Response of eggplant *Solanum melongena* L. To soil mulching, organic and inorganic fertilizers on vegetative growth traits and yield grown under unheated plastic house

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Abstract. This study was conducted in one of the unheated plastic house at the Department of Horticulture and Landscape design, College of Agriculture and Forestry, University of Mosul during the agricultural season 2013-2014 to study the impact of two factors, the first: Soil mulching with black plastic and without mulching, the second: Foliar application of Liquid organic fertilizers (Azomin , Vit Org) and chemical fertilizer (Rosa Sol) at a concentration of 3 cm$^3$. L$^{-1}$ on growth and yield of eggplant plants Belen variety grown under the unheated plastic house,the experiment was designed in the Split Plot system within a Randomized Complete Block Design (RCBD)with three replicates. The treatment of the soil mulching was laid in the main plots and the fertilizers in the sub plots. The results could be summarized as: The soil mulching and organic fertilizers spraying increased plant height , leaves number, branches number per plant, leaf area , fruits number, plant yield and total yield.

1.Introduction:
Eggplant (*Solanum melongena* L.) is the one crop of a family Solanaceae, an important economic family. Its fruits are important because it contains some important nutrients and some vitamins. It has medical importance for treating diabetes, asthma, cholera, dysuria, severe diarrhea and cholesterol reduction,and treatment of liver diseases [1].The cultivation of this crop in Iraq suffers from many problems leading to a decline in productivity of the unit area, so it has attracted the attention of researchers and specialists through the introduction of new varieties of high productivity and adoption of modern agricultural methods to increase productivity, including soil mulching as one of the important agricultural processes to improve plant growth and increase productivity,through their influence on the physio-biological activities of soil for plant growth [2]. The soil mulch with black polyethylene increased total yield of fruits [3].Plant height, branches number, leaves number, leaf area per plant, yield and fruits number per plant, fruits total yield increased when black polyethylene used soil mulch [4]. Used black polyethylene for soil mulch caused a significant increase in plant height, plant leaf area, yield per plant, number fruits per plant, fruits
total yield of cucumber plants *Cucumis sativus* L. [5]. [6] found that the yield and fruits number per plant, fruits total yield increased by soil mulching with black polyethylene.

Eggplant crop needs more quantities of organic and chemical fertilizers in more quantities than other crops, especially in protected agriculture [7]. Research has shown that 85% of plant nutrient needs can be given through leaf feeding [8]. Al-Badri et al. [9] found the use of aquatic extract of poultry waste at 15,30 and 45 gm.L$^{-1}$ concentrations increased number of fruits per plant, average fruit weight, fruits total yield of eggplant plant, and using of vermicompost at 6 t.H$^{-1}$ along with 75 kg.H$^{-1}$ inorganic fertilizers (urea 46%) caused increased plant height, fruits number. Plant$^{-1}$ and fruits total yield of eggplant plant [10]. And also [11] explained that addition of Farmyard manure and chemical fertilizer (640 and 120 kg.ha$^{-1}$) on eggplant plant increased plant height, plant dry matter, fruits total yield. [12] observed that spraying of nutrient solution (Nebras) at 2 ml.L$^{-1}$ concentration increased plant height, branches and leaves number, Plant$^{-1}$, leaf area. Plant$^{-1}$(cm$^{2}$), fruits number, average of fruits, plant yield and total fruits yield of eggplant. [13] found the spraying of humic acid on eggplant plant at 50 mg.L$^{-1}$ concentration and urea addition at 80 kg Urea. H$^{-1}$ pure increased plant height, branches number, fruits number. Plant$^{-1}$ and total fruits yield. Increasing the plant height, branches and leaves number, Plant$^{-1}$, leaf area, fruits number. Plant$^{-1}$, average of fruit weight, plant yield and total yield of fruits with spraying of nutrient solution (Micronet 15) at 2.5 ml.L$^{-1}$ on eggplant plant [14]. This study was conducted to determine the effect of soil mulching and liquid organic fertilizer and NPK (Rosa sol) on growth and yield of Eggplant.

2. Materials and Methods

The experiment was carried out in one of the unheated plastic houses of the Department of Horticulture and Landscape / Faculty of Agriculture and Forestry / University of Mosul, during the agricultural season 2013-2014, random samples of plastic house soil were taken before planting from the surface layer into 30 cm depth table (1)

| Sand g.kg$^{-1}$ | Loam g.kg$^{-1}$ | Clay g.kg$^{-1}$ | N mg.kg$^{-1}$ | P mg.kg$^{-1}$ | K mg.kg$^{-1}$ | O.M mg.kg$^{-1}$ | pH | EC dsm$^{-1}$ |
|----------------|--------------------|----------------|----------------|----------------|----------------|--------------------|----|----------|
| 60.23          | 32.95              | 6.82           | 44             | 13.9           | 120            | 1.76               | 7  | 1.39      |

The soil sample was analyzed in the Soil and Water Resources Department Laboratories / College of Agriculture and Forestry / Mosul University.

The area of plastic house was 500m$^{2}$, and the soil of plastic house was prepared by plowing the soil with a plow, and then smoothed it well and then cut in the form of a 1 m width and then extended the drip irrigation pipes along the length of the piper at the rate of two lines per meter, the distance between the irrigation line and another 50 cm. The seeds of the eggplant Belen variety were produced by the Western seed Company of America on 3/9/2013. After seed germination and the arrival of the seedlings to the second real leaf, they were transferred to the permanent place inside the house, the number of plants in each experimental unit was 10 plants (five plants on each side of the surface) and the number of experimental units in each sector 8 experimental units (2x4) and the total experimental units in experiment was 24 experimental unit, and the area of experimental unit 2 m$^{2}$ (1x2) m$^{2}$. Agricultural processes have been carried out since the beginning of the plant and till the end of the season, such as control of diseases and insects, irrigation and pruning, as practiced in the commercial fields, and as needed for these
agricultural operations. After planting, the plants were irrigated with the fungicide Pentanol with irrigation water to protect the seedlings from the damping-off at 1 ml–1 concentration, this pesticide was used periodically weekly until the seedlings reached the stage of the fifth and sixth real leaf. The experiment included two factors:

2.1. Soil mulch: included two treatments:
1- Mulching with black plastic.
2- No mulching.

2.2. Fertilizers spraying: included four treatments:
1- control.
2- Liquid organic fertilizer (Azomin) at 3ml. L–1 concentration.
3- Liquid organic fertilizer Vit- org at 3ml. L–1 concentration.
4- chemical fertilizer (Rosa sole) NPK ( 20-20-20) at 3ml. L–1 concentration.

The following fertilizer components used in the experiment:
- Liquid organic fertilizer (Azomin): organic N 5%, organic Carbon 15%, amino acid 32% and production of Italian company Cifo.
- Liquid organic fertilizer (Vit-org): organic N 3%, K₂O potassium dissolved in water 6%, organic Carbon 12%, organic material 24%. Produced by the Italian Green Company.
- chemical fertilizer (Rosa sole) NPK (20-20-20): N 20%, P (P₂O₅) 20%, K (K₂O) 20%, B (EDTA) 0.1%, Cu (EDTA) 0.0075%, Fe (EDTA) 0.0026%, Mn (EDTA) 0.032%, Zn (EDTA) 0.023%. Produced by the Belgian company Rosé.

Fertilizer was added spraying to the plants four times during plant growth period: the first on was two weeks after planting, the second at beginning of the flowering, the third after the first harvested fruits, the fourth after the third fruits harvested. The experiment consisted of 8 treatments (2 × 4), which were carried out in the plastic house with a factorial experiment a split block system within Randomized Complete Block Design, the mulch factor was laid in main plots and fertilizers treatments in sub plots with three replicates. The first fruits pound was made on 26/1/2013 and the last fruit finale was on 30/5/2014.

2.3. The vegetative growth traits were recorded after 10 days of the fourth spraying of fertilizers and included the following characteristics:
1- Plant height (cm). 2 - Number of leaves (leaf. Plant -1). 3 - Number of branches (branch. Plant -1). 4 - leaf area (cm². Plant -1).

2.4. The data yield were recorded and included the following characteristics:
1- Number of Fruits (fruit. Plant–1). 2- Average of fruit weight (gm). 3- plant yield (kg. Plant -1). 4 –early fruit yield (kg, plastic house 500 m²). 5- total fruit yield (ton. 500 m²).

The results were analyzed using the program [15](Statistical Analysis System). The averages were compared and tested by using the Duncan Multiplicity test at the probability level of 0.05 [16].

3. Results and Discussion:

3.1. Vegetative growth characteristics:
The results of table (2) indicate that the soil mulching with black plastic is significantly higher in the height of the plant 133.32 cm and in the number of leaves 163.75 leaf. Plant–1 and the number of branches 5.09 branch. Plant–1 and leaf area 2270 cm². Plant–1 compared to treatment without mulch, while no significant difference was observed between the two treatments in the percentage of dry matter in the vegetative growth.
While the fertilizers treatments results showed that the spraying of organic fertilizer (Azomin) a concentration of 3 ml. L⁻¹ gave the highest values in plant length 134.33 cm and the number of leaves 163.33 leaf. Plant⁻¹, branches 4.91 branch. Plant⁻¹ and leaf area 2323 cm². Plant⁻¹, and the percentage of dry matter in the vegetative growth 22.92% with significant difference with the control treatment, which gave the lowest values in all the above characteristics.

Table 2. Effect of soil mulching and chemical, organic fertilizers spraying on vegetative growth characteristics.

| Soil mulch | Plant height (cm) | Nu. Leaves (leaf. plant⁻¹) | Nu. Branches (branch. plant⁻¹) | Leaf area (cm². plant⁻¹) | Dry matter of vegetative% |
|------------|-------------------|----------------------------|-------------------------------|--------------------------|--------------------------|
| Mulching   | 133.32 a          | 163.75 a                   | 5.09 a                        | 2270 a                   | 22.57 a                  |
| No mulch   | 125.40 b          | 140.50 b                   | 3.74 b                        | 1485 b                   | 21.18 a                  |

Fertilizers

| Treatments  | Plant height (cm) | Nu. Leaves (leaf. plant⁻¹) | Nu. Branches (Branch.plant⁻¹) | Leaf area (cm². plant⁻¹) | Dry matter Vegetative% |
|-------------|-------------------|----------------------------|-------------------------------|--------------------------|------------------------|
| Control     | 124.18 b          | 125.29 b                   | 3.56 b                        | 1419 c                   | 20.46 c                |
| Azomin      | 134.33 a          | 163.33 a                   | 4.91 a                        | 2323 a                   | 22.92 a                |
| Vit-org     | 128.21 ab         | 156.58 a                   | 4.45 a                        | 1785 b                   | 21.55 b                |
| Rosa sole   | 130.17 ab         | 161.95 a                   | 4.73 a                        | 1981 b                   | 22.56 a                |

The average with same letter for each factor was no-significant according Duncan's multiple range of 0.05.

The results of table (3) in the interaction between the two factors showed that the soil mulch and spraying organic fertilizer (Azomin) gave the highest values in plant height 136.16 cm and the number of leaves 174.27 leaf. Plant⁻¹ and branches number 5.96 branch. Plant⁻¹ and leaf area 2802 cm². Plant⁻¹, and the percentage of dry matter in the vegetative growth 24.09%, which differed significantly with the interaction treatment without soil mulching in comparison only in plant height with no treatment in the comparison and spraying of Vit-org in the number of leaves per plant and with all treatments in the number of branches of the plant and the percentage of dry matter of the vegetative growth except for soil mulch treatment with spraying the chemical fertilizer Rosa sole and all the treatments in the leaf area of the plant, spraying with organic fertilizer was only Vit-org, and the lowest values for these traits were in the treatment without mulching in control.

Table 3. Effect of interaction of soil mulching and chemical, organic fertilizers spraying on vegetative growth characteristics.

| Treatments       | Plant height (cm) | Nu. Leaves (leaf. plant⁻¹) | Nu. Branches (Branch. plant⁻¹) | Leaf area (cm². plant⁻¹) | Dry matter Vegetative% |
|------------------|-------------------|----------------------------|-------------------------------|--------------------------|------------------------|
| Mulch            |                   |                            |                               |                          |                        |
| Control          | 131.06 a          | 135.63 ab                   | 4.16 c                        | 1762 c                   | 20.50 c                |
| Azomin           | 136.16 a          | 174.27 a                   | 5.96 a                        | 2802 a                   | 24.09 a                |
| Vit-org          | 130.53 a          | 172.78 a                   | 4.83 bc                       | 2324 ab                  | 22.18 b                |
| Rosa sole        | 135.53 a          | 172.77 a                   | 5.40 bc                       | 2192 bc                  | 23.51 a                |
| No mulch         |                   |                            |                               |                          |                        |
| Control          | 117.3 b           | 116.30 c                   | 2.96 d                        | 1076 d                   | 20.43 c                |
| Azomin           | 132.5 b           | 152.30 ab                  | 3.86 ed                       | 1844 bc                  | 21.75 bc               |
| Vit-org          | 125.9 ab          | 140.30 bc                  | 4.06 c                        | 1247 d                   | 20.93 bc               |
| Rosa sole        | 125.9 ab          | 151.63 ab                  | 4.06 c                        | 1771 c                   | 21.61 bc               |

The average with same letter for each factor was no-significant according Duncan's multiple range of 0.05.
And may explain the moral superiority of the treatment of mulching the soil with black plastic in plant height and the number of leaves, number of branches and leaf area as a table (2), that the soil mulch with black plastic lead to an increase in the temperature of the soil below it at a rate of (2 - 10) °C compared to untreated soil [17], thus optimizing plant growth by influencing the physio-biological activities of soil and the microlimitted of plant growth [2], this has positive effects in increasing water absorption, and nutrients by the roots of plants that activate the vital events in the plant, including increased division and elongation of cells, which is reflected in the increase in plant height (Table 2), and this heat in the soil mulching with black plastic increases the biological activity of soil microorganisms such as Actinomycetes, Nitrosomonas and Nitrobacter, which converts organic matter into nitrates (NO$_3^-$), a nitrogenous image that is suitable for plant absorption [18], reduce nutrient losses as a result of heavy irrigation, and help maintain the physical properties of the soil [19], they also reduce the growth of weeds because they inhibit the light necessary for their growth [20], as well as their role in increasing the readiness of many nutrients, the rate of nitrogen use is also increasing in the formation of proteins that accelerate the growth process. The soil mulching process stores carbon dioxide products, which are located near the lower parts of the plant through the holes from which the plants come out, which increases the efficiency of photosynthesis and carbohydrate accumulation and encourages plants are growing and rapidly developing [21]. The reason for its moral superiority in the leaf area per plant may be due to its superiority in plant height, number of leaves and number of branches, which is reflected in the increase in the leaf area per plant. The superiority of organic and chemical fertilizers in most vegetative characteristics is due to the components of these nutrients, especially nitrogen, which enters the structure of the protein, DNA, and RNA, this increase increases the mass of protoplasm and cell division and cause increasing vegetative growth [22]. In the interaction between the soil mulching and fertilizers adding, the relative superiority of most interaction treatments between soil mulching with black plastic and the fertilizers added in the vegetative characteristics mentioned above is due to the cumulative effect of soil mulching in black plastic and fertilizers as previously explained.

3.2: Yield characteristics

The results of table (4) indicate that the treatment of soil mulching with black plastic gave the highest values in the number of fruits, fruit weight, plant yield, early fruit yield and total yield (17.82 fruit. Plant$^{-1}$, 172.85 gm, 2.94 kg. Plant$^{-1}$, 1.46 t.500 m$^2$ and 7.36 t.500 m$^2$), respectively, in the treatment of fertilizers the results showed that the spraying of organic fertilizer (Azomin) gave a highest values in the number of fruits 17.94 fruits. plant$^{-1}$, fruit weight 168.63 gm, plant yield 3.02 kg. plant$^{-1}$, total yield of fruits 7.54 t. 500m$^2$, differ significantly with the comparison and spraying with Vit-org in the number of fruits per plant and the total yield of fruits, and with the treatment of comparison only in the average weight of fruit and plant yield, while no significant differences between fertilizer coefficients in the early yield of fruits. The lowest values for these characteristics were found in the comparison treatment.

Table 4. Effect of soil mulching and chemical, organic fertilizers spraying on yield characteristics.

| Soil mulch       | Nu. Fruits (fruit. Plant$^{-1}$) | Fruit weight (gm) | Plant yield (kg. Plant$^{-1}$) | Fruits Early yield (t.500 m$^2$) | Total fruits yield(t.500m$^2$) |
|------------------|----------------------------------|-------------------|------------------------------|---------------------------------|-----------------------------|
| Mulching         | 17.82 a                          | 172.85 a          | 2.94 a                       | 1.46 a                          | 7.36 a                      |
| No mulch         | 14.58 b                          | 155.00 b          | 2.35 b                       | 1.08 b                          | 5.88 b                      |

Fertilizers
The average with same letter for each factor was no-significant according Duncan’s multiple range of 0.05.

The results of table (5) in the interaction between the two factors indicate that the treatment of soil mulching and spraying with organic fertilizer (Azomin) gave the highest values in the number of fruits per plant, average fruit weight, plant yield, early yield and the total yield of the fruits 19.45 fruits.plant⁻¹, 174.56 gm, 3.41 kg.plant⁻¹, 1.57 t.500 m⁻² and 8.52 t.500 m⁻² respectively, and thus significantly differed with the comparison and spraying with Vit- org and Rosa sole with no soil mulch in the number of fruits per plant, and with all fertilizer treatments and without soil mulching in the weight of fruit and early yield of fruits, and with all fertilizer treatments and without soil mulching and the comparison spraying with Vit- org and mulching soil in the plant yield and the total yield of fruits, the lowest values for these characteristics found in the comparison treatment and without mulching the soil.

**Table 5.** Effect of interaction of soil mulching and chemical, organic fertilizers spraying on yield characteristics.

| Treatments | Nu. Fruits (fruit. Plant⁻¹) | Fruit weight (gm) | Plant yield (kg.Plant⁻¹) | Fruits early yield (t.500m⁻²) | Total fruits yield (t.500m⁻²) |
|------------|-----------------------------|-------------------|--------------------------|-------------------------------|------------------------------|
| **Control** | 17.08 ab                    | 170.83 ab         | 2.74 b                   | 1.34 abc                      | 6.86 b                      |
| **Azomin** | 19.45 a                     | 174.46 a          | 3.41 a                   | 1.57 a                        | 8.52 a                      |
| **Vit- org** | 16.10 ab                    | 173.22 ab         | 2.61 b                   | 1.32 abc                      | 6.52 b                      |
| **Rosa sole** | 18.64 a                     | 172.89 ab         | 3.02 ab                  | 1.53 ab                       | 7.54 ab                      |
| **Control** | 12.39 c                     | 147.37 d          | 1.95 c                   | 0.85 d                        | 4.87 c                      |
| **Azomin** | 16.43 ab                    | 162.81 bc         | 2.62 b                   | 1.28 abc                      | 6.55 b                      |
| **Vit- org** | 14.97 bc                    | 154.60 cd         | 2.43 bc                  | 1.12 bcd                      | 6.08 bc                     |
| **Rosa sole** | 14.53 bc                    | 155.25 cd         | 2.41 bc                  | 1.08 cd                       | 6.02 bc                     |

The average with same letter for each factor was no-significant according Duncan’s multiple range of 0.05.

The reason for the superiority of the treatment of soil mulching in black plastic in the characteristics of the quantity obtained is due to its superiority in the vegetative growth characteristics of plant height, number of leaves, number of branches and leaf area per plant (table 2), which is reflected to increase the components of the yield and increase the process of photosynthesis through increase the leaf area per plant, while the increase in the total fruit yield in the case of soil mulching with black plastic due to the increase in the number of fruits, the plant yield and the average of weight of the fruit and these are components of the yield and thus increase the total fruit yield. The reason for the moral superiority of organic fertilizer is due to all the characteristics of the yield relative to the treatment of the comparison, except the early yield (Table 4) to its moral superiority in all characteristics of vegetative growth studied (Table 2). It may be due to the superiority of organic fertilizer (Azomin) in the number of fruits to the contents of this fertilizer of the necessary nutrients which led to an increase in the number of branches of
plant and leaf area per plant, which increases the efficiency of photosynthesis and the amount of carbohydrates manufactured in the leaves and transfer to branches, more flowering buds, and the increase in the number of fruits and the increase in the amount of carbohydrates encouraged the conversion of buds and the formation of the principles of flowers, and a number of researchers pointed out that the food produced in the leaves significantly affect the composition of the principles of flowers [23], and increase the amount of carbohydrates manufactured in the leaves and their transfer to the fruits increase their weight. The increase of the plant yield is due to the increase in the number of fruits and the average of fruit weight and increase the plant yield (Table 4). The increase in the amount of fruit yield to the role of compost Azomin in increasing the number of fruits and the yield per plant and the average of fruit weight and thus increase the total fruit yield (Table 4). The treatment of soil mulching in black plastic with the addition of organic fertilizer (Azomin) may be due to the aggregate cumulative effect of single factors (soil mulching and organic fertilizer) in increasing vegetative characteristics and yield components as explained above.

4. Conclusions

The present assessment obviously indicated that the soil mulching with black polyethylene, and fertilizer with Azomin spraying, and the interaction between soil mulching with Azomin spraying increased superiority vegetative growth and yield characteristics.

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