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EFFECTS OF A GROWTH PROMOTER ON DIFFERENT VEGETABLE CROPS

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ABSTRACT

There are references of the use of the growth promoter VIUSID agro in crops such as bean (*Phaseolus vulgaris* L.), tomato (*Solanum lycopersicum* L.) and anthuriums (*Anthurium andreanum* Lind.) in tropical conditions, however, in horticultural crops such as lettuce (*Lactuca sativa* L.), Swiss chard (*Beta vulgaris var. cicla.*), beetroot (*Beta vulgaris* L.) and radish (*Raphanus sativus* L.) there is no product use technology. Whereby the aim of this experiment was to evaluate the effect of VIUSID agro on the productive performance of these vegetables in terms of organoponics or urban agriculture. Four experiments were designed where an experimental design of randomized blocks with different doses and a control group were used. Variables related to productive performance of the crops were evaluated. Positive results were achieved, such as the increase of the dry mass of lettuce leaves, compared to control (52.67% vs. 55.87%) and the dry mass of the root roots was over 50%. Yields increased in the most favourable treatments by 30.66% in lettuce, 25.90% in chard and over 50% in beetroot and radish. In the Pearson correlation analyses it was determined that there is a significant linear relationship between the vegetative growth of crops and their final yield or production. VIUSID agro favoured the productive performance of the horticultural crops evaluated; dosages with the best effect were 0.2 L ha^{-1} in lettuce and 0.7 and 1.0 L ha^{-1} in the remaining crops.

INTRODUCTION

Organoponic production is in constant development and the supply of vegetables throughout the year is a priority in Cuba. It is estimated that family tables receive at least 300 g per capita of these crops daily (Rodríguez *et al.,* 2007). Which is why the production of plants is impulsed daily, to ensure supply to consumers (Terry *et al*., 2011). The goal of these small production units in urban areas, whose surface does not exceed three hectares, is to grow vegetables and condiments of good quality to meet the needs of the population, due to the role they play in the daily family diet (Martinez *et al*., 2013). In Cuba, between two and three hundred thousand hectares of these crops are grown and they produce around 200 million tons per year. The most grown crops are tomato, onion and pepper with fifty-nine thousand tons between them (ONE, 2015). However production of other vegetables is still low and inverse to the existing high demand.

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In this sense, it is of great importance to find alternatives to increase the production, and one of the variants to be taken into account may be the use of growth promoters that do not affect humans or the environment adversely. In the last few years, and because of more efficient production systems (Peña *et al*., 2016), different agrochemical industries have brought supplements that contain nutrients, amino acids, and plant extracts, which have been called "growth promoters" or "biostimulants”, to the market. One alternative to take into consideration to increase the production of vegetables is the growth promoter VIUSID agro since, according to Catalysis (2014), it acts as a natural bioregulator and is basically composed of amino acids, vitamins and minerals. In addition, as a relevant aspect, all of its components are subjected to a biocatalytic process of molecular activation that allows the use of low dosages with good results. On the other hand, there are several vegetables in high demand in the country, including lettuce, chard, beetroot and radish. However, there are no reports of the use of this product in tropical conditions with any of them; experiments were found in other crops where its application lead to an increase in production. One was for beans (*P. vulgaris*) (Melendrez *et al*., 2015 and Peña *et al*, 2015). It was also found that it increased the quality of the leaves of the anthurium (*A. andreanum*) and the start of flowering (Peña *et al*., 2015 b), as well as the germination of the seed (Peña *et al*., 2015 c) and the production of tomatoes (*S. lycopersicum*) Peña *et al*, 2016). The aim of the experiment was to evaluate the effect of VIUSID agro in the productive performance of lettuce (*L. sativa*), Swiss chard (*B. vulgaris*), beetroot (*B. vulgaris*) and radish (*R. sativus*) in terms of organoponics or urban agriculture.

MATERIALS AND METHODS

Four experiments were conducted in different organoponic plantations in the province of Sancti Spiritus, which were selected based on the knowledge of their results in the production of the crops object of study. For the election of the dosage and application interval, the product recommendations (Catalysis, 2014) and the results obtained by other researchers when using it, as well as the nutritional requirements of the crops selected, were taken into account. The experiments were conducted under the criteria of low input conditions, without the use of chemical fertilizers and pesticides, as the incidence of pests and diseases did not reach the threshold of economic impact. Irrigation was by spraying and the frequency of application was two hours a day. Planting troughs were used for all crops, and soil they were filled with had the following characteristics: 20% soil, 70% compost and 10% cattle manure (O.M.), according to the technical standards for this type of production (Rodriguez *et al*., 2007).

Composition of VIUSID agro

Components	%
Potassium phosphate	5
Malic acid	4.6
Glucosamine	4.6
Arginine	4.15
Glycine	2.35
Ascorbic acid	1.15
Calcium pantothenate	0,115
Pyridoxal	0,225
Folic acid	0.05
Cyanocobalamin	0.0005
Monoammonium glycyrrhizinate	0.23
Zinc sulphate	0,115

All these compounds underwent a molecular activation process, according to the manufacturers.

Experiment 1

The experiment was conducted at La Isabela organoponics farm in the Jatibonico municipality, Sancti Spiritus province (Cuba), at coordinates: 21°56'19.56"N 79º15'01.79"W. The variety that was used in the experiment was *Black Seeded Simpson*. The climatic variables were registered by the Sancti Spiritus Provincial Station, the average daily temperature was 24.75 ºC, with a relative humidity of 86.33% and rainfall of 20.62 mm. The transplant date was the 16th of November 2015 and harvest was the 19th of December 2015.

Experiment design: The experimental design was random blocks with four treatments and three replicas. The plots were 4 m^2, the plantation framework was 20 x 15 cm and 10 plants per plot were sampled, 30 per treatment, at the time of harvest.

Means of application and treatments: The applications were carried out in the early hours of the morning, always bearing in mind avoiding wind drift and evaporation of dew. The applications were weekly using a manual backpack sprayer with a 16 litre capacity. The treatments were: control and dosage of 0.2, 0.5, 0.7 and 1.0 ~~l/ha-1~~ (L ha^{-1}).

Indicators evaluated

Different indicators related to the growth and productivity of the plant were evaluated: leaves per plant, leaf fresh mass (g), leaf dry mass (g) and dry matter yield of the leaves (%). Length of the plant to the largest extended leaf (cm), stem length (cm), stem diameter (cm) and stem mass (g). Root length (cm), root mass (g), mass of the plant without root (g) and yield (kg m^2). In the harvest, the selected plants per plot were evaluated: firstly, leaves were counted. Stem length was determined from the neck of the root to the apex using a ruler (cm). The value of the length of the plant to the largest leaf, from the neck of the root to the largest extended leaf, was measured using the same instrument. The thickness of stem was measured in its central region, immediately above the first two leaves from the root, callipers were used. The length of the root was measured from the neck to the root cap (or most extended fraction) with a graded ruler. The mass of the plant with root was determined with a Sartorius digital scale, with an accuracy of ± 0.01 g. The root was then separated at the neck region and the mass of the plant without root was registered. The fresh mass of the root of each plant was determined by subtraction. The leaves per plant were separated and their fresh mass was determined using a Sartorius digital scale, with an accuracy of ± 0.01 g. Then, all the leaves of each plant were placed in one or several marked paper envelopes and were placed in an oven at 75 ºC for 72 hours. After the appointed time, the samples were extracted and the dry mass was determined. For dry matter (%) the following formula was used:

$$\% \text{ MS} = \frac{\text{sDM} \cdot 100}{\text{sFM}}$$

Where:

MS: Percentage of dry mass (%).
MSm: Dry mass of the sample (g).
MFm: Fresh mass of the sample (g).
For yield, the indirect method according to Fuentes *et al*. (1999) was used.

Experiment 2

The experiment was conducted at El Tomate organoponics farm in the Sancti Spiritus municipality, Sancti Spiritus province (Cuba) (21°54'45.12"N 79°26'43.57"W). The climatic variables were registered by the Sancti Spiritus Provincial Station, the average daily temperature was 22.3 ºC, with a relative humidity of 83.67% and rainfall of 33.01 mm. Planting date was the 29th of January 2016 and harvest was on the 12th of March of the same year.

Experiment design: The experimental design was random blocks with four treatments and four replicas. The plots were 5 m^2 and the calculation surface was framed in 3 m^2. The plantation framework was 0.20 x 0.20 m and 10 plants per plot were selected from the calculation surface, 30 per treatment, for a total of 120 evaluations.

Means of application and treatments: The applications were carried out in the early hours of the morning, always bearing in mind avoiding wind drift and evaporation of dew. The applications were weekly using a manual backpack sprayer with a 16 liter capacity. The treatments were: control (without application of the product) and three dosages (0.2, 0.5 and 1.0 L ha^{-1})

Indicators evaluated

The indicators were: leaves per plant, stem diameter (cm), root length (cm), mass of the plant with root (g), mass of the plant without root (g), root mass (g) and agricultural yield (kg/m^2). All the indicators were evaluated at harvest for all the selected plants in the calculation surface. The leaves per plant were counted in all the plants under evaluation. Stem diameter was measured homogeneously in all the plants evaluated using callipers. The length of the root was determined with a ruler, and the mass of the plant with root was determined with a Sartorius digital scale, with an accuracy of ± 0.01 g. Root was removed by the neck area and the mass of the plant without root was determined with the aforementioned scale. The mass of the root was determined by subtracting the mass of the plant with and without root. Yield was determined by the same method as in the previous experiment.

Experiments 3 and 4

The experiments were carried out in El Picante organoponics farm. Location: Calle 4ta Reparto San Ramón; / Línea y 4ta, Sancti Spíritus (21°56´33.39´´N 79°26´38.9´´W). Planting date for beetroot was the 22nd of January 2016 and the harvest was on the 10th March of the same year, within the optimal time. The climatic variables were registered by the Sancti Spiritus Provincial Station. During the cultivation cycle, the average daily temperature was 21.82 ºC, with a relative humidity of 80.5% and rainfall of 18.32 mm. The radish was planted the 20th of October 2016 and harvested on the 21st of November of the same year. During the cultivation cycle, the average daily temperature was 26.13 ºC, with a relative humidity of 83% and rainfall of 36.16 mm.

Experiment design

The experimental design in both experiments was random blocks with five treatments and three replicas. The plots were 5 m^2 and the calculation surface was framed in 2.40 m^2. The plantation framework measured 0.10 x 0.15 m for the beetroot and 0.10 x 0.05 m for the radish and 10 plants per plot were selected from the calculation surface, 30 per treatment, for a total of 150 evaluations.

Means of application and treatments” The applications were carried out in the early hours of the morning, always bearing in mind avoiding wind drift and evaporation of dew. The applications were weekly using a manual backpack sprayer with a 16 litre capacity. The treatments were: control and dosage of 0.2, 0.5, 0.7 and 1.0 l/ha^{-1}.

Indicators evaluated: In experiment three, the equatorial diameter of the root (cm), the polar diameter of the root (cm), the root mass (g) and agricultural yield (kg/m^2) were evaluated. All the indicators were evaluated at harvest. Equatorial diameter was measured using callipers and the value from all the plants selected was recorded. Care was taken to place the instrument at the broadest part of the root, and this was done homogeneously in all samples. The polar diameter, or height of the root, was taken from the root cap to the neck, again using callipers. The mass of the root was determined with a Sartorius digital scale, with an accuracy of ± 0.01 g. It was also carried out at the time of the harvest and on all the selected plants in the calculation surface. For yield, the indirect method according to Fuentes *et al*. (1999) was used. In experiment four, the dependent variables were: leaves per plant, leaf fresh mass (g), leaf dry mass (g), equatorial diameter of the root (cm), polar diameter of the root (cm), root fresh mass (g) and yield (kg/m^2). At harvest, the number of leaves per plant on the selected plants from the calculation area were counted. For the fresh mass of the leaves, they were separated from the rest of the plant and their mass was determined using the digital scale mentioned above. For the dry mass, an oven was used where the marked samples were heated to 75 ºC for 72 hours. The samples were then extracted and dry mass was determined using the scale. For the diameter of the root, callipers were used, and for measuring its fresh and dry mass, the digital scale and the oven were used as stated. Yield was determined following the method described in the previous experiment.

Data analysis

The data for all experiments were processed using the SPSS statistical package version 15.1.0 [2006] for Windows. For normality, the Kolmogorov-Smirnov test was used, and Levene test for homogeneity of variance. When normality and homogeneity existed, an ANOVA was conducted and Duncan's multiple range test when $P<0.05$. The Kruskal-Wallis test and the Mann-Whitney U test were applied when there was no normality of the data. The significant association among the variables of each possible pair (Pearson correlation coefficient) was also evaluated.

RESULTS

Effect of treatments on the productive performance of lettuce

In the leaves per plant there were no differences ($p<0.05$) between the treatments with VIUSID agro, but they were different from the control group, with an increase of 15.09%, 12.53%, 14.03% respectively. In the fresh mass of leaves per plant, there were no differences ($p<0.05$) between the treatments with VIUSID agro. The variants with the 0.1 L ha^{-1} and 0.2 L ha^{-1} dosages differed statistically from the control and with an average increase of 17.79 g and 15.85 g respectively. The 0.3 L ha^{-1} treatment did not differ from any variant applied (Table 1). In general terms, the statistical behaviour between the means of the dry mass of the leaves showed the same tendency ($p<0.05$). Treatments with the 0.1 L ha^{-1} and 0.2 L ha^{-1} dosage showed an increase regarding the control of 55.87% and 52.67% respectively. However, the variant with the highest dose did not differ from the rest of the treatments. In the dry matter (%) variable, there were significant differences ($p<0.05$) between the variants evaluated (Table 1), and the best performance was obtained with the 0.1 and 0.2 L ha^{-1} dosages (Table 1). In the length of the plant to the largest extended leaf variable (Table 1), the best performance was for the variant with the 0.2 L ha^{-1} dosage, which differed ($p<0.05$) from the rest of the treatments and had a difference with the control of 5.46 cm, which meant a 20.58% increase in length. The treatment with the higher dose did not differ significantly from the variant of lower doses and these in turn from the control. The behaviour was similar in the stem length (Table 1), with the difference that the 0.1 L ha^{-1} treatment differed significantly from the control. The 0.2 L ha^{-1} variant differed ($p<0.05$) from the rest of the treatments and exceeded the control by 6.18 cm, the variant with lower dose by 2.46 and the higher by 2.01 cm. The results of the effect of the treatments on the diameter of the stem are shown in Table 1. The 0.2 L ha^{-1} variant differed significantly ($p<0.05$) from the control with an increase of 12.58%. The treatment with the lower dose did not differ from the rest of the variants treated with VIUSID agro and showed an increase over the control of 11.26%. The diameter of the stem had a positive correlation with all variables except with the dry mass of the leaves and the length of the root. In the mass of the stem (Table 1) variable, treatments with VIUSID agro differ significantly from the control group ($p<0.05$); average increases with regard to that group were 5.93 g, 9.73 g and 6.76 g.

In the length of the root variable, no significant differences were found ($P<0.05$) for the treatments using VIUSID agro (Table 1), compared to the control. However, in the fresh mass, the variants treated with the product had the greatest stimulant effect and reached significant differences ($P<0.05$) compared to the control. The mass of the root also had a significant linear relationship with the number of leaves (r=0.62**) and the diameter of the stem (r=0.53**), variables that influence crop yield. Taking into account the above, Table 1 is a summary of the results of the effect of the treatments on the mass of the plant with and without root. As seen, there were no significant differences ($p<0.05$) between the variants with the growth promoter VIUSID agro, but they did differ from the control in both variables. In the mass of the plant with root, treatments with the product exceeded the control in 16.56 g, 20.53 g and 15.82 g, respectively, and a linear relationship was highly significant ($p<0.01$) with the number of leaves, stem length, plant height, stem diameter and mass of the root. The Pearson correlation indices were: number of leaves (r=0.68**), stem diameter (r=0.67**) and mass of the root (r=0.78**), all favoured by treatment with the product.

The mass of the plant without root followed the same behaviour pattern, and the variants with the product exceeded the control by 23.09%, 29.97% and 21.57% with significant differences ($p<0.05$). As for the effect of the treatments in the yield per square meter, the better performance was that of the treatments with VIUSID agro, which did not differ significantly between them but did with the control treatment in plants with root, with an increase, in order of appearance, of 22.76%, 29.66% and 22.07%. When calculating the yield of the plants without root (Table 1), the increase regarding the treatment with zero application of VIUSID agro was of 23.36%, 30.66% and 21.70% compared to control, and the best performance was with the 0.7 dosage, which presented the greatest increase and significant differences from the rest of the variations. Upon correlating all possible variables it was found that the yield of the plants without root had a significant linear relationship with the number of leaves (r=0.68**), with the length of the plant (r=0.54**), the stem diameter (r=0.67**), the mass of the root (r=0.78**), mass of the plant with root (r =1.00**) and mass of the plant without root (r = 0.99**). So when the performance of these variables is stimulated, it positively influences yield.

Effect of treatments on productive performance of chard

The best performance in number of leaves per plant was obtained with the 1.0 L ha^{-1} dosage, which differed significantly from the rest of the variants except for treatment with the 0.5 L ha^{-1} dosage, which in turn did not differ from the lower dosage variants or control. The increase over the control of the variant with best result was of 2.13 leaves, which meant an increase of this variable by 15.70% (Table 2). The thickness of the stem had a similar behaviour, since the 1.0 L ha^{-1} treatment differed significantly ($p<0.05$) from the rest of the variants and exceeded the control by 14.41%. The treatments with foliar application of the 0.2 L ha^{-1} and 0.5 L ha^{-1} dosages also achieved a better response of the crop over the control treatment. The length and mass of the root are variables of great importance since root development is fundamental in the strength of the crop. Table 2 shows that all treatments with foliar application of VIUSID exceeded the control in the length of the root by 8.05%, 21.57% and 23.27%, respectively.

The mass of the root had the best performance with 0.2 L ha^{-1} dosage variant, which exceeded the control by 6.42 g and differed significantly ($p<0.05$) from all treatments. The 1.0 L ha^{-1} dosage also differed significantly from the control, surpassing it by 13.05%. Plant with roots mass showed significant differences ($p<0.05$) between the VIUSID treatments and the control group (table 3). The best yield was from the 1.0 L ha^{-1} dosage, where the plant reached 251.95 g, 25.90% greater than the control. Dosages of 0.2 L ha^{-1} and 0.5 L ha^{-1} did not differ significantly between them but did differ from the control (were 15.53 g and 16.58 g greater), which meant a more discreet increase of mass. The best yield was achieved with the 1.0 L ha^{-1} dosage, at 3.84 kg/m^2; this value exceeded the average recorded for this crop in terms of organoponics and control by 25.90%. The rest of the variants also differed significantly from the control, with more discrete increases of 10.16% and 10.81%, respectively. The yield had a significant linear relationship with the number of leaves, the diameter of the stem and the mass of the plant with and without root, variables that were benefited by foliar application of the product. Pearson correlation coefficients were: number of leaves (r=0.74**), stem diameter (r=0.64**), mass of the plant with root (r=0.97**) and mass of the plant without root (r=1.00**).

Effect of treatments on productive performance for beetroot and radish

The equatorial diameter of the root (Table 3) reached the best performance with 0.7 L ha^{-1} and 1.0 L ha^{-1} dosages; these differed significantly ($p<0.05$) from the rest of the variants and exceeded the control by 39.50% and 32.85%, respectively. The treatments with the 0.5 L ha^{-1}dosage also differed significantly from the control, with a discrete increase of 15.38%. The height and the diameter of the root are characteristics of the variety, and are directly related to yield, as well as mass. In this variable, performance was similar to that of the diameter variable, since the variants with the best result were the 0.7 L ha^{-1} and 1.0 L ha^{-1} dosages, which exceeded the control by 1.42 cm and 1.43 cm, which meant an increase of 32.95% and 33.18%, respectively. In the mass of the root (Table 3), it can be seen that the treatments with higher dosages (0.7 L ha^{-1} and 1.0 L ha^{-1}) exceeded the control in 120 g and 130 g respectively.

Table 1. Effect of treatments on the productive performance of lettuce

T	Leaves per plant	Fresh mass leaves (g)	Dry mass (g)	Dry matter (%)
Control	11.33 ± 0.34 b	44.53 ± 5.15 b	2.81 ± 0.32 b	6.54 ± 0.77 b
0,1 L ha^{-1}	13.04 ± 0.42 a	62.32 ± 4.92 a	4.38 ± 0.28 a	7.19 ± 0.50 a
0,2 L ha^{-1}	12.75 ± 0.44 a	60.38 ± 2.67 a	4.29 ± 0.49 a	7.10 ± 0.49 a
0,3 L ha^{-1}	12.92 ± 0.38 a	56.66 ± 5.82 ab	3.80 ± 0.48 ab	6.74 ± 0.50 b
cv	16.31	27.55	10.55	8.24
	Length of the plant (cm)	Stalk length (cm)	Stalk diameter (cm)	Mass of the stem (g)
Control	26.53 ± 0.61 c	9.73 ± 0.63 c	1.51 ± 0.06 c	15.39 ± 0.02 b
0,1 L ha^{-1}	28.29 ± 0.02 bc	13.45 ± 0.84 b	1.68 ± 0.05 ab	21.32 ± 0.05 a
0,2 L ha^{-1}	31.99 ± 0.57 a	15.91 ± 0.64 a	1.70 ± 0.05 a	25.12 ± 0.07 a
0,3 L ha^{-1}	29.75 ± 0.81 b	13.90 ± 0.70 b	1.61 ± 0.06 b	22.15 ± 0.03 a
cv.	6.28	12.11	17.79	12.86
	Length of the root (cm)	Fresh root mass (g)	Mass/plant without root (g)	Yield (kg/m^2)
Control	10.42 ± 0.34 a	3.88 ± 0.26 b	68.70 ± 4.95 b	1.37 ± 0.06 c
0,1 L ha^{-1}	11.44 ± 0.37 a	4.59 ± 0.32 a	84.56 ± 5.38 a	1.69 ± 0.05 b
0,2 L ha^{-1}	10.43 ± 0.43 a	4.07 ± 0.26 a	89.29 ± 5.79 a	1.79 ± 0.04 a
0,3 L ha^{-1}	11.24 ± 0.32 a	4.87 ± 0.35 a	83.52 ± 6.37 a	1.67 ± 0.02 b
cv	7.63	11.03	24.72	10.21

(Mean ± standard error)
Averages with different letters in the same column vary for $p<0.05$. T: treatments.

Table 2. Effect of treatments on productive performance of chard

Treatments	Number of leaves	Stalk diameter (cm)
Control group	13.57 ± 0.69 b	1.18 ± 0.03 c
0,2 L ha^{-1}	13.97 ± 0.60 b	1.29 ± 0.04 b
0.5 l/ha^{-1}	14.43 ± 0.52 ab	1.29 ± 0.04 b
1.0 l/ha^{-1}	15.70 ± 0.60 a	1.35 ± 0.04 a
cv	23.43	17.05
	Length of the root (cm)	Root mass (g)
Control group	9.41 ± 0.35 b	19.08 ± 1.64 c
0,2 L ha^{-1}	11.53 ± 0.37 a	25.50 ± 2.83 a
0.5 l/ha^{-1}	11.44 ± 0.39 a	20.70± 2.13 bc
1.0 l/ha^{-1}	11.60 ± 0.35 a	21.57 ± 3.88 b
cv	20.19	19.41
	MPSR (g)	Yield kg/m^2
Control group	152.50 ± 11.04 c	3.05 ± 0.05 c
0,2 L ha^{-1}	168.03 ± 10.47 b	3.36 ± 0.06 b
0.5 l/ha^{-1}	169.08 ± 13.26 b	3.38 ± 0.06 b
1.0 l/ha^{-1}	191.99 ± 12.39 a	3.84 ± 0.07 a
cv	28.49	18.41

(Mean ± standard error)
Averages with different letters in the same column vary for $p<0.05$. MPSR: mass of the plant without root.

Table 3. Effect of treatments on productive performance for beetroot and radish

Treatments	DE/R (cm)	DP/R (cm)	M/R (g)	R (kg/m^2)
Beetroot				
Control	4.81 ± 0.25 c	4.31 ± 0.23 c	140.23 ± 15.37 c	2.80 ± 0.30 c
0.2 Lha^{-1}	5.34 ± 0.18 bc	4.97 ± 0.19 b	166.97 ± 13.38 b	3.34 ± 0.27 b
0.5 Lha^{-1}	5.55 ± 0.16 b	4.95 ± 0.20 b	169.56 ± 14.04 b	3.39 ± 0.28 b
0.7 Lha^{-1}	6.71 ± 0.17 a	5.73 ± 0.22 a	260.33 ± 14.42 a	5.21 ± 0.29 a
1.0 Lha^{-1}	6.39 ± 0.23 a	5.74 ± 0.30 a	270.20 ± 22.48 a	5.40 ± 0.45 a
cv	22.40	26.53	21.08	21.07
Radish				
	H/P	MFH (g)	MSH (g)	DE/R (cm)
Control	6.93 ± 0.36 b	5.53 ± 0.45 c	0.48 ± 0.16 c	2.27 ± 0.09 d
0,2 L ha^{-1}	6.93 ± 0.46 b	6.08 ± 0.48 bc	0.55 ± 0.17 b	2.48 ± 0.07 c
0.5 l/ha^{-1}	7.86 ± 0.22 a	8.10 ± 0.49 a	0.70 ± 0.15 a	2.63 ± 0.06 b
0,7 L ha^{-1}	6.80 ± 0.26 b	6.89 ± 0.50 b	0.59 ± 0.18 b	2.85 ± 0.10 a
1.0 l/ha^{-1}	7.80 ± 0.32 a	8.03 ± 0.79 a	0.83 ± 0.17a	2.72 ± 0.10 a
cv	18.57	23.91	21.75	15.06
	DP/R (cm)	MFR (g)	MSR (g)	R (kg/m^2)
Control	2.88 ± 0.19 c	7.56 ± 1.13 d	0.44 ± 0.05 c	0.45 ± 0.06 d
0,2 L ha^{-1}	3.03 ± 0.16 bc	9.37 ± 0.61 c	0.51 ± 0.04 b	0.56 ± 0.03 c
0.5 l/ha^{-1}	3.40 ± 0.17 a	12.21 ± 0.77 b	0.66 ± 0.04 b	0.73 ± 0.04 b
0,7 L ha^{-1}	3.11 ± 0.17 b	13.66 ± 1.08 b	0.73 ± 0.06 a	0.81 ± 0.06 a
1.0 l/ha^{-1}	3.56 ± 0.32 a	14.56 ± 1.51 a	0.78 ± 0.08 a	0.87 ± 0.09 a
cv	27.89	22.02	4.68	22.64

(Mean ± standard error)
Averages with different letters in the same column vary for $p<0.05$. DE/R: equatorial diameter of the root, DP/R: polar diameter of the root, M/R: mass of the root, R: yield, H/P: leaves per plant, MFH: fresh mass of leaves, MSH: dry mass of leaves, MFR: fresh mass of the root, MSR: dry mass of the root.

The results for the remaining variants that also received the application of VIUSID agro were below the treatments mentioned, but also differed significantly from the control group ($p<0.05$) and exceeded it by 18.57% and 20.71%. In the yield variable, the best performance was from the 0.7 L ha^{-1} and 1.0 L ha^{-1} dosages, which both outperformed the rest of the variants and increased compared with the control by 2.41 kg/m^2 and 2.60 kg/m^2. Yield had a significant linear relationship with polar and equatorial diameter, as well as with the mass of the root. Pearson correlation coefficients were equatorial diameter (r=0.99**), polar diameter (r=0.94**) and mass of the root (r=1.00**).

In radish crops (table 3), in the number of leaves variable, the best performance was with the 0.5 L ha^{-1} and 1.0 L ha^{-1} dosages, with significant differences ($p<0.05$) compared to the rest of the variants. In the fresh mass of the leaves, performance was similar, with an increase over the control for the above-mentioned treatments of 43.47% and 45.21%, and for the dry mass, of 45.83% and 72.92%, respectively. In the equatorial diameter of the root, all the treatments where the product was applied significantly exceeded the control. The best performance was from the 0.7 L ha^{-1} and 1.0 L ha^{-1} dosages, with increases over variants not treated with VIUSID agro of 25.55% and 19.82%. In the polar diameter, the 0.5 L ha^{-1} and 1.0 L ha^{-1} dosages differed from the rest of the variants. In the fresh mass, it was the higher dose that differed from the rest of the variants ($p<0.05$) and exceeded the control by 7 g. Although it is important to mention that all the treatments with the product differed significantly from the control group ($p<0.05$) in this variable. In the dry mass of the root, performance was similar, with an increase in the 0.5 L ha^{-1} and 1.0 L ha^{-1} dosages, compared with the control, of 0.29 g and 0.35 g, which means an increase of over 50%. The agricultural yield is not high in these production conditions. However, with the use of the VIUSID agro, it increased in relation to the control treatment with all the variants used. The higher dosages had the best performance, with statistical differences ($p<0.05$) with regard to the untreated and the remaining treated variants. With the 0.7 L ha^{-1} and 1.0 L ha^{-1} dosages, there was an increase of 0.36 g and 0.42 g, which is almost double the yield per square meter. Pearson correlation coefficients were also determined and the yield had a significant linear relationship with the fresh mass of the leaves (r=0.48**), the dry mass of the leaves (r=0.61**), the fresh mass of the plant (r=0.95**), the equatorial diameter of the root (r=0.77**), the polar diameter of the root (r=0.54**), the fresh mass of the root (r=1.00**), as well as the dry mass of the root (r=0.95**). On the other hand, the fresh mass of the root had a significant linear relationship with the dry mass of the leaves (r=0.61**) and with the fresh mass of the plant (r=0.95**). These growth variables significantly influenced the yield and were favoured by the application of VIUSID agro.

DISCUSSION

In Cuba, the production of these vegetables is often below demand, and crop yields are among the lowest in Latin America. Lettuce, Swiss chard, beetroot and radishes have low levels of production since they are grown on a small scale and as associated crops. Typical yields in organoponics are generally: for lettuce, between 1 kg/m^2 and 1.5 kg/m^2; for the chard, between 2.0 kg/m^2 and 3.5 kg/m^2; for beetroot, between 1.6 kg/m^2 and 3.0 kg/m^2; and for radish from 0.5 kg/m^2 to 0.8 kg/m^2 (Rodriguez *et al*., 2007).

With the application of VIUSID agro, the national average production values are surpassed in all crops. This performance in terms of production increase is a result of foliar fertilization with the growth promoter. This product contains several elements that have a positive influence on this result. Among them, amino acids, which are considered the precursors and components of proteins, which are important for the stimulation of cell growth (Rai, 2002). They act as dampers that help maintain favourable pH values within plant cells (Davies, 1982). Moreover, amino acids are biostimulants, and it is well known that they have positive effects on plant growth and performance and significantly reduce injuries caused by abiotic stress (Kowalczyk and Zielony, 2008). There is evidence of their favourable impact on increased production in several crops. It has been raised that these increases are related to the plant's IAA synthesis and that they directly or indirectly influence the physiological activities such as growth and development. It has been proven that their foliar application had a positive effect on growth and productivity of different crops. Researchers such as Boras *et al*. (2011) proved this in the production and quality of tomatoes (*Solanum lycopersicum* L.) under plastic greenhouses. Other authors such as Saeed *et al*. (2005), in experiments with soya bean (*Glycine max* L.) crops, found that treatments with amino acids significantly improved the growth of shoots and the fresh mass, as well as legume yield.

In addition, in potato (*Solanum tuberosum* L.) crops, it was found that spraying amino acids at a concentration of 0.25 ml/l^{-1} significantly increased the plant's vegetative growth expressed as height and dry mass (El-Zohiri and Asfour, 2009). Abo Sedera *et al*. (2010) revealed that spraying strawberry (*Fragaria daltoniana* L.) plants with amino acids (peptone) at 0.5 and 1.0 g/l^{-1} significantly increased the total nitrogen, phosphorus and potassium in the foliage of the plant, as well as the total yield, weight, TSS, vitamin C and total sugars in the fruit, in comparison with the control treatment.

Another element of great importance is the zinc, which has been reported to play a part in the setting or filling of fruit and in the growth of plants. In cotton (*Gossypium barbadense* L.) crops, foliar application of combined Zn caused an increase in production by significantly increasing fruits and seeds per plant (Sawan *et al*., 2008). In addition, Cakmak (2008) set forth that foliar application of zinc, alone or combined, increased the content of this element in fruits, and stimulated plant growth and crop yield. Although we found no references of the use of the VIUSID agro in lettuce and chard, it was found that Peña *et al*.(2015 b) obtained favourable results in the number of leaves per plant and the thickness and length of these, in the cultivation of anthurium (*Anthurium andreanum* Lind.). These authors carried out foliar applications weekly using different dosages of the product and reported not only benefits to the vegetative growth of the crop, but also an accelerated onset of flowering. Neither are there reports of the use of VIUSID agro in beetroot and radish in tropical organoponic conditions. However, there were several investigations that assert the product's effectiveness in other crops. Peña *et al*. (2015 a) applied VIUSID agro and obtained better results in the variables related to yield. Regarding grains per plant, the best result was reached by using a weekly treatment, with 63.38 grains per plant on average, and a yield increase of 1.8 t/ha^{-1} compared to the control group. In addition, Peña *et al*. (2015 c), when using this product in bean crops and immersing seeds, determined that it favoured the germination and vigour of the seedlings.

They also found a 19.61 % increase in yield for seeds immersed in the product, compared to the control group. Meléndrez *et al.* (2015) compared the effect of three growth promoters (efficient microorganisms, VIUSID agro and a preparation of *Trichoderma harzianum*) in bean crops, and obtained significant differences ($p<0.05$) between treatments. They concluded that the weekly applications of *Trichoderma harzianum*, efficient microorganisms and VIUSID agro led to a positive effect on the growth of the plant and the agroproductive performance of bean crops. The application of VIUSID agro had the best agro productive performance in bean crops. Other authors reported satisfactory results in several crops when using VIUSID agro. As put forward by Galdo *et al*. (2014) and Quintana *et al*. (2015) in the production of pasture grasses, Valle *et al.* (2016) in bean crops, Dorta *et al.* (2016) in the assessment of the quality of seeds from plantations treated with the product and Peña *et al*. (2016) in tomato (*Solanum lycopersicum* L.) crops.

Conclusions

Foliar application of VIUSID agro improved the productive performance of lettuce crops. The treatments with the growth promoter surpassed the control in all variables except for the length of the root. The best yield was obtained with the 0.2 L ha^{-1} dosage. Foliar application of this product significantly improved the productive performance of chard crops. The best yield was obtained with the 1.0 L ha^{-1} dosage. Productive performance was favoured in beetroot and radish crops. Treatments with the growth promoter surpassed the control in all the evaluated variables and the best performance was reached with the 0.7 L ha^{-1} and 1.0 L ha^{-1} dosages.

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