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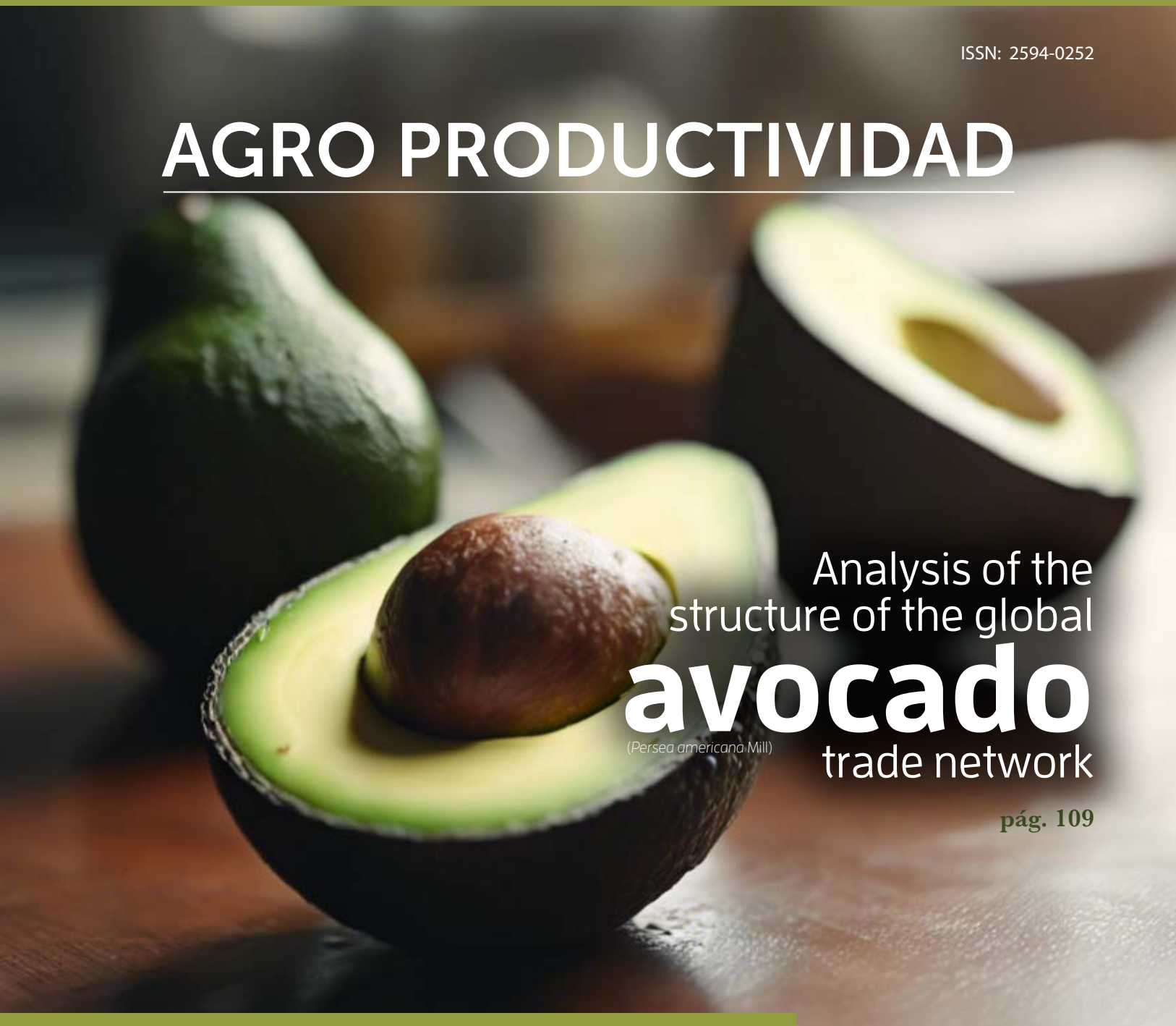

Analysis of the structure of the global avocado (*Persea americana* Mill) trade network

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Evaluation of homeopathic treatments for the control of moniliasis (*Moniliophthora roreri* Samson & Benny), in cacao (*Theobroma cacao* L.)

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ABSTRACT

Objective: To evaluate low- and high-dilution homeopathic products in the incidence of *Moniliophthora roreri* in cacao plants.

Design/Methodology/Approach: The plantation was studied using a randomized block design with three repetitions and six treatments: Homeopathic nosode 12C and 200C, Cacao homeopathic combination remedy 12C and 200C, water control, and control sample, with applications every 15 days. The studied variables were: Number of flowers, number of healthy and diseased cherelles, number of healthy and diseased pods, ripe pod weight, fresh grain weight, and leaf color.

Results: A significant difference was observed in the number of flowers with Cacao combined remedy 200C during November-December 2018. A significant difference was observed in leaf color with Cacao combined remedy 200C during October 2018-January 2019 and with Cacao combine remedy 12C in October 2018. No significant difference was found in treatments for number of healthy and diseased cherelles, number of healthy and diseased pods, ripe pod weight, and fresh grain weight.

Study limitations/Implications: The treatment application period was short. In order to obtain more convincing results, a one-year application period prior to evaluation is suggested.

Findings/Conclusions: The Cacao combined remedy 200C had a positive effect on the number of flowers during the period in which flowering decreases due to environmental conditions and on leaf greenness during four consecutive months of evaluation. Cacao homeopathic combination remedy 12C showed a significant difference for the latter variable only in October 2018. This suggests that the low-dose homeopathic medication and a high centesimal potency promotes a better response of the cacao plant to an acute disease such as moniliasis.

Keywords: Agrohomeopathy, *Moniliophthora roreri*, Tabasco.

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INTRODUCTION

The cultivation of cacao (*Theobroma cacao* L.) has cultural, social, economic, and environmental importance in Mexico. Tabasco is the leading producer nationwide with 68% and 61% of crop area and production respectively (SIAP, 2018). Mexico is the thirteenth worldwide producer with less than 1%, with yields of 0.62 to 0.46 tons/ha. This country showed a 27% decrease in planted area during 2003-2019 (CDRESSA, 2020)

due to old plantations, incidence of diseases and pests, and change in land use caused by low grain prices (Espinosa-García *et al.*, 2015). One of the main problems that impacts yield by up to 80% is moniliasis, caused by the fungus *Moniliophthora roreri* (Cif. and Par.) (Evans *et al.*; Tirado-Gallego *et al.*, 2016), which was first reported in Mexico in 2005 and mainly impacts fruits with less than a two-month development (Hernández *et al.*, 2015). Fruit ripening takes place approximately 140-205 days after pollination (Castelán, 2010; De Sousa *et al.* 2018). Moniliasis infection in fruits varies with fruit maturity: in 20- to 60-day-old cherelles, the infectious cycle lasts 40 days and fruits present malformations or humps; in 60- to 80-day-old pods the cycle lasts 55-75 days and causes premature ripening and malformations; 120- to 160-day-old pods do not present external symptoms and the seeds are not impacted (Evans, 2016). In Tabasco, this disease is controlled mainly through copper-based fungicides and cultural practices such as pruning, shade control, elimination of diseased fruits, and drainage (Arvelo *et al.*, 2017). Ortíz-García *et al.* (2015) achieved a 79% decrease in the incidence of moniliasis in cacao by using a chemical fertilizer, monocrotophos to control *Selenotrips rubrocinctus*, and fungicides azoxystrobin and copper hydroxide. However, this method entails risks of environmental pollution and health damage (Muhammetoglu *et al.*, 2010; Londoño-Franco *et al.*, 2016). Another way to deal with moniliasis has been the replacement of cacao plants from seeds (ungrafted) with resistant clones (grafts); however, this practice has impacted the biodiversity of plantations in Tabasco (Ramírez-Guillermo *et al.*, 2018). A harmless alternative in the control of pests and diseases in crops is agrohomeopathy, which consists in using homeopathic remedies in infinitesimal doses obtained by repeated dilutions. According to Da Silva *et al.* (2012), the use of homeopathic treatments in plants induces resistance to pathogenic organisms. There are few studies on the impact of agrohomeopathic medication on perennial crops. Narváez-Martínez *et al.* (2014) assessed the impact of homeopathic medication on the incidence of *Neoleucinodes elegantalis* in *Solanum quitoense* (known as "naranjilla" or "lulo" in Spanish-speaking countries), with a decrease in eggs, larvae, and damage to the plant. Pérez-Fernández *et al.* (2016) described the experience of farmers in Teocelo, Veracruz, with the use of agrohomeopathic agents to control stem rust in coffee with good results. Chávez-García and Castelán-Estrada (2019) reported that with agroecological management, which included the use of homeopathic medication for at least one year, farmers estimated a decrease of over 50% in moniliasis in 85% of the plantations studied; as well as an increase in the number of flowers, healthy pods, and leaf greenness (Chávez, 2019). In light of this, the objective of the present study was to evaluate the effects of two homeopathic preparations, in low and high dilutions, on the incidence of moniliasis in cacao plants.

MATERIALS AND METHODS

The study was carried out in an 8-year-old cacao plantation, with no history of agrochemical use, located in Miahuatlán 2a Sección, Cunduacán, Tabasco, Mexico (18° 00' 39" N, 93° 18' 23" W). We used a complete randomized block design with three repetitions and six treatments: Homeopathic nosode 12C, Homeopathic nosode 200C, Cacao homeopathic combination remedy (known as *Polifármaco Cacao* in Spanish) 12C, Cacao homeopathic combination remedy 200C, water control, and control sample.

Homeopathic nosode was prepared from 0.05 g of monilia spores, diluted first in grinded sugar and then in 50% alcohol, in 12 and 200 centecimal dilutions (C-potency). The Cacao combination remedies (potencies 12C and 200C) were prepared by the Centro Nacional de Investigación en Agrohomeopatía of the Universidad Autónoma de Chapingo, that safeguards the production formula and provided the preparations for the present study. All homeopathic products were prepared using the Hahnemannian centesimal method (Ruiz-Espinoza, 2015). To prepare the applications, a drop of homeopathic medication was added to a liter of water, which was then succussed (vertically shaken and then hit against a soft surface) for two minutes, with two minutes of rest; this dilution was placed in a new spray pump, in a 1:99 proportion in water. The whole plant was sprayed with this preparation every 15 days, from August to December 2018. The variables assessed were number of flowers, number of healthy and diseased cherelles, number of healthy and diseased pods, ripe pod weight, fresh grain weight, and cacao leaf color. The analysis of variance (ANAVA) and means test (Tukey $\alpha=0.05$) were conducted with InfoStat 2018.

RESULTS AND DISCUSSION

The variable number of flowers presented a significant positive difference with the Cacao homeopathic combination remedy 200C treatment during November-December 2018, in spite of the diminished flowering due to the beginning of the windy season and its concurrent decrease in temperature (Figure 1). According to Saénz and Cabezas (2007), cacao flowering decreases with average monthly temperatures lower than 20 °C, which occurs during the months of November-January in Tabasco. This drop in temperature and flowering marks two fruit harvest seasons as seen in Figure 2: the longest and more plentiful harvest period takes place in December-March, while the shortest and less copious one occurs during May-July (Ortiz *et al.*, 2010; SIAP, 2019). The flowering recorded in the present study corresponded to the December-March harvest (Figure 1). Higher arithmetic

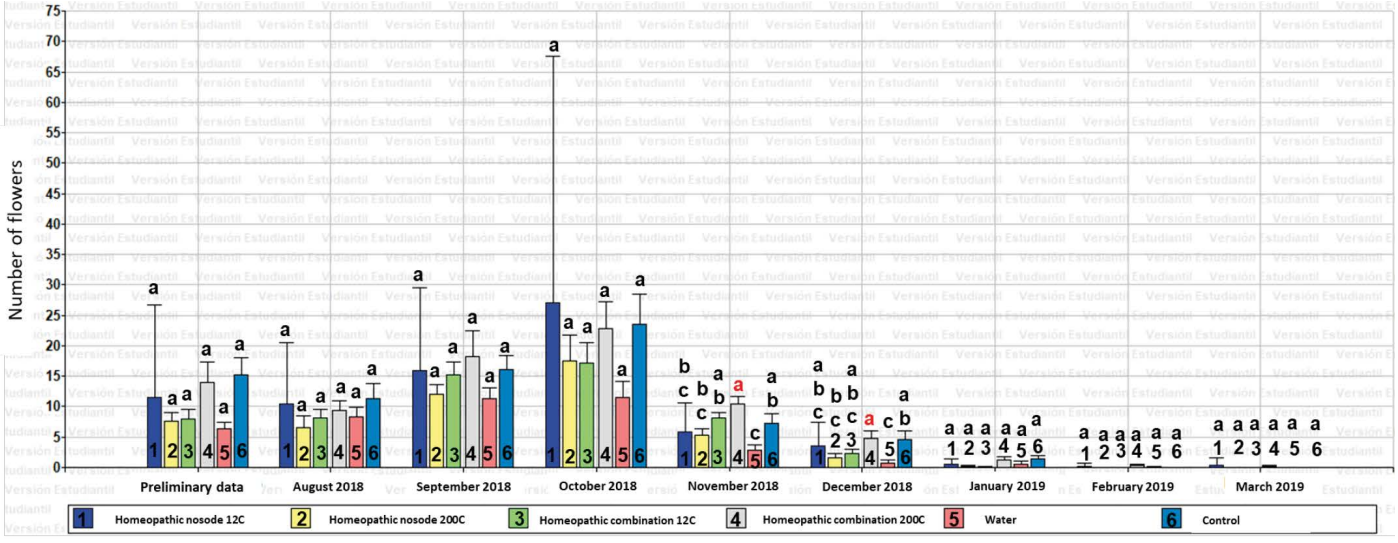

Figure 1. Variance analysis of treatments for number of flowers produced from August 2018 to March 2019 in the cacao plantation of Miahuatlán 2a Sección, Cunduacán, Tabasco. Tukey $\alpha=0.05$.

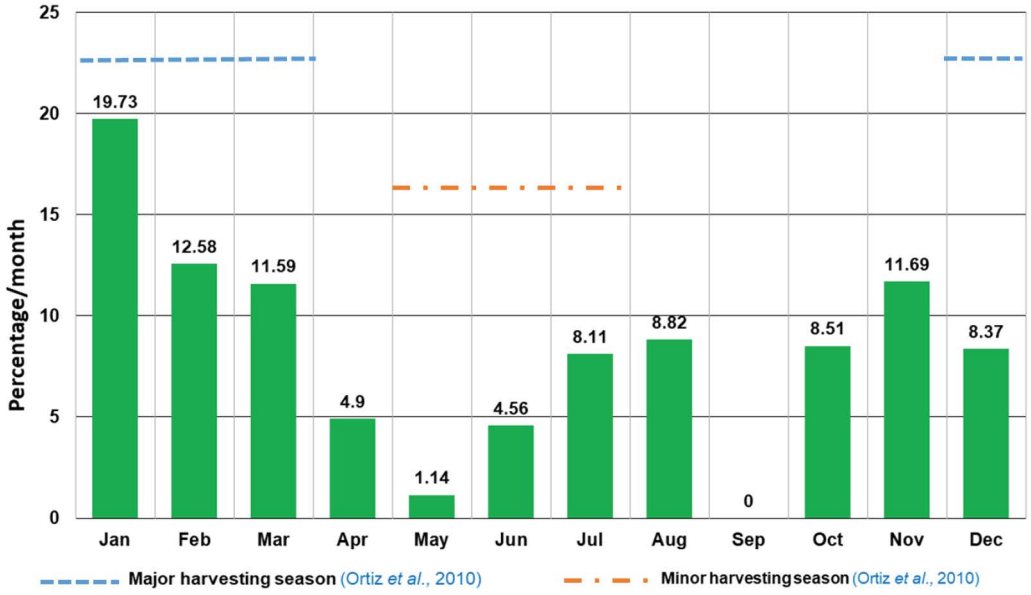

Figure 2. Monthly percentages of the annual flow of dry cacao bean production in Tabasco. Modified from SIAP (2019).

values were recorded with the Cacao homeopathic combination remedy 200C treatment during September 2018 and January 2019; similarly, higher values were observed with Homeopathic nosode 12C in October 2018 and in February 2018-March 2019. The control sample, however, also presented a higher arithmetic value in August 2018 and January 2019, which makes more statistical support necessary.

Figure 3 shows the results for the leaf color variable, with a significant difference for the Cacao homeopathic combination remedy 200C treatment during October 2018-January

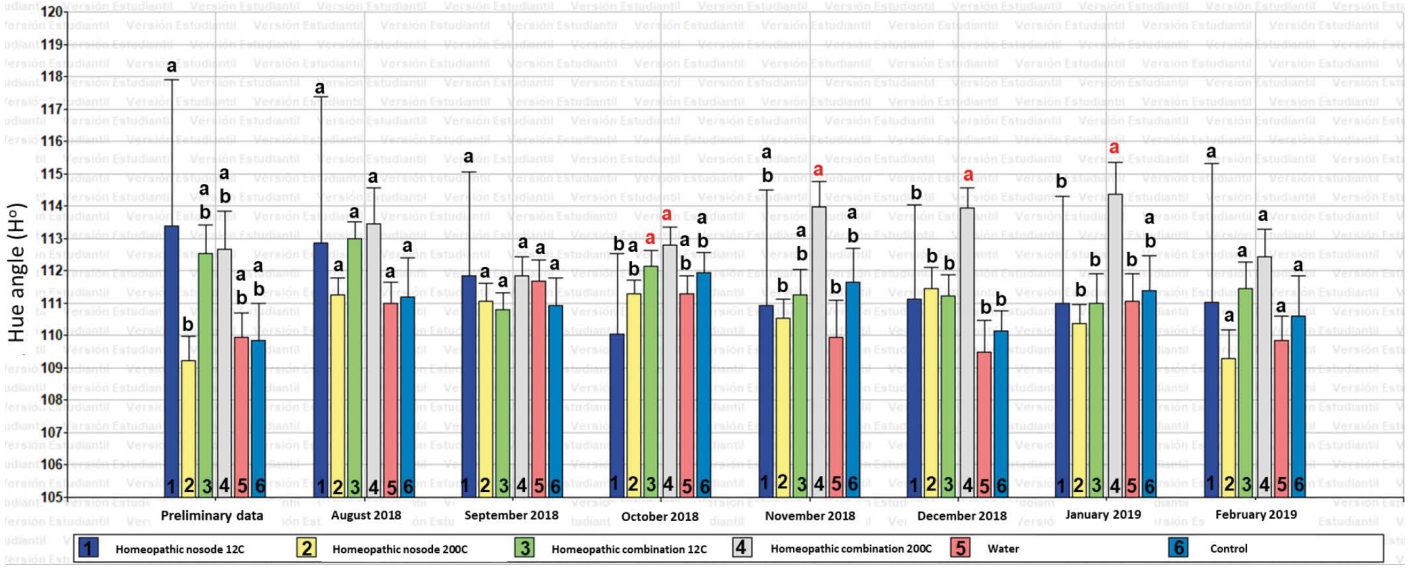

Figure 3. Variance analysis of treatments for leaf color (hue angle H°) during August 2018-February 2019 in a cocoa plantation in Miahuatlán 2a Sección, Cunduacán, Tabasco. Tukey $\alpha = 0.05$

2019. This same treatment showed higher arithmetic values during August 2018 and February 2019.

The Cacao homeopathic combination remedy 12C treatment showed a significant difference for this same variable in October 2018. As Chávez (2019) reported, the results showed that the farmers of Chontalpa, Tabasco, observed greater leaf greenness in cacao plants after applying the agrohomeopathic 200C medication in their plantations. Homeopathic preparations in low doses, with a large number of dilutions and high centesimal potencies, as in the case of the Cacao homeopathic combination remedy 200C, are recommended in situations of acute morbidity when the disease appears suddenly, with rapid evolution and resolution, as in the case of moniliasis. On the contrary, homeopathic remedies in high doses, with a low number of dilutions and low centesimal potencies, as in the case of the Cacao homeopathic combination remedy 12C, are recommended for chronic problems that impact an organism's health slowly and progressively until death (Ruiz-Espinoza, 2015; Anuja and Kshipra, 2018). Our results show that the low-dose Cacao homeopathic combination remedy 200C contributed to flowering and leaf greenness in cacao plants to a greater extent than the Cacao homeopathic combination remedy 12C, which only showed a significant difference for leaf greenness over a short period. This could suggest a better response of the cacao plant to low doses of the homeopathic preparation in the face of an acute disease such as moniliasis, that appears suddenly when favored by conditions of high humidity and temperature, and impacts the good development of fruits but without risking the life of the plant.

No significant difference was found in any of the treatments applied for the variables number of healthy and diseased cherelles, number of healthy and diseased pods, ripe pod weight, and fresh grain weight. According to Chávez-García and Castelán-Estrada (2019), the farmer estimate reporting less damage by moniliasis in cacao fruits under agroecological management with the use of the agrohomeopathic 200C medication came from plantations with at least one year under treatment. Although to date different hypothetical models have been proposed to explain the mechanism whereby homeopathic remedies work (Anuja and Kshipra, 2018), one of them suggests that they generate a self-defense reaction, like a vaccine, caused by infinitesimal doses of the pathogenic agent in the body (Da Silva *et al.*, 2012; Deboni, 2019). As a result, we consider that longer periods of application of the studied homeopathic preparations should be considered, at least one year prior to monitoring, to favor a possible autoimmune response that can be expressed more clearly and conclusively in the statistical analysis.

CONCLUSIONS

Of all the treatments applied and variables considered, the Cacao homeopathic combination remedy 200C had a higher positive impact on the number of flowers during the period in which flowering decreases due to a lower environmental temperature. It also favored a greater leaf greenness for four consecutive months in the evaluation period. The Cacao homeopathic combination remedy 12C also showed a significant difference for this same variable in October 2018 only. This could suggest a better response of the cacao plant to low doses (high centesimal potency) of the homeopathic preparation for an acute

disease such as moniliasis, which appears suddenly when favored by conditions, without putting the life of the plant at risk. We suggest considering longer application periods of the homeopathic preparations, at least one year prior to evaluation, to have more statistically conclusive results.

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