants and thus speeds up the biological processes inside the plant from the cell division and expansion And the plant's transition from the vegetative growth stage to the other stages access to the flowering stage [9]. found similar results. The results showed that a significant differences due to the effect of the interaction between planting distances and fertilizer combinations, as (F2×D1) gave the highest mean of days, which was 157.17 days, while the (F4×D5) gave the lowest number of days, as it was 148.97 days.

| Fertilization level (kg.h⁻¹) | Plant distances (cm) | Mean |
|-----------------------------|----------------------|------|
| F1 156.27 155.40 153.17 151.09 153.80 | 153.95 |
| F2 157.17 156.00 151.20 153.90 150.87 | 153.83 |
| F3 156.07 154.63 152.77 153.73 152.13 | 153.87 |
| F4 152.97 152.27 150.00 151.33 148.97 | 151.11 |
| Mean 155.62 154.57 151.78 152.51 151.44 | |

Table 2. shows effect of planting distances, fertilizer combination and their interaction of days to 75% flowering.

3.2. Plant Height (cm)

The results in Table (3) indicated that there are significant differences due to the effect of the difference between levels of fertilizer combination, where the fertilizer combination F4 gave the highest average plant height of 151.54 cm, while the F1 combination gave the lowest average plant height of 134.30 cm. This variation in plant height may be due to increase of nitrogen which leads to an increasing leaf area, and which increases the deception as a result of the role the phytochrome pigment by absorbing and reducing the red light permeable (R), and increasing the proportion of the far red light permeable (FR), which causes it to fall on the stems and increasing the production of gibberellin resulting the elongation cells. Or it may be explained that increased shading might decrease the photo-oxidation process of auxin, increasing its concentration, which works with gibberellin to elongate the internode. The results were identical to the findings of [10-13].

The results also indicate a significant effect of plant distances, as treatment D1 gave the highest average plant height of 157.00 cm, while treatment D4 gave the lowest mean of 125.30 cm, this is may be due to reducing the distance between plants led to increased competition for light due to shading that causes plants to elongate to obtain light. The results of the combination between levels of fertilizer and planting distances showed significant differences in this characteristic, as the combination (F4×D2) gave the highest value of plant height of 174.90 cm, while the combination (F1×D5) gave the lowest value of 116.00 cm.
Table 3 shows the effect of planting distances, fertilizer combination and their interaction in plant height.

| Fertilization level (kg.h⁻¹) | Plant distances (cm) | Mean |
|------------------------------|----------------------|------|
|                              | D1       | D2       | D3       | D4       | D5       |      |
| F1                           | 152      | 150      | 133.9    | 120.7    | 116      | 134.5 |
| F2                           | 154.8    | 141.3    | 139.6    | 126.3    | 126.9    | 137.8 |
| F3                           | 158.4    | 150.6    | 127.1    | 122.8    | 119.6    | 135.7 |
| F4                           | 162.9    | 170.9    | 146.3    | 131.5    | 142.2    | 151.5 |
| Mean                         | 157      | 154.2    | 136.7    | 125.3    | 126.2    | 134.5 |

L.S.D@0.05 Fertilization combination = 7.20
L.S.D@0.05 Plant distances = 8.05
L.S.D@0.05 Interaction = 16.10

3.3. Seed yield per plant

The results, Table (4) showed a significant difference between the fertilization treatments for the seed yield per plant, as the fertilizer combination treatment F4 gave the highest mean of seed yield for the plant which was 18.60 g, which differed significantly from the other treatments, while the lowest mean of seed yield per plant was for the fertilizer combination F1, which was 85.30 g. That is the superiority of the treatment F4 may be due to the increase in the addition of nitrogen, phosphorus and potassium, which contributed to the various positive effects of structure, physiology, and functions of different cells, tissues and their relationship to the efficiency of photosynthesis, which is referred to as the source and the efficiency of the reproductive organs, which is referred to as the sink. These results are in agreement with the findings of other researchers, who explained that the increase in the nitrogen level of fertilization was accompanied by an increase in the seed yield per plant [14,15]. The results that indicated there are significant differences due to the difference in planting distances, as treatment D5 gave the highest value of seed yield per plant, which was 145.7 g, while treatment D1 gave the lowest value which was 53.3 g. The reason can be attributed to the reduction in planting distances between plants which led to a reduction in biomass of plant compared to the increasing the distances between plants which led to an increase in biological processes inside the plant, which increased the production and transfer of manufactured materials to the sink and competition between plants also played a role in this increase due to the decrease in the number of plants per unit area and thus less competition for light, moisture and nutrients. These results are findings of other researchers [16,17] to significant differences in their studies.

Table 4 shows the effect of planting distances, fertilizer combination and their interaction in seed yield per plant (g).

| Fertilization level (kg.h⁻¹) | Plant distances (cm) | Mean |
|------------------------------|----------------------|------|
|                              | D1       | D2       | D3       | D4       | D5       |      |
| F1                           | 56.30    | 67.00    | 83.30    | 97.10    | 122.40   | 85.30 |
| F2                           | 43.30    | 66.30    | 83.50    | 130.30   | 152.10   | 95.10 |
| F3                           | 58.50    | 87.20    | 95.30    | 107.00   | 121.80   | 94.00 |
| F4                           | 55.10    | 76.00    | 143.30   | 132.30   | 186.30   | 118.60|
| Mean                         | 53.30    | 74.10    | 101.50   | 116.70   | 145.70   | 95.10 |

L.S.D@0.05 Fertilization combination = 16.22
L.S.D@0.05 Plant distances = 18.13
L.S.D@0.05 Interaction = 36.27

3.4. Total grain yield (Ton. h⁻¹)

The seed yield is the final outcome resulting from the effective of environmental, genetic factors, fertilization factors and planting distances and the combination between them and their effect on the yield components. The results in Table (5) showed that there was a significant difference between the fertilizer treatments. The treatment F4 gave the highest yield value of 4.89 tons. h⁻¹, while treatment F1 gave the lowest value of 3.38 tons. h⁻¹. This can be explained by the fact that increased fertilization with NPK increased photosynthesis, which increased the production of dry matter and its transfer to the seeds, and the addition of these nutrients provided the amount ready for absorption in the rhizosphere in addition to the increase in the total grain yield. These results are agreement with the findings of [18-20]. Which were indicated that the increase in the level of nitrogen fertilization was accompanied by an increase in the total grain yield. The results indicate that there was a significant differences between the plants distances coefficients. The treatment D1 showed the highest yield average of 5.56 h⁻¹ tons, while treatment D5 had showed the
lowest average of 3.13 h⁻¹ tons [24]. These differences may be due to the increase in the number of plants per unit area despite the superiority of treatment D5 in the plant yield. The results of the analysis of variance showed that there was a high significant effect of the interaction between the levels of the fertilizer combination, as the interaction (F3×D1) gave the highest yield value of 6.21 tons. h⁻¹, while the lowest value of interaction was (F1×D5) with a yield value of 2.21 tons. h⁻¹.

Table 5. shows effect of planting distances, fertilizer combination and their interaction in Total yield (ton.h⁻¹).

| Fertilization level (kg.h⁻¹) | Plant distances (cm) | Mean |
|-----------------------------|----------------------|------|
|                             | D1 | D2  | D3  | D4  | D5  |      |
| F1                          | 4.46 | 4.18 | 3.29 | 2.77 | 2.21 | 3.38 |
| F2                          | 5.44 | 5.45 | 4.21 | 3.96 | 3.44 | 4.50 |
| F3                          | 6.21 | 4.66 | 2.79 | 2.56 | 2.89 | 3.82 |
| F4                          | 6.13 | 4.75 | 5.53 | 4.09 | 3.96 | 4.89 |
| Mean                        | 5.56 | 4.76 | 3.96 | 3.55 | 3.13 |      |

Fertilization combination =1.106  L.S.D@0.05 =1.236  Interaction=2.472

3.5. Biological yield (ton.h⁻¹)

The results in Table (6) showed a significant difference due to the effect of the difference in the levels of fertilizer for the biological yield characteristic. The treatment F4 gave the highest value of biological yield of 15.15 tons. h⁻¹, which did not differ significantly with treatments F2 and F3, while treatment F1 gave the lowest value of 12.37 tons. h⁻¹. The difference may be due to the effect of fertilization on the plants, which provided the amount of nutrients ready for the plant, which reflected positively on the increase in the size of the Vegetative growth of plant, thus increasing the biomass such as the number of leaves and branches and the number of heads of the plant in addition to the increase in the specific weight of the seeds and the productivity of plant.

As for the role of potassium in an encouraging increase in demand for nitrogen, which has a role in the synthesis and physiology and function of cells and thus increasing the total vegetative, this gives the biggest disappointments of solar radiation. These results were similar finding from [13,14,15,21].

The plants planted at a distance of D1 gave the highest average biological yield 19.94 tons. h⁻¹, while the distance D4 gave the lowest average of 9.34 tons. h⁻¹. The increase in biological yield of treatment D1 may be due to an increase in the number of plants per unit area, thus an increase in the leaf area index, in addition to an increase in competition for light and thus stimulation of stem cells to elongation, which was positively reflected in the increase in total dry matter. These results were agreement with finding [6,16,22]. As for the effect of the interaction, the analysis of variance indicated the existence of a high significant effect if the interaction F3×D1 gave the highest mean of 22.04 tons. h⁻¹, while the interference F3×D5 gave the lowest mean of 8.28 tons. h⁻¹.

Table 6. shows effect of planting distances, fertilizer combination and their interaction in biological yield (ton.h⁻¹).

| Fertilization level (kg.h⁻¹) | Plant distances (cm) | Mean |
|-----------------------------|----------------------|------|
|                             | D1 | D2  | D3  | D4  | D5  |      |
| F1                          | 17.84 | 10.42 | 12.38 | 10.88 | 10.34 | 12.37 |
| F2                          | 17.90 | 16.73 | 11.08 | 8.13  | 11.69 | 13.11 |
| F3                          | 22.04 | 15.24 | 10.65 | 9.57  | 8.28  | 13.15 |
| F4                          | 21.97 | 17.06 | 16.10 | 8.77  | 11.87 | 15.15 |
| Mean                        | 19.94 | 14.86 | 12.55 | 9.34  | 10.54 |      |

Fertilization combination =2.907  L.S.D@0.05 =2.507  Interaction=6.501
Acknowledgments

It was concluded that; the highest seed yield per plant, total seed yield, biological yield and plant height were obtained from the treatment F4 compared with control treatment which is represented level of fertilizer. As for the treatment of plant distribution the treatment D1 which gave a highest total yield seeds ton.h⁻¹ and plant height (cm), and the treatment D5 which gave highest yield (cm) and seed per plant (g). As for the interaction treatment the combination (F4 X D5) which is gave highest day to 75% flowering and seed yield per plant (g), the treatment interaction (F3 x D1) which showed significant differences for the total yield (ton.h⁻¹) and biological yield (ton.h⁻¹).

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