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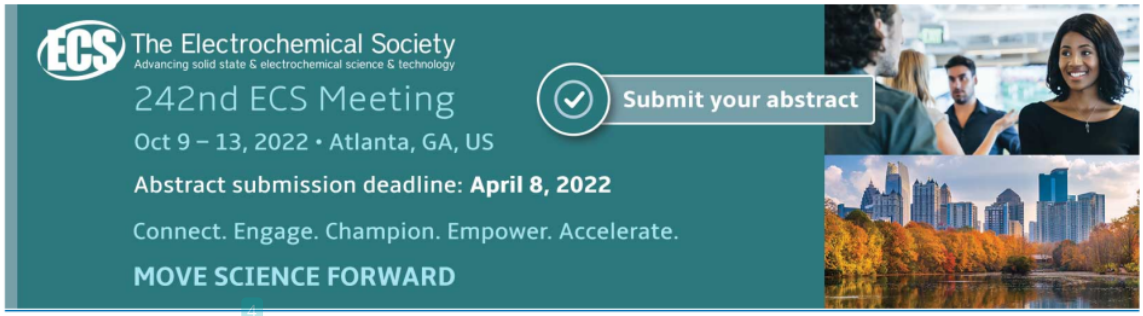

Effect of foliar nutrients application to the growth and yield of *Physalis peruviana* and *Physalis alkekengi*

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Abstract. *Physalis* Sp. is a potential medicinal plant and functional food. The use of appropriate nutrients can gain optimal plant growth and productivity. This study aimed to determine the macro and micronutrients that can provide optimal growth and yield of *Physalis* sp. This research was conducted at a greenhouse in Bangkalan Madura. A factorial randomized block design with four replications was used in this study. The first factor was the species of *Physalis* Sp., namely *P. peruviana* and *P. alkekengi*. The second factor is nutrition at four levels: a spray of water only as control; foliar application of macronutrients at a dose of 2 g/L; foliar application of micronutrients at a dose of 0,125 g/L; foliar Application of a combination of macronutrients 1 g/L and micronutrients 0,0625 g/L. The data obtained were analyzed using analysis of variance (ANOVA) followed by Least Significant Difference (LSD) at the 5 % level. Nutrition significantly affected growth (plant height, stem diameter, and number of leaves) and yield (number of fruit). The interaction between treatments occurred in the number of fruits. Micronutrients gave the highest number of fruit, both species of *Physalis* sp.

1. Introduction

Crop production is being hampered by micronutrient shortages, affecting crop quality. Micronutrients serve as a stimulant for the absorption and use of specific macronutrients [1]. Human and animal health is being affected due to poor micronutrient feed and food products. Provisioning these micronutrients in a balanced diet for humans is receiving much attention worldwide [2]. This need can be fulfilled through fortification in food processing or crops during growth and development [3, 4].

Every plant has different nutritional needs. Despite adequate NPK fertilizer application, normal development of high-yielding cultivars was not possible due to insufficient or no micronutrient delivery. When trace elements are used with NPK fertilizers, high fertilizer-sensitive cultivars reach their maximum output potential. When sprayed alone or in combination, micronutrients improved crop production considerably over controls. There was a substantial beneficial relationship between fertilizer treatments and crop growth physiological phases. It is important to investigate the elements influencing fertilizer efficiency [1].

An integrated approach, including foliar micronutrient feeding, is common worldwide to provide high-quality crops with high yields and achieve balanced nutrition for humans [5]. This approach will

assure providing micronutrients to the populations suffering from malnutrition through the increased consumption of wheat (Triticum aestivum L.)-based dietary products [6].

Physalis Sp. is an annual or short-lived perennial plant in the family Solanaceae, with yellow to orange fruit, juicy flesh, and tiny seeds [7,8]. The most distinguishing characteristic is the fruiting calyx, which expands to cover the fruit as it develops and ripens, protecting it from insects, birds, pathogens, and unfavourable weather conditions. It dangles down like a light [8, 9]. *Physalis* is rich in health-promoting compounds. Several compounds contain ascorbic acid, carotene, lactone, and phenolic compounds with various pharmacological effects [10]. This study aimed to determine the impact of macro and micronutrients on the growth and yield of 2 *Physalis* species, namely *P. peruviana* and *P. alkekengi*.

2. Material and Methods

2.1 Field location and material

A field experiment was conducted in a greenhouse at Bangkalan District Madura Island, Indonesia. Cultivation is carried out at an altitude of 5 meters above sea level with a maximum average temperature of 35.8 °C and a minimum average temperature of 23.8 °C.

Healthy and uniform-sized 30 days old seedlings of *P. peruviana* and *P. alkekengi* were transplanted at 40 cm × 40 cm polybag and cultivated for 30 days. The planting medium consists of soil, manure, and husk charcoal (3:1:1). Each plant was fertilized with NPK fertilized compound (16:16:16) at a dose of 3 mg/plant at the time of transplanting, at 14 and 32 days after transplanting.

Table 1. Chemical properties of planting medium

pH	Organic carbon (%)	N total (%)	Organic matter (%)	P.Olsen (mg kg^{-1})	K (%)
7,30	2,40	0,31	4,20	102,47	0,51

2.2. Experimental design

A factorial randomized block design with four replications was used in this study. The first factor was the species of *Physalis* sp., namely *P. peruviana* and *P. alkekengi*. The second factor was nutrition at four levels, namely: a spray of water only as control (N0); foliar application of macronutrients at a dose of 2 g/L (N1); foliar application of micronutrients at a dose of 0,125 g/L (N2); foliar application of a combination of macronutrients 1 g/L and micronutrients 0,0625 g/L (N3). The macronutrients containing P_2O_5: 52% and K_2O: 34%. The micronutrient containing Zn (5 %), Fe (2,5 %), Cu (2 %), B (2%), Mo (0,1 %) and Mn (7%). Treatments were given every 14 days starting from 10 days after transplanting

The growth and yield parameters observations were recorded at 90 days after transplanting. The observed growth parameters consisted of plant height, stem diameter and the number of leaves, while the observed yield parameters were the number of fruits.

2.3 Data analysis

Data were analyzed with a two-factor ANOVA procedure for Randomized block Design. The mean was further analyzed using Least Significance Difference (LSD) at $P<0.05$.

3. Result and discussion

3.1 Growth parameter

There was no interaction effect between *Physalis* species and the type of nutrition used to the plant growth in this study. Table 2 showed that *P. peruviana* had height, stem diameter and the number of leaves, respectively, 229.21 cm, 12.36 mm and 339.59 higher than P. alkekengi with height, stem diameter and the number of leaves, respectively 89.02 cm, 4.29 mm and 169.31. The ability of a plant

to alter its architecture is influenced by both developmental genetic and environmental stimuli, and the resulting shape can affect plant growth and reproduction [11]. Species of *Physalis* Sp showed morphological variations seen from several parameters such as habitus and height. Habitus variations ranged from shrubs to arborescent perennial, while based on height, it shows variations ranging from a few centimetres to more than 2 m [12]. However, the height obtained was higher than previous studies of *P. alkekengi* of the Popa-Mitroi study (2012) [13] and *P. peruviana* of the Bertoncelli et al. (2017) study [14] and Pedo et al. (2019) [15]. The high organic matter content of the growing media, around 4.2%, supported better plant growth (table 1). Soil organic matter plays a vital role in carbon storage, aggregate formation, supply of plant nutrients, retention, and immobilization and mobilization of metals and increases soil water retention capacity [16].

Nutrients increased plant growth compared to controls, but the findings were not significantly different between the types of nutrients used (table 2). Plant growth and development are highly influenced by nutrient availability [17]. The kind, form, amount and frequency of nutrients used impact plant development [18, 19]. The macronutrients P and K are essential for plant growth, particularly in the early stages and increasing yield. It is also essential for plant health, tolerance to environmental stresses, and yield quality by increasing grain nutritional content and extending shelf life [20]. The micronutrients such as zinc and boron were considered in the auxin production. It has an essential role in the formation and differentiation of cells for plant roots and shoots, causing plant height to increase [21, 22]. Increased plant growth parameters may be attributed to nutrient participation in chlorophyll production, which may contribute to cell division, meristematic activity in apical tissue, cell expansion, and cell wall formation [23].

Table 2. Plant growth parameter as affected by foliar nutrients application

Treatments	Height (cm)	Stem diameter (mm)	Number of leaves
P. peruviana	229.21 a	12.36 a	339.59 a
P. alkekengi	89.02 b	4.29 b	169.31 b
LSD 5%	7.65	0.45	35.11
Control	135.14 b	7.68 b	156.06 b
Macronutrients	162.68 a	8.53 a	291.00 a
Micronutrients	168.51 a	8.73 a	287.88 a
Macronutrients + micronutrients	170.13 a	8.36 a	282.88 a
LSD 5%	10.82	0.64	49.65

Mean values in the same column followed by the same letters are not significantly different ($P < 0.05$).

Table 3. Number of fruit as affected foliar nutrients application

Nutrients	Number of fruit	
	P. peruviana	*P. alkekengi*
Control	8.37 c	2.00 b
Macronutrients	17.13 b	6.12 a
Micronutrients	33.63 a	7.75 a
Macronutrients + micronutrients	20.50 b	3.00 b
LSD 5 %	3.44	

Mean values in the same column followed by the same letters are not significantly different ($P < 0.05$).

P. peruviana and *P. alkekengi* have different responses to nutrition. The macronutrient application in *P. peruviana* statistically was not significantly different from the results obtained from combined

nutrients. The number of fruits in *P. alkekengi* with micronutrients was not significantly different from macronutrients. Plant responses to fertilizer administration appear to be highly impacted by the nutritional requirements of each species, the chemistry of the planting media, and the environmental circumstances of each growing season [24]. The results of soil analysis on the media show that the planting media has a high organic matter content and moderate NPK content.

Micronutrients have numerous roles in plant physiology that can affect fruit production. Several vital functions include increasing the activity of metabolic enzymes, playing a role in the reproduction and metabolism of auxin and nitrogen metabolism [25]. The auxin also has an essential role in plant reproduction, fruit set, and development [26, 27].

4. Conclusion

The application of foliar nutrients affected the growth and yield of *P. peruviana* and *P. alkekengi*. Macronutrients, micronutrients, and their combination resulted in height, stem diameter, and the number of leaves significantly different from the control, but the values were not significantly different from each other. Meanwhile, the highest number of fruits of both species was obtained from micronutrients application.

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