Effect of planting distances and varieties on the yield of three cucumber hybrids (Cucumis sativus L.) using drip irrigation under protected cultivation conditions.

Amer N. N. Kakahy1, Wael F. A. ALShamary1 and Ayad A. Kakei2

1 Dep. of Mechanization & Agricultural Equipment, College of Agriculture/Alhawija University of Kirkuk, Kirkuk, Iraq.
2 Dep. of Mechanical Engineering, College of Engineering – University of Kirkuk, Kirkuk, Iraq.
Email: amer_kakahy@yahoo.com

Abstract

A field experiment was carried out in one of the plastic houses of the College of Agriculture, University of Kirkuk during the 2018-2019 agricultural season, to study the effect of three cultivation distances and three cucumber hybrids Cucumis sativus L. hybrids and their interaction on some of the characteristics of the cucumber plant using the drip irrigation system under protected cultivation conditions. The experiment included 18 treatments that consisted of matching three hybrids of cucumber (FAEQ F1, DALIA F1, and BARQ F1) with three distances between plants (40, 30, 20) cm. A factorial experiment was carried out according to the design of randomized complete sectors (R.C.B.D) and by the split plates method and with three replications. The significance of differences between the averages was tested according to the least significant difference L.S.D. between the arithmetic means and at a probability level p <0.01 and p <0.05. The results showed the significant effect of most of the studied treatments. It gave the highest significant value for the treatment of interaction between cucumber varieties and the interaction between V3D1 and V3D2 in characteristics of plant height and percentage chlorophyll in the plant, which reached (3.197 m plant-1 and 57.283%), respectively.

Keywords: Variety, drip irrigation, planting distances, cucumber plants, hybrid.

1. Introduction

Cucumber (Cucumis sativus L.) is one of the most important vegetable crops belonging to the Cucurbitaceous family that are cultivated under the conditions of protected cultivation due to the high material yield resulting from the lack of competition from open cultivation at a specific time of the year. It is known that cucumber plants are grown in open soils in summer and autumn seasons [1-3]. Because of the importance of vegetable crops, it is necessary to increase the cultivated areas to increase their productivity, and this requires the provision of sufficient water to irrigate these crops. One of the most important modern technologies is drip irrigation, which provides the plant's requirements of water and fertilizer with little loss in them, as well as soil, climate factors and new agricultural methods [4, 5]. The area occupied by a single plant affects plant growth and the amount of yield by increasing the exposure of the shoot to sunlight and reducing competition in obtaining water and nutrients from the soil, which may encourage the plant to grow well, as well as increase the plant’s height as the planting distance decreases [6]. In addition, planting potatoes at a narrow distance, increased the number of tubers and the average tuber weight.

The variety plays an important role in the productivity of crops, as there are special varieties for protected cultivation (hybrid varieties), and each variety has production characteristics in terms of vegetative growth of the plant, the size of the fruits, their texture, colour and hardness. There are long varieties, short varieties and pickling cucumber. The variety is chosen according to the high production capacity, the degree of resistance to diseases and the purpose of productivity according to the taste of the consumer and the needs of the market [7]. The use of good hybrids, which have high yield, excellent fruit quality and good resistance to diseases and insects, is one of the scientific means to increase plant productivity in plastic houses [8]. A research by [9] studied the growth and productivity of a number of cucumber varieties in Nigeria and noted the significant superiority of the Ashley variety in the yield of the plant and the total yield compared to the varieties Marketmore 76, Beth Alpha, Palmetto and Super marketer, while we did not notice any significant differences between the five varieties in number of fruits, fruit length and its diameter. The planting distance between plants is one of the factors that affect the success of the crop, as planting at long distances gives plants abundant vegetative growth and a good quality of yield, but the production per unit area may decrease, while cultivation on narrow distances produces plants that do not reach their normal
size in growth, which is reflected in the productivity of plants and that the yield characteristics may be less than the degree of cultivation of those are planted at long distances [10].

Therefore, this experiment was conducted to demonstrate the effect of planting distances and cucumber hybrids and the interaction between them on some cucumber plant characteristics by using the drip irrigation system in improving plant growth and increasing the yield in quantity and quality.

2. Materials and methods

The experiment was carried out in one of the plastic houses belonging to the Faculty of Agriculture, University of Kirkuk, which is 56 meters long and 9 meters wide, that is an area of 504 square meters, during the 2018-2019 agricultural season. The seeds of three cucumber hybrids were planted on 1.9.2018 in cork dishes after filling them with an agricultural medium containing sandy soil and peat moss. After the seedlings were ready for planting, as they were 12-16 cm long and with 3-4 real leaves, they were transferred to the plastic house on 11.1.2018, after making three terraces with a meter width of each terrace, including a ditch of 75 cm, and drip irrigation pipes were extended in the form of two lines for a terrace with a distance of (50 cm) between them and three distances between the plants (40, 30, 20) cm. Then all recommended agricultural service operations for cucumber cultivation were performed within protected cultivation facilities in a consistent manner for all treatments, according to the proposed design. The experiment was carried out using the split-plot design according to the Randomized Complete Block Design (RCBD), with three replications, and in each replicate, there were 18 treatments with two factors, the first one was distances between plants with three distances (40, 30, 20) cm that were placed in the main plots (D1, D2, D3). The second factor was using three cucumber hybrids of varieties (FAEQ F1, DALIA F1 and BARQ F1), which were placed in the sub-plots (V1, V2, V3). The length and width of the experimental unit was 3 m and 1 m respectively. Then the differences between the averages were tested according to the Least Significant Difference Test at a probability level p <0.01 and p <0.05 [11]. At the end of the experiment, the following characteristics were calculated as an average of five plants taken randomly:

2.1. Studied characteristics

At the end of the experiment on May 31, 2019, five plants from each experimental unit were randomly selected for the three replicates to measure the following characteristics:

2.1.1. The characteristics of vegetative growth

1- Plant height (m plant−1) : The height of the plants was measured from the point of its contact with the soil to the highest growing top of the plants taken from each experimental unit and for all treatments.

2. The leaf area (cm² plant−1) : The foliage area was measured by taking samples of plant leaves from each experimental unit and for all of the treatments and weighing it with the sensitive scale. Then they were cut and taken a known diameter (an area of 4 cm²) from each leaf and weighed with the scale and the leaf area was measured using the following equation:

\[
\text{Area of the cut leaf (4 cm²)} \times \text{Weight of the whole leaf} = \frac{\text{Weight of cut part of the leaf}}{\text{Area of a leaf}}
\]

3- Percentage chlorophyll in the plant leaves (%) : The percentage chlorophyll in the leaves of the cucumber plant was determined by a Chlorophyll meter (SPAD-502). The leaves were randomly taken for each replicate, then the average was measured [12].

4- Total number of leaves (leaf plant−1) : Total number of leaves was calculated for each plant in each experimental unit.

2.1.2 Characteristics of the yield and its components

1. Weight of a Single Fruit (g fruit−1) : The characteristic was calculated at the end of the season by dividing the sum of the experimental unit weight by the number of harvested fruits.

2. Single plant yield (kg plant−1) : The yield was calculated by multiplying the number of fruits by the average fruit weight for each experimental unit.

3. Early yield (kg plant−1) : It was calculated on the basis of the first three harvests [13, 14].
4. Total yield of the plant (kg plant\(^{-1}\) ) : It was calculated on the basis of the amount of the experimental unit by collecting all the harvested plants from 7.4.2019 to 31.5.2019 [12].

5- Plastic house Production (kg m\(^{-2}\)) : The production of the plastic house at the end of the season was calculated by dividing the production of an experimental unit by the number of its plants, then multiplied by the total number of plants in the plastic house.

3. Results and discussion

3.1 Characteristics of vegetative growth

The analysis of variance table (Table 1) indicates that there are differences in the effect of cucumber hybrids and planting distances and the interaction between them on the vegetative growth characteristics of the cucumber plant, some of which were significantly affected and others were not.

Table 1. ANOVA analysis of the effect of planting distances, varieties and their interaction on the vegetative growth characteristics of Cucumber.

| S.O.V       | d.f | Plant height (m plant\(^{-1}\)) | leaf area (cm\(^2\) plant\(^{-1}\)) | Chlorophyll in plant (%) | Total leaves number (leaf plant\(^{-1}\)) |
|-------------|-----|---------------------------------|-----------------------------------|--------------------------|----------------------------------------|
| Blocks      | 2   | 0.866195**                     | 5129.75**                         | 578.25398**              | 4076.44444**                           |
| Treat.      | 8   | 0.672715**                     | 16339.08**                        | 58.21148**               | 4477.77778**                           |
| V           | 2   | 0.073633**                     | 903.6214 ns                       | 12.51495**               | 439.55556 ns                           |
| D           | 2   | 0.090995                       | 629.14                            | 1.43016                  | 387.77778                              |
| DxC        | 4   | 0.0090995**                    | 629.14                            | 1.43016                  | 387.77778                              |
| Error      | 16  | 0.0090995                      | 629.14                            | 1.43016                  | 387.77778                              |
| Total      | 26  | ns not significant             | ns not significant                | ns not significant       | ns not significant                     |

It is evident from Table (2) that there are significant effects of planting distances on vegetative growth characteristics, plant height and total number of leaves, at a significant level p <0.01 as the distances between plants exceed (D\(_1\) = 40 and D\(_2\) = 30 cm) in giving the highest averages for these characteristics. They reached (2.838 m plant\(^{-1}\) and 197.111 leaves plant\(^{-1}\)), respectively. The distance (D\(_2\) = 20 cm) gave the lowest averages of the two vegetative growth characteristics, which were (2.3 m plant\(^{-1}\) and 161.556 leaves plant\(^{-1}\)) respectively. While the differences in the rest of the characteristics were not significantly affected. The reason may be that the high plant density increases the plant's height as a result of competition for light and the hormonal effect (auxins), and thus this leads to elongation of cells in the stem while the height of the plant decreases relative to the low plant density because there is no competition for light and the breakdown of auxins [15], and this is consistent with the findings of [6].

Table (2) indicates that there is a significant effect at p <0.01 for cucumber hybrids on plant height characteristics, leaf area, percentage chlorophyll in leaves and the total number of leaves. The BARQ F1 (V\(_3\)) hybrid gave the highest values for the vegetative growth characteristics which were 2.948 m plant\(^{-1}\), 166.815 cm\(^2\) plant\(^{-1}\), 53.756% and 194.222 leaves plant\(^{-1}\) respectively. The hybrid FAEQ F1 (V\(_1\)) gave the lowest values for the characteristics of vegetative growth, plant height, leaf area and the percentage chlorophyll in the leaves (2.358 m plant\(^{-1}\), 120.593 cm\(^2\) plant\(^{-1}\) and 37.75%) and the hybrid DALIA F1 (V\(_2\)) gave less values of the total number of leaves which were (152 leaves plant\(^{-1}\)).

Table (2) shows that there was no significant effect of the interaction between the treatments of planting distances and cucumber hybrids in the characteristics of leaf area and number of leaves, while for the characteristics of plant height and percentage chlorophyll in the leaves, the effect was significant at p <0.01, as the interaction treatment V\(_3\)D\(_1\) exceeded in giving the highest mean of plant height which was 3.197 m plant\(^{-1}\) and the interaction treatment V\(_3\)D\(_2\) exceeded in giving the highest average characteristic of percentage chlorophyll in leaves which reached 57.283%. The lowest averages were for the interaction treatment V\(_1\)D\(_3\) for the plant height characteristic, that reaching 1.923 m plant\(^{-1}\) and the treatment for V\(_1\)D\(_1\) for percentage chlorophyll in leaves (35.15%).
Table 2. Effect of planting distances, varieties and their interaction on the characteristics of vegetative growth of Cucumber.

| Treatments | Plant height (m plant⁻¹) | Leaf area (cm² Plant⁻¹) | Chlorophyll in leaves % | Number of leaves (leaf plant⁻¹) |
|------------|--------------------------|--------------------------|-------------------------|-------------------------------|
| Varieties  |                          |                          |                         |                               |
| V₁         | 2.358                    | 120.593                  | 37.750                  | 168.444                       |
| V₂         | 2.484                    | 133.333                  | 46.539                  | 152.000                       |
| V₃         | 2.948                    | 166.815                  | 53.756                  | 194.222                       |
| L.S.D. 0.01 | 0.54248                | 142.64256                | 6.80093                 | 111.98683                     |
| Distances  |                          |                          |                         |                               |
| D₁         | 2.838                    | 101.704                  | 44.056                  | 156.000                       |
| D₂         | 2.653                    | 186.000                  | 48.889                  | 197.111                       |
| D₃         | 2.300                    | 133.037                  | 45.100                  | 161.556                       |
| L.S.D. 0.01 | 0.54248                | 142.64256                | 6.80093                 | 111.98683                     |
| Varieties × Distances |                  |                          |                         |                               |
| V₁ × D₁    | 2.766                    | 72.000                   | 35.150                  | 148.000                       |
| V₁ × D₂    | 2.387                    | 160.889                  | 41.000                  | 195.333                       |
| V₁ × D₃    | 1.923                    | 128.889                  | 37.100                  | 162.000                       |
| V₂ × D₁    | 2.616                    | 171.111                  | 47.167                  | 136.667                       |
| V₂ × D₂    | 2.288                    | 132.444                  | 48.383                  | 166.667                       |
| V₂ × D₃    | 3.197                    | 136.667                  | 49.850                  | 183.333                       |
| V₃ × D₁    | 2.957                    | 226.000                  | 57.283                  | 229.333                       |
| V₃ × D₂    | 2.688                    | 137.778                  | 54.133                  | 170.000                       |
| L.S.D. 0.01 | 0.20118                | ns                       | 2.52215                 | ns not significant             |

3.2 The yield characteristics and components

Table of variance analysis (Table 3) shows that there are differences in the effect of planting distances and cucumber hybrids and the interaction between them on the yield characteristics and components of the eggplant plant, some of which were significantly affected and some others were not significantly affected.

Table 3. ANOVA analysis of the effect of planting distances, varieties and their interaction on yield characteristics and components of Cucumber.

| S.O.V  | d.f | A single fruit weight (kg) | A single plant yield (kg plant⁻¹) | Early yield (kg plant⁻¹) | Total yield of a plant (kg plant⁻¹) | Productivity of glass house (kg m⁻²) | MS. |
|--------|-----|---------------------------|-----------------------------------|--------------------------|-------------------------------------|--------------------------------------|-----|
| Blocks | 2   |                           |                                   |                          |                                     |                                      |     |
| Treat. | 8   |                           |                                   |                          |                                     |                                      |     |
| V      | 2   | 0.00158 ns               | 0.04947**                         | 0.63925*                 | 1.65707**                          | 0.03435**                           |     |
| D      | 2   | 0.00731**                | 0.09538**                         | 0.37447 ns              | 4.77731**                          | 0.06623**                           |     |
| VxD    | 4   | 0.00046 ns               | 0.00822 ns                        | 0.13033 ns              | 0.44661 ns                         | 0.00571 ns                          |     |
| Error  | 16  | 0.00074                  | 0.00543                           | 0.14036                 | 0.26562                            | 0.00377                             |     |
| Total  | 26  |                           |                                   |                          |                                     |                                      |     |

ns not significant; * significant at p <0.05; ** significant at p <0.01.
The results in Table (4) show that there was no significant effect of planting distances on the weight of the early yield, while the effect was significant in the rest of the studied characteristics at $p < 0.01$, as the distance between plants exceeded ($D_2 = 30$ cm) in giving the highest average of the early yield characteristic which was 0.189 kg fruit $^{-1}$, and the distance between plants ($D_1 = 30$ cm) gave the highest averages of plant yield characteristics, weight of the total yield and plastic house productivity, reaching 0.575 kg plant$^{-1}$, 3.968 kg plant$^{-1}$ and 0.479 kg m$^{-2}$ respectively. While the distance between plants ($D_3 = 20$ cm) gave the lowest value of the averages of the yield and its components, weight of a fruit, yield of a plant, total yield of the plant and the productivity of the plastic house as they reached 0.138 kg fruit $^{-1}$, 0.391 kg plant$^{-1}$, 2.773 kg plant$^{-1}$ and 0.326 kg m$^{-2}$ respectively. The reason for the increase in the total yield per unit area may be due to an increase in the number of fruits per plant in the narrow distance compared to the long distances. This is consistent with the findings of [6]. Table (4) indicates that there were no significant differences for cucumber hybrids in the weight of the fruit, while there was a significant effect at $p < 0.05$ for the early yield weight characteristic. The hybrid BARQ F1 ($V_3$) gave the highest values for the above characteristics (0.575 kg plant$^{-1}$, 1.201 kg plant$^{-1}$, 3.968 kg plant$^{-1}$ and 0.479 kg m$^{-2}$ respectively). It also did not show any significant effects of the interaction between the treatments of cultivation distances and cucumber hybrids in all the studied characteristics.

Table 4. Effect of planting distances, varieties and their interaction in the characteristics of the yield and its components for the Cucumber.

| Treatments | Weight of a fruit | Yield of a plant | Weight of early fruits | Weight of total fruits | Plastic house productivity |
|------------|------------------|-----------------|------------------------|-----------------------|---------------------------|
|            | (g fruit$^{-1}$) | (kg Plant$^{-1}$) | (kg plant$^{-1}$) | (kg plant$^{-1}$) | (kg m$^{-2}$) |
| **Varieties** |                  |                 |                        |                       |                           |
| $V_1$      | 0.147            | 0.487           | 0.687                  | 3.407                 | 0.406                     |
| $V_2$      | 0.150            | 0.427           | 0.823                  | 3.125                 | 0.356                     |
| $V_3$      | 0.171            | 0.575           | 1.201                  | 3.968                 | 0.479                     |

L.S.D. 0.05, 0.01 ns 0.01=0.41908 0.05=0.8932 0.01=2.9309 0.01=0.34924

**Distances** |                  |                 |                        |                       |                           |
| $D_1$      | 0.138            | 0.391           | 0.676                  | 2.773                 | 0.326                     |
| $D_2$      | 0.189            | 0.501           | 0.964                  | 3.496                 | 0.418                     |
| $D_3$      | 0.141            | 0.597           | 1.070                  | 4.231                 | 0.497                     |

L.S.D. 0.01 0.1542 0.41908 ns 2.9309 0.34924

**Varieties X Distances** |                  |                 |                        |                       |                           |
| $V_1$ $D_1$ | 0.125            | 0.313           | 0.461                  | 2.189                 | 0.261                     |
| $V_1$ $D_2$ | 0.189            | 0.524           | 0.643                  | 3.668                 | 0.437                     |
| $V_1$ $D_3$ | 0.128            | 0.623           | 0.956                  | 4.363                 | 0.519                     |

L.S.D. 0.127 0.349 0.810 2.555 0.291

**Varieties X Distances** |                  |                 |                        |                       |                           |
| $V_2$ $D_1$ | 0.172            | 0.428           | 0.853                  | 3.117                 | 0.356                     |
| $V_2$ $D_2$ | 0.149            | 0.506           | 0.805                  | 3.704                 | 0.421                     |
| $V_2$ $D_3$ | 0.162            | 0.511           | 0.758                  | 3.576                 | 0.426                     |

L.S.D. 0.205 0.553 1.397 3.703 0.461

ns not significant; * significant at $p <0.05$; ** significant at $p <0.01$. The increase in plant yield may be due to the formation of a good vegetative parts which in turn leads to accumulation of new sugars that will increase the speed of the cell division and thus increase the size of the shoots which will lead to an increase in...
the amount of carbohydrates manufactured by the source and their transfer to the sink. An increase in the number of fruits in the plant and then an increase in the weight of the fruit [16] resulted in an increase in the yield of the plant and thus led to an increase in the total production of the plastic house. We conclude from this study that the studied growth characteristics (plant height and percentage chlorophyll in the plant) were significantly affected by the interaction between the treatments of planting distance and cucumber hybrids. Likewise, the interaction treatment had no significant effect on the yield characteristics and its components.

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