Effect of the Growth Promoter VIUSID Agro on the Morphophysiological and Productive Performance of Tobacco Growth (*Nicotiana tabacum* L.)

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**Abstract:** With the objective of evaluating the effect of VIUSID agro on the morphophysiological and productive performance of tobacco seedlings, a randomised block experiment was designed with five treatments and three replications. The variants were: dosage of 0.2, 0.5, 0.7 and 1.0 L/ha and one control. The variables are recorded at three points of the cultivation cycle 10th, 20th and 30th days after planting (DAP). Among the indicators evaluated were the fresh and dry mass of the plants, the leaves per plant, foliar area, the length and diameter of the stalk as well as the characteristics of the root. The rates of physiological growth and agricultural yield were also evaluated. The results showed a significant increase (*p* ≤ 0.05) in the fresh and dry mass of the plants when VIUSID was used. Regarding the length of the stalk, the average increase of those treated in comparison to the control in the final evaluation were 28.42%, 30.51%, 41.17% and 38.43%. In terms of the diameter of the stalk and the foliar area in all evaluations, the treatments with VIUSID significantly exceeded the control. The absolute growth rate and net assimilation was significantly higher when the product was used. In the relative growth rate, the most favourable behaviour was the dosage of 0.5 L/ha, in final evaluation. With regard to yield, the best performance with significant differences (*p* ≤ 0.05) to the other treatments was the dosage of 0.5, 0.7 and 1.0 L/ha. Therefore, VIUSID agro had a positive influence on the morphophysiological and productive indicators of the tobacco seedlings.

**Key words:** VIUSID agro, tobacco, morphophysiological and productive characteristics.

1. **Introduction**

The use of growth enhancers that do not affect the environment is an option to increase the quality and to optimize the area allocated for seedlings. One product with these characteristics is VIUSID agro which consists of: potassium phosphate, malic acid, zinc sulphate, arginine, glycine, ascorbic acid, calcium pantothenate, pyridoxine, folic acid, cyanocobalamin, glucosamine and monoammonium glycyrrhizinate. All these ingredients undergo a biocatalytic process of molecular activation that increases the effectiveness of their properties which benefits crop [1].

On the other hand, tobacco in Cuba is one of the key pillars of the economy and it is important to establish a sustainable technology that allows obtaining a product in accordance with international standards that, at the same time, satisfy the needs of potential customers [2].

However, in the seed tray area alone, over 250 tonnes of chemical fertilizer are used, around 10 applications of cutting-edge chemical pesticides. This implies that the country must invest high quantities of money in acquiring the supplies, which in most cases
leads to a high environmental impact. Currently, it is highly important to search for and find variants that allow for the development of profitable, non-environmentally-contaminating agriculture [3].

As well as obtaining seed trays with uniform growth, this is a way of increasing the yield of useful seedlings, increasing the use of the seed tray areas and achieving a significant reduction in the production costs [4]. The tobacco seed tray must provide healthy, vigorous and uniform seedlings, at the appropriate time, in order to guarantee a good physiological state among the plants in the planting stage. However, it is common to find non-uniform tobacco seed trays in the Cuban tobacco agricultural activity [5].

The effect of VIUSID agro has been evaluated in different crops and various towns in the province of Sancti Spíritus, Cuba, including Cabaiguán, Jatibonico, Sancti Spíritus, Taguasco, Yaguajay and Fomento. Studies were found where the product helped to increase production: one of these was for kidney beans (*Phaseolus vulgaris* L.) favouring the pods and beans per plant, as well as yield [6, 7]. Positive effects on different varieties of bean and increased seeds’ yield and quality had been found, too [8, 9].

There was also an increase in the quality of the leaves and the start of flowering of anthuriums (*Anturium andreanum* Lind.) [10]. It was also found that VIUSID agro favoured germination of seeds and production of tomatoes (*Solanum lycopersicum* L.) [11, 12]. Similar results for increased yield of corn (*Zea mays* L.) had been obtained [13, 14].

In tobacco (*Nicotiana tabacum*), several studies have been carried out and the product favoured the number, length and width of the leaves and the final yield of the crop [15]. However, its VIUSID agro effect on production has not been evaluated in depth and there is no report published in this regard.

Therefore, the objective of this research was to evaluate the effect of the doses 0.2, 0.5, 0.7 and 1.0 L/ha of VIUSID agro in the production of fresh mass and dry mass, length and diameter of stem, leaf area, physiological growth rates (absolute rate of growth, net assimilation rate, relative growth rate) and agricultural yield in tobacco seedlings (*N. tabacum*) variety Sancti Spiritus 2006 (SS-2006).

## 2. Materials and Methods

### 2.1 General Aspects of the Research

The experiment was carried out in farm “La Angelita”, with coordinates: 21°54′37.78″ N, 79°27′27.9″ W, Sancti Spiritus, Cuba. The planting on October 21st and the harvest was on November 21st, 2016. The climatic variables were registered by the Sancti Spiritus provincial station, the average daily temperature was 26.15 °C, with an average daily relative humidity of 85.25% and accumulated rainfall of 99.88 mm. For the preparation of the substrate, the irrigation, the agro-technical work and the control of pests and disease, the standards established for cultivation, were followed [16].

### 2.2 Experimental Design

The experimental design was random blocks with five treatments and three replicas. The plots were 5.0 m in length and 1.50 m in width (7.5 m²) and the calculated surface was 5.5 m². The dosage for the planting of the seeds 0.20 g/m² was established by the Institute of Tobacco Research [17].

### 2.3 Means of Application and Treatments

The applications were carried out in the morning, taking into account the manufacturer’s recommendations for tropical regions. These were effectuated on a weekly basis and started 5 d after planting (DAP) in order to favour germination of the seed. A manual sprayer carried on a person’s back with capacity for 16 L was used.

To establish the treatments results, research was carried out by the experimental tobacco station Sancti Spiritus, together with the University of Sancti Spiritus (UNISS). Treatments were as follows: control (no product application) and four dosages 0.2, 0.5, 0.7
and 1.0 L/ha. VIUSID agro is produced by the Spanish company Catalysis, and its composition can be observed in Table 1.

2.4 Dependent Variables Assessed

In order to determine the variables, the establishments by the crop instructions were taken into account [16]. The variables were as follows: fresh mass of the plant (g), dry mass of the plant (g), length of the stalk (cm), diameter of the stalk (cm), foliar area (cm²), fresh mass of the root (g), dry mass of the root (g), length of the root (cm) and physiological growth rates.

The plants selected for calculation were transferred to UNISS. The number of leaves was counted, length and width of each one was measured. The fresh mass of the plant and its organs was determined with a Sartorius digital scale (model BS 124S) with accuracy of ± 0.01 g. The length of the plant was measured from the neck of the root to the apex of the stalk, using a millimetre ruler. For the diameter of the stalk, a vernier calliper was used and the value of all of the selected plants was recorded. For the dry mass of the plant, they were placed in the heater (MJW WS 100) at 75 °C for 72 h and then the dry mass was determined with the Sartorius digital scale, with accuracy of ± 0.01 g. Yield was obtained through the indirect method [18] and the crop regulations were taken into account [16]. For the growth rates, the methodology used was presented in Table 2.

### Table 1  Composition of the evaluated growth promoter g/100 mL.

| Composition                  | %     | Composition          | %  |
|------------------------------|-------|----------------------|----|
| Potassium phosphate          | 5     | Calcium pantothenate | 0.115 |
| Malic acid                   | 4.6   | Pyridoxal            | 0.225 |
| Glucosamine                  | 4.6   | Folic acid           | 0.05  |
| Arginine                     | 4.15  | Cyanocobalamin       | 0.0005 |
| Glycine                      | 2.35  | Monoammonium glycyrrhizinate | 0.23 |
| Ascorbic acid                | 1.15  | Sodium benzoate      | 0.2  |
| Zinc sulphate                | 0.115 | Potassium sorbate    | 0.2  |
| Distilled water (sufficient quantity) | 100 mL |

All these compounds underwent a molecular activation process.

### Table 2  Growth rates used in plant physiology [19].

| Growth rate            | Symbol | Formula                     | Units          |
|------------------------|--------|-----------------------------|----------------|
| Absolute growth rate   | TCA    | $TCA = (W_2 - W_1)/(T_2 - T_1)$ | g/d            |
| Foliar area            | AF     | $AF = (Ac \times M_f)/Mc$    | cm²/d          |
| Net assimilation rate  | TAN    | $TAN^* = 2(W_2 - W_1)/(AF_2 + AF_1) (t_2 - t_1)$ | g/cm²/d |
| Relative growth rate   | TCR    | $TCR = 2(W_2 - W_1)/((W_2 + W_1) (t_2 - t_1))$ | g/g/d |

AF = foliar area; T = time; W = dry mass; Ac= area of a square paper of 1 dm²; Mf = mass of all paper figures or silhouettes cut out (annex 7); Mc = mass of a square paper of 10 cm²; TAN*: the formula was used because $\alpha$ ranged between 1.5 and 2.5.

2.5 Statistics

Statistical analysis of results was carried out using the SPSS 15.0.1 statistical package for Windows [20] and the MINITAB statistical package release 14.12.0 [21]. Previously, normal distribution of data was evaluated using the Kolmogorov-Smirnov test for goodness of fit, and the Levene’s $F$ test was applied to evaluate the homogeneity of variance. One-way ANOVA was performed when normality and homogeneity existed and means were compared by the Tukey’s test of multiple ranges ($\alpha = 0.05$). The Student’s $t$ test for data without homogeneity of variance was carried out. One carries out a study of Polynomial regression between dose and yield like dependent variable [22].
3. Results and Discussion

3.1 Effect of Treatments on Fresh and Dry Mass of the Plants

In Table 3, the effect of the growth enhancer on the fresh mass of the tobacco seedlings at three points in the cultivation cycle was observed. Ten DAP, the best performance was obtained with the foliar application of VIUSID agro dosage 1.0 L/ha, with significant differences \( (p < 0.05) \) with regards to the control and the other variants. The increase compared with those not treated was 0.52 g. The treatments with application at dosages of 0.2, 0.5 and 0.7 L/ha also significantly exceeded the control and the increase of fresh mass was 0.37, 0.14 and 0.37 g (in the ascending order shown in Table 3).

In the second evaluation 20 DAP (Table 3), the performance was similar, all treatments with the product significantly exceeded the control \( (p < 0.05) \). The dosage of 0.7 L/ha statistically differed from the other treated variants except treatment of 0.2 L/ha. The increases with regards to those not treated by the order shown in Table 3 were of 3.68, 1.06, 4.51 and 2.92 g. The best performance on the 30th DAP was the dosages of 0.5, 0.7 and 1.0 L/ha, these differed significantly from the variant with a lower dosage and the control and exceeded the latter by 5.85, 6.22 and 6.05 g, respectively.

The dry mass of the plants was significantly higher in all variants with the growth enhancer with regards to the control (Table 3). The treatments with the best performance (10 DAP) were the dosages of 0.7 L/ha and 1.0 L/ha that exceeded those not treated by 0.02 g.

In the second evaluation 20 DAP, the performance was similar, all variants with the growth enhancer significantly exceeded \( (p < 0.05) \) the control and the dosage of 0.7 L/ha had the best stimulant effect. The average increases of those treated in comparison to the control, in the order of ascending position in Table 3, were 0.27, 0.09, 0.35 and 0.24 g, respectively.

In the last evaluation 30 DAP, the same trend was maintained and it was the treatments with foliar application of the VIUSID agro growth enhancer that showed the best performance. Significant differences were not found \( (p < 0.05) \) between the variants with the product dosage of 0.5, 0.7 and 1.0 L/ha but were found between these in comparison to the lower dosage and the control. The increases with regards to the latter were of 0.44, 0.68, 0.77 and 0.72 g (Table 3).

### Table 3  Effect of treatments on fresh and dry mass of the plants.

| Treatments  | Fresh mass (g) |  |  |
|-------------|----------------|---|---|
|             | 10 (DAP)       | 20 (DAP) | 30 (DAP) |
| Control group | 0.15<sup>d</sup> | 2.76<sup>d</sup> | 3.60<sup>c</sup> |
| 0.2 L/ha     | 0.52<sup>b</sup> | 6.44<sup>ab</sup> | 7.70<sup>b</sup> |
| 0.5 L/ha     | 0.29<sup>c</sup> | 3.82<sup>c</sup> | 9.45<sup>a</sup> |
| 0.7 L/ha     | 0.52<sup>a</sup> | 7.27<sup>a</sup> | 9.82<sup>a</sup> |
| 1.0 L/ha     | 0.67<sup>a</sup> | 5.68<sup>a</sup> | 9.65<sup>a</sup> |
| Standard error (SE) ± | 0.03 | 0.40 | 0.35 |
| Coefficient of variation (CV) (%) | 25.10 | 20.19 | 27.70 |

| Treatments  | Dry mass (g) |  |  |
|-------------|--------------|---|---|
|             | 10 (DAP)     | 20 (DAP) | 30 (DAP) |
| Control group | 0.01<sup>c</sup> | 0.18<sup>d</sup> | 0.44<sup>c</sup> |
| 0.2 L/ha     | 0.02<sup>b</sup> | 0.45<sup>b</sup> | 0.88<sup>b</sup> |
| 0.5 L/ha     | 0.01<sup>c</sup> | 0.27<sup>c</sup> | 1.12<sup>a</sup> |
| 0.7 L/ha     | 0.03<sup>a</sup> | 0.53<sup>a</sup> | 1.21<sup>a</sup> |
| 1.0 L/ha     | 0.03<sup>a</sup> | 0.42<sup>b</sup> | 1.16<sup>a</sup> |
| SE ±        | 0.002        | 0.03 | 0.05 |
| CV (%)      | 20.0         | 23.51 | 28.63 |

Averages with different letters in the same column vary for \( p < 0.05 \), according to the Tukey’s test of multiple ranges (\( \alpha = 0.05 \)).
Foliar application of VIUSID agro is favourable as the tobacco seedlings with the best nutrition accumulate a higher content of dry material, which is advantageous to them in the seed tray period and makes them more resistant to post-transplant stress [23, 24].

This growth enhancer contains in its composition several elements that have a positive influence on plant growth and therefore on the increase of fresh and dry mass. These include pyridoxal, potassium phosphate, folic acid and amino acids such as glycine. It is also attributed particular importance for the biocatalytic process of molecular activation where, once culminated, the molecules are activated and a greater effect is obtained from these components on the crops [1].

On the other hand, the total production of dry mass is a result of the efficiency of the crop’s foliage in the interception and use of the solar radiation available during the growth cycle [25]. In this sense, the treatments with VIUSID agro had better results in comparison to the control.

Similar results were found in different vegetable crops [26]. Researchers reported that foliar application of VIUSID agro increases fresh and dry masses of the plants, mass of beetroot, lettuce, chard and radish plants.

### 3.2 Effect of the Treatments on Stalk Length

The effects of the treatment on the length of the stalk at three points in the seed tray stage are shown in Table 4. Ten DAP, the most favourable performance was reached with the dosages of 0.5 L/ha and 0.7 L/ha with increases in comparison to the control of 1.80 cm and 1.78 cm. The variants with dosages of 0.2 L/ha and 0.7 L/ha also significantly differed from the control and exceeded it by 0.28 cm and 0.5 cm, respectively.

Twenty DAP, the trend was similar, treatments with dosages of 0.7 L/ha and 1.0 L/ha differed significantly from the control and exceeded it by 1.81 cm and 1.71 cm. The dosage of 0.5 L/ha differed significantly from the treatment without VIUSID agro and exceeded it by 0.53 cm while the variant with a lower dosage did not differ from the control.

In the last evaluation (30 DAP), all treated variants significantly exceeded the control. The dosages of 0.7 L/ha and 1.0 L/ha had the most favorable performance. The increases of those treated with the product in comparison to the control, in the order of ascending position in Table 3, were 28.42%, 30.51%, 41.17% and 38.43%, respectively.

The results reached were attributed to the VIUSID agro growth enhancer as this product has a positive influence on the growth of the plants [1]. On the other hand, the tobacco seedlings are optimal for transplant when the length of the stalk is between 13 cm and 15 cm [16] therefore only those treated with VIUSID agro are within this range. This makes it possible to transplant the plant in a shorter period of time than with the control treatment, a very important aspect for crops that require greenhouses before being brought to the fields.

### Table 4  Effect of the treatments on stalk length.

| Treatments | Stalk length (cm) |
|------------|-------------------|
|            | 10 (DAP)         | 20 (DAP)       | 30 (DAP)       |
| Control group | 1.80<sup>a</sup> | 3.78<sup>a</sup> | 10.98<sup>a</sup> |
| 0.2 L/ha | 2.08<sup>b</sup> | 4.02<sup>bc</sup> | 14.10<sup>b</sup> |
| 0.5 L/ha | 2.30<sup>b</sup> | 4.31<sup>b</sup> | 14.33<sup>b</sup> |
| 0.7 L/ha | 3.60<sup>a</sup> | 5.59<sup>a</sup> | 15.50<sup>a</sup> |
| 1.0 L/ha | 3.58<sup>a</sup> | 5.49<sup>a</sup> | 15.20<sup>a</sup> |
| SE ± | 0.06 | 0.16 | 0.11 |
| CV (%) | 20.17 | 14.18 | 15.21 |

Averages with different letters in the same column vary for \( p < 0.05 \), according to Student’s \( t \) test for non-homogeneous variances.
3.3 Effect of Treatment on Stalk Diameter

The effect of the treatment on the diameter of the stalk is observed in Fig. 1. In the first evaluation, the most favorable performance was reached with the dosage of the growth enhancer. There were no significant differences between them but there was with regards to the control. The average increase of those treated with VIUSID over the control was 49.97%.

In the second evaluation 20 DAP, the trend was similar. The variants where the product was used differed significantly from those not treated with the same. The increases with regards to the control were of 64.71%, 47.06%, 64.71% and 52.94%, respectively.

In the final evaluation, the best performance was obtained with the highest treatment, which significantly differed from all variants except for the dosage of 0.7 L/ha. The treatments with the dosages of 0.2 L/ha and 0.5 L/ha also significantly differed from the control. The increases of the treatments with VIUSID agro in comparison to the control, were 18.92%, 27.03%, 29.73% and 40.54%.

The diameter of the stalk is one of the quality indicators for tobacco production. The optimum values for harvest are found between 0.3 cm and 0.5 cm [17], therefore the results reached with the use of the product are satisfactory as, in general, this value was favoured during the entire seed tray phase and the time of transplant for all treatments was within the range established.

When the tobacco seedlings have a suitable supply of nutrients, they achieve values of length and diameter of the stalk that are within the optimum ranges for guaranteeing post-transplant stress [24].

![Fig. 1  Effect of treatment on stalk diameter.](image)

Averages with uneven letters differ for \( p < 0.05 \) according to Student’s \( t \) test.
3.4 Effect of Treatment on Foliar Area

Table 5 shows the effect of the treatments on the foliar area. In the first evaluation, the best performance was in the variants with the growth enhancer as all significantly differed ($p < 0.05$) from those not treated with the product. The best performance was that of the dosage of 1.0 L/ha, the increase here with regards to the control was of 8.38 cm$^2$. The increases of the dosages of 0.2, 0.5 and 0.7 L/ha with regards to those not treated were of 5.13, 5.09 and 5.45 cm$^2$, respectively.

At 20 DAP, the performance was similar as all variants with VIUSID differed significantly from the control. In this type of experiment where the evaluations are carried out through the destructive method, i.e. a single plant is not evaluated from beginning to end of the cycle, the trends are of great interest. In the last evaluation the trend was similar (Table 5) and on this occasion it was the dosages of 0.5, 0.7 and 1.0 L/ha that had the best performance with increases in comparison to the control of 132.85, 130.53 and 140 cm$^2$. The dosage of 0.2 L/ha also had favorable results and exceeded the control significantly by 69.95 cm$^2$.

The results reached with the use of the growth enhancer VIUSID agro were favourable as the increase in plant biomass is carried out from the expanded foliar area as a source of production of photoassimilates [27].

3.5 Effect of Treatments on the Physiological Growth Rates

The absolute growth rate (TCA) is observed in Table 6, at 20 DAP. The treatments with best performance were the dosages of 0.2 L/ha and 0.7 L/ha that differed significantly from the rest of the various with and without the product. The increases with regards to the control were of 0.0253 g/d and 0.0337 g/d. The treatments of 0.5 L/ha and 1.0 L/ha also significantly differed from the control and exceeded it by 0.0093 g/d and 0.0222 g/d.

In the last evaluation (30 DAP) it was observed that

Table 5  Effect of treatment on foliar area.

| Treatments   | 10 (DAP) | 20 (DAP) | 30 (DAP) |
|--------------|----------|----------|----------|
| Control group| 8.17a    | 62.42a   | 75.88b   |
| 0.2 L/ha     | 13.30b   | 138.38b  | 145.83b  |
| 0.5 L/ha     | 13.26b   | 136.49b  | 208.73c  |
| 0.7 L/ha     | 13.62b   | 154.09a  | 206.41a  |
| 1.0 L/ha     | 17.55a   | 124.60b  | 216.43a  |
| SE ±         | 0.54     | 4.87     | 7.68     |
| CV (%)       | 21.12    | 20.31    | 22.78    |

Averages with different letters in the same column vary for $p < 0.05$, according to the Tukey’s test of multiple ranges ($\alpha = 0.05$).

Table 6  Effect of the treatments on the absolute growth rate, the net assimilation rate and the relative growth rate.

| Treatments   | TCA (g/d) | TAN (g/cm$^2$/d) | TCR (g/g/d) |
|--------------|----------|------------------|-------------|
|              | 20 (DAP) | 30 (DAP)        | 20 (DAP)    | 30 (DAP)    | 20 (DAP) | 30 (DAP) |
| Control group| 0.0163c  | 0.0265c         | 0.0476c     | 0.0636d     | 0.1721b  | 0.0602c  |
| 0.2 L/ha     | 0.0416c  | 0.0456d         | 0.0536c     | 0.0966c     | 0.1785b  | 0.0653c  |
| 0.5 L/ha     | 0.0256b  | 0.0848a         | 0.0519c     | 0.2014a     | 0.1783c  | 0.0949a  |
| 0.7 L/ha     | 0.0500c  | 0.0688c         | 0.0579a     | 0.1004b     | 0.1781a  | 0.0765b  |
| 1.0 L/ha     | 0.0385b  | 0.0745b         | 0.0549b     | 0.1205b     | 0.1691b  | 0.0936b  |
| SE ±         | 0.001    | 0.004           | 0.001       | 0.009       | 0.001    | 0.001    |
| CV (%)       | 16.67    | 13.33           | 15.23       | 12.31       | 15.21    | 14.21    |

Averages with uneven letters in the same column differ for $p < 0.05$ according to the Tukey’s test of multiple ranges ($\alpha = 0.05$). (Average ± SE).
all treatments with the product significantly differed from those not treated, with a more favorable performance of the dosage of 0.5 L/ha. The increases with regards to the control were (in the consecutive order appearing in Table 6) of 0.0191, 0.0592, 0.0432 and 0.0489 g/d. This meant that the treatments with VIUSID agro reached a higher increase in dry mass by unit of time than the control.

In the net assimilation rate at 20 DAP, the most favorable performance was obtained with the treatment of 0.7 L/ha that exceeded the control by 21.64%. The other treatments with the product significantly differed from the control and the treatment of 0.7 L/ha. The increases with regards to those not treated (in the order appearing in Table 6) were of 12.61%, 9.03% and 15.62%, respectively. This means that these variants obtained higher net gain in dry mass per unit of foliar area and therefore a greater photosynthetic efficiency.

At the 30th DAP (Table 6), the best performance was the dosage of 0.5 L/ha with an increase with regards to those not treated of 0.1378 g/cm²/d. The dosages of 0.7 L/ha and 1.0 L/ha did not differ significantly from each other but exceeded those not treated with the product by 0.0368 g/cm²/d and 0.0569 g/cm²/d, respectively. The lower dosage also had a favorable performance and exceeded the control by 0.033 g/cm²/d.

The TAN is an indicator of the average photosynthetic efficiency, as it measures the net gain of assimilates per unit of foliar area and per unit of time [28]. With the results obtained, it can be affirmed that the plants treated with VIUSID agro had a higher average photosynthetic efficiency, as all treatments significantly exceeded the control at 20 DAP and 30 DAP.

In the TCR, it is observed that 20 DAP there was no significant difference between the treatments of 0.2, 0.5 and 0.7 L/ha but there was with regards to the control which exceeded significantly. However, the treatment with the highest dosage did not statistically differ from the variant without VIUSID agro. In the last evaluation, the treatments with the dosages of 0.5, 0.7 and 1.0 L/ha had the best performance and statistical differences with regards to those not treated with the product. The increases with regards to this were (order of appearance in Table 6) 57.64%, 27.08% and 55.48%.

This result means that the tobacco seedlings treated with VIUSID agro had higher efficiency for producing new dry material in a certain period. This rate is considered an efficiency rate for the production of dry mass in plants.

Independently of the treatments, the crop followed a performance that did not alter the normal trend during the ontogeny, as the highest TCR values were reached at 20 DAP. This meant that in the initial stage, the crop was most efficient in the elaboration of new material [29].

3.6 Effect of Treatment on Yield

Fig. 2 shows the effect of the treatments on the agricultural yield. The treatments with dosages from 0.5 L/ha had the most favorable results without significant differences between each other but with differences in comparison to the control and variant with the lowest dosage. The increased yields in useful seedlings per square meter with regards to those not treated with the product (in the order appearing in Fig. 2) were 64, 87 and 62 seedlings per square meter, respectively. The treatment with lower dosages also had a favorable performance with regards to the control and exceeded it by 43 useful seedlings per square meter.

Fig. 2 shows that there is a polynomial link between the yield and the treatments, with a coefficient of determination close to one, therefore the link between both variables is very strong. The trend line is observed where the yield tends to increase as the dosage is increased, up to a point where it later decreases with the increase of the same.

The increase of yield with regards to the control was of 21.48% for the dosage of 0.5 L/ha, of 29.19%
Fig. 2  Relationship between agricultural yield and the treatments.
Averages with uneven letters differ for \( p < 0.05 \), according to the Tukey’s test of multiple ranges.

with the dosage of 0.7 L/ha and of 20.81% for the highest dosage. The lowest dosage 0.2 L/ha also significantly exceeded the control with an increase of useful seedlings per square metre of 14.0%.

The performance in the increase of production is due to the foliar application of the VIUSID agro growth enhancer. This product contains several elements that had a positive influence on this result. Among them, amino acids, which are considered the precursors and components of proteins, are important for the stimulation of cell growth [30]. They act as dampers that help maintain favorable pH values within plant cells [31]. Moreover, amino acids are biostimulants, and it is well known that the application of formulations containing amino acids has positive effects on plant growth and yield and significantly reduces injuries caused by abiotic stress [32].

Another element of great importance in the composition of VIUSID is the zinc, which has been reported to play a part in the setting or filling of fruit and in the growth of plants. Various authors have stated that when Zn is applied, alone or in combination with other nutrients, in formulations for agricultural use, favourable results are obtained [33].

There are no reports on the use of VIUSID agro on the yield of useful plants per square metre in tobacco seedlings. However, there were several investigations that assert the product’s effectiveness in other crops. In the cultivation of Anthurium (Anthurium andreanum Lind.), favorable results were obtained for the number of leaves per plant and the thickness and length of the same [8].

Also, for beans, better performance was obtained in the variables related to yield. Increased yield of 1.8 t/ha was achieved with regards to the control when VIUSID agro was applied to the foliar area with a weekly interval [7]. In this same crop, upon immersing the seeds in a solution of 0.02%, the germination and vigour of the plants was favoured, as well as the yield of those treated with the product in comparison to the control by 19.61%, merely in the concept of immersion [9].

Other authors reported satisfactory results in several crops when using VIUSID agro, in the production of grasses [34], the cultivation of tomato (S. lycopersicum) [10] and in onions (A. cepa) [35].

4. Conclusions

VIUSID-agro growth promoter influences the increase of the fresh and dry mass of the tobacco
seedlings, as well as the height, stem diameter and leaf area. Also, it causes increases in the active growth rate, the net assimilation rate and the relative growth rate. The best results in the yield increase are reached with the doses 0.5, 0.7 and 1.0 L/ha.

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