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Original Article

Effect of FitoMas-E on seed germination and plant quality of *Chrysophyllum cainito L*. (caimito) in nursery conditions

Efecto del FitoMas-E sobre la germinación de semillas y calidad de plantas de *Chrysophyllum cainito* L. (caimito) en condiciones de vivero

Efeito do PhytoMas-E na germinação das sementes e qualidade das plantas de *Chrysophyllum cainito L*. (caimito) em condições de viveiro

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ABSTRACT

In order to evaluate the effect of the bionutrient FitoMas-E on the seed germination and plant quality of *Chrysophyllum cainito* L. (caimito), two experiments were designed, completely at random, in a rustic nursery in the mountainous town of Topes de Collantes. In the experiment, related to the germination, five treatments were applied: immersion in water, mechanical scarification, scarification with sulfuric acid, immersion in solution of PhytoMas-E at 3 % and a control; while in the experiment related to the quality of plants four treatments were established consisting of foliar application of the bionutrient in solutions of different concentrations. In both cases three replicates were established. The variables evaluated were: accumulated and total germination up to 50 days, as well as the main attributes and morphological indexes of the plants at 150 days. The data obtained were subjected to simple ANOVA and comparison of means through Duncan's multiple range test *($p \leq 0.05$)*. The main results showed the effectiveness of PhytoMas-E in both processes, with an increase in the total germination of the seeds and advance in the beginning of it. In all treatments with the bionutrient, good quality representative values were observed in terms of attributes and morphological indexes, with statistically significant differences with respect to the control; the best results were obtained with the 2 % solution.

Keywords: FitoMas-E; germination; seeds; quality; *Chrysophyllum cainito* L.; nursery.

RESUMEN

Con el objetivo de evaluar el efecto del bionutriente FitoMas-E sobre la germinación de semillas y calidad de plantas de *Chrysophyllum cainito* L. (caimito), se diseñaron dos experimentos, completamente al azar, en un vivero rústico de la localidad montañosa Topes de Collantes. En el experimento, relacionado con la germinación, de semillas se aplicaron cinco tratamientos: inmersión en agua, escarificación mecánica, escarificación con ácido sulfúrico, inmersión en solución de FitoMas-E al 3 % y un testigo; mientras que en el experimento relacionado con la calidad de plantas se establecieron cuatro tratamientos consistentes en aplicación foliar del bionutriente en soluciones de diferentes concentraciones. En ambos casos se establecieron tres réplicas. Las variables evaluadas fueron: la germinación acumulada y total hasta los 50 días, así como los principales atributos e índices morfológicos de las plantas a los 150 días. Los datos obtenidos fueron sometidos a ANOVA simple y comparación de medias a través del test de rangos múltiples de Duncan *(p≤0.05)*. Los principales resultados pusieron de manifiesto la efectividad del FitoMas-E en ambos procesos, con un incremento en la germinación total de las semillas y adelanto en el inicio de la misma. En todos los tratamientos con el bionutriente se observaron valores representativos de buena calidad en cuanto a los atributos e índices morfológicos, con diferencias estadísticamente significativas respecto al testigo; los mejores resultados se obtuvieron con la disolución al 2 %.

Palabras clave: FitoMas-E; germinación; semillas; calidad; *Chrysophyllum cainito* L.; vivero.

SÍNTESE

A fim de avaliar o efeito do bionutriente FitoMas-E na germinação da semente e na qualidade da planta do *Chrysophyllum cainito* L. (caimito), dois experimentos foram projetados, completamente ao acaso, em um viveiro rústico na cidade montanhosa de Topes de Collantes. No experimento, relacionado à germinação, foram aplicados cinco tratamentos: imersão em água, escarificação mecânica, escarificação com ácido sulfúrico, imersão em solução de PhytoMas-E a 3 % e um controle; enquanto no experimento relacionado à qualidade das plantas foram estabelecidos quatro tratamentos que consistiram na aplicação foliar do bionutriente em soluções de diferentes concentrações. Em ambos os casos, foram estabelecidas três réplicas. As variáveis avaliadas foram: germinação acumulada e total até 50 dias, assim como os principais atributos e índices morfológicos das plantas aos 150 dias. Os dados obtidos foram submetidos a ANOVA simples e comparação de meios através do teste de alcance múltiplo da Duncan *(p≤0.05)*. Os principais resultados mostraram a eficácia do PhytoMas-E em ambos os processos, com um aumento da germinação total das sementes e avanço no início do mesmo. Em todos os tratamentos com o bio-nutriente, foram observados valores representativos de boa qualidade em termos de atributos e índices morfológicos, com diferenças estatisticamente significativas em relação ao controle; os melhores resultados foram obtidos com a solução a 2 %.

Palavras-chave: PhytoMas-E; germinação; sementes; qualidade; *Chrysophyllum cainito* L.; viveiro.

INTRODUCTION

The establishment of plantations with tree species is generally affected by various factors, including poor management, unfavourable environmental conditions and the use of poor quality plants. This last factor can be conveniently managed, so that in the nursery phase the appropriate work is done so that the seedlings obtained are successfully established in planting conditions. The use of quality seeds and their optimal management is the first step to achieving success in silvicultural management, growth, yield, quality, productivity, competitiveness and sustainability of the plantations (Espitia *et al.,* 2017).

Among the methods commonly used in nurseries, foliar fertilization is presented as an important complement that, although it does not replace soil fertilization, contributes greatly to the correction of nutritional deficiencies of plants, favors the proper development of crops, while improving the yield and product quality.

In the present schemes of sustainable agriculture, this technique has been applied at national and international level, with good results in multiple species. This has led to the production and evaluation of various compounds such as Bayfolán, FitoMas-E, Enerplant, Pertimorf, Liplant, Biplant, Biostan, EcoMic, Biobras 16 and liquid worm humus, among others. In spite of the successes achieved, the greatest number of investigations have been carried out in agricultural crops, being more limited in tree species, where the most studied product so far has been PhytoMas-E.

The importance of valuing the influence of this type of compounds on the development of woody species is justified by the need to seek the simplest and cheapest alternatives to spread them massively and thus be able to respond to the problems of deforestation and loss of biodiversity. For this, it is essential that good quality plants are produced in the shortest possible time.

Today, in Cuba, great importance is given to the production of fruit species, in order to guarantee the satisfaction of the country's food needs and the rescue of varieties that today are a rarity in Cuban fields, as well as to increase biological diversity in agro-ecological farms. Such is the case of *Chrysophyllum cainito* L. (caimito), which, in addition to being a fruit tree, is a hardwood and heavy wood tree that can also be used for reforestation and restoration plans (Hernández *et al.,* 2009). The fundamental way for the propagation of this species is sexual; however, in most of the conditions of the country, the germination of its seeds is erratic and with low percentages, the causes have not been studied in depth. Another difficulty is the slow growth of the plants in the nursery, which causes them to remain for a very long period of time, making their production more expensive; all of which results in a poor quality plant with limited possibilities of surviving in the field. In view of these difficulties, it is necessary to search for alternatives that contribute to minimizing them. Therefore, the objective of this research was: to evaluate the effect of the bionutrient FitoMas-E on the germination of seeds and plant quality of *Chrysophyllum cainito* L. (caimito) in nursery conditions.

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MATERIALS AND METHODS

Location and generalities of the research

The study was carried out during the period from September 2016 to February 2017), in areas of the Teaching Unit of the University of Sancti Spíritus (UD-FAME), located in the mountainous massif of Guamuahaya, specifically in the locality of Topes de Collantes (21°53′00″N 80°00′00″O), municipality Trinidad. During this time the average temperature in the area was 20.8 ºC, the average rainfall was slightly over 100 mm and the relative humidity was over 87 % according to data recorded by the Topes de Collantes Meteorological Station (Annex 1). The predominant soil type is ferrallitic red leached, this area is located at an approximate height of 760 meters above sea level and presents excellent conditions for the establishment of a large number of fruit species both native and exotic. The fundamental economic activities are nature tourism and coffee production.

Vegetal material used

Seeds obtained from mature fruits of trees located in areas of the Estación Experimental de Suelos de Barajagua, Cienfuegos province, collected during the month of May 2016, were used. These were dried naturally and stored for 4 months in closed glass jars at room temperature, so before the assembly of the experiments they were subjected to the buoyancy test to discard possible non-viable seeds.

Packaging, substrate and watering

Standard polyethylene bags were used, which were manually filled with a mixture of leached red ferrallitic soil collected in the "organoponic area" of UD-FAME, whose chemical and physical properties according to Valero, Reyes and Cairo, (2016), are shown in Annex 2, and organic material of sheep origin, obtained from a local agro-ecological farm, forming a substrate with a 3:1 ratio. The bags were placed in a rustic nursery with plastic mesh to regulate light intensity. Irrigation was done manually directly to the substrate; the intensity and frequency of irrigation was in correspondence with the stage of development of the plants, being more frequent and intense during the first 30 days (establishment stage), later the frequency was reduced maintaining the intensity (fast growing stage) and in the last 30 days was lesser both frequency and intensity (hardening stage); this irrigation regime varied depending on the behavior of rainfall.

Growth promoting substance

The growth stimulating substance used was FitoMas-E, obtained from the Empresa Agropecuaria "Ramón Ponciano" of the municipality Fomento in the province of Sancti Spíritus and the solutions were prepared at the UD-FAME facilities, as recommended in the specialized literature. The product is presented in liquid form and its chemical composition is 150 g.L-1 of organic extract, 55 g.L-1 of total Nitrogen, 60 g.L-1 of K2O and 31 g.L-1 of P2O5 (Calero *et al.,* 2019).

The selection criteria for this substance was determined by its availability in the region, by the fact that it contains macro and microelements necessary for plant nutrition and by the background information on its application to woody species such as *C. odorata* (Mendoza, 2012), *S. mahagoni* (Bango *et al.,* 2013) and *T. elatum*

(Falcón *et al.,* 2015). The doses, form and frequency of application of the product were determined based on an exhaustive bibliographic review and what was published by Montano, (2008) on the results of the application of the product in different crops, selecting for this research intermediate doses and frequencies between the minimum and maximum applied.

Experiment 1. Effect of PhytoMas-E on the germination of *Chrysophyllum cainito* L. seeds

For the experiment the following treatments were conformed on the basis of what was recommended by several authors for different species:

- Witness (untreated seeds).
- Soaking in water at room temperature for 24 hours (Sánchez and Ramírez, 2006).
- Mechanical scarification: small incision in the head on the opposite side of the radicle using pliers (Sánchez and Ramírez, 2006; Rojas and Torres, 2012).
- Scarification with concentrated sulfuric acid for 10 minutes followed by rinsing with running water (Martinez *et al.,* 2006).
- Immersion in solution of PhytoMas- E at 3 % for 3 hours.

The experiment had a completely randomized design where 10 seeds per replicate were used, (30 per treatment).

The variables evaluated were:

- Accumulated germination. (Number of seeds germinated up to 50 days) by observation and recording every five days.
- Total germination (%): Calculated through mathematical expression (Equation 1).

$$GT = \left(\frac{Nsg}{Nst}\right)100$$

Where:

Nsg was the number of seeds germinated;
Nst the total number of seeds sown.

For the count of germinated seeds, the emergence of the plant was considered.

Experiment 2. Effect of different doses of PhytoMas-E on the quality of *Chrysophyllum cainito* L. plants under nursery conditions

It was an independent experiment with respect to the germination experiment, whose purpose was to check whether a stimulant type of foliar fertilization with the bionutrient PhytoMas-E has a significant effect on the growth and morphological quality of the seedlings of the species. Therefore, seeds previously germinated from the treatment traditionally used in the area (mechanical scarification) were sown in polyethylene bags to avoid an additional effect of PhytoMas-E. A total of 30 bags per treatment were established in a completely randomized design.

The treatments were as follows:

- Witness. No application of growth promoting substances.
- Treatment 1. 1 % PhytoMas-E
- Treatment 2. 3 % PhytoMas-E
- Treatment 3. 5 % PhytoMas-E

These consisted of foliar sprays of the product (solutions) in the morning hours with weekly frequency, using a manual atomizer bottle, during 90 days counted from the emergence of the plants. The first sprays were made when the plants reached a height of 5 cm.

For the evaluation of the different variables, 15 plants of each treatment were randomly selected avoiding in all cases the edge effect. The evaluations were carried out 150 days after sowing.

- The morphological attributes evaluated were the following:
- Total height of the plant (cm): It was measured with a graduated ruler, from the base of the root collar to the apex.
- Number of leaves per plant: Determined by visual count
- Root collar diameter (RCD) (mm): Measured with a caliper at the point of attachment between the stem and the main root.
- Root volume (cm3): Determined by the water displacement method.
- Biomass of aerial and root part (g). Both parts were separated with gardening scissors and the mass was determined with a digital scale to an accuracy of hundredths of a gram. First the wet masses were recorded and then they were placed inside paper bags in an oven at 70 ºC for 72 hours (until a constant mass was obtained) and finally the dry masses of each part of the plant were determined separately.

With the previous variables, the following plant quality indexes were determined (Equation 2).

a) Relationship height/root collar diameter or Slimness Index (E): It relates the height in cm and the root collar diameter in mm of the plant and was determined by the following mathematical expression:

$$H/D = \frac{Altura\ total\ (cm)}{DCR\ (mm)}$$

b) Relationship between aerial and root part: it was calculated by dividing the values of aerial dry biomass by those of the root part. It reflects the development of the plant in the nursery, for species of normal growth.

c) Dickson Quality Index (QI): it gathers several morphological attributes into a single value that is used as a quality index; the higher the value of this index, the better the quality of the plants, and it was calculated through mathematical expression (Equation 3).

$$QI = \frac{Total\ dry\ plant\ biomassB\ (g)}{E + \frac{Air\ dry\ biomass\ (g)}{Root\ dry\ biomass\ (g)}}$$

d) Lignification Index (IL): it relates the total dry mass and the total wet mass of the plant, which determines the percentage (%) of lignification. It was calculated through mathematical expression (Equation 4).

$$IL = \left(\frac{Total\ dry\ plant\ biomass\ (g)}{Total\ wet\ plant\ biomass\ (g)}\right) 100$$

Statistical analysis

The data obtained were processed by a simple analysis of classification variance using the Statgraphics ver package. 5.0. The comparison of means and determination of homogeneous groups was carried out by means of the Duncan 95 % multiple range test.

RESULTS AND DISCUSSION

Effect of PhytoMas-E on the germination of *Ch. cainito* seeds

The treatments applied to *Ch. cainito* seeds caused different effects on the start of germination and the number of seeds germinated.

The bionutrient anticipated the start of germination by 5 days with respect to mechanical scarification, which is the treatment traditionally applied to the seeds of the species in the area, and by 15 days with respect to the control. The application of concentrated sulfuric acid significantly delayed the beginning of germination and did not favor an increase in the number of germinated seeds (Figura 1), which could be due to damage to the embryo caused by this substance. The results obtained with respect to the beginning of germination, with the application of the bionutrient, mechanical scarification and immersion in water, are within the range referred to for the species of between 15 and 25 days (Rojas and Torres, 2012) (Figure 1).

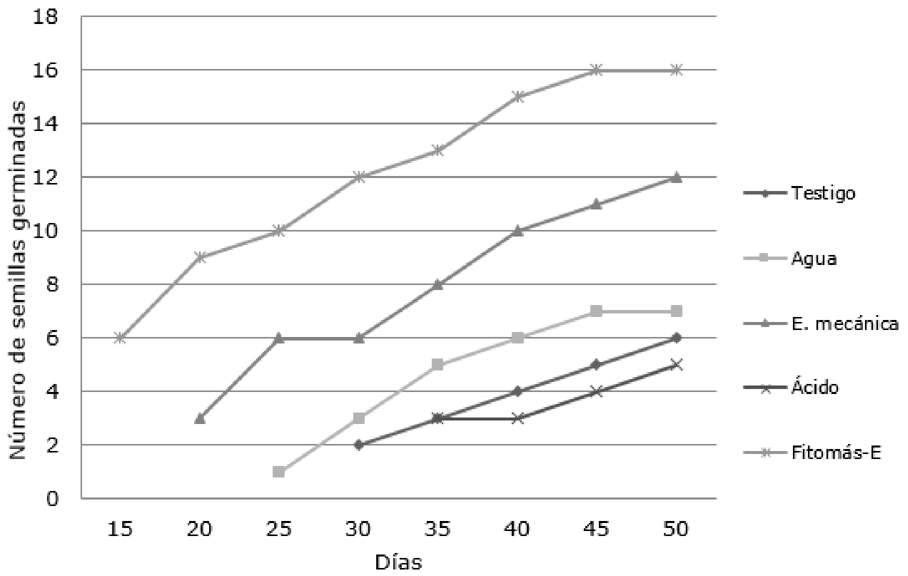

Figure 1.- Germination dynamics of *Ch. cainito* seeds under the effect of different treatments

These results corroborate that the seeds of this species present latency, which constitutes an obstacle to achieve quick germinations in the nursery; it is evident that when the seeds were not submitted to any pre-germination (control) treatment, the beginning of germination took place after 30 days and a low number of seeds managed to germinate, that is, delay and irregularity in the process was observed. According to Rojas and Torres, (2012), high percentages of germination of caimito seeds are achieved only if they are sown immediately after harvest; therefore, the behavior observed in this research could also be influenced by the time and storage conditions to which the seeds used were subjected.

On the other hand, the germinative response to the application of the bionutrient FitoMas-E suggests that the latency may be determined by the presence of inhibiting substances that are removed with the addition of growth stimulators (chemical latency), because according to Hernández *et al.,* (2009), this fruit presents a pulp composed of high concentrations of total sugars (up to 185.9 mg-g-1) and other substances. Many bionutrients are also used to improve germination when the type of dormancy is physical, since their chemical composition often causes changes in the permeability of the seed cell membrane; therefore, taking into account the results obtained and that, by applying mechanical scarification good results were obtained with respect to other treatments, one can think of the presence of these two types of dormancy in the seeds of the species.

The marked effect of the bionutrient FitoMas-E on the speed and germination capacity with respect to other treatments, is a very important result if it is considered the influence of these processes on improving the diameter of the seedlings, this being a measure of robustness, which has been considered as the best individual predictor of growth and survival in the field (Sánchez *et al.,* 2016). Similarly, it was demonstrated that this biological preparation is effective in breaking the latency of seeds of different species, in correspondence with what was referred by Serbelló, *et al.,* (2014).

Although in no case were high percentages obtained, the application of the bionutrient increased total germination up to 50 days, by more than 10 %, with respect to mechanical scarification, which was the second most effective treatment, and by more than 30 % with respect to the control (Figure 2).

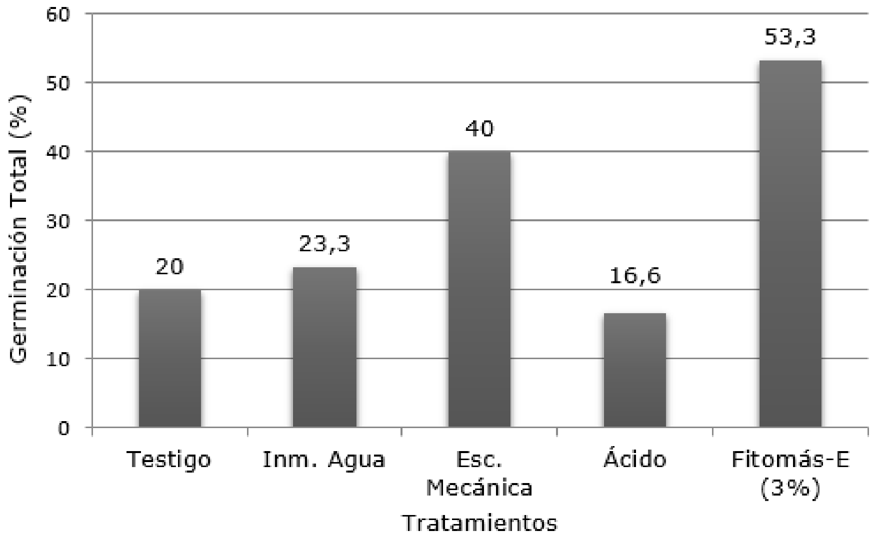

Figura 2. - Total germination behaviour of *Ch. cainito* seeds up to 50 days

The results indicate that the bionutrient composed of mineral and biochemical substances of high energy, could easily penetrate into the interior of the seeds and enhance the germination process, so it is inferred that this substance could act in two main ways: eliminating substances inhibiting germination, modifying the permeability of the hard shell that have the seeds of this species, or both.

Martínez *et al.*, (2006) refer that the response of seeds to the exogenous application of growth-stimulating substances leads to the assumption that they are permeable, although they have a hard head, which points more towards the presence of a physiological or chemical latency than a physical one, since the penetration of the substances stimulates the maturation of the embryo with the consequent increase in germination.

The negative response of *Ch. cainito* seeds to treatment with sulphuric acid suggests that both the immersion time and the concentration used were lethal to the embryo in most of the seeds. These results contrast with Muñoz *et al.*, (2009), who have stated that in many species with hard-testa seeds germination rates above 95 % are obtained by applying this type of treatment.

Álvarez *et al.*, (2004) state that *Ch. cainito* plants emerged between 25 and 28 days after sowing when the seeds were subjected to mechanical scarification and the combination of this treatment with gibberellin immersion for 24 hours. They also found between 80 and 87 % germination of the seeds subjected to these treatments; results superior to those obtained in this research.

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The Table 1 shows the results obtained when evaluating the effect of PhytoMas-E on the morphological variables of *Ch. cainito* plants. It is evident that the application of the bionutrient significantly improved most of these variables with statistical differences with respect to the control.

Table 1. - Effect of PhytoMas-E on the main morphological attributes of *Ch. cainito* plants under nursery conditions

TRATAM	HEIGHT (cm)	DCR (mm)	No. of LEAVES	VOL. Of root (cm^3)	LENGTH OF ROOT PPAL (cm)
Witness	$28{,}79^{c}$	$4{,}93^{c}$	$28{,}9^{c}$	$2{,}63^{c}$	$30{,}1^{b}$
Phytomas - E 1%	$29{,}55^{b}$	$5{,}52^{b}$	$31{,}9^{b}$	$6{,}96^{b}$	$29{,}9^{c}$
Phytomas - E 2%	$30{,}39^{a}$	$6{,}84^{a}$	$36{,}5^{a}$	$7{,}50^{a}$	$32{,}35^{a}$
Phytomas - E 3%	$28{,}61^{c}$	$5{,}14^{b}$	$32{,}6^{b}$	$6{,}62^{b}$	$31{,}3^{ab}$
Es	0,39	0,13	0,95	0,13	0,34
CV (%)	4,13	6,73	5,64	5,69	3,52

Different letters in the same column indicate significant differences according to Duncan ($p \leq 0.05$)

In all treatments, values were obtained that are within the desirable range for broadleaves according to Santiago *et al.,* (2007); the application of PhytoMas-E at 2 % is highlighted, with results significantly higher than the rest from a statistical point of view *($p \leq 0.05$).*

The RCD and root volume values obtained with the application of the bionutrient are relevant, since many authors state that these attributes are the best predictors of field survival. An adequate balance between them prevents that seedlings with large diameters and poor root systems are sent to planting conditions or vice versa, which is one of the factors that determine the success of the same. With the application of different doses of PhytoMas-E, RCDs higher than 5 mm were obtained, which indicates that these plants will show greater resistance to bending and will better tolerate damage by pests and harmful fauna when taken to the field (Muñoz *et al.,* 2014). Likewise, the best characteristics of the root system of these plants are highlighted with respect to those in which the product was not applied, which means that the treatments were very effective for the development of secondary roots, which increases the possibilities of exploring the soil to capture water and nutrients.

In general, with the intermediate dose, the best values were obtained in all the morphological attributes evaluated, suggesting that the chemical composition of the substrate used provided elements that were complemented with the foliar application of the bionutrient, reaching sufficient concentrations for the seedlings to reach an optimal nutritional status according to the stage of development in which they were at the time of evaluation. As it is known, the movement of nutrients is closely related to the demand of the plants, when the availability of these exceeds the demand, a series of processes take place, as much at ground level, as at plant level to achieve the balance and to correct this excess; this means that a control system exists that allows them to reduce or to stop the absorption of a certain nutrient when this one is in a suitable level. On the other hand, among the external factors that affect the penetration of nutrients through the leaves are the concentration of the product and the nutritional status of the plant (Fernández *et al.,* 2015), so the results obtained can find an explanation in these aspects: when the concentration of the bionutrient solution was increased and the plants were in an optimal nutritional state, the product was not completely absorbed and growth was not influenced by the increase in concentration.

A similar effect of the bionutrient FitoMas-E was observed by Mendoza, (2012) and Bango *et al.*, (2013) in the forest species cedar (*Cedrela odorata* L.) and *Antillean mahogany* (*Swietenia mahagoni* L., Jacq.) respectively, who, when combining the application of the product with the inoculation of mycorrhiza, obtained a significant improvement in the morphological attributes of the plants during the nursery stage.

Foliar applications of the bionutrient were also effective in increasing biomass production. There were significant differences between the treatments where the product was applied and from these with respect to the control (Table 2). These results corroborate the stimulating effect of the compound, especially its action at the leaf level.

Table 2. - Effect of PhytoMas-E on biomass production in *Ch. cainito* plants under nursery conditions

TRATAM	BFA(g)	BFR (g)	BSA (g)	BSR (g)	BSA/BSR
Witness	22,45^{d}	9,69^{b}	9,29^{c}	3,70^{c}	2,51^{bc}
Phytomas - E 1%	30,74^{b}	11,15^{a}	10,10^{b}	3,95^{c}	2,55^{c}
Phytomas - E 2%	29,44^{c}	9,88^{b}	9,61^{c}	4,15^{b}	2,31^{a}
Phytomas - E 3%	31,57^{a}	11,28^{a}	11,28^{a}	4,48^{a}	2,51^{bc}
Es	0,24	0,25	0,15	0,08	0,06
CV (%)	2,53	7,39	4,63	6,47	4,87

Different letters in the same column indicate significant differences according to Duncan *(p≤0.05)*
Legend: BFA= Fresh air biomass; BFR= Fresh root biomass; BSA= Dry air biomass; BSR= Dry root biomass

The higher production of aerial and root biomass obtained with the higher dose of the product was not reflected in a better balance between both parts of the plants (BSA/BSR); in this sense, the intermediate dose was more effective, indicating a more proportionate development between the absorbing and photosynthesizing parts.

Sotolongo *et al.*, (2010), have referred to the importance of this relationship being in the range of 1.5 to 2.5 so that the plants are brought to the field in better conditions of adaptability, and can overcome certain stresses when they arrive at the site, starting from the fact that in many cases the soil preparation tasks for the forest species are not the most suitable.

These results coincide with those obtained in other woody species such as *C. odorata* (Mendoza, 2012), *T. elatum* (Falcón *et al.,* 2015) and *C. arabica* (Gutiérrez and Gaskin, 2017), where the application of different doses of PhytoMas-E increased the dry matter production of plants under nursery conditions.

In the caimito, the bionutrient also showed a significant effect on morphological indices, with differences from the control, except for the lignification index (Table 3), with the intermediate dose obtaining the best results.

Table 3. - Effect of PhytoMas-E on the main morphological indices characterising the quality of *Ch. cainito* plants under nursery conditions.

TRATAM	IE	QI	IL (%)
witness	5.83^{d}	1.55^{d}	40.41^{a}
Phytomas - E 1%	5.26^{b}	1.79^{c}	33.54^{c}
Phytomas - E 2%	4.39^{a}	2.05^{a}	34.99^{c}
Phytomas - E 3%	5.59^{c}	1.94^{b}	36.77^{b}
Es	0.12	0.03	0.62
CV (%)	7.35	5.67	5.57

Different letters in the same column indicate significant differences according to Duncan (*pâ‰¤0.05*)
Legend: IE= Slimness Index; QI= Dickson Quality Index; IL= Lignification Index

The values of slenderness are closely related to the RCD; despite the fact that there were significant differences between the treatments, in all cases this index remained below 6, which is desirable for broadleaf species, which allows us to infer that the density of plants was adequate and expresses the potential of these for survival and growth in accordance with their living space.

The best value in terms of Dickson's quality index was obtained by applying the intermediate dose of PhytoMas-E (2 %), with significant differences from the statistical point of view with respect to the rest of the treatments, which corroborates the better development of these plants in general terms and, at the same time, the balance between the aerial and root fractions.

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Regarding the lignification index, the control and the higher dose of PhytoMas-E showed superiority; with these treatments the lowest height values were obtained, which coincides with the results of Villalón *et al.*, (2016), who in Quercus canby Trel. found an inverse relationship between this morphological attribute and lignification.

The application of the bionutrient PhytoMas-E was more effective in increasing total germination, and in advancing the start of this process in the seeds of *Chrysophyllum cainito L.* (caimito), compared to other methods that are traditionally used.

Foliar nutrition with a 2 % solution of PhytoMas-E was effective in raising the quality of *Ch. cainito* plants in nursery conditions up to 150 days with significant increases in most of the attributes and morphological indices evaluated.

Appendix 1. - Behavior of the main climatic variables during the study

Months	Precipitation (mm)	Humidity (%)	Medium temperature (ºC)
September/16	141.6	87	22.8
October /16	224	88	22.4
November/16	160	92	20.8
December/16	14.8	90	20.3
January/17	43.1	83	18.6
February/17	65	86	20.1
Average	**108,08**	**87,66**	**20,83**

Source: registration of the Topes de Collantes Meteorological Station.

Appendix 2. - Characterization and classification of the soil used in the investigation

	Characteristic	Value	Classification
CHEMICALS	pH (H_2O)	4,61	Very acid
	pH (KCl)	3,72	acid
	M.O. (%)	3,56	Medium
	P_2O_5 ($mg.100g^{-1}$)	6,87	Medium
	K_2O ($mg.100g^{-1}$)	8,20	Medium
	Y_1 ($cmol^{(+)}.kg^{-1}$)	4,79	Very high
	Y_2 ($cmol^{(+)}.kg^{-1}$)	0,41	Low
	Al ($cmol^{(+)}.kg^{-1}$)	0,11	Low
PHYSICAL	L.I.P (% H.b.s.s)	29,09	
	L.S.P (% H.b.s.s)	47,15	
	IP	18,06	moderately plastic
	F.E. (%)	60,35	Regular
	A.E. (%)	44,84	Satisfactory
	Perm. (log 10K)	1,97	Adequate

Source: Valero, Reyes y Cairo, (2016).

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