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# IMPACT OF SPRAYING A NUTRIENT SOLUTION ON SOME EGGPLANT GENOTYPES UNDER PROTECTED CULTIVATION

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**Abstract**

This study investigated the response of several genotypes of eggplant under protected agriculture to different levels of spraying with nutrient solutions. The study involved spraying five hybrid eggplants, namely Barcelona, Emerald, E35, E21, and E53 with the Brexil Dou nutrient solution at three levels of 0, 2.5, and 5 gm $L^{-1}$. The treatments were distributed in a factorial experiment within a completely randomized block design (CRBD) with three replications. The Barcelona hybrid excelled in most of the growth traits and yields attaining the highest values for the number of branches and leaves. It also achieved the highest number of fruits as well as yield per plant at 5.15 branches $plant^{-1}$, 63.34 leaves $plant^{-1}$, 20.77 fruits $plant^{-1}$, and 2.650 kg $plant^{-1}$, respectively, while the E21 registered the lowest values for the same traits. The 5 gm $l^{-1}$ nutrient solution concentration produced the highest values for the number of branches 5.71 plant $branches^{-1}$, leaves 59.71 plant $leaves^{-1}$, fruits per plant 19.68 plant $fruits^{-1}$, and plant yield 2.432 kg compared to the control which had the lowest values.

**Keywords:** Nutrient solution, Genotypes, Eggplant, Protected Cultivation.

# استجابة بعض التراكيب الوراثية للباذنجان للرش بالمحلول المغذي تحت ظروف الزراعة المحمية

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**الخلاصة**

نفذت تجربة حقلية خلال الموسم الزراعي 2022-2023 في أحد البيوت البلاستيكية غير المدفأة التابعة لقسم البستنة وهندسة الحدائق – كلية الزراعة – جامعة الانبار، لدراسة استجابة عدة تراكيب وراثية من الباذنجان الخاص بالزراعة المحمية لمستويات مختلفة من الرش بالعناصر الدقيقة، تضمنت الدراسة عاملين الأول خمسة هجن من الباذنجان الخاص بالزراعة المحمية وهي برشلونة وزمرد وE35 وE21 وE53 بالتتابع، بينما تضمن العامل الثاني ثلاثة مستويات من الارش بالمحلول المغذي BREXIL DUO هي 0 و2.5 و5 غم لتر$^{-1}$ بالتتابع. وزعت المعاملات في تجربة عامليه ضمن تصميم القطاعات العشوائية الكاملة بثلاثة مكررات، واظهرت نتائج الدراسة ما يلي:

تفوق الهجين برشلونة في اغلب صفات النمو الخضري والحاصل فقد حققت نباتاته اعلى قيم لعدد الافرع وعدد الأوراق كما حققت نباتاته اعلى عدد للثمار بالنبات واعلى حاصل للنبات وبلغت 5.15 فرع نبات$^{-1}$ و63.34 ورقة نبات$^{-1}$ و20.77 ثمرة نبات$^{-1}$ و2.650 كغم نبات$^{-1}$ بالتتابع بالمقارنة مع نباتات الهجين E21 والتي أعطت اقل القيم للصفات المذكورة انفا بالتتابع. حقق التركيز 5 غم لتر$^{-1}$ من المحلول المغذي اعلى صفات نمو خضري وحاصل اذ حققت اعلى قيم لعدد الافرع وعدد الأوراق واعلى عدد ثمار للنبات واعلى حاصل نبات وبلغت قيمها 5.71 فرع نبات$^{-1}$ و59.71 ورقة نبات$^{-1}$ و19.68 ثمرة نبات$^{-1}$ و2.432 كغم بالتتابع مقارنة بنباتات المقارنة والتي أعطت اقل قيم للصفات المذكورة سابقا.

**كلمات مفتاحية:** محلول مغذي، التراكيب الوراثية، باذنجان، الزراعة المحمية.

## Introduction

The eggplant (*Solanum melongena* L), which originated from India and China, belongs to the Solanaceae family and is one of the summer vegetable crops of much economic importance, especially in the Middle East and subtropical regions (8). Its fruits are widely used as food, especially among the poor, while the plant has various medicinal uses in treating bronchitis, asthma, and diabetes, and for lowering blood cholesterol levels (17). Its economic and nutritional values has led to its widespread and increasing cultivation throughout the year. Various agricultural techniques have been explored to grow the crop, including protected agriculture, especially outside its normal production times (9). Hence the importance of using different genetic compositions, including first-generation hybrids produced for the purposes of protected agriculture, which are characterized by their rapid growth, high productivity, and resistance to many different diseases and stresses (7).

Agricultural production under protected conditions is one of the methods used to increase plant density per unit area, which requires the development of feeding programs commensurate with this increase in the number of plants (1). This includes the application of complementary methods for ground fertilization, such as foliar spraying with nutrients. The effectiveness of this method is seen in the plants favorable response to the treatment especially when repeated multiple times during the season. It is considered one of the important means of meeting the needs of plants with various nutrients, as well as treating cases of nutritional deficiency in them (18). It also plays a role in the metabolism of fats and carbohydrates and increases the plant's tolerance to stress through their combination with physiologically active molecules and the formation of different types of nutrients enzymes (15).

In view of the importance of protected agriculture in the production of various vegetable crops and eggplants in particular, it is important to ensure that all production requirements are met. These include first-generation hybrids having high growth and yields, and to implement an appropriate feeding program for the purpose of increasing their efficiency and performance in a protected environment. As such, this study aimed to:

1. Examine the responses of several eggplant hybrids under protected agriculture to different levels of spraying with the Brexil Dou nutrient solution.

2. Determine the best hybrids and the ideal nutrient solution concentration for ensuring optimum growth and highest yield within the protected environment.

## Materials and Methods

The study was carried out in one of the unheated greenhouses at the Department of Horticulture and Landscape Engineering, College of Agriculture, University of Anbar (latitude 33.4, longitude 43.3) using completely randomized block design. The study involved two factors. The first was the use of five genotypes of the first generation eggplants under protected cultivation i.e., Barcelona (labeled V1), Emerald (V2), E35 (V3), E21 (V4), and E53 (V5). The second involved spraying the Brexil Dou nutrient solution (as shown in Table 1) at levels of 0, 2.5, and 5 gm $L^{-1}$ and labeled T1, T2, and T3, respectively, according to (16).

**Table 1: Contents of the BRIXIL DOU nutrient solution used in study.**

| Elements | Calcium | Boron | Zinc | Manganese | Mgo | Copper |
|---|---|---|---|---|---|---|
| **Content (%)** | 18 | 0.5 | 2.0 | 2.0 | 4.0 | 0.5 |

The greenhouse site was prepared by plowing and fertilized with organic and chemical matter as recommended by (2). The greenhouse was divided into five 80-cm-wide and 45-meter-long terraces. GR-type drip irrigation pipes were installed 40 cm apart with two pipes for each terrace. The site was divided into three sectors, each containing 15 treatments resulting from the interaction of the five genotypes and spraying with the three levels of nutrient solutions. On September 1, 2022, the seeds of the five hybrids were planted in cork dishes in one of the private nurseries. Once the seedlings reached the appropriate size they were transferred to the greenhouse on November 1, 2022 and all service operations appropriate to the crop were performed. At the age of 8 true leaves, they were sprayed with the nutrient solution at the mentioned concentrations early in the morning until completely wet. The spraying was repeated weekly at a rate of 10 sprinkles, and the following characteristics were studied:

Vegetative growth:

1. The number of branches of the plant (plant $branch^{-1}$).
2. Number of leaves per plant (plant $leaf^{-1}$).
3. Stem diameter (mm).

Yield traits:

1. Number of fruits per plant (fruit per $plant^{-1}$) calculated as an average for five random plants.
2. Fruit weight (g) as an average of five random fruits.
3. Plant yield (kg $plant^{-1}$) was taken for five meals.

Vegetative growth data were collected from five randomly selected plants of each experimental unit. Measurements of the yield and its components were derived from the yield of the entire experimental unit. The data obtained were analyzed using the Gene stat program according to the proposed experimental design, and the averages compared using the least significant difference test at the 5% probability level (3).

## Results and Discussion

Vegetative growth: As shown in Table 2, the V1 genotype was significantly superior in the number of main branches of the plant, producing 5.15 branches per $plant^{-1}$ compared to the lowest for the E21 at 4.07 branches per $plant^{-1}$. The T2 treatment plants also excelled significantly and gave the highest number of branches at 5.71 per $plant^{-1}$ compared to the comparison plants (3.91 branches per $plant^{-1}$). The interaction had a significant effect with the V2T2 treatment plants having the highest number of branches at 6.78 per plant, close to the 6.67 for the V1T2. The lowest branch figure was for the V3T0 plant at 3.44 branches per $plant^{-1}$.

**Table 2: Effect of genotype and nutrient solution spraying on number of branches ($Branch.plant^{-1}$).**

| Mean of V | Nutrient levels | | | Hybrids |
|---|---|---|---|---|
| | T2 | T1 | T0 | **V** |
| 5.15 | 6.67 | 4.33 | 4.44 | **V1** |
| 5.07 | 6.78 | 4.44 | 4.00 | **V2** |
| 4.15 | 4.56 | 4.44 | 3.44 | **V3** |
| 4.07 | 4.56 | 4.00 | 3.67 | **V4** |
| 4.56 | 6.00 | 3.56 | 4.11 | **V5** |
| | 5.71 | 4.16 | 3.93 | **Mean of T** |
| 0.05 | 0.44 | | | **LSD T** |
| | 0.57 | | | **LSD V** |
| | 0.99 | | | **LSD TV** |

Table 3 shows that the Barcelona hybrid plants were notably superior in terms of number of leaves per plant, amounting to 63.34 per plant$^{-1}$, compared to the E21 hybrid which registered the lowest at 36.74 per plant$^{-1}$. The level of fertilization had a significant effect with the T2 plants producing the highest number of leaves at 59.71 leaves per plant-1 compared to the lowest for the control (48.02 leaves/plant$^{-1}$). The effect of the interaction was significant in this trait. The V1T2 treatment plants excelled at 69.59 leaves per plant compared to the lowest number of leaves for the V4T0 at 31.58.

**Table 3: Effect of genotype and nutrient solution spraying on number of leaves (Leaf.plant$^{-1}$).**

| Mean of V | Nutrient levels | | | Hybrids |
|---|---|---|---|---|
| | T2 | T1 | T0 | V |
| 63.34 | 69.56 | 64.79 | 55.66 | **V1** |
| 62.31 | 68.11 | 65.07 | 53.74 | **V2** |
| 52.05 | 57.00 | 50.43 | 48.71 | **V3** |
| 36.74 | 43.67 | 34.98 | 31.58 | **V4** |
| 56.61 | 60.22 | 59.22 | 50.39 | **V5** |
| | 59.71 | 54.90 | 48.02 | **Mean of T** |
| 0.05 | 1.91 | | | **LSD T** |
| | 2.46 | | | **LSD V** |
| | 4.26 | | | **LSD TV** |

The two study factors had a significant effect on the stem diameter characteristics of the eggplants with the Barcelona hybrid exhibiting the highest value at 17.47 mm, compared to the lowest at 12.38 mm for the E35 hybrid (Table 4). The T2 treatment plants also showed good diameters at 16.55 mm compared to the control's 12.42 mm. The effect of the interaction was significant where the V1T2 treatment plants showed largest stem diameter of 19.35 mm over the lowest for the V4T0 treatment plants at 10.40 mm.

**Table 4: Effect of genotype and nutrient solution spraying on stem diameter (mm).**

| Mean of V | Nutrient levels | | | Hybrids |
|---|---|---|---|---|
| | T2 | T1 | T0 | V |
| 17.47 | 19.35 | 17.64 | 15.41 | **V1** |
| 16.24 | 18.20 | 15.90 | 14.62 | **V2** |
| 12.38 | 14.33 | 12.27 | 10.55 | **V3** |
| 12.95 | 16.60 | 11.86 | 10.40 | **V4** |
| 12.94 | 14.28 | 13.41 | 11.11 | **V5** |
| | 16.55 | 14.22 | 12.42 | **Mean of T** |
| 0.05 | 0.65 | | | **LSD T** |
| | 0.83 | | | **LSD V** |
| | 1.44 | | | **LSD TV** |

Tables 3, 4, 5 and 6 clearly demonstrate the significant differences in the vegetative growth characteristics of the five genotypes in terms of branch and leaf numbers per plant, plant heights, and stem diameters. These differences can be attributed to the different genotypes of the hybrids and the gene expression of these traits, which in turn affects the plant's physiological ability and efficiency in converting the products of the carbon assimilation process. Similar results were obtained by (7) who noted that spraying with the Brexil Dou nutrient solution led to an increase in the vegetative growth indicators under study. This may be due to the role of microelements in building a strong root system with high efficiency in absorbing major elements from the soil (nitrogen in particular) and increasing their concentration within the plant. Increased absorption of nitrogen within the plant leads to higher concentrations of chlorophyll in the plant cells, an essential factor in building the chlorophyll molecules with the magnesium element. It is also involved in the synthesis of amino and nucleic acids and leads to stimulating vegetative growth and increasing leaf areas and the number of branches. Boron stimulates and increases hormone levels, especially auxins and cytokines (11).

These results are consistent with the findings of (14) who found that spraying boron on pepper plants led to improvements in vegetative growth indicators. The effect of this interaction can be attributed to the two factors working together and improving the responses of the genotypes to foliar nutrition levels and eventually on vegetative growth indicators.

Yield traits: The results in Table 5 show that the Barcelona hybrid plants were superior in number of fruits which amounted to 20.77 fruits per plant$^{-1}$, significantly higher than the lowest at 14.49 per plant$^{-1}$ for the E21 hybrids. The effect of nutrient solution spraying was significant with the treatment plants T2 attaining the highest number of fruits (19.68 per plant$^{-1}$), compared to the lowest at 16.40 fruits per plant$^{-1}$ of the T0. The interaction also had a significant effect on the number of fruits per plant with treatment V1T2 producing the highest number 22.96 compared to the lowest for V4T0 (13.94).

**Table 5: Effect of genetic composition and nutrient solution spraying on the number of fruits (fruit per plant$^{-1}$).**

| Mean of V | Nutrient levels | | | Hybrids |
|---|---|---|---|---|
| | T2 | T1 | T0 | V |
| 20.77 | 22.96 | 20.91 | 18.45 | **V1** |
| 20.09 | 21.73 | 20.50 | 18.04 | **V2** |
| 16.81 | 17.63 | 17.22 | 15.58 | **V3** |
| 14.49 | 15.17 | 14.35 | 13.94 | **V4** |
| 17.90 | 20.91 | 16.81 | 15.99 | **V5** |
| | 19.68 | 17.96 | 16.40 | **Mean of T** |
| 0.05 | 0.78 | | **LSD T** | |
| | 1.01 | | **LSD V** | |
| | 1.75 | | **LSD TV** | |

Meanwhile, Table 6 shows that the Barcelona hybrids were significantly superior producing the highest fruit weight at 127.27 g compared to the lowest by the E21 hybrid of 108.02 g. Spraying with the nutrient solution has a significant positive impact on fruit weight especially for the T2 treatment plants which recorded the highest value for this trait at 123.04g compared to the lowest 116.36 for the control. The interaction between treatments also significantly impacted fruit weight with the V1T2 achieving the highest at 133.85 grams, compared to the lowest for the V4T0 at 103.66 g.

**Table 6: Effect of genotype and nutrient solution spraying on fruit weight (g).**

| Mean of V | Nutrient levels | | | Hybrids V |
|---|---|---|---|---|
| | T2 | T1 | T0 | |
| 127.27 | 133.85 | 124.16 | 123.80 | **Barcelona V1** |
| 126.89 | 128.64 | 127.36 | 124.69 | **Emerald V2** |
| 116.40 | 122.05 | 114.37 | 112.79 | **E35 V3** |
| 108.02 | 113.26 | 107.12 | 103.66 | **E21 V4** |
| 117.23 | 117.39 | 117.43 | 116.87 | **E53 V5** |
| | 123.04 | 118.09 | 116.36 | **Mean of T** |
| 0.05 | 2.13 | | | **LSD T** |
| | 2.75 | | | **LSD V** |
| | 4.76 | | | **LSD TV** |

The Barcelona hybrid plants gave the highest plant yield of 2,650 kg $plant^{-1}$ compared to the lowest plant yield of the E21 hybrid plants at 1,576 kg $plant^{-1}$ (Table 7). Spraying with the nutrient solution led to a significant increase in plant yield with the T2 treatment achieving the highest at 2,439 kg $plant^{-1}$, compared to the lowest by the control at 1,921 kg $plant^{-1}$. The interventions also significantly affected plant yield with the V1T2 achieving the highest at 3.075 kg $plant^{-1}$, compared to the lowest for the V4T0 at 1.446 kg $plant^{-1}$**.**

**Table 7: Effect of genotypes and nutrient solution spraying on plant yield (kg $plant^{-1}$).**

| Mean of V | Nutrient levels | | | Hybrids V |
|---|---|---|---|---|
| | T2 | T1 | T0 | |
| 2.650 | 3.075 | 2.592 | 2.283 | **Barcelona V1** |
| 2.552 | 2.795 | 2.610 | 2.250 | **Emerald V2** |
| 1.959 | 2.151 | 1.968 | 1.758 | **E35 V3** |
| 1.567 | 1.719 | 1.536 | 1.446 | **E21 V4** |
| 2.099 | 2.456 | 1.974 | 1.868 | **E53 V5** |
| | 2.439 | 2.136 | 1.921 | **Mean of T** |
| 0.05 | 0.096 | | | **LSD T** |
| | 0.125 | | | **LSD V** |
| | 0.216 | | | **LSD TV** |

As Tables 5, 6 and 7 show, there is a clear significant difference between the genotypes in the characteristics of yield and its components. This could be due to the genetic differences among the hybrids and their ability to adapt, as well as the extent of their interaction with the prevailing environmental conditions in their area. The superiority of the Barcelona hybrid in yield and its components may be due to the efficiency of this combination in converting the food stock from the leaves to the fruits, which leads to an increase in fruit weight and eventually the yield. This superiority may be due to the advantage of the plants of this hybrid in the characteristics of vegetative growth (Tables 2, 3 and 4) which positively impacted yield components and thus plant yield. This is consistent with what was found by (5).

As for the superiority of plants treated with the nutrient solution, the reason may be due to the role of the nutrients present in the solution, such as boron and zinc in particular, which tends to increase cell division and elongation of the roots, especially the growing tips. This has a major role in increasing the absorption of nutrients necessary for the plant, such as nitrogen, phosphorus, and potassium. Also, they encourage the biological and physiological activities and growth of the plant, in addition to the role of boron which increases the accumulation of dry matter manufactured by the plant. This positively affects the growth and production of the plant, which is reflected in one way or another on the plant's yield (13).

The reason for the superiority of plants sprayed with the nutrient solution may be attributed to the role of boron in improving flower growth characteristics, such as the number of flowers and the percentage of knots. It also increases the fertilization process, the vitality of pollen grains, and the activity of eggs, as well as has a positive role in pollen germination, pollen tube formation, and rapid cell division after nodulation. All of these lead to an increase in the yield components and, consequently, the total yield of the plant (4). Spraying of the eggplant plants with boron increased the translocation rate of these compounds from source tissues such as leaves to sink tissues like fruits thus leading to the accumulation of different biochemical compounds in the fruits and increasing fruit yield (6, 10 and 12).

The above results show the advantage of planting the Barcelona hybrid and spraying it with the Brexil Dou nutrient solution at a concentration of 5 g $L^{-1}$ to achieve the highest qualities of vegetative growth. Further, new genetic combinations and increasing nutrient solution concentrations to above the 5 g $L^{-1}$ level should also be investigated, keeping in mind that economically viable limits are not exceeded.

## Conclusions

The Barcelona hybrid gave the highest values in vegetative growth and yield characteristics while the 5 g $L^{-1}$ nutrient solution concentration achieved the highest rates in vegetative growth and yield characteristics. Therefore, we recommend planting the Barcelona hybrid and spraying at a nutrient solution concentration of 5 g $L^{-1}$.

**Supplementary Materials:**

No Supplementary Materials.

**Author Contributions:**

Hussain. A. Addai: methodology, analyses of data, writing—original draft preparation; Maath M.AL-Abdaly and Saad A. Mahmood: writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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**Data Availability Statement:**

The study was based on primary data collected from a random sample of eggplant farmers in Anbar Governorate.

**Conflicts of Interest:**

The authors declare no conflict of interest.

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