

Effects of homeopathic preparations on phenological development and control of insects and diseases of sweet pepper (*Capsicum annuum* L.)

Efeito de preparados homeopáticos no desenvolvimento fenológico e no controle de insetos e doenças do pimentão (*Capsicum annuum* L.)

Efectos de los preparados homeopáticos sobre el desarrollo fenológico y el control de insectos y enfermedades del pimiento dulce (*Capsicum annuum* L.)

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Abstract

The use of homeopathic preparations in horticultural crops allows reestablishing their homeostasis and reducing production losses caused by biotic and abiotic factors. This study aimed to assess the action of the homeopathic preparations *Sulphur* 30CH and *Calcarea carbonica* 30CH in the phenological development and control of insects and diseases that naturally affect sweet pepper. The experiment was conducted between 2018 and 2019 at the Research and Extension Center in Agroecology of the Experimental Farm Ressacada – UFSC, Florianópolis, Santa Catarina, Brazil. The experimental design consisted of randomized blocks in the field and a completely randomized design in a greenhouse and laboratory. The homeopathic preparations were chosen by the repertorization technique, based on symptoms observed in a previous crop test. The homeopathic preparation *Sulphur* enabled positive increases in the development of plants and production and diameter of fruits under field cultivation. *Calcarea carbonica* showed significant results at the height of plants grown in the greenhouse. The presence of caterpillars, ants, aphids, mites, fungi, and bacteria was found during cultivation. The homeopathic preparations showed no evident effects in reducing the populations of these pathogens in attacked plants and fruits, but they may favor the resilience of plants affected by these parasites, helping in the growth after the damage. *Calcarea carbonica* presented a trend of smaller quantities of fruits with signs of anthracnose. The application of the homeopathic preparations *Calcarea carbonica* and *Sulphur* on sweet pepper showed different effects depending on the growing environment.

Keywords: High dilutions; *Calcarea carbonica*; *Sulphur*; Agroecology.

Resumo

O uso de preparados homeopáticos em cultivos hortícolas possibilita reestabelecer a homeostasia dos vegetais e reduzir as perdas na produção causada por fatores bióticos e abióticos. O objetivo deste trabalho foi avaliar a ação dos preparados homeopáticos *Sulphur* 30CH e *Calcarea carbonica* 30CH no desenvolvimento fenológico e no controle de insetos e doenças que acometem naturalmente a cultura do pimentão. O experimento ocorreu durante os anos de 2018 e 2019 no Núcleo de Pesquisa e Extensão em Agroecologia da Fazenda Experimental da Ressacada - UFSC, em Florianópolis (Santa Catarina, Brasil). O delineamento adotado a campo foi o de Blocos ao Acaso (DBC) e, em estufa e laboratório, o Delineamento Inteiramente Casualizado (DIC). Os preparados utilizados foram escolhidos pela técnica da repertorização com base em sintomas observados em ensaio prévio da cultura. O preparado homeopático *Sulphur* possibilitou incrementos positivos no desenvolvimento das plantas e na produção e diâmetro de frutos no cultivo a campo. *Calcarea carbonica* demonstrou significativos resultados na altura das plantas cultivadas em estufa. Foi constatado a presença de lagartas, formigas, pulgões, ácaros, fungos e bactérias durante o cultivo. Os preparados homeopáticos não demonstraram efeitos evidentes na redução das populações destes patógenos nas plantas e nos frutos

atacados, entretanto podem favorecer a resiliência de plantas acometidas por estes parasitas, auxiliando no crescimento após o dano. *Calcarea carbonica* demonstrou uma tendência de menores quantidades de frutos com sinais de antracnose. A aplicação dos preparados homeopáticos de *Calcarea carbonica* e de *Sulphur* na cultura do pimentão demonstrou diferentes efeitos em função do ambiente de cultivo.

Palavras-chave: Altas diluições; *Calcarea carbonica*; *Sulphur*; Agroecologia.

Resumen

El uso de preparados homeopáticos en cultivos hortícolas permite restablecer la homeostasis vegetal y reducir las pérdidas en la producción provocadas por factores bióticos y abióticos. El objetivo de este trabajo fue evaluar la acción de los preparados homeopáticos Azufre 30CH y *Calcarea carbonica* 30CH en el desarrollo fenológico y en el control de insectos y enfermedades que afectan naturalmente el cultivo del pimiento. El experimento se llevó a cabo durante los años 2018 y 2019 en el Centro de Investigación y Extensión en Agroecología de la Finca Experimental Ressacada - UFSC, en Florianópolis (Santa Catarina, Brasil). El diseño adoptado en campo fue el Random Blocks (DBC) y, en invernadero y laboratorio, el Fully Randomized Design (DIC). Las preparaciones utilizadas se eligieron mediante la técnica de repertorización en función de los síntomas observados en una prueba de cultivo previa. El preparado homeopático *Sulphur* permitió incrementos positivos en el desarrollo de las plantas y en la producción y diámetro de frutos en el campo. *Calcarea carbonica* mostró resultados significativos a la altura de plantas cultivadas en invernadero. Durante el cultivo se encontró la presencia de orugas, hormigas, pulgones, ácaros, hongos y bacterias. Los preparados homeopáticos no mostraron efectos evidentes en la reducción de las poblaciones de estos patógenos en las plantas y frutos atacados, sin embargo pueden favorecer la resiliencia de las plantas afectadas por estos parásitos, ayudando en el crecimiento posterior al daño. *Calcarea carbonica* mostró una tendencia a menores cantidades de frutos con signos de antracnosis. La aplicación de preparados homeopáticos de *Calcarea carbonica* y *Sulphur* en el cultivo de pimiento mostró efectos diferentes según el entorno de cultivo.

Palabras clave: Altas diluciones; *Calcarea carbonica*; *Sulphur*; Agroecología.

1. Introduction

Sweet pepper (*Capsicum annuum* L., Solanaceae) is a vegetable that has significant importance in the diet of the Brazilian population, whether fresh or as a condiment. It is a crop of relevant social and commercial impact to producers in the state of Santa Catarina, Brazil, mainly for coastal farmers (CEASA, 2019). Characteristics such as soil, temperature, and precipitation are factors that support the production of this vegetable in the fields of the state, but insects and diseases are still obstacles to production.

Disease control is based mainly on the use of agrochemicals, which have been causing resistance of pathogens because of the extended use of the same chemical compounds (Hawkins et al., 2019). This production scenario tends to generate numerous direct aggravating factors for the environment, which absorbs a large part of crop residues, as well as indirect aggravating factors for the health of farmers, who handle these chemicals, and consumers, who purchase the food (Lopes and Albuquerque, 2018).

Approximately 70% of the agricultural establishments in Santa Catarina use some synthetic chemical product in the crops (IBGE, 2017), which represents a high risk for the state's agriculture since a significant portion of the produced food is grown by small and medium-sized family farmers who allocate the production to agroindustries or directly to consumers. The farmers use a labor-intensive production system in which the economic and environmental scheme of farmers often does not match the reality of purchasing pesticides due to their high costs and the used cultivation method (polyculture), representing risks of cross-contamination between crops, justified by their proximity and diversity. In this context, family farmers, especially those who practice or wish to practice agriculture closer to the functioning of natural systems, are a possible group for the application and diffusion of plant homeopathy. Its low cost and non-existent risk compared to synthesized chemical agents qualify it as a tool with a positive social impact and non-toxic to the environment and health of the population (Pustiglione et al., 2017).

Originally studied for the cure of human diseases (Hahnemann, 2001), the admission of homeopathic preparations in plants was proposed in experiments carried out by Junker in 1928 (Ilana, 2017) and, over time, their use has gained significant followers in agriculture. Since the regulation for the control of pests and plant diseases in organic crops, provided by

Normative Instruction No. 7, of May 17, 1999, and more recently by Normative Instruction No. 46, of October 6, 2011, and Normative Instruction No. 17, of June 18, 2014 (Brasil, 2014), the use of homeopathy was legally effective for organic and agroecological farmers.

Homeopathy stimulates the vital force of plants through the balance triggered by the environment, working to reduce diseases and undesirable insects through a systemic approach and with no side effects (Baumgartner et al., 2000). The application of homeopathic preparations on plants validates the benefits of this technique in stimulating growth and behavior of plants in producing secondary defense compounds, the quantity and shape of fruits, the abundance of leaves, and the ability to control or reduce the incidence of most known insects and diseases (Ileana et al., 2017).

In this context, the reduction of insect populations and pathogens in crops with the application of homeopathic preparations has favored the restoration of the dynamic balance of existing natural services, helping the natural biological control (Casali, 2004). Tomás et al. (2016) tested the pepper weevil (*Anthonomus eugenii*) biotherapeutic under two different preparation methods and found that the homeopathic preparations did not decrease the pepper weevil populations but protected the plants against insect attacks. The study developed by Toledo et al. (2015) to control early blight in tomatoes showed that the homeopathic preparations *Propolis*, *Sulphur*, and *Ferrum sulphuricum* were effective in controlling the disease, acting positively on plant growth. Bertalot et al. (2012) obtained positive results in the control of leaf spot caused by *Mycosphaerella fragariae* in strawberry using the homeopathic preparation *Equisetum hyemale*, with effects similar to the Bordeaux mixture in controlling the disease and reducing the number of leaf spots. The reduction in the incidence of fruit fly larvae in peach fruits was possible using the homeopathic preparation of *Staphysagria* and the fruit fly nosode at 6CH (Rupp et al., 2012). Bonato et al. (2003) found that the use of *Sulphur* at certain potencies allowed increasing leaf length and height of radish plants.

Thus, this study aimed to assess the effects of the homeopathic preparations *Sulphur* 30CH and *Calcarea carbonica* 30CH on the phenological development and control of insects and diseases that naturally affect the sweet pepper crop.

2. Materials and Methods

2.1 Experimental site

The experiment was conducted between 2018 and 2019 at the Research and Extension Center in Agroecology of the Experimental Farm Ressacada of the Federal University of Santa Catarina, located in Florianópolis, Santa Catarina, Brazil, (27°10' and 27°50' of latitude and altitude at sea level). The history of the area includes its use for the annual cultivation of agroecological vegetables, sheep production in the Voisin Rational Grazing system, and areas with natural regeneration of native forest since 2014. The soil of the experimental area is classified as Typic Hydromorphic Quartzarenic Neosol (CQFS-RS/SC, 2004).

2.2 Plant materials

Sweet pepper seeds from the cultivar Casca Dura Ikeda were purchased from the company Feltrin® RS/BR. Planting was carried out in the field and greenhouse in February 2019. One seed was sown per cell in 126-cell Styrofoam trays filled with an organic substrate (composting). Seedlings remained in the greenhouse for thirty days until transplanting to the field and greenhouse.

The fruits used in the postharvest experiment were obtained from field cultivation plants (Experimental Area 1), after its completion, starting in June 2019.

2.3 Homeopathic preparations

Homeopathic preparations were chosen based on the anamnesis process of plants and the cultivation environment in a

previous test carried out in 2018. The selection of symptoms occurred by the mechanical method without hierarchization and a director symptom through digital repertorization. The symptoms found during the crop anamnesis were transcribed with the maximum possible similarity to human symptoms already described in the Homeopathic Materia Medica (Lathoud, 2002). The symptoms selected during the anamnesis were mental confusion, alteration or confusion of body identity, dissatisfaction with the environment, general precocity, subinvolution, developmental delay, increased appetite (general hunger), insect bites, bites, and humidity worsens in general.

Repertorization was performed using the software Homeopro[®] and consultation with the Repertório de Homeopatia (Ribeiro Filho, 2014). The preparations consisted of *Sulphur*, which covered the highest number of symptoms, and *Calcarea carbonica*, which presented the highest score in repertorization. Homeopathic preparations were produced according to the Brazilian Homeopathic Pharmacopoeia (2011) at the Milligram Compounding Pharmacy in Florianópolis, Santa Catarina, Brazil. The 30CH potency was chosen based on the scale of symptom pathologies, in which the symptoms were classified between acute and chronic.

The applications of homeopathic preparations occurred every seven days until the time of plant harvest, totaling 11 applications for cultivation in the field and 7 applications for greenhouse plants, always in the morning. Twenty drops of each homeopathic preparation were dynamized in 200 mL of water and used for each treatment of the experiments carried out in the field and greenhouse. The mixture was stirred and sprayed on the plants (Rezende, 2009). The concentration of the homeopathic preparations and water were gradually adjusted according to the crop development until a final proportion of 100 drops dynamized in 1 L of water. Individual pre-compression trigger sprayers with a capacity of 1.6 L were used for each treatment.

Homeopathic solutions used in the postharvest experiment consisted of 100 drops of each homeopathic preparation diluted in 5 L of water, placed in a 10-L capacity circular container, and stirred for one minute before fruit immersion. Moreover, 20 mL of hypochlorite (2.5% active chlorine) was used for fruits of the immersed control group. These fruits remained immersed only once for five minutes. Subsequently, they were removed, dried with paper towels, and placed on a bench in the laboratory. The fruits remained at room temperature of approximately 20 °C for four weeks.

2.4 Field experiment

The randomized block design was adopted in the field planting (Experimental Area 1), consisting of four blocks and 12 replications (plants) per block and three treatments: *Calcarea carbonica* 30CH, *Sulphur* 30CH, and control (water). The adopted spacing was 80 cm between rows and 40 cm between plants. A 1-m spacing was adopted between each treatment to avoid possible contaminations. Fertilizers and limestone were not applied to the beds. Irrigation was controlled as a function of the daily temperature, precipitation, and humidity.

2.5 Greenhouse experiment

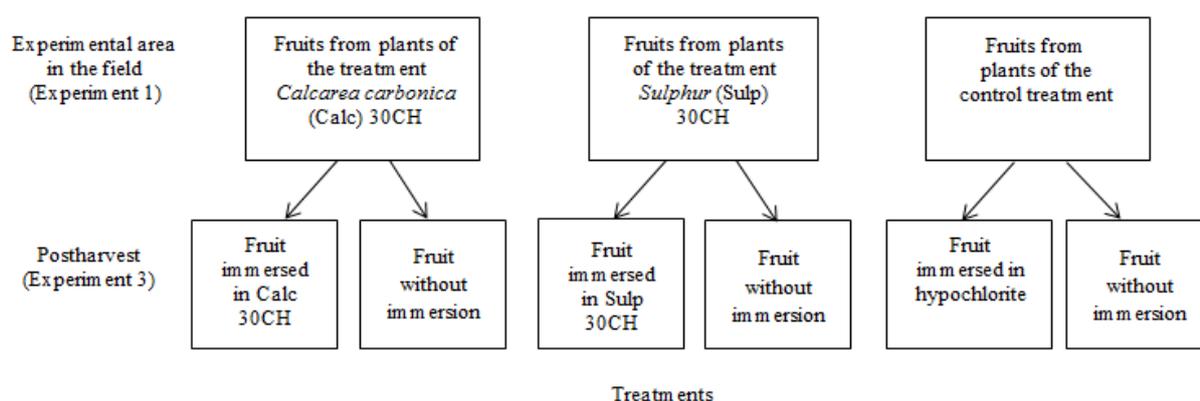
Planting (Experimental Area 2) was carried out in a greenhouse covered using a 125-micron transparent anti-UV plastic screen at the top and an 80% shade Sombrite[®] screen at the sides. One plant was cultivated per plastic pot with a 14-L capacity spaced from each other at a radius of 50 cm. Organic substrate (composting) and organic fertilizer (poultry litter) were used at a 3:1 ratio, respectively. The experiment was conducted in a completely randomized design, with three replications, three plants per replication, and three treatments: *Calcarea carbonica* 30CH, *Sulphur* 30CH, and control (water).

2.6 Postharvest experiment

After harvest and assessment in Experimental Area 1, the fruits used in the postharvest were separated and used as

follows: fruits from plants that received the preparation *Calcareo carbonica* in the experimental phase in the field were used for the postharvest treatment with *Calcareo carbonica* and so on for the other treatments, as shown in Figure 1. The tested treatments consisted of fruits immersed in a solution with the preparation *Calcareo carbonica* 30CH, fruits immersed in a solution with the preparation *Sulphur* 30CH, control fruits immersed in hypochlorite solution, and fruits from control, *Calcareo carbonica*, and *Sulphur* groups without immersion. The experimental design was completely randomized, with six treatments and four replications per treatment, with ten fruits per replication.

Figure 1. Obtaining fruits and experimental treatments in the postharvest.



Source: Authors.

2.7 Insects and diseases

The number of plants naturally affected by insects and diseases (*Colletotrichum* sp. and *Pectobacterium* sp.), the severity of damages (diameter of lesions), and the recovery response of plants after attack by parasites (length after injury) were assessed in the field and greenhouse cultivations. The percentage of attacked plants was estimated by subtracting the number of plants affected by diseases from the number of healthy plants. The defoliation level caused by defoliating insects was estimated according to the visual sampling of EMBRAPA, with adaptations (Quintela, 2001).

The number of fruits affected by *Pectobacterium* sp. and *Colletotrichum* sp. and the degree of severity of lesions (diameter) in fruits with anthracnose were assessed in the postharvest experiment. The size of the lesion was measured with a digital caliper (mm) to assess the degree of severity of anthracnose lesions. Fruits affected by soft rot were discarded from the experiment after assessment. All these assessments were carried out every three days for four weeks.

2.8 Phenological development

The shoot height (SH) and weekly plant mortality (Mort) for field and greenhouse cultivations during the stages of leaf development, floral organ appearance, and flowering and fruit appearance were assessed. Moreover, plant weight (PW), root length (RL), root weight (RW), number of plants at flowering (NPF), number of plants at fruiting (NPF), number of fruits per plant (NFP), number of immature fruits per plant (NIFP), fruit length (FL), fruit diameter (FD), fruit weight (FW), and total fruit weight (TFW) were assessed during the phenological stages of fruit development and harvest in the field experiment. The shoot height and root length were measured using a measuring tape in centimeters, while fruit length and fruit diameter were measured using a digital caliper, with values expressed in millimeters. A precision digital scale with values in grams was used in the measurement of the variable weight. The percentage of plant mortality was determined by the ratio between the number of dead plants and viable plants in each plot for a period of 50 days. The number of plants at the flowering and fruiting stage

were counted weekly. Plants that did not reach the phenological stage of fruit production were not assessed at the end of the experiment.

2.9 Statistical assessment

A unidirectional analysis of variance was performed for the parametric quantitative parameters (SH, FW, FL, FD, and TFW) by comparing the means by the Tukey HSD test when F was significant ($p < 0.05$). Kruskal-Wallis test ($p < 0.05$) was employed for non-parametric variables (SH, PW, RW, RL, NIFP, and NFP by harvesting stage) ($p < 0.05$). The analyses were performed using the package *agricolae* of the software R Core Team v. 3.4.6. (2019).

3. Results and Discussion

3.1 Crop phenological development

Plant growth in the field was higher for the phenological stages of leaf development in weeks I ($p = 0.0127$) and II ($p = 0.0001$) for *Sulphur* and week III ($p = 0.0012$) for *Sulphur* and *Calcarea carbonica*. Plants that received the preparation *Sulphur* during the flowering phase (week VII) had the highest height ($p = 0.0596$) than plants in the control group (Table 1). Plants that received *Calcarea carbonica* from fruit development until harvest (weeks VIII to XI) showed a trend ($p > 0.10$) of a continuous increase in the growth relative to the other treatments.

Plants that received *Sulphur* applications had significant values of fruit production per plant (week XII), with higher fruit weight ($p = 0.0030$) and diameter ($p = 0.0166$) than the control group. The homeopathic preparation *Calcarea carbonica* showed no differences between treatments ($p > 0.05$). The total fruit production (kg/ha) was higher in the treatment with *Sulphur*, followed by the control group and *Calcarea carbonica* (Table 1).

Shoot length in plants of the treatment *Calcarea carbonica* in the controlled environment (greenhouse) was significantly different ($p < 0.05$) from the control group and equal to the group that received *Sulphur* at all phenological stages (Table 2).

Table 1. Effect of the homeopathic preparations *Calcarea carbonica* 30CH and *Sulphur* 30CH on the development of sweet pepper plants in the field during their phenological stages.

Phenological stage	Week	Variable	Treatment			CV%
			<i>Calcarea carbonica</i>	Control	<i>Sulphur</i>	
Leaf development	I	SH (cm)	8.46 ^b	8.27 ^b	9.52 ^a	24.18
		Mort (%)	4	10	4	–
	II	SH (cm)	10.68 ^b	9.83 ^b	12.57 ^a	26.69
		Mort (%)	4	4	14	–
	III	SH (cm)	14.62 ^a	12.41 ^b	15.73 ^a	29.69
		Mort (%)	10	2	8	–
	IV	SH (cm)	20.51 ^a	20.00 ^a	17.78 ^a	36.18
		Mort. (%)	2	2	6	–
Floral organ appearance	V	SH (cm)	27.15 ^a	24.89 ^a	27.27 ^a	38.30
		Mort (%)	8	8	4	–
Flowering	VI	SH (cm)	29.09 ^a	27.63 ^a	30.16 ^a	39.00
		Mort (%)	0	4	0	–
Fruit appearance	VII	NPf	12	17	26	–
		SH (cm)	41.28 ^{ab}	38.04 ^b	44.27 ^a	27.64
		Mort (%)	2	0	0	–
	VIII	NPf	13	11	6	–
		SH (cm)	49.77 ^a	47.04 ^a	51.89 ^a	29.65
		NPF	4	0	15	–
Fruit development	IX	SH (cm)	58.94 ^a	55.29 ^a	59.45 ^a	28.13
	X	SH (cm)	65.52 ^a	61.68 ^a	63.97 ^a	26.84
	XI	SH (cm)	72.03 ^a	67.05 ^a	65.95 ^a	24.70
	Harvest	XII	SH (cm)*	92.21	83.63	86.30
PW (gr)*			281.4	196.0	245.1	66.6
RW (gr)*			13.21	11.15	10.82	51.4
RL (cm)*			21.25	21.81	20.84	34.4
NIFP*			5.84	3.76	5.41	84.2
NFP*			4.85	4.54	5.64	71.9
FW (gr)			47.2 ^{ab}	43.6 ^b	50.0 ^a	36.8
FL (cm)			7.77 ^a	7.79 ^a	7.65 ^a	15.2
FD (dm)			4.83 ^{ab}	4.67 ^b	5.21 ^a	36.0
TFW (kg/ha)			8731 ^c	10000 ^b	12175 ^a	28.2

*No statistical difference using the Kruskal-Wallis test ($p < 0.05$). Means followed by the same letter do not differ statistically from each other by the Tukey test ($p < 0.05$).

Source: Authors.

Table 2. Effect of the homeopathic preparations *Calcarea carbonica* 30CH and *Sulphur* 30CH on the shoot length (cm) of sweet pepper plants in the greenhouse during their phenological stages.

Phenological stage	Week	Treatment			CV %
		<i>Calcarea carbonica</i>	Control	<i>Sulphur</i>	
		SH (cm)			
Leaf development	I	11.0 ^a	7.44 ^b	9.83 ^{ab}	19.87
	II	19.7 ^a	13.5 ^b	17.0 ^{ab}	17.81
	III	29.5 ^a	20.3 ^b	24.8 ^{ab}	20.16
	IV	37.8 ^a	28.9 ^b	30.8 ^{ab}	21.4
Floral organ appearance	V	49.6 ^a	38.4 ^b	42.6 ^{ab}	19.9
Flowering	VI	59.2 ^a	44.2 ^b	50.6 ^{ab}	21.7
Fruit appearance	VII	67.1 ^a	46.8 ^b	55.3 ^{ab}	24.7
	VIII	70.3 ^a	48.0 ^b	57.0 ^{ab}	26.7

Means followed by the same letter do not differ statistically from each other by the Tukey test ($p < 0.05$).
Source: Authors.

The results observed in plants grown in the field are due to changes in their internal conditions and the environment, and the effect of the homeopathic preparation comes into action in response to their structural reorganization. This effect can be distinguished on the behavior of *Sulphur* in plants after the high mortality observed in the second week, when this preparation allowed a progressive decrease in seedling mortality. This preparation has a wide range of symptoms and covers the largest number of diseases described in the Homeopathic Materia Medica (Lathoud, 2002). Therefore, various mechanisms of action of this homeopathy may act positively in the self-regulation and homeostasis of these plants with the growing environment. Likely, the symptoms of loss of identity, lack of naturalness, and attack by insects showed a prognosis of recovery with the use of this preparation. The disturbance triggered in the second week was the effect of this preparation to act on the plants by stimulating their adaptation to the environment.

The positive effects of homeopathic preparations on SH of plants grown in the field and greenhouse at certain phenological stages suggest improvements in the lack of nutrients compared to the control group, enabling a stable development for these plants. A pilot study by Lensi et al. (2010) showed the superiority of growth in bean plants that received *Natrum muriaticum* compared to the control group, indicating the potential use of homeopathy in plants.

Sweet pepper plants require fertile and well-drained soils, and any disturbance can compromise their phenological development. Casali et al. (2009) found that one of the functional signs described for *Sulphur* is the metabolism with disturbed assimilation and intense appetite, showing improvement in a dry and hot environment. These authors also reported that soils under fertility limitations for plant growth were stimulated by the action of this preparation, which, in many cases, contributed to increasing crop productivity with its application.

Plants grown in the field that received the preparation *Sulphur* showed early flowering, fruiting, and fruit maturation although not statistically evidenced. Factors such as temperature, humidity, and soil fertility influence the physiological development of the plant and are related to early induction in reproduction. Similar characteristics were observed at reperforization. Thus, no changes were observed relative to early reproduction, indicating the non-similarity between this symptom and the selected preparation.

The higher fruit production evidenced in plants that received *Sulphur* may be related to the lower expenditure of energy for growth after the flowering stage, in which the vegetative meristematic differentiation was reduced and the floral differentiation was accentuated (week XII). This preparation helped in the process of stabilizing the vegetative growth rate of

plants during this stage, directing their metabolism to fruit production. Reis et al. (2013) studied tomato (Solanaceae) and observed a lower leaf area index after the beginning of flowering and fruit production, and an increase in the mean weekly productivity. All preparations positively favored some stage of sweet pepper development, but the prolonged use of *Calcareo carbonica* after the flowering stage should be avoided, as plants treated with this preparation directed their metabolism for vegetative growth and not for full fruit production.

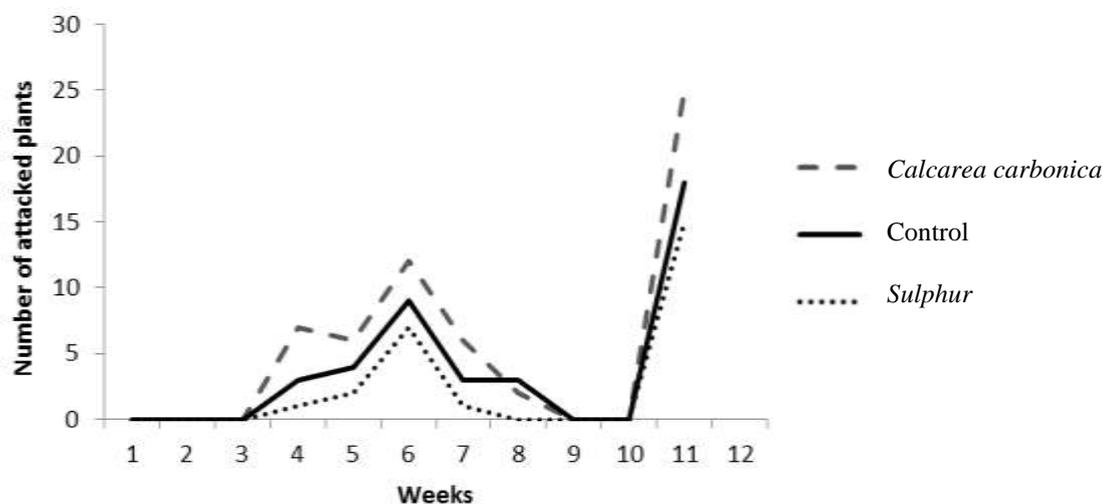
Plants grown in the field are subject to a more intense action of the environment compared to the greenhouse cultivation, being predisposed to different changes in their vital energy. Therefore, the response of homeopathic preparations in plants also tends to be different. The preparation *Sulphur* showed higher similarity with plants grown in the field, which is an environment considered heterogeneous due to the most varied environmental predispositions to which these plants are subject, reflecting the characteristics of this preparation, especially symptoms related to intolerance to a humid climate and excessive heat, which predispose the formation of cankers and rot in fruits (human symptom related to problems of external nature and eruptions) and the need for high soil fertility (marked food desire) (Lathoud, 2002). The highest similarity of plants treated with *Calcareo carbonica* was observed in the greenhouse cultivation, an environment in which environmental conditions are homogeneous, showing characteristics of the preparation, such as a more active evolution in early life stages, and stimulating nutrition and improvements in dry weather (Lathoud, 2002).

3.2 Incidence of insects and diseases and recovery response of sweet pepper plants

Plant mortality during the crop development in the field due to insect attack (*Agrotis ipsilon*, Lepidoptera and *Atta* sp., Formicidae) and environmental causes (rain, wind, and humidity), showed similar behavior between treatments (Table 1). The total mortality rate reached by plants that received *Sulphur* was 36%, followed by *Calcareo carbonica* (32%) and control (30%) during the observed weeks. The treatment *Sulphur* presented high plant mortality in the second week, followed by a trend of gradual decrease and stabilization in losses. Oscillations between weeks were observed for the other treatments. Plants assessed in the greenhouse showed no mortality during this period.

Defoliation caused by ants (*Atta* sp., Formicidae) was evidenced with higher intensity during the third week after seedling transplanting until the beginning of fruit harvest in the field experiment. Periods without attacks and periods with severe attacks were observed after the first defoliation, as observed in the flowering stage, following some plants until the harvest stage (Figure 1). The homeopathic preparations tested in this study showed no reduction in the attack of ants or their preference for plants of a certain group, presenting, on average, a similar number of attacked plants between treatments during the total cycle.

Figure 1. Number of plants attacked by ants (*Atta* sp.) during the phenological stages of sweet pepper in the field under the application of the homeopathic preparations *Calcarea carbonica* and *Sulphur* at potency 30CH.



Source: Authors.

Ants cut the leaves and take them to their nests to feed and grow a fungus (Order: Agaricales), feeding on substances released by it. However, when ants accidentally bring toxic leaves or with some component that is rejected by the fungus, a chemical substance is secreted by it to warn the ants not to collect the plant anymore (Hebling et al., 1985). Control studies using *Belladonna* at potency 30CH applied directly to these insects have shown a reduction in the foraging activity of *A. laticeps* anthills and a prolonged effect at 20 days after the first application (Giesel et al., 2017). In our study, the interference of the preparations on the action of insects would be indirectly related to the feeding activity of the fungus grown in anthills or the later generations of ants.

According to Casali (2004), plants attacked by insects respond to the stimulus of homeopathic preparations in the production of secondary substances such as glucosinolate, tannins, and essential oils, which assists in the defense process against attacks. The recovery response of predated plants over the weeks showed no differences between treatments regarding the final plant height at harvest.

The development of plants grown in the greenhouse during the third week, at 21 days after transplanting (DAT), showed defoliation caused by black cutworm (*Agrotis* sp.) in some plants. The mean defoliation caused by this insect remained below the economic injury level (30%) in all treatments (Figure 2). However, some plants in the control and *Calcarea carbonica* group showed maximum defoliation levels between 50 and 80%, while the *Sulphur* treatment reached only 10%. The mean number of leaves attacked by the caterpillar was low and no significant difference was found between treatments. However, some plants in the control and *Calcarea carbonica* group showed more severe damage in all leaves of plants with the presence of this insect. In addition, a positive recovery response was observed in plants subjected to *Calcarea carbonica* even with severe attacks in some plants. Plants treated with this homeopathy after the caterpillar attack had a length of 55 cm at 35 DAT, similar to the *Sulphur* treatment (52 cm), which showed the lowest defoliation rates. The treatment *Sulphur* had the lowest incidence of damage due to the presence of the caterpillar. Therefore, no evident recovery response was observed, which suggests that this homeopathy possibly demonstrated a repelling power over the insect at the time of leaf herbivory. According to De Barros et al. (2019), the homeopathic preparation *Sulphur* 12CH has an inhibitory effect on the development of the third stage of screw-worm (*Cochliomyia hominivorax*) larvae under laboratory conditions.

The occurrence of aphids in the field experiment was observed only in some plants of the *Sulphur* treatment, with few

insects per plant, not compromising the crop development. The low incidence of this insect in the field may be related to the balance generated in the agroecological cultivation system. Insects present in the field are subject to varying conditions, and it is likely that high temperatures and humidity, in addition to the application of homeopathic preparations, provide insect control. The occurrence of ladybugs, natural aphid predators, may also have contributed to the management and balance of the target insect.

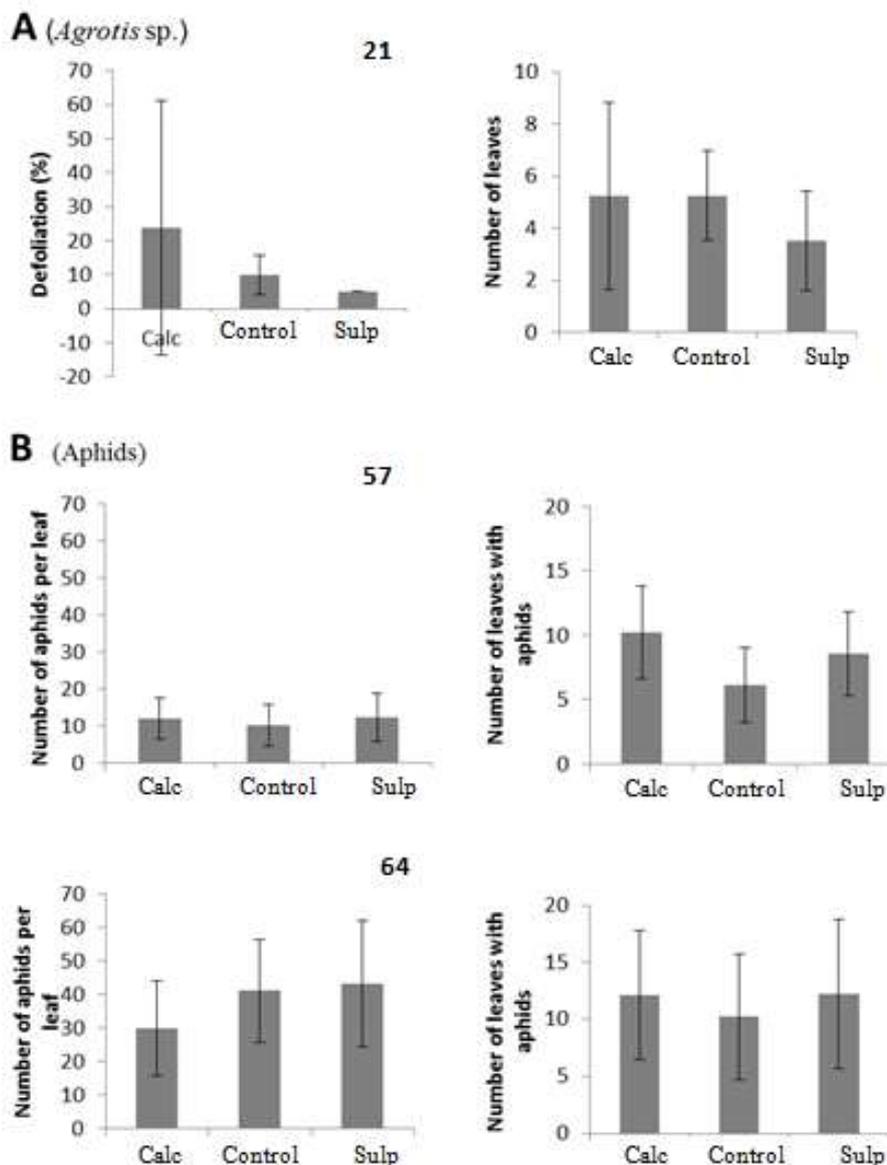
However, the appearance of these insects in plants grown in the greenhouse was noticed after the incidence of white mites (49 DAT). At this stage, the plants were in a very weak state due to the severity of the mite attack. The spread of aphids was extremely fast, affecting all plants within a week. The low humidity and the internal temperature of the greenhouse around 25–30 °C contributed to the proliferation of the insect.

Treatments showed no statistical difference for the number of leaves with aphids at 57 and 64 DAT ($p > 0.05$). An increase was observed in the mean number of aphids per leaf between 57 and 64 DAT in all treatments ($p < 0.05$) (Figure 2). Homeopathies showed no reduction in the number of insects per leaf on plants. Proença et al. (2018) used *Calcarea phosphorica* at potency 30CH and observed that the homeopathy contributed to lower mean amounts of aphids in arugula plants even without differences between treatments.

Some plants showed dryness and apical leaf fall after the sixth week of cultivation in the greenhouse. An investigation showed the white mite (*Polyphagotarsonemus latus*) attack. These arachnids are preferably located in the apical portion of plants. The damages make the leaves leathery, with the edges curved downwards and leaflet rolling, followed by a stop in the growth of terminal buds and a tan color (Pereira et al., 2007). These changes were noticeable in all plants, especially those that received treatments with *Sulphur* and *Calcarea carbonica*, which were at the flowering and fruiting stage, being very affected by the mite attack. Plant flowering was inhibited, and the fruits showed deformations. However, attacked plants started to develop lateral buds and emit new leaves, which was not observed in the Control group.

Both studied treatments did not affect the reduction and control of mites. However, the homeopathic preparations may have stimulated sweet pepper plants to recover their vital force and continue the development. Plants that emitted new sprouts were again attacked by mites, resulting in the depletion of their energy reserves and subsequent growth stoppage, leading to the loss of vital energy and permanent illness.

Figure 2. Effect of the homeopathic preparations *Calcarea carbonica* (Calc) and *Sulphur* (Sulp) at potency 30CH on A) the defoliation and number of leaves attacked by black cutworm (*Agrotis* sp.) and B) the mean number of aphids per leaf and mean number of leaves per plant with aphid colonies at different DAT in sweet pepper plants grown in the greenhouse.



No statistical difference by the Kruskal-Wallis test ($p > 0.05$).
 Source: Authors.

An organism becomes ill only because its vital force is affected by the dynamic influence of an external or internal agent, hostile to its normal cycle, thus leading it to irregular functions, called disease (Hahnemann, 2001). Any agent hostile to life that acts in the organism disturbs the vital force, as it is also present in the organism (Eisayaga, 1992). It means that, at first, the plants attacked by mites tried to reestablish their homeostasis, which in fact occurred, but the vital force of the plant was again disturbed after the second attack, leading it to a chronic illness unable to cure.

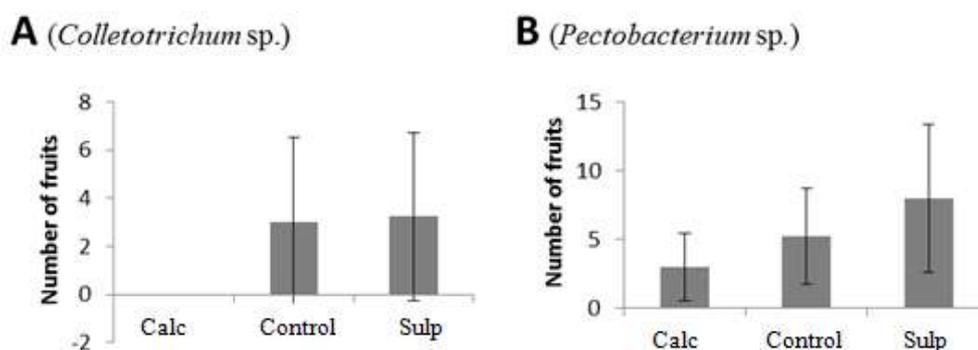
The appearance of white mites, aphids, black cutworm, and leaf-cutting ants, especially at the flowering and fruiting stages of the crop, may be mainly related to the nutritional levels of plants during this period. Plants are hypersensitive to parasitic attack under excess proteolysis, that is, excessive protein breakdown. On the other hand, plants have better immunity when there is a dominant proteosynthesis. A higher trend for proteolysis dominance is observed at flowering and fruit

production, which provides greater vulnerability to parasites in attacking plants (Chaboussou, 2006).

The presence of the fungus *Colletotrichum* sp. and the bacterium *Pectobacterium* sp., causal agents of anthracnose and soft rot, respectively, were observed from the beginning of physiological maturation until fruit harvest in the field for some treatments. In this period, a higher incidence of *Colletotrichum* was found in fruits of the treatments *Sulphur* and control (Figure 3). Plants treated with *Calcarea carbonica* did not present fruits with signs of this pathogen. Alternatives for management and control of anthracnose have been researched extensively, as there are no commercial cultivars of *Capsicum annuum* resistant to the pathogen. According to Alan et al. (2017), the use of *Arsenicum album* can significantly inhibit the growth of *C. gloeosporioides* in mango fruits (*Mangifera indica* L.).

Fruits affected by *Pectobacterium* sp. were evidenced in plants of the treatment *Sulphur*, control, and *Calcarea carbonica*, showing a total of 15, 10, and 5 fruits, respectively, during the stages of growth and physiological maturation of fruits. The number of affected fruits at harvest showed a different prevalence between treatments (Figure 3).

Figure 3. Mean number of sweet pepper fruits in the field cultivation with (A) signs of anthracnose (*Colletotrichum* sp.) and (B) soft rot (*Pectobacterium* sp.) in plants submitted to the application of the homeopathic preparations *Calcarea carbonica* and *Sulphur* at 30 CH.



No statistical difference by the Kruskal-Wallis test ($p > 0.05$).
Source: Authors.

The assessments in the postharvest showed a low number of fruits affected by anthracnose and soft rot, regardless of the treatment. In total, three fruits with anthracnose were observed for the treatment *Sulphur*, with a mean lesion diameter of 5.9 mm, while one fruit was found for the treatment using *Calcarea carbonica* (4.3 mm), immersed *Calcarea carbonica* (3.9 mm), and immersed control (4.1 mm). Three fruits with signs of soft rot were found for the treatments *Sulphur* and immersed *Sulphur*, two fruits for control, immersed control and immersed *Calcarea carbonica*, one fruit for control, and none for *Calcarea carbonica* during the assessment period.

The low number of fruits affected by pathogens during postharvest may be related to the balance in the crop system established during production in the field. According to Primavesi (1990), the appearance of diseases is natural indicators of the fragility of plant health. Insects and diseases are symptoms of a deficiency (or excess) of nutrients in the plant and tend to appear in moments of physiological vulnerability associated with stressful factors caused by the environment. Thus, the agroecological management adopted in the cultivation of plants combined with the application of homeopathic preparations enabled positive responses in the low incidence of pathogens in postharvest of sweet pepper fruits.

4. Conclusion

Applications of the homeopathic preparations *Sulphur* 30CH and *Calcarea carbonica* 30CH have positive effects on the phenological characteristics of sweet peppers and the stimulation of the vital force of plants attacked by insects and diseases. The action of homeopathic preparations on sweet pepper plants was different according to the cultivation environment. Plants grown in the field with *Sulphur* application presented higher height in the initial weeks of growth, total productivity, and weight and individual fruit diameter. Plants grown in the greenhouse with the application of *Calcarea carbonica* allowed increases in plant height up to the flowering stage. Continuous application of *Calcarea carbonica* after the flowering stage should be avoided, as the plants treated with this homeopathic preparation directed their metabolism towards vegetative growth and not towards full fruit production.

The homeopathic preparations showed no evident effects in reducing the populations of insects and pathogens that occurred naturally in plants and fruits but stimulated the maintenance of the vital force of the plant after the disease was triggered by insects. *Calcarea carbonica* showed a trend of lower amounts of fruits affected by anthracnose in the field and both treatments in the postharvest period.

For future works, we suggest that the homeopathic repertorization process should be carried out in several stages of plant cultivation, enabling different homeopathic medicines to be chosen and tested throughout the experimentation, which could present more promising results in the control of insects and diseases of the plants.

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