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PASSIFLORA QUADRANGULARIS GROWTH RESPONSE TO FERTILIZATION REGIMES IN CONTROLLED CLIMATE

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Abstract

Enriching the assortment of flowering plants in Romania by introducing exotic species in the context of contemporary climate changes is of real interest. Passiflora quadrangularis is a climbing plant cultivated for its fruits, nutraceutical properties, secondary metabolite content and ornamental value. This research was developed in order to validate the influence of foliar fertilizers on morpho-biometric traits. A bifactorial experiment was performed using the method of randomized blocks with three replicates. In this regard, the organic biostimulator Cropmax and the mineral fertilizer Nutricomplex 20-20-20 + M.E. were tested. Fertilization was carried out periodically during the vegetation period, in three doses: 0.05%, 0.1% and 0.2%. Determinations were made regarding the main morpho-biometric traits, the results being statistically interpreted. All treatments recorded higher values than the control variant (untreated), and the Cropmax biostimulator has a significantly positive effect on plants development.

Key words: *foliar fertilizers, morpho-biometric traits, Passiflora.*

INTRODUCTION

Passiflora genus is little known due to the diversity and complexity of species existing in nature (Lucarini et al., 2019) comprising over 750 species (Feuillet & MacDougal, 2007). Over 60 species produce edible fruits, but only some are used in the food industry (Thokchom & Mandal, 2017).

P. quadrangularis is a tendril-climbing vine with winged stem (Cantor et al., 2021) and woody stems at the bottom. The shoots can reach lengths of 18-50 m (Lim, 2012). The alternate leaves have an ovate or elliptical-ovate shape, are glabrous, with entire edges and a sharply acuminate peak. The long petiole has globular nectariferous glands (Narel Paniagua-Zambrana & Bussmann, 2020). The flowers are large, up to 12 cm in diameter, fragrant and pendulous. The fruits are very large (15-30 cm), ovoid-elongated or ellipsoid, yellowish green. Beneath the bark is found the fleshy, spongy, edible, juicy, sweet, white-yellow mesocarp (Lim, 2012).

P. quadrangularis or "giant granadilla", widespread in the tropics, is the most cultivated species after *P. edulis* in tropical America (Lucarini et al., 2019). The aryl (pulp) is the primary product that can be eaten fresh, with ice cream or processed into fruit juice, syrup or preserved nectar. The pulp can be eaten with the addition of sugar or honey (Lim, 2012). Before ripening, this fruit can be used as a vegetable. According to Morton, 1987, *P. quadrangularis* fruit has the following nutritional composition of the pulp, per 100 g product: water 94.4 g, protein 0.112 g, fat 0.15 g, crude fiber 0.7 g, ash 0.41 g, calcium 13.8 mg, phosphorus 17.1 mg, iron 0.80 mg, carotene 0.004 mg, riboflavin 0.033 mg, niacin 0.378 mg, ascorbic acid 14.3 mg. The nutritional value of aryl and seeds is: water 78.4 g, protein 0.299 g, fat 1.29 g, crude fiber 3.6 g, ash 0.80 g, calcium 9.2 mg, phosphorus 39.3 mg, iron 2.93 mg, carotene 0.019 mg, thiamine 0.003 mg, riboflavin 0.120 mg and niacin 15.3 mg (Lim, 2012).

According to Carranza et al., (2016), among the passion flower species in Colombia, *P. quadrangularis* is considered a priority by the Ministry of Agriculture and Rural Development, listed as a promising fruit for export, due to its acceptance as fresh fruit, juices and snacks. According to FAO, (2005) the fruit has a pleasant, sweet and at the same time slightly acidic characteristic aroma. The aroma of the fruit is mainly provided by the chemical compound geraniol (Montero et al., 2016).

For medicinal purposes, *P. quadrangularis* is used for the treatment of diabetes, strokes, burns, hypertension, arthritis, neuralgia and liver disease (Rodríguez et al., 2020) and has a cardiodepressant and a calming role (Osorio et al., 2000).

For growth and development, the Passion flower requires nutrition at all stages. Macronutrients N, K and Ca are absorbed in large quantities, followed by S, P and Mg. Among micronutrients, Mn and Fe are absorbed in the largest amounts, followed by Zn, B and Cu (Joy, 2010). The need for nutrients is related to the age and stage of development of the plants. According to Thokchom & Mandal, (2017), the approximate nutrient requirement for *Passiflora* is 150 kg/ha N, 100 kg/ha P and 200 kg/ha K.

In the study conducted by Ramaiya et al., 2021 the crop of *P. quadrangularis* was fertilized in the form of 250-50-80 kg/ha N-P_2O_5-K_2O or organic fertilizer, manure, 20 t/ha.

This study is part of a research plan for *P. caerulea* (Boboc Oros et al., 2021) and *P. quadrangularis* species. Growth and flowering in these species are dependent on the fertilization program. Thus, the present research aimed to establish the most advantageous fertilization program for *P. quadrangularis* to lead to the attainment of an optimal cultivation system for the circumstances in Romania.

MATERIALS AND METHODS

The research on the influence of the fertilization program on *P. quadrangularis* plants` growth and development was located in the greenhouse of the Department of Ornamental Plants, belonging to the Institute of Advanced Horticultural Research of Transylvania, of the University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca and was began on April 22, 2019. From a climatic regard, the greenhouse is placed, according to the W. Köppen system in the Dfclimatic region, described as the boreal climate with cold and humid winters (Bunescu et al., 2005). Plants were cultivated in a greenhouse with automatically controlled ecological conditions: natural light, 25/20°C day/night temperature and 60% relative humidity.

P. quadrangularis seedlings from two months old, obtained from rooted cuttings at the end of February 2019, represent the biological material of the present research. After the plants were transplanted to soil, were watered everyday in the first two weeks after transplantation, and after that period doubly a week.

Two fertilizers were tested: an organic biostimulator (Cropmax®) and a mineral fertilizer [Nutricomplex® 20-20-20 + microelements (M.E.)]. Cropmax® (Holland Farming, Groenekan, The Netherlands) is an organic growth biostimulant for all types of crops, contains amino acids, macro- and microelements, vitamins and polysaccharides. Cropmax® contains N (0.2%), P (0.4%), K (0.02%), Fe (220 mg/l), Mg (550 mg/l), Zn (49 mg/l), Mn (54 mg/l), Cu (35 mg/l), Bo (70 mg/l), Ca + Mo + Cb + Ni (10 mg/l), vitamins C and E, enzymes and carotenoids. The recommended concentration rate in greenhouse crops is 0.05 - 0.2%, every 7-10 days (Balint et al., 2018).

Nutricomplex® 20-20-20 + M.E (Trade Corporation International, Madrid Spain) is produced by high pure raw materials, supplemented with chelated micro-nutrients and it's free of chloride, sodium and carbonates. This fertiliser contains N (20% w/w), P_2O_5 (20% w/w), K_2O (20% w/w), Fe (0.06% w/w), Mn (0.04% w/w), Zn (0.02% w/w), Cu (0.01% w/w), B (0.02% w/w), Mo (0.003% w/w). In foliar application, the advised dosage is 250-400 g/hl. Nutricomplex® 20-20-20 (n.d.) (Boboc (Oros) et al., 2021).

A bifactorial experience was organized in randomized block method with three traits (Sestraș, 2019) as follows:

Factor A – the fertilizer:

a_1 – Nutricomplex

a_2 – Cropmax

a_3 – unfertilized (control)

Factor B – the dose applied:

b_1 – 0.05%

b_2 – 0.1%

b_3 – 0.2%

Fertilizers were performed every 14 days by foliar application. The treatments were accomplished from the first week after transplantation until the flowering. The results were compared to the control treatment, where

the plants were sprayed with the same volume of water (without fertilizer). Tillage of plants was done using good agricultural practices.
Determinations regarding the main morpho-biometric traits have been performed to assess the quality of *P. quadrangularis* plant species. The morpho-biometric traits were: the average plant length, the average number of shoots per plant, the average number of internodes on the main stem, the average length of internodes (cm), the average number of leaves / plant, the stem diameter at 50 cm from the ground (mm) and the relative growth rate RGR. Regarding flowering and fruiting, were made determinations on the first node at which the flower on the shoot was occurred, the average number of flowers per plant, the flower diameter and the average number of fruit per plant. As different growth rates were observed during the growing season, four time intervals were established (22 April - 3 June, 4 June - 5 August, 6 August - 7 October, 8 October - 30 December) for which calculated the evolution of the relative daily growth rate (RGR). RGR was determined using the formula: RGR = W_2 -W_1/ T, where W_1 = first measurement, W_2 = second measurement, and T = the number of days between each (Boboc (Oros) et al., 2021).
Data were tested using the analysis of variance procedure, and the Duncan's Multiple Range Test (Duncan's MRT, $p<0.05$) was used as a post hoc test for comparison among treatment means.

RESULTS AND DISCUSSIONS

In order to determine the average growth of *P. quadrangularis* plants during the whole year after transplanting (April 22, 2019) (Figure 1), weekly determinations on plant growth were performed. At the end of 2019, the plants fertilized with Cropmax recorded average growths of 434.2 cm, those fertilized with Nutricomplex 368.6 cm, and the control variant 160.7 cm.

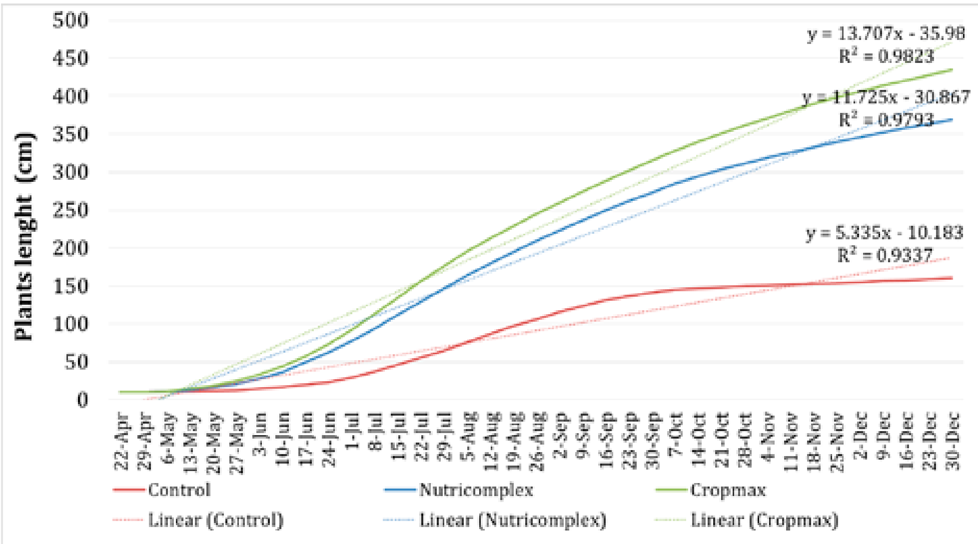

Figure 1. The evolution of average growths at *Passiflora quadrangularis* in 2019

Analyzing the evolution of average growths, different growth rates were found during the vegetation period, so four time intervals were established (April 22 - June 3, June 4 - August 5, August 6 - October 7, October 8 - December 30) for which has calculated the evolution of the relative growth rate (RGR). As shown in Figure 2, the Cropmax organic biostimulator favoured average growth rates for fertilized plants, superior to the Nutricomplex mineral fertilizer for each time interval analyzed (0.54; 2.61; 2.14; 1.29; 1.70).
According to Figure 3, a bifactorial analysis of RGR was performed for the experimental years 2019 and 2020. In 2019, RGR recorded the average independent value of fertilizer, of 1.25

and in 2020 by 1.11. The RGR values have not registered statistically significant differences.

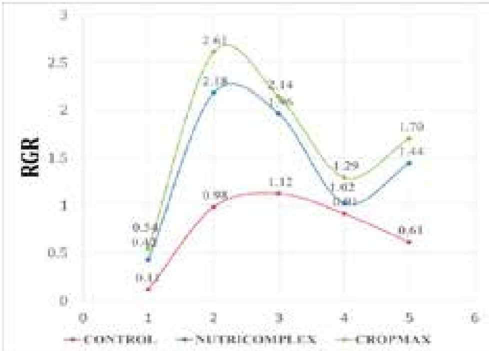

Figure 2. Relative growth rate (RGR) over time intervals in 2019 at *P. quadrangularis*

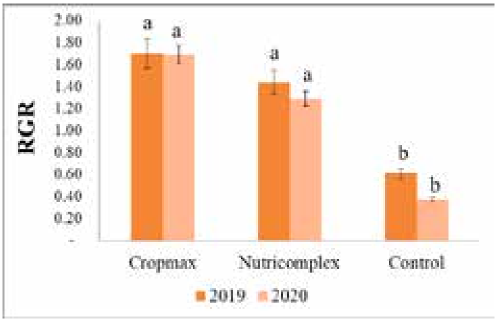

Figure 3. Results on the influence of fertilizer on relative growth rate in 2019 and 2020

A brief analysis of the information provided by RGR on the growth of *Passiflora* plants indicates that in the first year after planting, the growth was more pronounced.

Then, analyzing on time intervals, during the summer, in the interval 4.06-5.08 the increases were significantly superior to the other time intervals.

The application of fertilizers during the growing season to *P. quadrangularis* showed increases in the case of all morphological traits (Table 1) compared to the control variant (V_7). Regarding the average plant length, the longest shoots, of 475.27 cm (v_6) were obtained on the lot fertilized with Cropmax 0.2%, and statistically significant differences were registered at variants V_1 and V_5-V_7. The average number of shoots varies between 8.23 (V_7) and 21.73 (V_6). Regarding the average number of internodes, the average values varied between 17.42 (V_7) and 37.80 (V_6). There were statistically assured differences between each experimental variant. The average length of the internodes varied between 8.44 cm (V_7) and 12.29 cm (V_6). The average number of leaves per plant varied between 73.33 (V_7) and 154.77 (V_6). The average stem diameter at 50 cm from the ground was between 6.69 mm (V_7) and 8.65 mm (V_6). Regarding the unilateral influence of the fertilizer on the morphological traits, there were statistically assured differences between the two fertilizers, the plants treated with Cropmax fertilizer demonstrating superior values to those treated with Nutricomplex for analyzed traits.

The decorative morphological traits (Table 2), regarding the flowering and fructification registered average values superior to the control variant (V_7). The first node at which the flower formed varied on average from 3.03 (V_6) to 6.44 (V_7). For this index, a lower average numerical value denotes a higher ornamental potential, with a higher number of flowers per shoot. Regarding the average number of flowers per plant, a maximum of 55.23 flowers were obtained when fertilizing with Cropmax 0.2%, the differences being statistically significant. The average diameter of the flower was between 10.37 cm (V_7) and 8.08 cm (V_6), the differences being statistically assured. The plants produced on average 16.73 (V_6) fruits per plant at the fertilization with the biostimulator Cropmax 0.2% and 13.33 at the plants fertilized with Nutricomplex 0.2.

The rate of fertilizer administered is directly proportional to fruit production. Plants fertilized with Cropmax produced a higher number of fruits compared to those treated with Nutricomplex, regardless of dose. Statistically significant differences were obtained between each experimental variant. Regarding the influence of the fertilizer on the decorative morphological characters, for the average number of flowers and the diameter of the flower there are superior differences, statistically assured when fertilizing with Cropmax. Regarding the average number of flowers and fruits per plant, Cropmax registers higher values. (on average 46.12 flowers and 11.22 fruits per plant) compared to Nutricomplex (which averaged 42.42 flowers and 8.94 fruits per plant).

Table 1. Results on the effect of fertilizer and dose applied on the morpho-biometrics traits

Var. no.	Fertilizer	Doze (%)	Morpho-biometrics traits					
			Plant length (cm)	Shoots number	Number of internodes on the main stem	Internodes lenght (cm)	Number of leaves / plant	Stem diameter (mm)
V_1	Nutricomplex	0.05	311.97 d	13.83 c	29.2 f	10.73 d	128.13 c	7.22 d
V_2		0.1	370.07 c	14.50 c	31.9 e	11.46 c	139.83 b	7.42 cd
V_3		0.2	395.9 c	16.23 bc	33.15 d	11.84 bc	150.83 a	7.54 c
		Average ($\bar{x}$)	359.31 B	18.88 A	31.42 B	11.34 A	139.6 B	7.39 B
V_4	Cropmax	0.05	369.33 c	16.03 c	34.28 c	10.78 d	142.63 b	7.60 c
V_5		0.1	437.47 b	18.87 b	35.90 b	11.93 ab	150.37 a	8.23 b
V_6		0.2	475.27 a	21.73 a	37.80 a	12.29 a	154.77 a	8.65 a
		Average ($\bar{x}$)	427.36 A	14.86 B	35.99 A	11.67 A	149.26 A	8.16 A
V_7	Unfertilized (Control)		146.73 eC	8.23 dC	17.42 gC	8.44 eB	73.33 dC	6.69 eC
DS 5%			25.89-30.3	2.66-3.00	1.09-1.22	0.38-0.43	6.62-7.46	0.22-0.24
DS 5% ($\bar{x}$)			28.22-28.79	2.33-2.38	1.94-1.98	0.33-0.34	8.92-9.10	0.36-0.37

Note: The difference between any two values followed by at least one different letter is significant. The average values followed by at least one different capital letter reflect the unilateral influence of the fertilizer.

Table 2. Results on the effect of fertilizer and dose applied on the morpho-decorative traits

Var. no	Fertilizer	Doze (%)	Morpho-decorative traits			
			The first node at which the flower occurred	Number of flowers / plant	Flower diameter (cm)	Number of fruits / plant
V_1	Nutricomplex	0.05%	3.63 b	35.37 d	8.33 ef	3.67 f
V_2		0.1%	3.23 c	42.70 c	8.83 de	9.83 d
V_3		0.2%	3.10 c	49.17 b	9.27 cd	13.33 b
		Average ($\bar{x}$)	3.36 A	42.41 B	8.81 B	8.94 A
V_4	Cropmax	0.05%	3.20 c	36.97 d	9.42 bc	5.43 e
V_5		0.1%	3.13 c	46.17 bc	9.87 ab	11.50 c
V_6		0.2%	3.03 c	55.23 a	10.37 a	16.73 a
		Average ($\bar{x}$)	3.12 A	46.12 A	9.88 A	11.22 A
V_7	Unfertilized (Control)		6.44 aB	8.67 eC	8.08 fC	0.47 gB
DS 5%			0.37-0.41	3.82-4.30	0.52-0.59	1.13-1.28
DS 5% ($\bar{x}$)			0.55-0.56	2.26-2.30	0.40	3.13-3.19

Note: The difference between any two values followed by at least one different letter is significant. The average values followed by at least one different capital letter reflect the unilateral influence of the fertilizer.

In the study carried out in parallel with the *P. caerulea* species, by (Boboc (Oros) et al., 2021), the fertilization with Nutricomplex and Cropmax influenced all morphological and decorative traits, the best results being obtained on the plants treated with 0.2% Cropmax.

In his research, Pacheco et al., (2017) made three types of fertilizers for *P. edulis* cultivated for fruit production: recommended mineral fertilizer, organic fertilizer represented by manure and the equivalence of recommended fertilization with potassium for *Passiflora* culture by double dose of organic fertilizer.

The fruits obtained from double-dose fertilized plants have maintained its commercial quality better and the single dose of organic fertilizer proved to be insufficient.

CONCLUSIONS

Applying foliar fertilizers to *P. quadrangularis* leads to more decorative, uniform and vigorous plants. The application of organic biostimulators is justified both for increasing the biomass of ornamental plants and in the case of an organic crop, justified by the important therapeutic and food properties.

Thus, in the first year after planting, the plants fertilized with Cropmax showed average growths of 427.36 cm, higher than the other experimental variants, and main decorative characteristics reached the best values when fertilizing with Cropmax 0.2% in both years after planting.

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