Effect Of Organic Fertilizer and Emitter Type on The Growth and Yield of Broccoli (Brassica Oleracea Var Italica) With Evaluation of The Drip Irrigation System

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Abstract

The experiment was conducted in field during the season 2020-2021 at The Al-sayade Research Station of the College of Agriculture /University of Kirkuk, and aimed to study the impact of three types of organic fertilization (without fertilization, sheep fertilizer, organic fertilizer), and three types of Emitter (GR, Turbo, Spiral) and the interaction between them in the growth and yield of Broccoli (Brassica oleracea Var.italica) and the evaluation of the Drip Irrigation System. A factorial experiment was carried out according split split plot design of the Random Complete Block Design R.C.B.D and obtained data was statistical analyzed by using SAS system and Duncan multi –Range test at the probability level of %5 used to compared among the mean of treatment. The results showed that organic fertilization of sheep fertilizer gave a significant increase in the height of the plant 66.27 cm. The H (250g.d⁻¹ in four stages) fertilizer adding showed a significantly Superiority for traits of the yield of plant and total yield of plant (902.84 g plant⁻¹ and 45.142 ton ha⁻¹, respectively). However, the treatment without fertilization has given a significant increase of total chlorophyll ratio to 25.44 mg. g⁻¹. Turboemitter recorded a significant increase in the height of the plant 67.233 cm. whereas, the GR emitter showed a significant increase the total chlorophyll ratio by 25.830 mg. g⁻¹ and superior in percentage of dry material in main head recorded by %12.694. The interaction between H fertilizer and Turbo emitter, had significantly differences of the most of the qualities traits were studied. When evaluating the drip irrigation system, it noted the superiority of the GR emitter treatment was gave the lowest plants the Coefficient of Variation 0.051 % with the highest absolute field emission uniformity reach to 98.84%, the highest efficient water distribution with 98.08% and the lowest water consumption 43.17mm.

Keywords : Broccoli, Organic fertilization, Emitter, Water Consumptive, Absolute field Emission uniformity.

1. Introduction

Broccoli (Brassica oleracea var.italica) is a plant from the Brassicaceae family and it has several labels such as Broccoli, sprouting cauliflower, Italian Asparagus and Calabrese. Winter vegetable crops that need a mild atmosphere for vegetative growth and a cold atmosphere during the period of formation of heads [1]. The word brocco is derived from the Italian word broccio, meaning flowering top or small nail [2]. Broccoli is a vegetables plant around the leg ends with a dense cluster integrated from green floral buds and the plant produces a number of side heads over several weeks rapidly disintegrate heads if it not harvested in time, it has large long leaves carried on the short leg and increases the height of the plant when blooming, as a result of the elongation of the floral stand, the broccoli plant give a floral discs during growth stages before the open of their buds, which can be used in eat with the thick floral stand [3].

[4], reported that cauliflower and broccoli crops in Iraq is estimated at 989 hectares with a productivity of 27,669 tons ha⁻¹ for 2019. When Iraq's production is compared with some neighbors countries such as Turkey and Jordan, where production 223616 and 519989 tons .ha⁻¹, respectively. The low production rate in this crop belong to some reasons including, the inability of Iraqi farmers to follow modern methods of agricultural production and they not caring about agricultural service processes such as fertilization, irrigation and improved seeds [5],to increase agricultural production, it is preferable to add organic fertilization, either animal or plant residues, which it is added according to programs studied in terms of quantity, quality and timing of the addition of these fertilizers, in proportion to the development of plant growth and need [6]. Drip
irrigation is a way to increase agricultural production, due to delivers a ground moisture to field capacity in a limited area around the plant, with save the amount of irrigation waters, by reducing leaching loss with significantly reducing surface evaporation [7].

Organic fertilization is the most important way to develop and raising the agricultural production value and reduce the environmental pollution resulting from the excessive use of mineral fertilizers [8,9]. Organic fertilizers contain a wide range of organic compounds dissolved in water, such as sugars, proteins, amino acids, organic acids, and phytohormone-like compounds [10], and all these compounds contribute directly or indirectly to plant growth and development, organic matter supplies macro and micronutrients to plants and improves soil chemical and physical properties. Incorporation of organic matter increase nutrient availability and provide food for soil microorganisms. Organic matter acts as a soil conditioner and considers nutrients reservoir [11].

[12], who were studied the effect of organic fertilization with five levels from sheep fertilizer (0, 2.5, 5.0, 7.5, 10.0 %) of soil size based on the area of the experimental unit and mixing it with the soil at a depth of 0.3m in the growth and product of cauliflower, the results showed that the level (10% ) of addition led to a moral increase in the rate of weight of the floral disc by 1.27 gm, and total yield reached 46.11 ton.ha⁻¹. However, to know the effect of drip irrigation system on plant growth and productivity, [13] noted in their experience about the impact of drip irrigation system on the growth and productivity of red leaf plant using two types of drip irrigation system GR and Turbo, the GR emitter gave a significant increase in the leaf area recorded 4498 cm² plant⁻¹ compared to Turbo emitter which gave the lowest leaf area reached 400 cm² plant⁻¹, while Turbo emitter exceeded the total yield and head length by 504.25 kg ha⁻¹ 13,690 cm, respectively, compared to GR emitter which gave the lowest percentage in total yield and head length of 413.25 kg ha⁻¹ and 13,243 cm, respectively. Whereas, their results on the evaluation of the drip irrigation system showed the highest value of GR emitter in efficient capacity. Add water 84.54% and absolute uniformity of field emission 85.41% compared to Turbo emitter in efficient water add 80.06% and absolute uniformity of field emission 81.26%. Therefore, aims of this study were:-

- Study the extent to which organic fertilization affects the improvement of production in relation quantity and quality of the crop.
- Find out the best emitter that gives the highest broccoli product.

2. Materials and Methods

The experiment was carried out at the Al-sayade Research Station of the college of Agriculture, University Kirkuk from 1/9/2020 to 15/2/2021. The soil of the field was analyzed before cultivated by taking samples from field soil at the depth surface layer approximately 30 cm from different places and randomly and then mixing samples with each other harmoniously. Some physical and chemical qualities of field soil, the results as shown in table (1).

| pH     | EC | Potassium availability | Phosphorus availability | Nitrogen availability | Organic matter | soil texture | silt | Clay | sand | Traits |
|--------|----|------------------------|-------------------------|-----------------------|----------------|--------------|------|------|------|--------|
| 7.24   | 0.56 | 160 mg.kg⁻¹          | 10.5 mg.kg⁻¹            | 0.213 g.kg⁻¹          | 3.415 g.kg⁻¹   | sandy loam   | 28   | 16   | 56   | result |

The field soil was prepared by cleaning and get rid of large stones and burning grass, the field has been irrigated the ground heavy irrigation for three days to accelerate the growth of the remaining jungles and grass to get rid them. Field has been ploughed by discus ploughing tool in a perpendicular way. The field experiment was divided into four replicates, each replicate contains 18 experimental units 2m⁻². Each one experimental unit contained to one line with a line length 4m and a width of 50 cm and it contains 10 plants and the distance between plant and another 40 cm, the distance between the lines and other 50 cm, and it was left a distance of 1.5m among replicates. Broccoli seedlings were obtained ready for cultivation of the Ajasi class (Agassi RZ hybrid Dutch origin) and before planting in the field the regionalization process was carried out and placed in the wood shadow. Three days after the seedlings were transferred to the field on 1/9/2020 for regionalization. The seedlings were planted in the center of the terraces with it used drip irrigation system to irrigate plants, irrigation times were used according to the need of the plant for watering and according to the weather conditions of the area. The total seedlings planted 720 seedlings for experiment transactions.
2.1. The studied factors

2.1.1 The first factor / organic fertilization includes

- Without fertilization and symbolized (O).
- Add H fertilizer and the trade name (H 850) and its components (heumic acid 48%, fulvic acid by 37% and potassium in the form of Water-dissolved hemat 15%) It was added after the seedling operation by 250g.d⁻¹ and in four stages and symbolized (H).
- The addition of sheep fertilizer and symbolizes it (M).

2.1.2 The second factor/ includes three types of emitters

- Turbo: The diameter of its opening ranges from (1-2) mm this emitter features the whirlpool movement of water and symbolizes it (T).
- Spiral: A tube with a small internal diameter of (0.5-0.8) mm consisting of several spiral rings and symbolizes it (S).
- GR: This emitter is self-drip and symbolizes it (GR).

2.2. The studied characteristics include

2.2.1. Plant characteristics include

- Plant height (cm): It measured from its contact area to the soil until the end of the plant's longest leaf using the measuring tape formation of the floral disc.

- The leaves content of total chlorophyll (mg g⁻¹ fresh weight): laboratory estimated in [14] where the broccoli leaves were cut into small pieces by scissors and took the weight of 0.25g of small pieces and placed in containers 100ml dark, 15ml of concentrated ethanol alcohol was added to it and placed in a dark place for one day, then, the second day it was filtered and added 15ml of ethanol alcohol and the process was repeated three times, then the solution was read by spectrophotometer on two wavelengths of 665 and 649 nm.

- Percentage of dry matter in the floral disc (%): Taking a random sample of the floral disk of five plants and weight them, it has been cutting into small parts and placed in perforated paper bags and at a temperature of 65- 70°C, it must be the weight is stable after taking it out and weighed and applied the following equation to calculate the percentage of dry matter in the floral disc.

  \[
  \text{Percentage of dry matter in the floral disc} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100
  \]

- The plant yield (g plant⁻¹): It was done by combining the weight of the floral disk with the weight of the plant's secondary disk, then finding the rate.

  \[
  \text{Average of the plant yield (g plant}^{-1}) = \frac{\text{The product of the experimental unit}}{\text{Number of plants in the experimental unit}}
  \]

- Total yield (ton h⁻¹):The total yield of the main disk has been calculated only according to the following law:

  \[
  \text{Total yield (ton h}^{-1}) = \frac{\text{The experimental unit product}}{\text{Experimental unit area}} \times 10000
  \]

The experimental unit is the product = the plant product rate × the number of plants per experimental unit.
2.2.2. Characteristics of Drip Irrigation System

- Coefficient of Variation (CV)\%: is the difference in the discharges of the emitters resulting from the inability to manufacture similar emitter it is calculated as a following [15]
  \[ CV\% = \frac{SD}{qm} \times 100 \]
  
  CV: difference coefficient \%.
  SD: Standard deviation of discharge L/h.
  qm: average emitter discharge L/h.

- Absolute field Emission uniformity (F. EUa %)
  Expresses the regularity of water distribution in the field (practically measured in the field) and through it the irrigation system can be assessed and can be calculated by the following equation [16].
  \[ F.\text{EU}_a(\%) = 50 \left( \frac{q_{\text{min}}}{q_{\text{avg}}} + \frac{q_{\text{avg}}}{q_x} \right) \]
  
  qmin: Lowest discharge rate of the emitters 1/4 (L/h).
  qx: highest discharge rate of the emitters 1/8 (L/h).
  qavg: Average emitters discharge (L/h).

- Efficiency Irrigation application (Ea)\%
  It is the result of dividing the amount of water that reaches the root area and benefits the crop on the amount of water that reaches the field is calculated as a following [17].
  \[ Eu = \left( \frac{1.27 \times CV}{\sqrt{n}} \right) \frac{qn}{qm} \]
  
  EU: Efficient water addition %.
  CV: Coefficient of Variation %.
  qn: Lowest discharge of the emitters (L/h).
  qm: Average discharge %.

- Water Consumptive (mm)
  It is defined as the amount of water consumed by the plant (plant, soil and the environment around the plant), and water consumption equals evaporation and transpiration symbolizes it Evapotranspiration, ET [15].
  \[ E_{\text{ta}} = (P + Ir) - \Delta S \]
  
  Eta: Water Consumptive
  P: Amount of rainwater (mm)
  Ir: Amount of irrigation water (L/h).
  \Delta S: Difference in soil moisture.

3. Results and Discussion

3.1. Plant height (cm)

Table (2) shows the excelling of the Turbo emitter, which gave the highest average of plant height amounted to 67.23 cm compared to GR emitter recorded the lowest average only 63.42 cm. Whereas, the fertilizer of sheep exceeded morally by giving the highest height of the plant amounted 66.27 cm and it did not differ with H fertilizer which it reached 65.58 cm compared to a treatment without fertilization which gave 64.10 cm. However, the interaction between emitter type and type of fertilization, the results showed the GR emitter with H fertilizer exceeded and gave the highest height of the plant to 68.63 cm compared to the lowest height of the plant was at spiral emitter with sheep fertilizer of 62.93 cm. This increase may be due to the importance of animal manure in improving soil fertility when added and it has an important role in vital and reproductive processes, which it may be increased cell division and the result of increased plant height [18].
Table 2. Shows the effect of organic fertilization and emitter type and interaction between them in the characteristic of plant height (cm).

| Emitter Type | Interaction between emitter type and fertilization type | Effect of Emitter type |
|--------------|--------------------------------------------------------|------------------------|
|              | Without fertilization | H fertilizer | Sheep fertilizer |                      |
| GR           | 65.93 | 68.63 | 64.26 | 63.42 |
|              | b     | a     | bc    | C      |
| Turbo        | 65.80 | 67.90 | 63.06 | 67.23 |
|              | b     | a     | c     | A      |
| Spiral       | 64.20 | 65.16 | 62.93 | 65.31 |
|              | bc    | b     | c     | B      |
| Effect of organic fertilization Type | 64.10 | 65.58 | 66.27 | - |

3.2. The leaves content of total chlorophyll (mg g\(^{-1}\) fresh weight)

Table (3) shows that the GR emitter significantly affected and gave the highest rate of chlorophyll leaf content of 25.83 mg. g\(^{-1}\) compared to the lowest amounted to 24.19 mg. g\(^{-1}\) at Turbo emitter. As for the effect of fertilization type, it noted that the treatment without fertilization has given a significant increase of 25.44 mg. g\(^{-1}\) and is not very different from the adding H fertilizer, which it amounted to 25.02 mg. g\(^{-1}\). While, the lowest chlorophyll content was recorded at the addition of sheep fertilizer was 23.77 mg. g\(^{-1}\). The treatment of interaction between GR emitter and the addition of H fertilizer achieved the highest amount to 26.94 mg. g\(^{-1}\) compared to the lowest number was 23.18 mg. g\(^{-1}\) between spiral emitter and the addition of sheep fertilizer. This may be due to the good distribution of irrigation water by GR emitter around the root total spread area and increased efficiency of water absorption by plant roots and to meet plant needs [19].

Table 3. Shows the effect of organic fertilization and emitter type and interaction between them in the leaves content of total chlorophyll (mg g\(^{-1}\) fresh weight).

| Emitter Type | Interaction between emitter type and fertilization type | Effect of Emitter type |
|--------------|--------------------------------------------------------|------------------------|
|              | Without fertilization | H fertilizer | Sheep fertilizer |                      |
| GR           | 26.20 ab | 26.94 a | 24.79 abc | 25.83 a |
| Turbo        | 24.83 abc | 24.39 ab | 23.35 bc | 24.19 b |
| Spiral       | 25.99 abc | 24.20 bc | 23.18 c | 24.22 b |
| Effect of organic fertilization Type | 25.44 a | 25.02 a | 23.77 b | - |

3.3. Percentage of dry matter in the floral disc %.

Table (4) shows that the emitter type significantly affected, GR emitter and Turbo emitter gave the highest percentage of dry matter in the floral disc at 12.694% and 12.278%, respectively, compared to spiral emitter which it gave the lowest rate of 11.472%. In the effect of the fertilization type rate in the same table, there are no significant differences between the treatment of the type of fertilization. The treatment of interaction between GR emitter and the addition of sheep fertilizer achieved the highest amounted to 12.800% compared to the lowest number which it was 11.133% between spiral emitter and the addition of sheep fertilizer. The reason may be that the GR emitter discharge has played an important role in making the level of soil moisture suitable for the melting of nutrients N and K and the readiness of these nutrients in the soil solution to be absorbed by the plant [20].

Table 4. Shows the effect of organic fertilization and emitter type and interaction between them in the percentage of dry matter in the floral disc %.

| Emitter type | Interaction between emitter type and fertilization type | Effect of Emitter type |
|--------------|--------------------------------------------------------|------------------------|
|              | Without fertilization | H fertilizer | Sheep fertilizer |                      |
| GR           | 12.616 | 12.667 | 12.800 | 12.694 |
|              | a     | a     | a     | a      |
| Turbo        | 11.916 | 12.733 | 12.183 | 12.278 |
|              | ab    | a     | ab    | a      |
| Spiral       | 12.017 | 11.267 | 11.133 | 11.472 |
|              | ab    | b     | b     | b      |
| Effect of organic fertilization Type | 12.183 | 12.222 | 12.039 | - |
3.4. The plant yield (g.plant⁻¹)

Table (5) shows that the emitter type treatment did not significant effect on the product of a plant yield, Whereas, the significant differences appeared between the treatment of the type of fertilization, H fertilizer treatment gave a significant increase in plant yield by 902.84 g.plant⁻¹ with increase percentage reached 13.92%, while the lowest yield per plant in the treatment without fertilization was 792.47g.plant⁻¹. The result in the same table showed significant differences for interaction between Turbo emitter and H fertilizer, the results showed the highest plant production 943.20 g.plant⁻¹ with percentage increase reach 25.10% compared to the lowest plant production with the GR emitter interference treatment and without fertilization was 753.93 g.plant⁻¹. The reason may be that, in the case adding organic fertilization increases soil fertility and the plant gets all its needs of essential nutrients in the period of green and syphilis development, thus increases the productivity of the plant in quantity and quality [21].

Table 5. Shows the effect of organic fertilization and emitter type and interaction between them in the plant yield (g plant⁻¹).

| Emitter type | Interaction between dotted type and fertilization type | Effect of Emitter type |
|--------------|-------------------------------------------------------|------------------------|
|              | Without fertilization | H fertilizer | Sheep fertilizer |                            |
| GR           | 753.93               | 849.17      | 895.81          | 832.97                   |
|              | c                    | abc         | abc             | A                         |
| Turbo        | 768.03               | 943.20      | 821.57          | 844.27                   |
|              | bc                   | a           | abc             | A                         |
| Spiral       | 855.45               | 916.17      | 854.23          | 875.28                   |
|              | abc                  | ab          | abc             | A                         |
| Effect of organic fertilization Type | 792.47               | 902.84      | 857.20          | -                         |

3.5. Total yield (ton.h⁻¹)

The data from table (6) indicate that there are not significant differences to the effect of the emitter type on the total yield. In the same table, it is noted that there are significant differences in the treatment of the type of fertilization, which led to a significant increase in total yield when the addition of H fertilizer amounted to 45,142 tons.h⁻¹ compared to the lowest yield when treated without fertilization amounted to 39,624 tons.h⁻¹. In the same table showed significant differences interaction between Turbo emitter and H fertilizer and gave the highest yield of 47,160 tons.h⁻¹ with percentage increase was 25.10% compared to the lowest yield when interaction between the GR emitter and the treatment without fertilization was 37,697 tons.h⁻¹. The reason may be that when organic fertilizer is added to soil, it increases the soil's content of the necessary nutrients and thus increases the plant's efficiency to absorb nutrients, including nitrogen, as an important element in increasing the composition of chlorophyll and increasing the efficiency of photosynthesis and proteins, thereby increasing vegetative growth and the result of increased incidence [22].

Table 6. Shows the effect of organic fertilization and emitter type and interaction between them in the total yield (ton h⁻¹).

| Emitter type | Interaction between emitter type and fertilization type | Effect of Emitter type |
|--------------|-------------------------------------------------------|------------------------|
|              | Without fertilization | H fertilizer | Sheep fertilizer |                            |
| GR           | 37.697               | 42.458       | 44.790           | 41.648                   |
|              | b                    | ab           | ab               | a                         |
| Turbo        | 38.402               | 47.160       | 41.078           | 42.213                   |
|              | b                    | a            | ab               | a                         |
| Spiral       | 42.773               | 45.808       | 42.712           | 43.764                   |
|              | ab                   | a            | ab               | a                         |
| Effect of organic fertilization Type | 39.624               | 45.142      | 42.860           | -                         |
3.6. Evaluation of drip irrigation system

Table (7) shows the results of the evaluation of the drip irrigation system, which includes three types of emitter GR, Turbo, spiral, and that the evaluation of the drip irrigation system depends mainly on the work of the emitter and we note from the table that the GR emitter has outperformed by achieving the lowest value for the coefficient of variation which was 0.051 % compared to spiral and Turbo emitter where they recorded a value of 0.061% and 0.082 % respectively. The reason for this difference is due to the inaccuracy and discipline during the manufacturing process and the other factor is due to the different pressure inside the pipes of the irrigation system due to the loss of friction due to the different nature of the material from which the pipe is made [23]. From the same table, it is noted that there are no significant differences between the emitter in the characteristic of absolute field emission regularity. In the efficient capacity of water distribution, it noted the superiority of GR and Spiral emitter gave the highest percentage 98.08% and 97.75%, respectively. Whereas, the efficiency of water distribution equally and systematically on all field-grown plants compared to Turbo emitter was 94.67%. The reason may be was the irrigation system is exposed to weather conditions, including sunlight, and fluctuating temperatures between night and day leads to increased evaporation of water from the surface of the soil near the emitter opening, which leads to the accumulation of salts on the emitter opening and causes blockage and thus affects the efficiency of the emitter in the distribution of water in the field as mentioned[24].

As for water consumption, it is noted in the same table, there are significant differences between the three emitters, Turbo gave the highest water consumption of 446.23 mm compared to GR and Spiral 431.73 m and 437.90 m in sequentially. Most likely the amount of water consumption in the drip irrigation system is low due to the fact that the amount of water added to the soil by the emitter is limited in quantity and varies by different type of emitter and thus the evaporation of water from the soil is low [25].

| Irrigation system characteristics | Emitter type |
|----------------------------------|--------------|
| Coefficient of Variation ( CV) %  | Turbo | Spiral | GR |
|                                  | 0.082 | 0.061 | 0.051 |
| Absolute field Emission uniformity (F. EUa %) | a | b | b |
|                                  | 96.66 | 98.02 | 98.84 |
| Efficiency Irrigation application % | b | a | a |
|                                  | 94.67 | 97.75 | 98.08 |
| Water Consumptive (mm)           | a | b | c |
|                                  | 44.62 | 43.79 | 43.17 |

Conclusions

- The results of the addition of H fertilizer achieved the best values in most of the qualities studied.
- GR emitter showed significant superiority in most of the qualities studied, but the characteristic of the yield of plant and the total yield did not show the type of emitter any significant effects where spiral emitter recorded a numerical increase only.
- GR emitter outperforms most of the qualities related to the evaluation of the irrigation system.

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