Application of Paclobutrazol and Electrical Conductivity value of nutrient solutions to improve yield and quality
*Cucumis sativus L var Japanese on the hydroponic system

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Abstract. Many factors influence the yield and quality of hydroponically cultivated Japanese cucumber plants. This study aims to study the interaction of Paclobutrazol and the Electrical Conductivity (EC) of nutrient solution to improve the yield and quality of cucumbers. The study was conducted in February 2019-April 2019 at the greenhouse of Universitas Padjadjaran, Jatinangor. The research method used was a split-plot design consisting of two factors and three replications. The first factor is the value of EC n1 = (2.0-3.2 mS cm⁻¹), n2 = (2.0-3.4 mS cm⁻¹) and n3 = (2.0-3.6 mS cm⁻¹) and the second factor is Paclobutrazol concentration p1 = 0 ml l⁻¹, p2 = 0.375 ml l⁻¹ and 0.75 ml l⁻¹. The parameters of growth and yield of plants observed were leaf area, day of flowering, number of male flowers, number of female flowers, number of fruits, fruit weight, and percentage of normal fruit shape. The observational data were then analyzed by the variance analysis of 5% significance level and continued with Duncan's test at 5% level. The results showed there was no interaction of Paclobutrazol factors and EC of nutrient solution values. Plant growth without the application of Paclobutrazol and EC generative stage 3.2 mS cm⁻¹ yields better crop quality and yield.

1. Introduction

Japanese cucumbers in Indonesia, including exclusive vegetables, are offered to particular groups of restaurants, hotels, supermarkets, and catering entrepreneurs. Particular commodities generally require a hygienic cultivation process, and cucumber fruit must meet certain qualities, namely straight, uniform, and fruit weighing 100-120 g. Strategic steps to get demand for premium quality Japanese cucumber using the hydroponic system. The advantage of a hydroponic system is the more hygienic planting process, more stable growth, and yield [1,2]. Japanese cucumber cultivation also has obstacles. Farmers generally face problems such as low productivity and low quality of cucumbers. Cucumber plants usually produce more male flowers than female flowers and have a high percentage of flowers falls [3].

The results of previous studies showed that the application of paclobutrazol (PBZ) to conventional cucumber cultivation could increase yields 36% -58.5% higher compared to without the application of PBZ [3,4], PBZ application in hydroponic cucumber cultivation is still limited in information. In the hydroponic system, the microenvironment conditions of plant growth are more controlled, especially the availability of plant nutrients. The hydroponic system commonly used for cucumber plants is the drip irrigation system. The drip irrigation system has the disadvantage of fluctuating water availability for plant growth. Hydroponic cucumber cultivation in Indonesia generally uses burnt husk media. Burnt
husk media has good porosity to support rooting but can hold water lower than Rockwool or cocopeat. The combination of the right fertilizer dose and the right concentration of growth hormones can reduce the adverse effects of the weaknesses of the hydroponic system used.

Controlling the electrical conductivity (EC) value of hydroponic solution nutrients can increase the growth and yield of cucumber [5]. Efforts to control male flowers is to apply growth regulators paclobutrazol [3,6]. The combination of adjusting the EC value at each phase of Japanese cucumber growth and application of paclobutrazol concentration is expected to increase the productivity and quality of cucumbers [7]. This research suggests looking for the recommended dose of paclobutrazol and the best EC value. In addition, this study also aims to interact with paclobutrazol and EC growth values, yields, and quality of Japanese cucumber plants.

2. Methods
This research was conducted in February 2019 - April 2019 at the greenhouse of the Faculty of Agriculture, Padjadjaran University, Jatinangor-Sumedang, West Java Province, with a height of + 700 m above sea level (asl). The equipment and materials used in this study were Japanese cucumber seed cultivar Expo, Paclobutrazol, husk charcoal, AB Mix, EC meter, pH meter, water pump, nipple, emitter, and timer.

The research method used was experimental research using a split plot design. The independent variable in the main plot of EC (N) values are (n1 = Vegetative = 2 mS cm\(^{-1}\), Generative = 3.2 mS cm\(^{-1}\); n2 = Vegetative = 2 mS cm\(^{-1}\), Generative = 3.4 mS cm\(^{-1}\), and n3 = Vegetative = 2 mS cm\(^{-1}\), Generative = 3.6 mS cm\(^{-1}\)). The vegetative phase starts at 7-20 days after transplanting (DAT), and the generative phase starts 21-42 DAT. The independent variable in the sub plots concentrations of paclobutrazol (P) namely (p1 = 0 ml l\(^{-1}\); p2 = 0.375 ml l\(^{-1}\); p3 = 0.750 ml l\(^{-1}\)) Each unit of the experiment was repeated three times so that in total 27 units of the experiment were obtained. The parameters of growth and yield of plants observed were leaf area, day of flowering, number of male flowers, number of the female flower, number of fruits, fruit weight, and percentage of normal fruit shape. The observational data were then analyzed by analyzing the variance of 5% significance level and then followed by Duncan's test of 5% significance level.

3. Results and discussion
The results of the analysis of variance at 5% level (Table 1) did not result in an interaction between the EC value and the Paclobutrazol concentration on all parameters observed. Paclobutrazol concentration has an independent effect on leaf area, day of flowering, number of male flowers, number of the female flower, number of fruits, fruit weight, and percentage of normal fruit shape. The observational data were then analyzed by analyzing the variance of 5% significance level and then followed by Duncan's test of 5% significance level.

Table 1. Matrix of Analysis variance (ANOVA) on parameters of *Cucumis sativus* L var Japanese growth and yield.

| Parameters                      | CV % | N     | P     | N X P |
|---------------------------------|------|-------|-------|-------|
| Leaf Area                       | 25.3 | 0.750* | 0.001* | 0.859* |
| Age of Flowering               | 2.19 | 0.342* | 0.018* | 0.202* |
| Number of Male Flower          | 16.42| 0.228* | 0.000* | 0.499* |
| Number of Female Flower        | 12.16| 0.514* | 0.000* | 0.531* |
| Number of Fruit                | 18.18| 0.578* | 0.000* | 0.670* |
| Fruit Weight                   | 12.77| 0.200* | 0.000* | 0.736* |
| Percentage of Normal Fruit     | 16.47| 0.971* | 0.198* | 0.846* |

Note: CV = Coefficient of Variance; N = Electrical Conductivity (EC) Value; P = Concentration of Paclobutrazol; N X P = Interaction between EC value and concentration of Paclobutrazol; * = significant at level p 0.05; ns = nonsignificant.
3.1. Leaf area
The results of the analysis of variance (Table 1) showed that the concentration of paclobutrazol had an independent effect on leaf area. Based on the results of Duncan's analysis of 5% (Table 2) the concentration of paclobutrazol 0.375 ml ml\(^{-1}\) can suppress the growth of leaf area 34.5% compared without the application of paclobutrazol. Paclobutrazol is a retardant that is used to slow plant growth [6,8]. Increasing the EC value or nutrient concentration to meet the needs of plant nutrients does not affect the increase in leaf area. Leaf area measurements in this study were carried out at 42 days after transplanting (DAT).

The increase in EC values was carried out in the final vegetative phase 21 DAT so that EC values did not affect. All the treatment of electrical conductivity at the vegetative phase has the same EC value 2 mS cm\(^{-1}\). Increasing EC value at the generative phase in this research did not affect the leaf area growth. According to research Frasetya [2] at EC 3.4 mS cm\(^{-1}\) Japanese cucumber can only reach leaf area 3807.27 cm\(^2\) at this research at the same EC value 3.4 mS cm\(^{-1}\) has higher leaf area 4142.75 cm\(^2\).

Table 2. Duncan Test Results (\(\alpha = 5\%\)) on the parameters of Leaf Area (LA), Day of Flowering (DF), Number of Male Flower (MF), Number of Female Flower (FF), Number of Fruit (NF), Fruit Weight (FW), and Percentage of Normal Fruit Shape (FS).

| Treatment          | LA (cm\(^2\)) | DF | MF | FF | NF | FW | FS (%) |
|--------------------|---------------|----|----|----|----|-----|--------|
| EC Value (N)       |               |    |    |    |    |     |        |
| n\(_1\)            | 3774.04 a     | 28 | 33 | a  | 18 | 6.7 | a      |
| n\(_2\)            | 4124.75 a     | 28 | 11 | a  | 18 | 7.7 | a      |
| n\(_3\)            | 4265.70 a     | 29 | 00 | a  | 17 | 1.6 | a      |
| Paclobutrazol Concentration (P) |               |    |    |    |    |     |        |
| p\(_1\)            | 5520.70 b     | 28 | 11 | a  | 38 | 8.9 | b     |
| p\(_2\)            | 3615.20 a     | 29 | 00 | a  | 7.7 | 5.9 | a      |
| p\(_3\)            | 3028.56 a     | 28 | 33 | ab | 8.0 | 0.0 | a      |

Note: The average number in each of the same labeled columns is not significantly different according to Duncan Multiple Range Test at 5% level.

3.2. Day of flowering
Based on Table 2 the effect of paclobutrazol (PBZ) 0.375 ml l\(^{-1}\) inhibits the appearance of flowers more slowly than without PBZ application on Japanese cultivar cucumber plants. The results of this study differ from the results of previous studies, which stated that PBZ could induce flowering early 24 day after transplanting [3].

3.3. Number of male and female flower
Duncan Table 2 test results show that the application of paclobutrazol (PBZ) can reduce the number of male flowers and increase the number of female flowers more than without the PBZ application. These observations confirm previous research on the role of PBZ in the generative phase of plants [3,9,10]. PBZ application of 0.375 ml l\(^{-1}\) is the best concentration to suppress male flowers from 39 male flower without PBZ until 7-8 male flower. The PBZ application increase the number of female flowers from 9.6 – 11.9 female flower or 23.9% higher than without PBZ application. The number of female flowers more will increase the number of fruits per plant.

3.4. Number of fruit and fruit weight
The analysis of variance (Table) shows that PBZ concentrations influence the parameters of the number of fruits and weight per fruit. The PBZ application increases the amount of fruit but decreases the weight of the fruit produced. Cucumber plants that were given PBZ 0.375 ml l\(^{-1}\) and 0.750 ml l\(^{-1}\) produced more fruit than without PBZ application (Table 2). The amount of fruit produced is not directly
proportional to the weight of the fruit produced. More fruit is produced but weighs less (Table 2) compared to cucumber without PBZ application (Fig. 1). According to previous research on watermelon plants, the application PBZ has a significant effect of suppressing fruit weight because PBZ inhibits plants from producing gibberellin.

Increasing the EC value in the generative phase cannot help speed up fruit enlargement. Fruit enlargement is hampered because the leaf area in plants given PBZ is smaller in leaf area so that the resulting photosynthate is less but must be distributed to more fruit. Delaying the longer harvest time on PBZ applied plants is expected to provide fruit enlargement time because, in this study, harvesting was carried out simultaneously for all treatments given.

![Figure 1](image1.png)

**Figure 1.** Cucumber yields a. Without the PBZ application, b. PBZ application.

3.5. *Percentage of normal fruit shape*

Based on the analysis of variance (Table 1), the percentage of normal fruit shape is not affected by all levels of treatment given. The results of this study show that the intervention of cucumber plant growth by providing retardant hormones and sufficient plant nutrition cannot affect fruit shape. The results of this study contradict the results of previous studies [7] that PBZ administration significantly affected fruit quality.

4. **Conclusion**

Paclobutrazol application at various levels and variations in the value of electrical conductivity (EC) did not show interactions with all growth parameters, yields and fruit quality observed. The variation in EC values in the generative phase does not help much in increasing fruit growth, yield and quality. Plant growth without the application of Paclobutrazol and EC generative stage 3.2 mS cm\(^{-1}\) yields better crop quality and yield. Further research needs to be done to delay the longer harvest time on plants that are treated with paclobutrazol.

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