JSAT
Journal of Science and Agricultural Technology
Research Article
https://doi.org/10.14456/jsat.2024.8
e-ISSN 2730-1532, ISSN 2730-1524

# Effects of electrical conductivity of the nutrient solution on the growth of pepino (*Solanum muricatum* Aiton) plants under hydroponic cultivation

**Chorpaka Wongsorn,[1*] Methinee Nakdee,[1] Parinyawadee Sritontip,[2] Butsarin Boontem,[2] and Chiti Sritontip[1,2]**

[1]Faculty of Science and Agricultural Technology, Rajamangala University of Technology Lanna, Lampang Campus, 200 Phichai Subdistrict, Mueang Lampang District, Lampang 52000 Thailand
[2]Agricultural Technology Research Institute, Rajamangala University of Technology Lanna, 202 Phichai Subdistrict, Mueang Lampang District, Lampang 52000 Thailand

***Corresponding author**: *chorpaka.wongsorn@gmail.com*

*Received: May 30, 2024. Revised: August 9, 2024. Accepted: October 25, 2024.*

## ABSTRACT

This study aimed to investigate the difference in the electrical conductivity (EC) levels of nutrient solutions on the vegetative growth of pepino (*Solanum muricatum* Aiton) under a hydroponic culture established in the greenhouse. The experiment was conducted from November 2023 to January 2024 at the Agricultural Technology Research Institute, Rajamangala University of Technology Lanna, Lampang, Thailand. The experiment was carried out using a completely randomized design (CRD) with four treatments and ten replications. The treatments were four levels of EC, including 1, 2, 3, and 4 millisiemens per centimeter (mS/cm), respectively. The results demonstrated that the EC of the nutrient solution caused statistical differences in the vegetative growth of the pepino. The 1 and 2 mS/cm EC levels induced the percentage of pepino flowering. Meanwhile, 2 and 3 mS/cm EC levels led to the highest chlorophyll fluorescence and leaf green index (SPAD). In addition, an EC level of 4 mS/cm results in the most significant plant height, canopy width, stem diameter, leaf length, number of new shoots per plant, and leaf green index (SPAD).

## INTRODUCTION

Pepino (*Solanum muricatum* Aiton), also known as pepino melon and melon pear. It belongs to the *Solanaceae* family of crops, including several significant crops like eggplant, tomato, pepper, and potatoes. The pepino is indigenous to South America's northern highlands in the Andes Mountain range. Pepino has been cultivated in many countries, such as China, Chile, Spain, Israel, New Zealand, etc. (Contreras et al., 2016; Sun et al., 2022). Pepino fruits vary in shape and color depending on the cultivar. Fruits can have round or elongated shapes, and their skin can be cream- or golden-colored with purple stripes. The fruit pulps have orange to pale yellow colors with juicy, mildly sweet berries with aroma and taste similar to melon and pear blends. (Levy et al., 2006; Rodríguez-Burruezo et al., 2011). Pepino fruits are high in moisture and minerals, including calcium (Ca), phosphorus (P), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), and zinc (Zn). Pepino also contains water-soluble vitamins such as $B_1$, $B_2$, $B_3$, and C, as well as some antioxidants (Sudha et al., 2011; Pacheco Toabanda, 2022; Mutua, 2023). There is limited information on based on commercial cultivation in Thailand. A few studies have been conducted, but only under the Mae Lot Royal Project at Mae Taeng District, Chiang Mai, in the northern part of the country. However, some concerns still remain in managing appropriate nutrient levels for pepino's growth. Currently, the method of growing plants in a nutrient solution (hydroponics) is increasing in popularity due to its efficient use in fertilizers and water, which is better for controlling climate and pest factors, resulting in increasing productivity with better crop quality, income earnings, and competitiveness (Trejo-Téllez and Gómez-Merino, 2012; Al Meselmani, 2022). Moreover, plants can grow faster and shorten their production cycle (Wdowikowska et al., 2023). In hydroponics, the nutrient solution significantly impacts plant growth because the plants rely solely on sources of nutrients from the hydroponic nutrient solution; low concentrations of nutrients lead to inhibited growth and morphological development. In contrast, high or too much nutrient solution concentrations may lead to adverse effects on growth restriction and osmotic stress.

The most critical factors in controlling nutrient solutions for hydroponic systems are electrical conductivity (EC) and acidity-alkaline (pH). The EC value represents the nutrient concentration of the solution and an indicator of the electrolyte concentration of the solution, while the pH of a nutrient solution affects nutrient availability, uptake, and solubility (Savvas and Adamidis,1999; Al Meselmani, 2022; Fathidarehnijeh et al., 2023). The electrical conductivity levels vary depending on plant species, season, growth stage, and water quality. Previous studies have shown that the pepino cultivated in soilless cultures with 3 mS/cm of EC had the most extended new shoot length but the widest leaf width when grown with 4 mS/cm of EC and the highest fresh and dry weight when grown with 1 mS/cm of EC (Apina, 2022). Investigations into the EC of the nutritional solution for Pepino were conducted, but they were unclear. Therefore, this study was conducted to determine the optimal EC concentration level of the nutrient solution for Pepino grown under hydroponic conditions.

## MATERIALS AND METHODS

The research was conducted in a greenhouse from November 2023 to January 2024 using dynamic root floating techniques (DRFT) at the Agricultural Technology Research Institute, Rajamangala University of Technology Lanna, Lampang, Thailand. The experiment was assigned using a completely randomized design (CRD) with ten replications. The treatments consist of four EC levels, i.e., 1, 2, 3, and 4 mS/cm. Pepino plants were obtained from the Mae Lod Royal Project Research Station. The seedlings in the experiment were 28 days old after cutting in media. Then, seedlings were cleaned and transplanted onto the DRFT hydroponic system. The U-shaped PVC containers were sized 35 cm in width, 3 m in length, and 12.5 cm in height. Add water to the nutrient solution container, which has a volume of 200 liters. A hydroponic nutrient solution was modified from Huett (2003), and Sritontip et al. (2017), and the 1-liter solution fertilizers consisted of stock fertilizers A and B. Stock A fertilizer contained 128 g $Ca(NO_3)_2.4H_2O$ and 5.6 g Fe-EDTA and the stock B fertilizer contained 8.7 g $NH_4\ H_2PO_4$, 13.6 g, $KH_2PO_4$, 133 g $K_2NO_3$, 51.8 g $MgSO_4\ 7H_2O$, 0.3 g $MnSO_4.H_2O$, 0.20 g $ZnSO_4.7H_2O$, 0.035 g $CuSO_4\ 5H_2O$, 0.55 g $H_3BO_3$, and 0.018 g $Na_2MoO_4.2H_2O$. The pH of the nutrient solution was maintained at 6.5–7.0 for the entire growing period (Sritontip et al., 2022).

The data collections were divided into three parts. The first part was the plant growth index, which includes plant height (cm), plant diameter (mm), and canopy width (cm). It was measured weekly after transplanting in a hydroponics system. Moreover, leaf flushing was checked every week, and the number of new shoots, number of leaves per new shoot, leaf width (cm), and leaf length (cm) were recorded 49 days after the transplant. The second part was physiological changes, including leaf greenness index measured using the Konica Minolta model SPAD-502 plus and chlorophyll fluorescence measured using Handy PEA (Hansatech instruments, England). The fully expanded leaves were measured at the position of the third leaf (counting from the tip down) at 35, 42, and 49 days after treatments. The subsequent measurement was made at the same position and in the morning from 8.30–11.00 a.m. The third part was flowering, the number of inflorescences, and the number of flowers per inflorescence after floral emergence until fruit sets were recorded. Data were analyzed for Analysis of Variance (ANOVA) with P-values less than 0.05 considered significant, and the treatment means were compared using Duncan's new multiple range test.

## RESULTS

### *Plant height*

EC levels did not significantly affect plant height at 7–14 days after treatments (DAT); however, significant effects were observed at 21–49 DAT. When the EC hit 4 mS/cm, pepino had the tallest plant height. (Figure 1).

### *Plant diameter*

The plant diameters of pepino were not significantly different at 7–14 DAT but were significantly affected by EC concentration levels at 21–49 DAT. The highest plant diameter was obtained at the maximum EC of 4 mS/cm (Figure 2).

### *Plant canopy width*

The levels of EC did not affect the plant canopy width of Pepino at 7–21 DAT. However, significant differences in plant canopy width were found at 28–49 DAT; the EC of 4 mS/cm showed the highest plant canopy width (Figure 3).

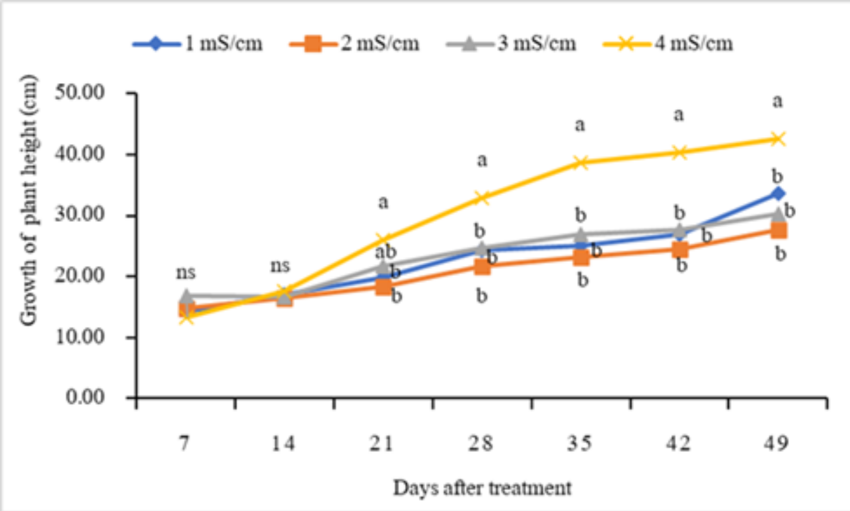


**Figure 1.** Effect of EC levels on plant height of pepino.

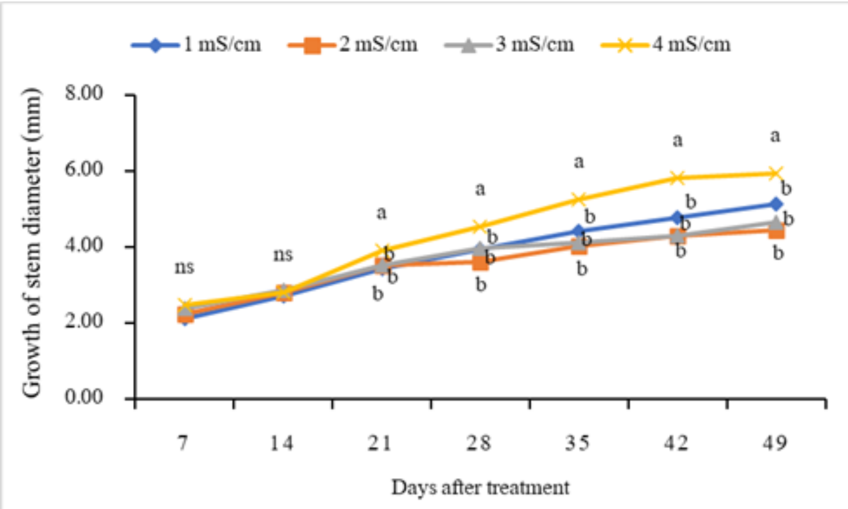


**Figure 2.** Effect of EC levels on plant diameter of pepino.

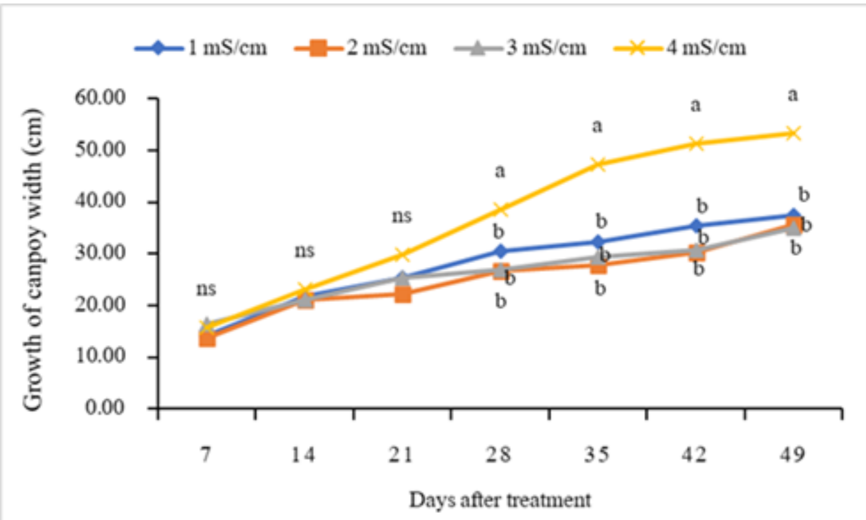


**Figure 3.** Effect of EC levels on canopy width of pepino.

The effects of differences in EC levels on leaf flushing, number of new shoots per plant, number of leaves per new shoot, and leaf sizes are shown in Table 1. The results indicated no significant difference in the percentage of leaf flushing, number of leaves per new shoot, or leaf width after leaf flushing. However, there were significant differences in the EC of 4 mS/cm, which showed the highest number of new shoots per plant and leaf length.

**Table 1.** Effects of EC of nutrient solutions on leaf flushing, number of new shoots per plant, number of leaves per new shoot, and leaf sizes of pepino

| Treatments | Percentage of leaf flushing | Number of new shoot per plant | Number of leaves per new shoot | Leaf sizes | |
|---|---|---|---|---|---|
| | | | | Leaf width (cm) | Leaf length (cm) |
| EC 1 mS/cm | 90.00 | 14.33$^{b}$ | 13.50 | 3.77 | 7.71$^{b}$ |
| EC 2 mS/cm | 80.00 | 13.63$^{b}$ | 12.20 | 3.60 | 8.18$^{b}$ |
| EC 3 mS/cm | 80.00 | 13.50$^{b}$ | 14.50 | 3.50 | 7.94$^{b}$ |
| EC 4 mS/cm | 90.00 | 17.00$^{a}$ | 11.30 | 4.38 | 11.20$^{a}$ |
| F-test | ns | ** | ns | ns | ** |

The values with the same letter within a column are statistically non-significant by Duncan's test at P > 0.05.
The asterisk indicates significantly different means (**for < 0.01); otherwise, it is not significant (ns).

The effect of nutrient solution concentrations on leaf green color index and chlorophyll fluorescence is shown in Table 2. The results indicated a substantial difference in the leaf green color index between 35 and 42 days. With an EC of 4 mS/cm, the leaf green color index at 35 days was the highest, but it did not change significantly from one at 3.0 mS/cm. At 42 days, a high leaf green color index was observed at EC concentrations of 2, 3, and 4 mS/cm. The EC concentrations also had a significant effect on the chlorophyll fluorescence at 35 and 42 days. With an EC of 2 mS/cm, the chlorophyll fluorescence at 35 days was the highest, and the concentration of 2−3 mS/cm caused the maximum chlorophyll fluorescence at 42 days. However, at 49 days, there was no statistical difference in the leaf green color index or the chlorophyll fluorescence.

**Table 2**. Effects of EC of nutrient solutions on physiological characteristics of pepino

| Treatments | Leaf green color index (SPAD Unit) | | | Chlorophyll fluorescence (Fv/Fm) | | |
|---|---|---|---|---|---|---|
| | 35 d | 42 d | 49 d | 35 d | 42 d | 49 d |
| EC 1 mS/cm | 41.98$^{c}$ | 41.75$^{b}$ | 49.74 | 0.75$^{b}$ | 0.79$^{b}$ | 0.78 |
| EC 2 mS/cm | 48.61$^{b}$ | 52.64$^{a}$ | 53.50 | 0.79$^{a}$ | 0.81$^{a}$ | 0.79 |
| EC 3 mS/cm | 51.42$^{ab}$ | 49.43$^{a}$ | 55.00 | 0.76$^{b}$ | 0.81$^{a}$ | 0.79 |
| EC 4 mS/cm | 54.91$^{a}$ | 53.15$^{a}$ | 52.09 | 0.76$^{b}$ | 0.79$^{b}$ | 0.79 |
| F-test | ** | ** | ns | * | ** | ns |

The values with the same letter within a column are statistically non-significant by Duncan's test at P > 0.05.
The asterisk indicates significantly different means (*for < 0.05, **for < 0.01); otherwise, it is not significant (ns).

The effect of nutrient solution concentrations on the flowering of Pepino is shown in Table 3. The results indicated the flowering of Pepino treated with EC of 1, 2, 3, and 4 mS/cm had no statistical difference in the number of inflorescences and number of flowers per inflorescence but a statistical difference in the percentage of flowering at EC concentrations of 1−2 mS/cm, which showed the highest percentage of flowering. (Table 3).

**Table 3.** Effects of electrical conductivity of nutrient solutions on the flowering of pepino

| Treatments | Flowering (%) | Number of Inflorescence | Number of flowers per inflorescence |
|---|---|---|---|
| EC 1 mS/cm | 64.63$^{a}$ | 9.37 | 4.18 |
| EC 2 mS/cm | 65.98$^{a}$ | 11.02 | 4.45 |
| EC 3 mS/cm | 39.74$^{b}$ | 10.82 | 3.01 |
| EC 4 mS/cm | 37.68$^{b}$ | 8.24 | 3.14 |
| F-test | * | ns | ns |

The values with the same letter within a column are statistically non-significant by Duncan's test at P > 0.05.
The asterisk indicates significantly different means (*for ≤ 0.05); otherwise, it is not significant (ns).

## DISCUSSIONS

The investigation into the effect of EC levels on the vegetative growth of pepino revealed that the various levels of EC in the nutrient solution caused significantly different vegetative growth. An EC of 4 mS/cm resulted in the greatest plant height, canopy width, stem diameter, leaf length, number of new shoots per plant, and leaf green index (SPAD). This result indicates that high EC in the early establishment phase can build strong plant cell walls (Janse, 1995). When plants receive a proper nutrient solution with sufficient concentration, it will cause them to have higher growth and yield while increasing electrical conductivity, resulting in more vigorous plants with faster growth (Nantakit, 2010). Consistent with Naik et al., (2013), who reported that plant growth parameters increased in response to a higher EC in the fertilizer solution. Lu et al., (2022) reported tomato plants given nutrient solutions with EC at 4.5 mS/cm during the stage of harvesting had increased in high chlorophyll relative content (SPAD). The nutrient solution concentrations with EC of 2, 3, and 4 mS/cm affected the highest leaf green color index. Nutrient solution concentrations with EC at 2 and 3 mS/cm had an effect on increasing the chlorophyll fluorescence of plants due to the high concentration of the nutrient solution, high uptake of nutrients, and increasing the process of photosynthesis (Thichuto, 2022). These results agree with the previous research by Ding et al. (2018), who reported high EC increased the levels of chlorophyll, leaf water, ascorbic acid, and crude protein in pakchoi (*Brassica campestris* L. sp. *Chinensis*) in hydroponic systems whereas, EC level at 4 mS/cm decided leaf chlorophyll fluorescence in pepino. In addition to chemical cues produced by the root, reduced leaf turgor and atmospheric vapor pressure typically cause the stomatal closure brought on by salinity stress (Chaves *et al*., 2009). Moreover, saffron plants found that increasing EC levels can lower the photosynthetic rate, stomatal conductance, and transpiration rate (Dewir and Alsadon, 2022). Moreover, increasing the EC in nutrient solutions has decreased flowering; this result agrees with a previous study: salt-treated plants produced about 50% fewer flowers than untreated plants done by Grunberg et al. (1995). Extreme salinity conditions can affect flowering depending on factors like temperature, tomato cultivar, salinity severity, and the duration of salinity exposure (Dorai et al., 2001). Furthermore, in the experiment, higher plant nutrient concentration levels led to higher plant nitrogen contents, allowing plants to absorb more nitrogen and, hence, lessen flowering. According to the experiment with tomatoes, high nitrogen fertilizer rates resulted in yield reductions that could be sold (Andersen et al., 1999).

## CONCLUSIONS

Differences in electrical conductivity (EC) levels affect the growth and development of Pepino. The application of EC at a level of 4 mS/cm positively affected plant height, canopy width, stem diameter, leaf length, the number of new shoots per plant, and the leaf green index (SPAD) of the pepino plant. However, a lower EC level leads to the highest chlorophyll fluorescence and induces the highest percentage of flowering in pepino.

## ACKNOWLEDGMENTS

Thanks to the Agricultural Technology Research Institute, Rajamangala University of Technology Lanna, for providing convenience in using various equipment and tools for conducting this research.

## REFERENCES

Andersen, P. C., Rhoads, F. M., Olson, S. M., and Hill, K, D. 1999. Carbon and nitrogen budgets in spring and fall tomato crops. HortScience. 34(4): 648–652.

Al Meselmani, M. A. 2022. Nutrient solution for hydroponics. In: Turan, M., Argin, S., Yildirim, E., and Güneş, A (eds). Recent Research and Advances in Soilless Culture. IntechOpen. Online: https://www.intechopen.com/books/11093.

Apina, A. 2022. Effect of the electrical conductivity level of nutrient solution on the growth of pepino in soilless cultivation system. Master thesis. Rajamangala University of Technology Lanna, Lampang campus, Lampang.

Chaves, M.M., Flexas, J., and Pinheiro, C. 2009. Photosynthesis under drought and salt stress: Regulation mechanisms from whole plant to cell. Ann. Bot. 103: 551–560.

Contreras, C., González-Agüero, M., and Defilippi, B. G. 2016. A review of pepino (*Solanum muricatum* Aiton) fruit: A quality perspective. HortScience. 51(9): 1127−1133.

Dewir, Y.H. and Alsadon, A. 2022. Effects of nutrient solution electrical conductivity on the leaf gas exchange, biochemical stress markers, growth, stigma yield, and daughter corm yield of saffron in a plant factory. Horticulturae. 8: 673.

Ding, X., Jiang, Y., Zhao, H., Guo, D., He, L., Liu, F., ... and Yu, J. 2018. Electrical conductivity of nutrient solution influenced photosynthesis, quality, and antioxidant enzyme activity of pakchoi (*Brassica campestris* L. ssp. *Chinensis*) in a hydroponic system. PLOS One. 13(8): e0202090.

Dorai, M., Papadopoulos, A., and Gosselin, A. 2001. Influence of electric conductivity management on greenhouse tomato yield and fruit quality. Agronomie. 21(4): 367–383.

Fathidarehnijeh, E., Nadeem, M., Cheema, M., Thomas, R., Krishnapillai, M., and Galagedara, L. 2023. Current perspective on nutrient solution management strategies to improve the nutrient and water use efficiency in hydroponic systems. Can. J. Plant Sci. 104: 88–102.

Grunberg, K., Fernández-Muñoz, R., and Cuartero, J. 1995. Growth, flowering, and quality and quantity of pollen of tomato plants grown under saline conditions. Acta Hort. 412: 484–489.

Huett, D.O. 2003. Managing nutrient solutions in hydroponics. NSW Industry and Investment. Orange.

Janse J. 1995. Flavour of tomatoes, In: XXX. Vortragstagung der Deutschen Gesellschaft für Qualitätsforschung. Heilbronn, Deutschland, 27–28 März, 1995. p. 179–194.

Levy, D., Kedar, N., and Levy, N. 2006. Pepino (*Solanum muricatum* Aiton): Breeding in Israel for better taste and aroma. Isr. J. Plant Sci. 54(3): 205‒213.

Lu, T., Yu, H., Wang, T., Zhang, T., Shi, C., and Jiang, W. 2022. Influence of the electrical conductivity of the nutrient solution in different phenological stages on the growth and yield of cherry tomato. Horticulturae. 8(5): 378.

Mutua, C. M. 2023. Influence of NPK fertilizer rates on growth flower abortion, concentration of secondary metabolites and quality of field and greenhouse grown pepino melons *(Salanum muricatum Aiton).* Doctoral dissertation, Egerton University, Nakuru.

Naik, S. K., Barman, D., Rampal, and Medhi, R. P. 2013. Evaluation of electrical conductivity of the fertilizer solution on growth and flowering of a Cymbidium hybrid. S. Afr. J. Plant Soil. 30(1): 33‒39.

Nantakit, A. 2010. Growing hydroponic plants for business in Thailand. Sukhothai Thammathirat Open University Publisher Press, Bangkok.

Pacheco Toabanda, J. E. 2022. Development of biotechnological tools for the genetic improvement of pepino *(Solanum muricatum)* and tree tomato *(S. Betaceum)*. Doctoral dissertation, Universitat Politècnica de València.

Rodríguez-Burruezo, A., Prohens, J., and Fita, A. M. 2011. Breeding strategies for improving the performance and fruit quality of the pepino (*Solanum muricatum*): A model for the enhancement of underutilized exotic fruits. Food Res. Int. 44 (7): 1927‒1935.

Savvas, D., and Adamidis, K. 1999. Automated management of nutrient solutions based on target electrical conductivity, pH, and nutrient concentration ratios. J. Plant Nutr. 22(9): 1415‒1432.

Sritontip, C., Changjeraja, C., Khaosumain, Y., Panthachod, S., Sritontip, P. and Lasak, S. 2017. Low-cost soilless cultivation ( 1 st ed). Rajamangala University of Technology Lanna, Chiang Mai.

Sritontip, C., Nuon, D., Tong, R., Sritontip, P., Chidburee, A. and Thonglek, V. 2022. Effects of micro-nano bubbles and electrical conductivity of nutrient solution on the growth and yield of green oak lettuce in a hydroponic production system. J. Sci. Agri. Technol. 3(1): 16‒24.

Sudha, G., Priya, M. S., Shree, R. I., and Vadivukkarasi, S. 2011. *In vitro* free radical scavenging activity of raw pepino fruit (*Solanum muricatum* aiton). Int. J. Curr. Pharm. Res. 3(2): 137‒140.

Sun, Z., Wang, L., Zhang, G., Yang, S., and Zhong, Q. 2022. Pepino (*Solanum muricatum*) metabolic profiles and soil nutrient association analysis in three growing sites on the loess plateau of northwestern China. Metabolites. 12(10): 885.

Thichuto, S., Sritontip, P., Thonglek, V., and Sritontip, C. 2022. Effects of electrical conductivity and micro/nanobubbles in nutrient solutions of hydroponics on growth and yield of cherry tomato. J. Sci. Agric. Technol. 3(2): 29–36.

Trejo-Téllez, L. I., and Gómez-Merino, F. C. 2012. Nutrient solutions for hydroponic systems. In: Asao, T. (ed). Hydroponics-a standard methodology for plant biological researches. InTech, Rijeka. p.1‒22.

Wdowikowska, A., Reda, M., Kabała, K., Chohura, P., Jurga, A., Janiak, K., and Janicka, M. 2023. Water and nutrient recovery for cucumber hydroponic cultivation in simultaneous biological treatment of urine and grey water. Plants. 12(6): 1286.