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Tank mixture of pesticides for *Tuta absoluta* and *Neoleucinodes elegantalis* control in tomato crop

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Abstract

The use of pesticides in tank mixtures is important to reduce application costs and increase pest control, mainly. The objective of this study was to evaluate the influence of manganese foliar fertilizers on the effectiveness of the chlorantraniliprole (Chlt) to control tomato leaf miner and tomato fruit borer in tomato crop and to evaluate the possible effects of these mixtures on plant physiology. The experiment was conducted in a greenhouse, on randomized block design with eight treatments and four replications each. The treatments were: 1 – Chlt; 2 – Chlt + $MnSO_4$; 3 – Chlt + $Mn(NO_3)_2$; 4- Chlt + Break-Thru (BTH); 5 - Chlt + $MnSO_4$ + BTH; 6 – Chlt + $Mn(NO_3)_2$ + BTH; 7 – Chlt + $MnSO_4$ + $Mn(NO_3)_2$ + BTH; 8 - Control. The physical chemical properties, physiological effects, pesticide efficacy and yield were evaluated. The results showed that the use of chlorantraniliprole in mixture with adjuvant and foliar fertilizers did not influence its efficacy against *Tuta absoluta* and *Neoleucinodes elegantalis*. Also, the mixture did not influence the chlorophyll content and all the nutrients content were in appropriate levels. We conclude that tank mixture with manganese foliar fertilizers do not have influence over the efficacy nor the physiological characteristics. The physical chemical evaluations changed according to each manganese salt add in the mixture.

Keywords: adjuvant, chlorantraniliprole, manganese salts, organosilicon, pesticide efficacy

Introduction

The tomato (*Solanum lycopersicum* L.) is one of the most grown vegetables in the world being economically and socially important. Brazil is among the top 10 tomato producers with 4.39 million metric ton, in a cultivated area of 64.80 thousand hectares (IBGE, 2017).

Insect pests such as *Bemisia tabaci*, *Frankliniella schultzei*, *Tuta absoluta* and *Neoleucinodes elegantalis*, frequently attack the tomato plant, and intense infestation can happen throughout the whole crop cycle. The most important of them are the tomato leaf miner - *Tuta absoluta* (Resende et al., 2020) – attacking leaves, branches and fruits. The tomato fruit borer - *Neoleucinodes elegantalis* - cause reduction on yield as well as unfit the fruit (Benvenga et al., 2010).

Due to this high number of pests on tomato plants, the use of pesticides is frequent and they exceed three weekly applications, reaching more than 35 applications per crop cycle. This leads the growers to choose the tank mixture, and this have become a common practice at Brazil. The main problem is the uncertain effects that each mixture of different products can cause on the application (Gazziero, 2015).

Besides this, the combination of pesticides with an adjuvant and a foliar fertilizer is one of the most common mixtures. This reflects the need to conduct studies to evaluate the application of the products together as performed by Zandonadi et al. (2019), since the individual application of pesticides rarely occurs alone.

Some pesticides can affect plant physiology mainly in photosynthetic redox chain (Sharma et al., 2019), as well as some adjuvants could increase the spray spread over the leaf surface, influence some physical-chemical characteristics and increase the uptake of some products (Cunha et al., 2010).

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Associations between products may have advantages compared to the application of a single compound due to the increase in efficiency against the target organisms and the reduction of applied quantities and costs (Gazziero, 2015). Given that, studies are needed to demonstrate whether such mixtures influence the efficacy of pest control.

Castro (2009) has already highlighted the importance of determining concentrations of pesticide combinations that cause harmful effects on non-target species, as well as the need to carry out experimental studies related to the joint exposure of agrochemicals. Specifically, for tomato, joint actions of pesticides need clarification, including foliar fertilizers and influences on the physiology of this crop.

Therefore, this work aimed to evaluate the influence of foliar fertilizers on the effectiveness of the chlorantraniliprole over *T. absoluta* and *N. elegantalis* in the tomato crop, as well as to evaluate the possible effects of these mixtures on plant physiology.

Material and Methods

Experimental Site

The experiment was conducted in a greenhouse, located at Gloria Farm (18° 57'S and 48° 12'W), belonging to the Federal University of Uberlândia. The plots were spaced 0.7 m between plants and 0.9 m between rows (3.15 m^2 each plot), totalizing 201.6 m^2 area with plant density of 15,800 plants ha^{-1}. Soil analyzes were performed at the experiment site and the results were presented in Table 1:

Table 1. Soil chemical attributes in greenhouse, Uberlândia, MG.

Layer	pH H_2O	P	K	Al	Ca	Mg	H+Al	SB	t	T	V	m	OM
m	(1:2.5)	mg dm^{-3}			-------------------- cmolc dm^{-3} ---------------						%		dag kg^{-1}
0-0.2	6.3	229.2	111	0.0	5.7	1.3	3.10	7.28	7.28	10.38	70	0	3.3
0.2-0.4	6.2	218.7	95	0.0	4.5	1.1	3.10	5.84	5.84	8.94	65	0	2.5

P, K = (HCl 0.05 mol L^{-1} + H_2SO_4 0.0125 mol L^{-1}) P available (extractor Mehlich-1); Ca, Mg, Al, (KCl 1 mol L^{-1}); H + Al = (Tampon solution - SMP at pH 7.5); SB = Sum of basis; t = cation-exchange capacity (CEC) effective; T = CEC in pH 7.0; V = Saturation for basis; m = Saturation for aluminum; OM = organic material.

Treatments

The treatment solutions were prepared with two manganese salts (Manganese sulfate and Manganese nitrate), one adjuvant (trisiloxane-based super spreader Break-Thru® S240) and one insecticide (chlorantraniliprole (Chlt), MW 483.15 g mol^{-1}, water solubility 1.023 mg L^{-1}, United States Environmental Protection Agency, 2008) on commercial formulation (Premio®, Dupont, Delaware, USA).

Solutions of Manganese Sulfate and Manganese Nitrate (0.05 M) were prepared with the adjuvant Break-Thru (BTH) (0.05 %, v/v) and the insecticide (60 g AI ha^{-1}; 100 mL ha^{-1}; spray volume 200 L ha^{-1}; corresponding to 0.05% v/v). The treatments were as follows: 1 – Chlt; 2 – Chlt + $MnSO_4$; 3 – Chlt + $Mn(NO_3)_2$; 4- Chlt + Break-Thru (BTH); 5 - Chlt + $MnSO_4$ + BTH; 6 – Chlt + $Mn(NO_3)_2$ + BTH; 7 – Chlt + $MnSO_4$ + $Mn(NO_3)_2$ + BTH.

Experiment conduction

Tomato seeds of the hybrid 'Débora Max', 'Santa Cruz' group of undetermined growth, were sowed in polyethylene trays (200 cells) containing agricultural substrate until the development of 5 to 7 final leaves, when they were transplanted. On May 16th, 2017 (15 days after sowing) the transplant were carried out.

The planting fertilization consisted in the application of 318 g of the formula NPK (04-14-08) per plot. Cover fertilization was carried out during the recommended periods for full development of the crop, according to Alvarenga (2004).

Drip irrigation was used, with a nominal flow of 3.8 L h^{-1} m^{-1} at 70 kPa of service pressure and with emitters every 0.50 m. The crop was irrigated during the whole cycle, initially, with two 15-minute shifts per day, which passed to three shifts of 15 minutes in the beginning of flowering.

For diseases control, preventive applications with protective fungicides were applied, using mancozebe + azoxistrobin (Unizeb Gold + Amistar wg – 80g c.p. and 300 g c.p. per 100 L of water). Weed control was done manually.

It was adopted one rod per plant system. Crop dealings were carried out according to the need and development of the crop. The plants were stamped with individual bamboo stakes vertically, every 5 meters and use of iron wire (horizontally) and polyethylene wire (vertically). The polyethylene wire was tied at the base of the plant and suspended vertically, being fixed in a galvanized iron wire, stretched over the line of plants at 2 m high and attached at its ends to wooden stakes.

On August 3th (79 days after the transplanting – DAT), the treatments were applied, when the average number of leaves per pointers attacked was 4%. For the applications it was used a compressed CO_2 propellant sprayer equipped with a boom containing three Magnojet MGA04 hollow cone tips, with a working pressure of 40 Psi and a spray volume of 487 L ha^{-1}. The sprayer boom was used vertically, so that all parts of the plant received the same volume of spray. The mean climatic data at the time of application were: temperature 24.0 °C; relative humidity 37.5 %; wind speed 2.7 km h^{-1}.

Evaluations

Physical-chemical evaluations

Different tank mixtures were prepared to evaluate the physical-chemical characteristics: density, pH, electric conductivity (EC) and viscosity. In the ways of comparison, it was evaluated distilled water. The evaluations were done as described elsewhere (Cunha & Alves, 2009). The evaluations of physical-chemical properties were realized on the Agricultural Mechanization Laboratory (LAMEC), from the Federal University of Uberlândia, Campus Uberlândia.

Pest Evaluation

The main pests evaluated were Tomato pinworm or leaf miner (*Tuta absoluta*) and the Tomato fruit borer (*Neoleucinodes elegantalis*). For each type of pest, specific sampling methods were performed.

Evaluations of treatments efficacy for tomato leaf miner were carried out in addition to the previous count, at five, seven and 10 days after application (DAA), counting the number of leaf miner attack symptoms (mines) or verification of galleries in the fruits of the first cluster, found in five plants per plot. The control level adopted was 20% of leaves or 1% of fruits damaged (Alvarenga, 2004).

The tomato fruit borer was evaluated from the fruiting, with 5 plants per plot being sampled, observing the number of fruits with caterpillars input signals. The control level adopted was 5% of fruits with freshly hatched caterpillars or 1% for fully developed caterpillars (Benvenga et al., 2010).

Physiological evaluations (Foliar chlorophyll index and chlorophyll a fluorescence)

The physiological evaluations were realized during the morning one day before the first treatment application and one day after the insecticide application.

The evaluation of chlorophyll index was made with a chlorophyll meter (model SPA-502 Konica-Minolta). In each leaf five leaflets were evaluated, being two from each side and one terminal leaflet, representing the whole leaf surface.

The same plants used in the determination of chlorophyll index were selected to measure the chlorophyll a fluorescence. The minimum (F0) and the higher (Fm) fluorescence of the chlorophyll a in the photosystem II (PSII), in adapted dark conditions, were evaluated with a fluorescence analyses of chlorophyll a (Mini-PAM, Walz). The adapted dark condition was established after 30 minutes of simulated dark with metal clips for leaves (DLC-8). In this condition, it was evaluated the PSII fluorescence after one pulse of light saturation (0.8 s) and calculating the PSII maximum quantum yield (ØPSII=[Fm-F0]/Fm).

Foliar nutrient content

Leaf samples were collected for nutrient content analysis at 64 DAT, removing a fourth leaf from the apex. For chemical analysis, the sampled material was washed with deionized water and dried in a forced air circulation oven at 70 °C for 72 hours. Then, the samples were crushed in a Wiley type mill, equipped with a 20 mesh sieve. N-total was determined by the Kjeldahl method. The elements P, K, Ca, Mg, S, Fe, Mn, Zn and Cu were analyzed after mineralization by nitric-perchloric digestion.

Tomato yield (t ha^{-1})

The harvest started when most fruits of the cluster presented a red coloration. It was made in two different times, the first on August 17th and the second on August 29th. The average yield (t ha^{-1}) of both harvests, was determined from the tomato production data per plant (fruits from all plants of the plot where collected), in which the average fruit yield was extrapolated to an area of 15,800 plants, equivalent to the number of plants found in one hectare, in the spacing used in the experiment.

Experimental design and statistical analysis

The experiment was conducted in randomized block design (RBD), with eight treatments (seven solutions and a control) and four replications. The obtained data was submitted to normality test of normal distribution of errors (Shapiro Wilk), homogeneity of variances from Levene and additivity block test by the Tukey F test, in 0.01 of significance.

The “F” test was performed to determine levels of significance of 0.05 and 0.01 for the analysis of variance. When these tests were significant, the averages were compared with the Scott-Knott test at 0.05 level of probability. When necessary data was transformed by square root (x+1).

Results and Discussion

Physical-chemical evaluations

The results showed that the addition of manganese sulfate as well the manganese nitrate into the mixture, individually or together in the mixture, reduced the pH and EC (Table 2).

Table 2. Physical-chemical characteristics of water and pesticide mixtures used in tomato crop.

Treatments	Hydrogen potential(pH)	Electric conductivity(μS cm^{-1})	Viscosity (mPa s^{-1})
Chlorantraniliprole	6.16 C	5.57 B	0.95 B
Chlorantraniliprole + $MnSO_4$	5.91 E	4.92 C	1.01 A
Chlorantraniliprole + $Mn(NO_3)_2$	6.01 D	2.76 F	0.91 C
Chlorantraniliprole + BTH	6.68 A	6.07 A	1.00 A
Chlorantraniliprole + $MnSO_4$ + BTH	6.17 C	4.83 C	1.02 A
Chlorantraniliprole + $Mn(NO_3)_2$ + BTH	6.04 D	4.68 D	1.01 A
Chlorantraniliprole + $Mn(NO_3)_2$ + $MnSO_4$+ BTH	6.34 B	3.85 E	1.02 A
Water	5.02 F	1.18 G	1.01 A
CV(%)	1.02	1.79	1.20
F	179.407*	1,329.253*	30.443*
F_{levene}	4.219^{ns}	3.835*	1.057*
SW	0.942*	0.929*	0.969*

Uppercase letters in same column indicate differences according to the Scott-Knott test at 0.05 level of significance. F- values of calculated F for different treatments.

The viscosity was more influenced by the nitrate salt, with a decrease in the value. The other mixtures values presented the same results than water. In comparison between the two fertilizers, the nitrate salt presented lower values of pH and EC than the sulfate (Table 2).

Each foliar fertilizer has a different effect over the physical-chemical characteristics when added to chlorantraniliprole. BTH is a wide used adjuvant and its use is very common in Brazilian fields. Research indicates that this adjuvant can reduce the spray pH as well as EC. As described by Cunha et al. (2010), viscosity did not change statistically from different treatments.

The incompatibility in tank mixtures can be minimized with the use of adjuvants and pH reducers. The active molecules ingredient, when in solution, dissociate into ions, which can be negative and positive charges, being able to bind to other ions present in the solution, possibly forming precipitates (Petter et al., 2012), which did not occur in the present study. As higher was the acid dissociation constant (Ka) or lower is the basic dissociation constant (Kb), lower is the compound capacity to dissociate in aqueous solution and still have the capacity to form other molecules. This is a peculiar characteristic of each product, which may determine its behavior in mixture (Cunha et al., 2017).

Pest Evaluation

The number of caterpillars had all decreased in comparison to the control for almost all the mixtures, except the one with chlorantraniliprole and the adjuvant. All mixtures had reduced the values of brocaded fruits comparing to the control (Table 3).

After the treatments application, it was observed a significant reduction in the average number of caterpillars (Table 4).

Table 3. Average number of *Tuta absoluta* caterpillars and brocaded fruits as function of the application of mixtures of phytosanitary products in the tomato crop.

Treatments	Caterpillar[A]	Brocaded Fruits[A]
Chlorantraniliprole	0.06 A	1.32 A
Chlorantraniliprole + $MnSO_4$	0.31 A	1.18 A
Chlorantraniliprole + $Mn(NO_3)_2$	0.19 A	1.48 A
Chlorantraniliprole + BTH	0.38 AB	1.43 A
Chlorantraniliprole + $MnSO_4$ + BTH	0.19 A	1.27 A
Chlorantraniliprole + $Mn(NO_3)_2$ + BTH	0.19 A	1.06 A
Chlorantraniliprole + $Mn(NO_3)_2$ + $MnSO_4$+ BTH	0.12 A	1.23 A
Control	0.81 B	2.06 B
CV(%)	57.02	70.46
DMS	0.397	0.556
F	5.709*	5.798*
F_{levene}	9.882^{ns}	11.040^{ns}
SW	0.852^{ns}	0.929^{ns}

Uppercase letters in same column indicate differences according to the Tukey test at 0.05 level of significance. F- Values of calculated F for different treatments. ns;*;A - not significant; significant at 0.05. Transformed data by square root (x+1.0).

Table 4. Average number of *Tuta absoluta* as function of evaluation dates.

Dates	Caterpillars
Pre-application	0.78 B
5 DAA	0.15 A
7 DAA	0.15 A
10 DAA	0.03 A
CV(%)	57.01
DMS	0.248
F	18.470*
F_{levene}	9.882 ^{ns}
SW	0.852 ^{ns}

Uppercase letters in same column indicate differences according to the Tukey test at a 0.05 level of significance. F- values of calculated F for different treatments. ^{ns};* - not significant; significant at 0.05.

As presented in some research the main tomato pest control is well done by chlorantraniliprole (Larraín et al., 2014). Although some cases of resistant insect to diamides were reported in tomato crops (Ribeiro et al., 2017; Roditakis et al., 2017). In this study, the use of chlorantraniliprole in mixture with foliar fertilizers and adjuvant did not influence its efficacy.

Different results were showed by Vukovic et al. (2009) when studying the effects of the mixture (cypermethrin, azoxystrobin, mancozeb) with a complex fertilizer, depending on components and water quality over the mortality of *Leptinotarsa decemlineata*. The effectiveness of the double combinations was significantly increased (to 89–98%) by adding a fertilizer or a wetting agent. Regarding to the insecticide application, a significant increase in effectiveness was achieved only with the mixture cypermethrin + azoxystrobin + fertilizer.

Physiological evaluations

The physiological parameters evaluated did not present statistical significance (Table 5).

Table 5. Efficiency of photosystem II and chlorophylls index evaluations in tomato cultivar treated with different pesticides in mixture.

Treatments	∅PSII[A]	SPAD[B]
Chlorantraniliprole	0.61	44.55
Chlorantraniliprole + $MnSO_4$	0.62	44.56
Chlorantraniliprole + $Mn(NO_3)_2$	0.53	44.99
Chlorantraniliprole + BTH	0.60	47.79
Chlorantraniliprole + $MnSO_4$ + BTH	0.49	48.05
Chlorantraniliprole + $Mn(NO_3)_2$ + BTH	0.50	45.11
Chlorantraniliprole + $Mn(NO_3)_2$ + $MnSO_4$+ BTH	0.55	46.02
Control (04/07)	0.51	47.49
Pre-application (02/07)	0.60	47.01
CV	25.40	4.90
F	0.470^{ns}	1.599^{ns}
F_{levene}	2.323*	1.049*
SW	0.964*	0.974*

A: maximum quantum yield of photosystem II (ØPSII =(Fm-F0)/Fm); B: SPAD chlorophyll index. F- values of calculated F for different treatments. ^{ns}; * - not significant; significant at 0.05.

In addition, it was found that the bioactivity of pesticides differed between compounds. Salem (2016) found that some insecticides within one insecticide class (organophosphate, carbamate, and pyrethroid) could reduce photosynthesis while other insecticides in the same class did not.

Physiological parameters were good indicators of plant physiological activity. These parameters can be correlated to yield. In some cases, pesticides applications affect metabolic pathways and could report an increase or decrease over crop growth as well as an adverse effect on plant photosynthesis. In some cases, the adjuvant presence in the mixture may be responsible for the noted effect on plant physiology (Izadi-Darbandi et al., 2019).

The chlorophyll index did not vary in this study. Salem (2016) analyzing the effect of different insecticides such malathion and thiamethoxan over the chlorophyll content of maize and tomatoes found that some of these products could reduce the it in 9 to 80% during the evaluation time. According to Araújo et al. (2018), SPAD index between 48 to 62 in tomato plants showed that these plants present nutritional and physiological status within the expected for good development, similar to those found in this work.

According to Shakir et al. (2016) pesticides application above the recommended dose can adversely affect tomato growth. At higher doses, all the tested pesticides caused toxic effects on all the studied parameters of tomato. Since pesticide dealers usually suggest farmers to apply pesticides in doubled doses to the recommended dose, it can be harmful and affect tomato growth and yield.

Foliar nutrient content

Tank mixture applications had influenced the concentration of phosphorus (P), Sulfur (S), Manganese (Mn) and Cupper (Cu).

Phosphorus content decrease in plants that received applications of the mixture with manganese sulfate and manganese sulfate with BTH. These treatments presented the same values as the control. Concerning to sulfur, the mixtures with BTH presented lower content than the control (Table 6).

Manganese content were higher in almost all the treatments that had the foliar fertilizers, in comparison to control and the treatments with chlorantraniliprole and with chlorantraniliprole with BTH. An unexpected value was presented for the treatments that had mixture application of manganese nitrate and the adjuvant that presented the same content as the control. For cupper, the lower contents were observed in the control and in the mixture with manganese sulfate and BTH (Table 6).

Table 6. Tomato foliar nutrient content in function of different pesticide mixture application.

Treatments	N	P	K	Ca	Mg	S	Fe	Mn^A	Cu	Zn
	(g Kg^{-1})						mg Kg^{-1}			
Chlorantraniliprole	35.37	6.35 A	35.50	30.85	5.62	4.00 A	4.18	1.10 B	0.20 A	0.41
Chlorantraniliprole + $MnSO_4$	37.40	5.77 B	33.00	28.70	4.95	4.15 A	3.91	7.88 A	0.19 A	0.38
Chlorantraniliprole + $Mn(NO_3)_2$	37.82	7.00 A	36.00	29.62	5.80	4.57 A	4.18	5.75 A	0.21 A	0.38
Chlorantraniliprole + BTH	37.30	6.87 A	34.50	26.60	4.77	3.47 B	4.62	1.76 B	0.21 A	0.34
Chlorantraniliprole + $MnSO_4$ + BTH	31.10	5.07 B	28.62	26.87	4.67	3.35 B	4.60	11.47 A	0.15 B	0.36
Chlorantraniliprole + $Mn(NO_3)_2$ + BTH	31.87	7.60 A	31.87	32.72	5.67	3.22 B	3.32	3.43 B	0.23 A	0.39
Chlorantraniliprole + $Mn(NO_3)_2$ + $MnSO_4$+ BTH	34.32	6.45 A	33.37	23.95	4.67	3.20 B	3.91	6.75 A	019 A	0.45
Control	34.85	4.77 B	33.12	26.67	4.35	3.90 A	3.64	1.20 B	0.15 B	0.28
CV (%)	10.52	18.74	11.68	18.91	16.23	16.54	17.92	27.25	13.81	17.62
F	1.879^{ns}	2.762*	1.423^{ns}	1.090^{ns}	1.808^{ns}	2.602*	1.662^{ns}	7.165*	4.566*	2.397^{ns}
F_{levene}	2.503*	3.707^{ns}	1.255*	1.868*	2.352*	0.865*	2.436*	2.649*	4.367^{ns}	2.274*
SW	0.988*	0.954*	0.970*	0.968*	0.982*	0.981*	0.933*	0.874^{ns}	0.949*	0.967*

Uppercase letters in same column indicate differences according to the Scott-Knott test at 0.05 level of significance. F- values of calculated F for different treatments. ^{ns};*;^{A} - not significant; significant at 0.05; transformed data by square root (x+0.5).

All the nutrients content was in appropriate levels. As sulfur present mobility in phloem, it is expected lower concentration in treatments that the element was not applied. However, on the treatment with manganese sulfate and BTH, the foliar concentration was lower than the treatment without BTH. Treatments with sulfate presented higher manganese concentration than the nitrate mixtures (Table 6).

But Zandonadi et al. (2018) found that the addition of the organosilicone adjuvant significantly increased the cuticular penetration of both salts to 20% for $MnSO_4$ and 35% for $Mn(NO_3)_2$. And both manganese salts, when mixed in equal proportion, showed a penetration of 25%, which was not significantly different from 23% when the adjuvant was added.

Alexander & Hunsche (2016) studied cuticular penetration of fertilizers and found about 22% of absorption for manganese sulfate. They concluded that the use penetration enhancer significantly reduced the surface tension, as well as the contact angle, and the penetration rate of Mn could be considerably increased, despite the low cuticular absorption of these insoluble compounds.

Tomato yield (t ha^{-1})

The average yield did not present statistical significance (Table 7). However, the total yield production was within the expected for the variety. It can be observed that although the insecticide treatments showed control effectiveness on the evaluated pests, they were not enough to influence tomato yield.

Table 7. Tomato average yield (t ha^{-1}) in function of different pesticide mixture application.

Treatments	Yield (t ha^{-1})
Chlorantraniliprole	25.94
Chlorantraniliprole + $MnSO_4$	28.26
Chlorantraniliprole + $Mn(NO_3)_2$	38.08
Chlorantraniliprole + BTH	29.91
Chlorantraniliprole + $MnSO_4$ + BTH	30.01
Chlorantraniliprole + $Mn(NO_3)_2$ + BTH	29.90
Chlorantraniliprole + $Mn(NO_3)_2$ + $MnSO_4$+ BTH	40.04
Control	43.13
Average	33.16
CV(%)	57.60
F	0.964^{ns}
F_{levene}	3.040*
SW	0.933*

F- values of calculated F for different treatments. ns;* - not significant; significant at 0.05.

Initially, it was expected at least two applications, but the control level was not achieved anymore after the first treatments application, in this case, it was made only one application and two harvest during the experiment period.

In addition, with the low presence of pests, there was a high concentration of white mold in the leaves. This fact caused a reduction of active leaf area and consequent fall, which may have influenced the physiological and agronomic evaluated parameters.

Conclusions

The physical-chemical evaluations changed according to each manganese salt added in the mixture. Chlorantraniliprole has efficacy over the *Tuta absoluta* and *Neoleucinodes elegantalis* and the tank mixture with manganese foliar fertilizers and organosilicon adjuvant did not have influence over the efficacy nor the physiological characteristics.

Nevertheless, more research over field conditions should be done, mainly with other fertilizes, to provide a better understanding on the tank mixture effects.

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