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MANAGEMENT OF PRUNING AND NUTRITIONAL SOLUTION IN THE GROWTH AND PRODUCTION OF CUCUMBER IN A GREENHOUSE

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Abstract: In the present investigation, the growth and yield of pickle type cucumber plants were evaluated. An experiment was established under greenhouse conditions with pickle-type cucumber plants in flexible plastic containers with a substrate of volcanic origin and coconut fiber in a 75:25 v/v ratio. The treatments consisted of evaluating two pruning systems: a) pruning with axillary shoots and b) pruning without axillary shoots, leaving one leaf and one fruit. Likewise, two variants of Steiner's Universal Solution were used: a) nutrient solution at 75% of its original concentration and b) nutrient solution at 75% of its concentration, varying the NO3:K+ ratio (9:10 meq L-1). Four samplings were carried out at 76, 91, 106 and 121 days after sowing. A completely randomized design with a 2x2 factorial arrangement with five repetitions per treatment was used. It was quantified: days to flowering, days to harvest, plant height, number of leaves and leaf area, leaf area index, number of fruits per plant, total yield and diameter, length and weight of the fruit. It was determined that the Steiner solution with the variation in the NO3: K+ (9:10) ratio and a pruning of axillary shoots produced a greater number of leaves and leaf area than that of Steiner at 75 % while, for the number of fruits produced per plant, the 75 % Steiner solution was the one that promoted the best results. Therefore, the use of the 75% Steiner nutrient solution and pruning with axillary shoots are recommended, for large-scale establishments such as greenhouses, since greater production is obtained from 76, 91 and 106 days later. of sowing.

Keywords: Nutritional need, physiological processes, production

INTRODUCTION

The cultivation of vegetables in protected environments represents an option to increase the productivity of the crops since it generates little limiting conditions that allow the growth and development of the plants. In greenhouse cucumber cultivation, planting density and stems per plant are agronomic management variables associated with the productivity of this vegetable (Ayala-Tafoya et al., 2019), since it represents a less restrictive space compared to open field production (Smitha and Sunil, 2016). The pruning of stems and axillary shoots in cucumber is an agronomic practice widely used in greenhouse horticultural crops, which is carried out in order to direct the growth and development of the plant to more productive forms (Olalde et al., 2014). In some species, pruning favors aeration and lighting inside the plant and at the same time reduces the incidence of some pests and diseases (Reche, 1996). The way to do it can impact the yield and quality of the cucumber crop. In general, the nutritional needs required by the plant vary according to the crop, variety, time of year, stage of development, production system and environmental factors (Alejo et al, 2021). However, it has been documented in vegetables of indeterminate type, that when the plants reach the flowering stage, the other phases such as vegetative development, flowering and fruiting occur simultaneously (Peil and Gálvez, 2002). The composition of the nutrient solution (NS) depends on the climatic conditions, the phenological state of a particular crop and the part to be harvested (Steiner, 1997). In accordance with what was indicated by Ramírez et al. (2012), the fertilization for cultivation of cucumber variety paradise, must be modified during the development of the plant based on its phenological stage. During the first four weeks of development it is recommended to apply up to 18 and 7 meq L^{-1} of NO3- and K+ respectively. From the fifth week it is recommended to modify the concentrations of NO_3^- and K+ by applying 12 and 8 meq L^{-1}. Hence the importance of evaluating the effect of two concentrations of the nutrient solution, since in cucumber when the plants reach the flowering stage, the other phases such as vegetative development, flowering and fruiting occur simultaneously (Peil and Gálvez, 2002).

In this sense, the management of nutrition and the analysis of its effect on plant growth is basic to understand the physiological processes that determine plant production and thus more rationally base crop management practices (Azofeifa and Moreira, 2004). Hence the importance of providing bases that allow obtaining a practical recommendation for the intensive management of cucumber in greenhouses on the effects on the growth, development and production of pickle-type cucumber plants depending on the frequency and intensity of pruning and two types of nutrient solutions.

MATERIALS AND METHODS

An experiment was established under greenhouse conditions at the Academic Unit of Agriculture of `` Universidad Autónoma de Nayarit``, Mexico. Pickle type cucumber plants (Cucumis sativus L.) var. Supremo, which were placed in 30 X 30 cm flexible plastic containers using red volcanic rock known locally as "tezontle" as a substrate and coconut tow in a 75:25 v/v ratio. Two pruning systems were evaluated: a) pruning with axillary shoots (PDBA) and b) pruning without axillary shoots (PSDBA). Two variants of Steiner's (1984) nutrient solution (SN) were used: a) SN at 75 % of its original concentration and b) SN at 75 % of its concentration, varying the ratio NO_3: K+ (9:10 mmol L^{-1}) (Table 1).

Nutrient solutions were supplied from the transplant at the experimental site. Four

Treatment	Description
T1	Pruning with axillary shoots and Steiner 75% nutrient solution
T2	Pruning without tipping of the axillary shoot and Steiner 75% nutrient solution.
T3	Pruning with axillary shoots and Steiner nutrient solution 75% NO_3^-:K+ (9:10).
T4	Pruning without tipping of the axillary shoot and Steiner nutrient solution 75 % NO_3^-:K^+ (9:10).

Table 1. Description of evaluated treatments.

Treatment	**Plant height (cm)**
T1: PDBA and NS 75%	142.52 a
T2: PSDBA and SN 75 %	132.55 a
T3: PDBA and SN 75 % NO_3^-:K^+ (9:10)	136.28 a
T4: PSDBA and SN 75 % NO_3^-:K^+ (9:10)	143.00 a

Table 2. Plant height by effect of the evaluated treatments.

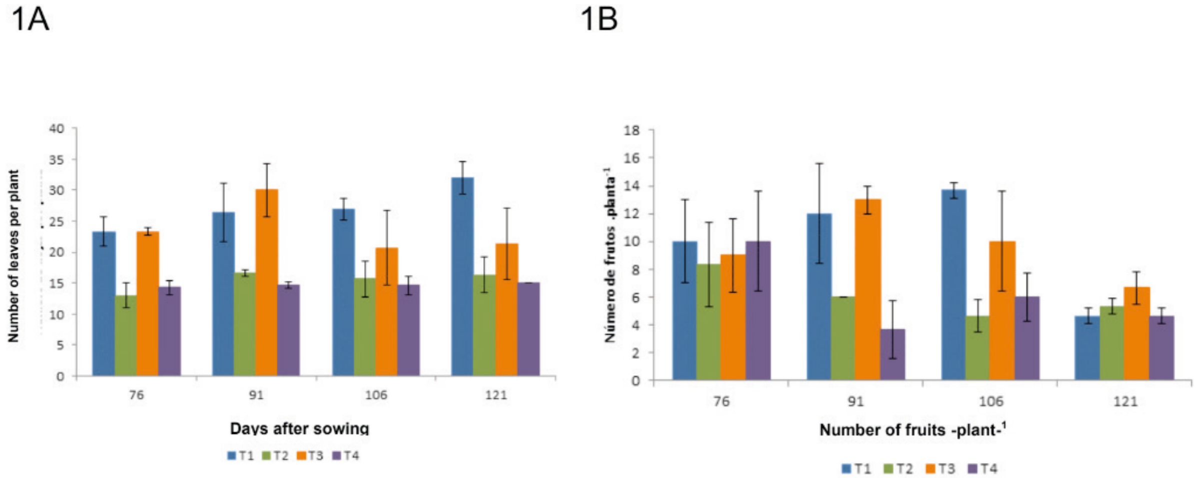

Figure 1A. Number of leaves per plant by effect of the type of treatment in cucumber plants. **1 B**. Number of fruits per treatment in cucumber plants.

Source of variation	Fruit diameter (mm)	Fruit length (cm)	Fruit weight (g)
PDBA	44.10.a	12.07 a	154.77 a
PSDBA	44.05 a	11.90 a	151.12 a
SN75%	43.66 a	11.84 a	148.56 a
SN NO_3^-:K^+ 9:10	44.50 a	12.13 a	157.33 a

Table 3. Weight, diameter and length of the fruit by effect of the evaluated treatments.

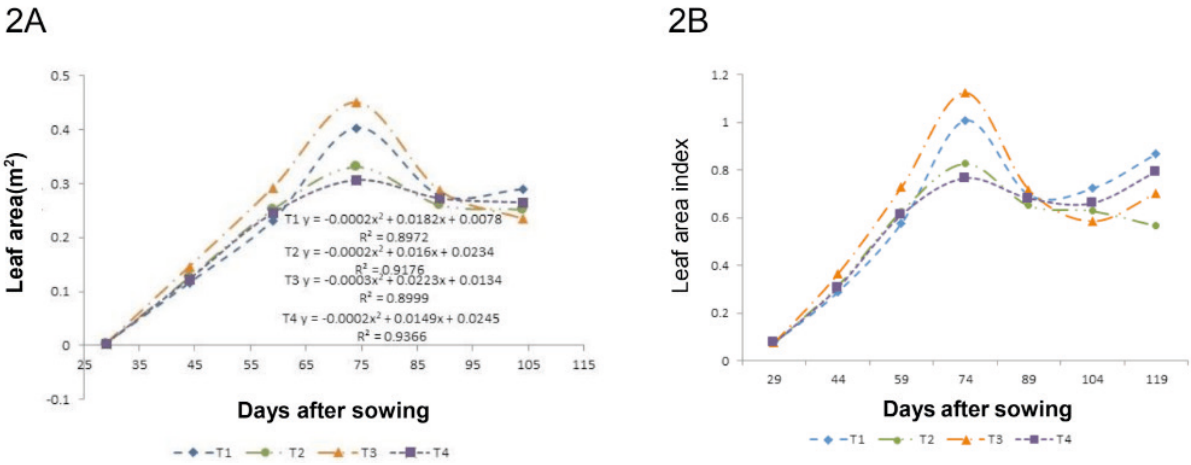

Figure 2A: Leaf area accumulation kinetics and 2B: Leaf area index by type of pruning and nutrient solution in cucumber plants.

samplings were carried out at 76, 91, 106 and 121 days after sowing (dds). It was determined: days to flowering which was recorded from the date in which 50 % of the population showed the first open flowers. Days to harvest, recorded from the days that elapsed from sowing to the moment of making the first cut. The height of the plant was evaluated on each sampling date from the level of the substrate using a flexometer graduated in cm. For the variables number of leaves and leaf area, the samplings were destructive and the leaf area was measured with a portable leaf area integrator (Model CI-202 CID Bio Science® Inc.). The leaf area index was determined according to the methodology of Aguilar-García et al. (2005). The number of fruits per plant was recorded during the evaluated period and the diameter and length were determined using a digital vernier. For the weight of fruits, an Ohaus® CS2000 brand digital scale was used. The data obtained were analyzed under a factorial model with the SAS® program and the Tukey test was used.

RESULTS AND DISCUSSION

The date on which 50 % of the population showed the first open flowers was 24 days after transplantation. In the plants without axillary bud pruning, there was greater flower production than those that had axillary bud pruning; however, not all the flowers reached anthesis and the flowers were aborted. This effect was also documented by Ayala-Tafoya et al. (2019) who evaluated cucumber plants pruned to one and two stems. Plant height did not present statistical differences between treatments (Table 2). These results could be due to the fact that there was no competition between plants for nutrients since they were in individual containers. There was also no restriction of solar radiation due to the distance between plants (40 cm).

One of the variables to evaluate the speed of plant growth was the number of leaves. The analysis of variance showed highly significant changes in this variable ($P \leq 0.0001$) due to the effect of the treatment, highlighting treatment 1 and 3 (figure 1A), in which there was pruning of axillary shoots and the leaves were larger. Which favors a greater photosynthetic activity, turning it into a source and exporter of assimilates to favor the growth of fruits (Peil and Gálvez, 2002). The first fruit cut was recorded 62 days after sowing and a weekly harvest rhythm was observed when the fruit had a length of between 10 and 12 cm.

In this work, for the fruit yield indicator per plant, there were differences between treatments depending on the sampling stage, where it is observed that at 91 and 106 days after sowing, the pruning of axillary shoots favors the formation of fruits since there is a lower demand for nutrients in the productive axes and this effect is independent of the composition of the nutrient solution supplied (Figure 1B), this result may be associated with an internal competition between the axes of the same plant that causes a greater demand for nutrients and a Excess shade and little interception of radiation and by pruning the axes the plant obtains an adequate architecture (Sánchez et al., 1999).

For the number of fruits produced per plant, the 75 % Steiner solution was the one that promoted the best results, which contrasts with Alejo et al. (2021) who indicate that nutrient solutions with 9 and 11 mmol L^{-1} of K do not modify fruit production.

Average yield per surface area for each treatment was determined. The fruits were harvested in a slightly immature state, when they were approximately 43 mm in diameter in the middle part and 12 cm in length. No significant statistical differences were detected in the diameter, length and weight of fruits (Table 3) between treatments, because the fruits were harvested when they had an approximate length of 12 cm, which is preferred by local consumers. On the other hand, harvesting very ripe fruits can reduce their quality because the structure of the fruit becomes hard and the flavor deteriorates (Limbongan, 2023).

The growth kinetics of the leaf area followed a sigmoidal trend in all treatments, which coincides with the behavior shown by most plants and plant organs (Taiz and Zeiger, 2006). The slow growth phase elapsed during the first 29 das and from this stage a greater growth was observed. The rapid growth phase lasted approximately 45 days, being at 74 das when the plants of all the treatments reached their maximum leaf area. In this regard, Ayala-Tafoya et al. (2019) point out that the management of pruning is decisive to increase the leaf area, the interception of light and, in turn, the biomass assigned to the fruits. In this study, the plants that had pruning with axillary shoots and a 75 % nutrient solution with a NO3-: K+ (9:10) (T3) ratio were the ones with the greatest leaf area (4,497 m 2), while in the other treatments an average of 3,897 m^2 was obtained (Figure 2A). These differences may be primarily related to the amount of intercepted radiation, the efficiency of its transformation, and the duration of the leaf area. As observed by Ortíz et al. (2009) in cucumber cultivation in greenhouses and hydroponics, where this effect is attributed to a lower level of shading between them that allowed them a greater and better radiation interception and therefore greater production of photoassimilates per plant.

The leaf area index (IAF) followed a sigmoidal trend. The maximum IAF was for the plants with pruning with axillary shoots (T1 and T3) from 59 to 89 dap (Figure 2B). The minimum values of the LAI were obtained in the plants with pruning without tipping of axillary shoots, due to the fact that the size of the leaf was smaller and they were independent of the ionic concentration of the nutrient solution. The LAI increases as the number of leaves and leaf area in the plant increases (Azofeifa and Moreira, 2004). In this sense, the production of leaf biomass of the cucumber plant is directly related to the leaf area that the crop develops when using the water, light and nutrients supplied that intervene in its physiological processes (Ayala-Tafoya et al., 2019)

CONCLUSIONS

Plant height was not modified by the effect of the treatments used in this study. Cucumber plants that were subjected to axillary shoot pruning produced a greater number of leaves and leaf area size, which were favored by the nutrition supplied, in which the Steiner nutrient solution stands out with the variation in the $NO3^-$:K^+ ratio (9:10). The number of fruits produced per plant was higher in those that supplied 75 % Steiner nutrient solution in its original concentration.

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