

## EFFICIENCY OF BIOLOGICAL CONTROL OF FALL ARMYWORM IN SWEET CORN

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### ABSTRACT

The cultivation of sweet corn has great importance in Brazil due to its nutritional quality and several possibilities for use. It is a crop that attracts a large number of pests, especially the carcass caterpillar, which can generate great qualitative and quantitative losses. Because it is mainly used *in natura* the application of agrochemicals to the control of these pests can cause risk to human health. Thus, the experiment was carried out with the objective of testing the efficiency of the use of biological insecticides in comparison to conventional chemical insecticides in the control of the military caterpillar. The biological insecticides Bio BB, Bio MB, Bio Bt Premium Akb, Agree and Bac-Control WP and the chemical insecticides Dimax 480 SC and Incrível, were applied in the maize crop at 3 different times at 28, 43 and 50 days after seeding. In all applications, the biological products proved to be as efficient in controlling the caterpillar carcass as the chemical insecticides. The products based on *Beauveria bassiana* and *Metharrizium anisopliae* showed greater efficiency in pest control proving that the biological insecticides are efficient in pest control in sweet corn contributing to a sustainable management of the crop.

**Keywords:** Biocontrol, *Spodoptera frugiperda*, *Zea mays*

## INTRODUCTION

Corn (*Zea mays* L., Poaceae) is a cereal produced in almost all continents, and its economic importance is mainly characterized by the amount and nature of reserves accumulated in the grains, in addition to its various forms of use, ranging from animal feed to the high technology industry, such as the production of biodegradable films and packaging (DOURADO NETO & FANCELLI, 2000). In Brazil, the corn crop occupies a significant economic position due to the value of agricultural production, the cultivated area and the volume produced, mainly in the South, Southeast and Midwest regions (MORAES & BRITO, 2013). Among the corn varieties the sweet one (*Zea mays* L. var. *saccharata*), better known as sweet corn, is highly susceptible to fall armyworm attack (KWIATKOWSKI & CLEMENTE, 2007). Sweet corn is cultivated on approximately 1 million hectares distributed around the world, with North America, mainly the United States, concentrating the highest percentage of production. In Brazil, the area planted with this variety of maize exceeds 36 thousand hectares (BARBIERI et al., 2005).

It is a crop that suffers pest attack from the seed at the time of planting until close to harvest. The initial pests are considered the most important due to their ability to kill the plant, reducing the number of plants per unit area, and consequently affecting production. To control these pests, several applications of synthetic insecticides are usually carried out, increasing the production cost and bringing risks of intoxication and environmental contamination (VIANA et al., 2007).

The fall armyworm *Spodoptera frugiperda* (J.E. Smith, 1797) (Lepidoptera: Noctuidae) is a polyphagous species that attacks several economically important crops in several countries (LOPES et al., 2008). In Brazil, it is considered a key pest of the corn crop, causing losses in practically all stages of development, which can reduce production by more than 25% (WAQUIL; VILELLA, 2003; DEQUECH et al., 2007).

The number of pests that attack the corn crop varies according to the climatic conditions and biotic factors of each region due to the biological imbalance caused by the high rate of applications of broad-spectrum insecticides, which eliminate their natural enemies, especially the wasps of the genus *Trichogramma* (GALVÃO, 2004).

Due to the negative impacts generated by the indiscriminate use of chemical insecticides and the evolution of resistance of *S. frugiperda* populations to these products, alternative methods

are increasingly being used to reduce the population of this pest, including biological control (CRUZ & PEREIRA FILHO, 2002).

Therefore, the objective of this work was to evaluate the efficiency of biological insecticides to control the fall armyworm in comparison to conventional chemical control in the municipality of Palmeiras de Goiás, State of Goiás, Brazil.

### **The Sweet Corn Culture**

Sweet corn (*Zea mays* L.) is classified as a special product and is considered a vegetable crop and is intended exclusively for human consumption. It is mainly used in the form of green corn, both “*in natura*” and for processing by canned vegetable products industries (CRUZ & PEREIRA FILHO, 2002; OLIVEIRA JUNIOR et al., 2006). This cereal is very popular in the United States and Canada. In these countries, sweet corn is traditionally consumed “*in natura*” (BORDALLO et al., 2005). Currently, the world cultivated area is 900,000 hectares. In Brazil, 36 thousand hectares are cultivated, where practically 100% of the production is destined for industrial processing (BARBIERI et al., 2005).

Green corn is destined for the consumption of grain “*in natura*”, either directly or in the preparation of traditional dishes, being commercialized in the form of ears, canned grains and their by-products (RODRIGUES et al. al., 2009). The crop is exploited throughout the year using irrigation, allowing production to be scaled and a constant flow of products for processing and commercialization (TEIXEIRA et al., 2001). This segment has grown annually and the tendency is to maintain this growth, mainly targeting the export market (BARBIERI et al., 2005).

### **Fall armyworm (*Spodoptera frugiperda*)**

The corn fall armyworm, *Spodoptera frugiperda*, described in 1797 by J. E. Smith, has a wide geographic distribution and occurs year-round on various crops such as corn, *Zea mays* L.; sorghum, *Sorghum bicolor* (L.) Moench; cotton, *Gossypium herbaceum* L.; pasture, *Panicum maximum* Jacq. Cv. Tanzania; sugar cane, *Saccharum officinarum* L. and soybean, *Glycine max* (L.) Merrill. Thus, *S. frugiperda* constitutes one of the most harmful species for annual crops in the tropical regions of the Americas, mainly in Brazil. Caterpillars, both in corn and sorghum, can cause losses from 17% to 38.7% in production, depending on the environment and the

development stage of the attacked plants (CRUZ & TURPIN, 1983, WILLIAMS & DAVIS, 1984, CORTEZ & WAQUIL, 1997, MENDES et al., 2011).

In the corn crop, the caterpillar of *S. frugiperda* has the cartridge as its preferred niche (CRUZ & TURPIN, 1983; CRUZ & MONTEIRO, 2004). The caterpillar attack occurs at all stages of plant growth. At the beginning of development, they scrape the leaves and when they become more active they perforate them, causing great losses in crop yield (DEQUECH et al, 2005). The cultivation of corn in the “safrinha” period offers good conditions for the development of this pest, with resistance and the high cost of the pesticides used being the main problems encountered for its control (YU et al., 2003; Lima et al., 2006). Recent studies demonstrate that *S. frugiperda* develops in cultivated and non-cultivated hosts, hitherto unknown (SÁ et al., 2009, PRASIFKA et al., 2009, BARROS et al., 2010).

The importance of the insect in the corn crop is due to the damage caused and the difficulty of its control. The attack allows the entry of pathogens and moisture, which leads to the rotting of the ears. In corn consumed *in natura*, the commercial depreciation of the product occurs (SANTOS et al, 2004).

### **Biological Control**

Applied biological control consists of the massive release of a large number of biological control agents, aimed at reducing the population of a particular pest and restoring its equilibrium level (PARRA et al., 2002).

The main method of controlling *S. frugiperda* in areas cultivated with maize is the use of pesticides. However, due to the negative impacts generated by chemical insecticides and the evolution of resistance of populations of *S. frugiperda* to these products, biological control methods have gained space (CRUZ & PEREIRA FILHO, 2002). The main alternatives for controlling this pest with biological control agents are the use of the egg parasitoid *Telenomus remus* Nixon, 1937 (Hymenoptera: Scelionidae), and the entomopathogenic bacterium *Bacillus thuringiensis* Berliner, 1911 (Eubacteriales: Bacillaceae) (HILL & FOSTER, 2000; BRUNNER et al., 2001, PRATISSOLI et al., 2006).

The use of biological agents to control insect pests has intensified in recent years in Brazil, with significant results in the management of these phytophagous organisms. Natural enemies minimize the need for human intervention in pest control. However, in current

agriculture, only in some situations is natural biological control efficient to control pests without complementing other control methods (DEGRANDE et al., 2002).

Thus, scientific research aimed at reducing aggression to the ecosystem is growing, highlighting the interest in organisms capable of promoting the biological control of pests, especially those that can be manipulated in laboratories and/or on an industrial scale. Fungi were the first insect pathogens used in microbial control (ALVES, 1998) and more than 150 products for the biological control of insect pests made from entomopathogenic fungi have already been commercialized (FARIA & WRAIGHT, 2007). The entomopathogenic fungi *Beauveria bassiana* and *Metarhizium anisopliae* are known worldwide and used as biocontrol agents for agricultural pests of several species in different orders (ALVES et al., 2008).

## MATERIAL AND METHODS

The experiment was conducted at the Experimental Farm of the State University of Goiás - Câmpus Palmeiras, located on the GO-408 Km 8 highway, Palmeiras de Goiás, Goiás State, Brazil, with geographic coordinates 16°52'26,48" South 49°59'42, 37" West and the average altitude of 600 meters. The predominant climate in the region is tropical, with annual precipitation of 1,575 mm, average annual temperature of 23.2°C and relative humidity of 66%. The topography is relatively flat, and the soil is classified as an Oxisol.

A completely randomized experimental design was used, in a factorial 8 x 12 system, consisting of eight treatments and three replications (7 insecticides and control) in three applications (12 times), and in each application the number of insects present was counted. in the plots, with the 1st evaluation 24 hours before application, the 2nd evaluation 24 hours after application, the 3rd evaluation 72 hours after application and the 4th evaluation 144 hours after insecticide application. The sprays were made at 28, 43 and 50 days after sowing (DAS).

Sowing was carried out on December 15, 2015, using the cultivar LG 6030 Vt Pro2, with 0.5 m spacing between rows and 2.8 seeds per meter. Each plot measured 20x25 meters, totaling an area of 500 m<sup>2</sup> per plot and a total area of 1500 m<sup>2</sup>.

The treatments consisted of biological and chemical insecticides arranged according to Table 1, which presents the product used and the respective doses applied per hectare.

**Table 1.** Treatments indicating the products used and the doses applied per experimental plot in L/ha. UEG Experimental Farm – Campus Palmeiras de Goiás, Palmeiras de Goiás, Goiás State, Brazil, Harvest 2015/2016.

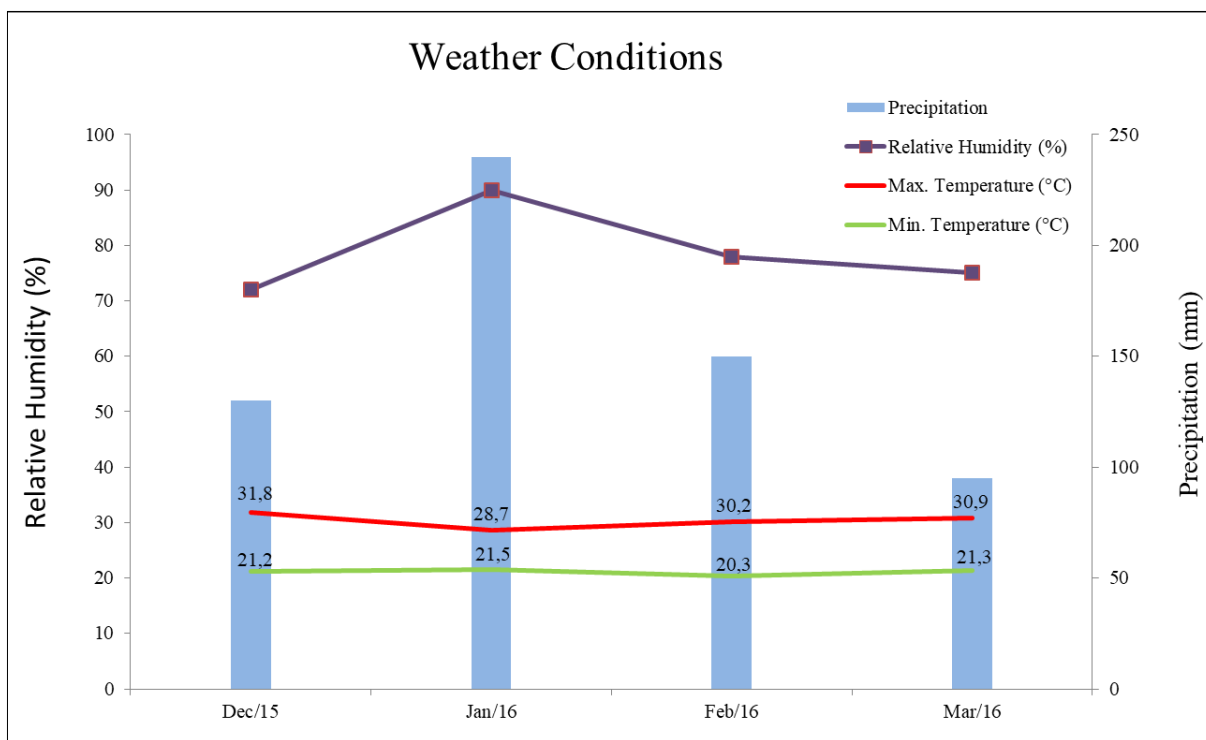
Treatment	Product	Dose
T1 _	WITNESS	no application
T2 _	BIO BB	1000 ml.ha <sup>-1</sup> in 200 l.ha <sup>-1</sup> of syrup.
T3 _	BIO MB	1000 ml.ha <sup>-1</sup> in 200 l.ha <sup>-1</sup> of syrup.
T4 _	BIO Bt PREMIUM Akb	1000 ml.ha <sup>-1</sup> in 200 l.ha <sup>-1</sup> of syrup.
T <sub>5</sub>	agree	1000 mg.ha <sup>-1</sup> in 200 l.ha <sup>-1</sup> of syrup.
T <sub>6</sub>	Dimax 480 SC	40 ml.ha <sup>-1</sup> in 200 l.ha <sup>-1</sup> of syrup.
T <sub>7</sub>	Bac-Control WP	500 mg.ha <sup>-1</sup> in 200 l.ha <sup>-1</sup> of syrup.
T <sub>8</sub>	Incredible	300 ml.ha <sup>-1</sup> in 200 l.ha <sup>-1</sup> of syrup.

\*The BIO ORGANIC adjuvant was added to the sprayer at a dose of 1 L.ha<sup>-1</sup> as an aid in fixing the products on the leaves.

BIO BB is a biological insecticide based on *Beauveria bassiana*. BIO MB is a blend of *Beauveria bassiana* and *Metharizium anisopliae*. BIO Bt PREMIUM Akb, AGREE and BAC-CONTROL WP insecticides contain the bacterium *Bacillus thuringiensis* as the main entomopathogen, with one or more strains of this bacterium.

The chemical insecticides used as comparatives in relation to biological products were: Dimax 480 SC, which is a growth regulator product from the Benzoylurea Chemical Group (Difublenzurom), widely used to control caterpillars, and Incredible, which is a mixture of Neonicotinoid (Acetamiprid) and Pyrethroid (Alpha-Cypermethrin), used to control bed bugs with action on caterpillars and other insects.

The climatic conditions during the experiment were ideal for the application of biological products based on fungi and bacteria, with temperatures varying between 20 °C and 32 °C, with monthly precipitation above 100 mm, reaching 200 mm in January. The relative humidity in the period was above 70%, favoring the microbiological development of the applied products (Figure 1).



**Figure 1.** Precipitation (mm), Relative Air Humidity (%), Maximum Temperature (°C) and Minimum Temperature (°C) in the municipality of Palmeiras de Goiás during the experimental period. UEG Meteorological Station, Palmeiras de Goiás, Goiás State, Brazil, 2016.

## RESULTS AND DISCUSSION

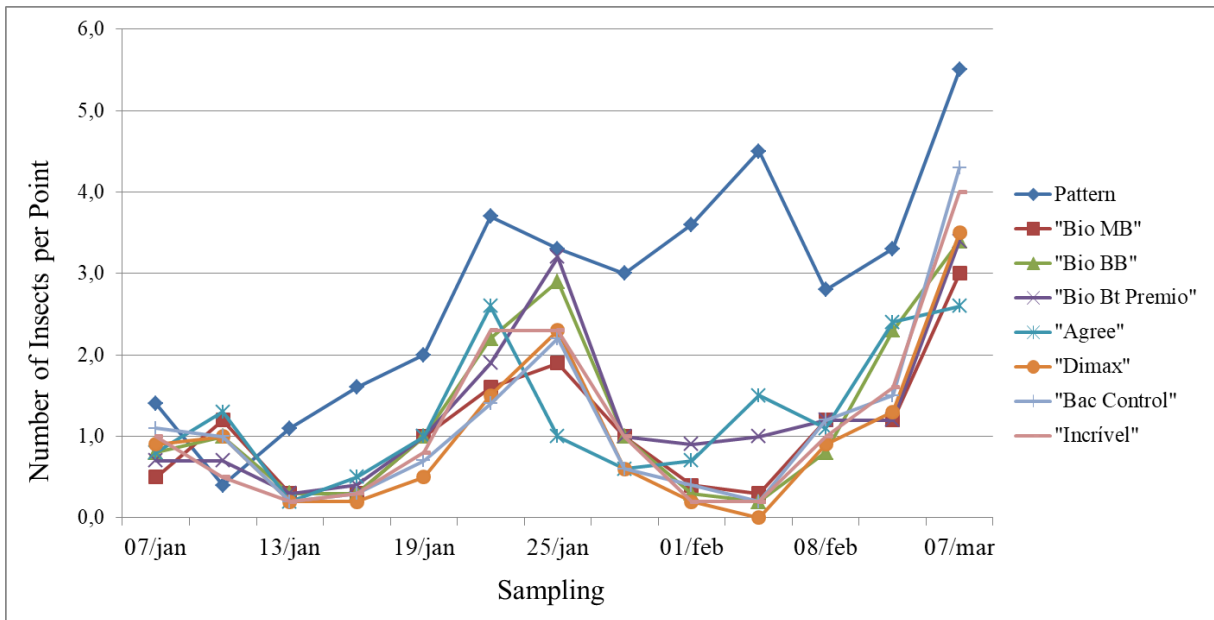
It was possible to observe the presence of the fall armyworm already 19 days after sowing. Table 2 shows the population fluctuation of *Spodoptera frugiperda* in the samples before and after the application of the products in each treatment.

It could be observed that, statistically, the products used showed a similar efficiency, reducing the pest population in the different observed periods. Throughout the study, the treatments showed satisfactory results in controlling the fall armyworm.

In the insect counts, after 24, 72 and 144 hours from the 1st application of the products to the 28 DAS, the control showed increasing numbers in relation to the other treatments. The other treatments showed a reduction in the caterpillar population in the respective samples.

In all applications, with the exception of the third application at 50 DAS, the treatment with *Beauveria bassiana* provided a decrease in the population level of caterpillars (Table 2). The

results of research carried out in the laboratory indicated the use of *B. bassiana* as a potential method for use in the biological control of corn pests (CRUZ, 2002). *Bacillus thuringiensis in corn* is frequent since the commercial products available on the market have shown satisfactory results in controlling lepidopterans (CAPALBO et al., 2005). The data shown in Figure 2 show that the use of biological products based on *B. thuringiensis*, BIO Bt premium, Agree and Bac control, reduced the number of caterpillars during sampling.



**Figure 2.** Population fluctuation of *Spodoptera* sp in treatments during sampling. UEG Experimental Farm – Campus Palmeiras de Goiás, Goiás State, Brazil, 2015/2016 harvest.



**Table 2.** *Spodoptera* population fluctuation *frugiperda* per plant sampled in the treatments. UEG Experimental Farm – Campus Palmeiras de Goiás, Palmeiras de Goiás, Goiás State, Brazil, January/2016.

Samplings	T1	T2	T3	T4	T5	T6	T7	T8
1st Application 24h Before	1.42 aH	0.50 bEF	0.80 ABC	0.67 bEF	0.77 abcDEF	0.90 abDEFG	1.12 abDEF	1.02 abDE
1st Application 24h After	0.37 cI	1.20 abcDE	0.97 abcC	0.67 abcEF	1.32 BC	0.97 abcDEF	1.00 abcDEFG	0.52 bcEFG
1st application 72 hours after	1.10 aHI	0.25 bF	0.27 bC	0.27 bF	0.17 bF	0.15 bGH	0.22 bGH	0.20 bFG
1st application 144 hours after	1.60 aGH	0.25 bF	0.25 bC	0.42 bEF	0.50 bEF	0.17 bFGH	0.25 bGH	0.32 bEFG
2nd Application 24h Before	2.27 aFG	0.95 bDEF	0.95 bC	0.95 bEF	0.97 bcDEF	0.47 bEFGH	0.72 bDEFGH	0.77 bEFG
2nd Application 24 hours after	3.70 aCD	1.62 cdeBCD	2.15 bcdB	1.87bcdeCD	2.57 bAB	1.47 of CD	1.37 eDE	2.25 BCBC
2nd Application 72 hours after	3.30 BC	1.92 cBC	2.90 ABAB	3.15 aAB	1.00 dCDE	2.25 BCBC	2.22 BCBC	2.27 BCBC
2nd Application 144h After	3.02 aDEF	1.00 bDEF	0.97 bC	0.95 bEF	0.55 bDEF	0.55 bEFGH	0.60 bEFGH	0.97 bDEF
3rd Application 24h Before	3.57 BC	0.40 bEF	0.32 bC	0.87 bEF	0.65 bcDEF	0.22 bFGH	0.42 bFGH	0.22 bEFG
3rd application 24 hours after	4.52 AB	0.25 cdF	0.17 AD	0.97 bcEF	1.45 BC	0.02 dH	0.17 dH	0.16 dG
3rd application 72 hours after	2.77 aEF	1.20 bcDE	0.80 bC	1.20 bDE	1.12 bcED	0.87 bDEFG	1.20 bDEF	1.02 bDE
3rd application 144 hours after	3.30 BC	1.20 dCDE	2.30 bcb	1.17 dDE	2.37 bB	1.27 dDE	1.47 dCD	1.62 cdCD
Flowering	4.00 BC	2.40 bAB	2.15 bB	2.47 bBC	3.30 aA	2.37 bB	2.35 bB	2.45 bB
Filling	5.75 aA	3.00 deA	3.42 cdA	3.42 cdA	2.57 eAB	3.50 cdA	4.25 ba	4.00 bcA
CV (%)	26.04							
DMS	For Columns = 0.8123 For Rows = 0.7346							

\*Means followed by different UPPERCASE letters in the same COLUMN differ significantly from each other and Means followed by different LOWERCASE letters in the same ROW differ significantly from each other by the Tukey test t 1% probability.

In the samplings of the second application, the BIO Bt PREMIUM Akb (T4) showed an increase in the fall armyworm population after 24 hours, which only decreased the amount per sampling point in the third application, as well as the Bac-Control WP (T7). The Agree product (T5) showed a population increase in the first count of the second application, but after 72 hours and 144 hours there was a reduction in the number of caterpillars per sampled point, showing that the residual effect in the second application of this product was superior to the other treatments. In the third application the treatments differed, while T4 and T7 showed a reduction in the caterpillar population, T5 continued to increase. In 2014 Silva et al., proved that due to the low mortality rates of insects, the Agree product was classified as innocuous (class 1).

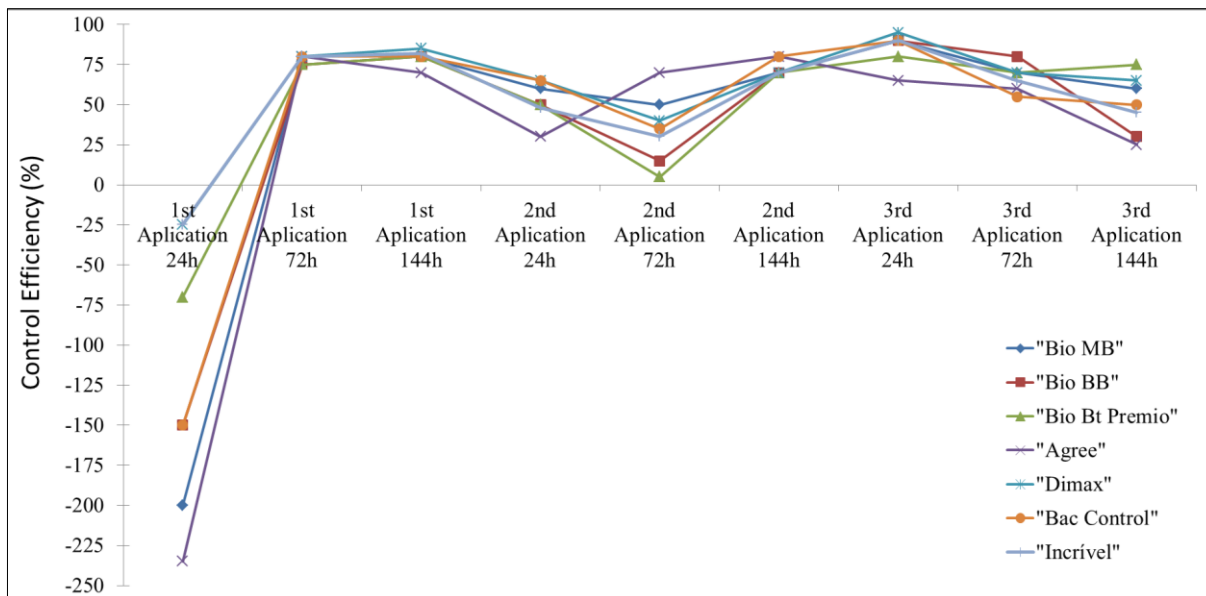
The entomopathogenic fungi *B. bassiana* and *M. anisopliae* are used to control stored product pests, proving to be efficient in their control (CHERRY et al., 2005; SHAMS et al., 2011). From the data acquired during the study, the product based on *B. bassiana* and *M. anisopliae* (T2), presented satisfactory results in reducing the fall armyworm population both in the vegetative and reproductive phases of the crop. The first counts show that the number of caterpillars per point was reduced in T2 (BIO BB) in the 2nd application (after 24 hours) there was a decrease and then in the 3rd application the population level of caterpillars continued to evolve.

The products Dimax 480 SC (T6) and Incredible (T8) showed results similar to previous treatments. Therefore, it can be said that there is a similar behavior of biological and conventional products in relation to the fall armyworm population fluctuation, allowing the replacement of chemical control by biological control.

Regarding the efficiency of application, the best results observed were after the first application, in the second and third samplings (after 72 hours and 144 hours of application), where all the applied products reached about 75% of efficiency in the control of the armyworm. corn cartridge. In the second application, the only treatment that proved to be efficient was T5 (Agree), presenting 50% efficiency in the first sampling, as well as the other treatments, and 100% in the second and third samplings.

After the third application, treatments T2 (Bio BB), T3 (Bio MB), T6 (Dimax 480 SC), T7 (Bac-Control WP) and T8 (Incrível) showed 100% efficiency in the first sampling (24 hours after application), while T4 (BIO Bt PREMIUM Akb) and T5 (Agree) showed averages of 60 to 65% in control efficiency. In the second sampling, all treatments showed an efficiency of 50%,

with a decrease, only in treatments T3 (Bio MB) and T5 (Agree), in the third sampling, reaching close to 0%, that is, not showing efficiency in the control (Figure 3).



**Figure 3.** *S. frugiperda* control efficiency in each treatment during sampling. UEG Experimental Farm – Campus Palmeiras de Goiás, Palmeiras de Goiás, Goiás State, Brazil, 2015/2016 harvest.

## CONCLUSIONS

All the analyzed treatments differed from the control, being able to affirm the efficiency of the biological products compared to the conventional chemical control in the control of pests in the corn crop.

Biological products based on *B. bassiana* and *M. anisopliae*, showed efficiency in controlling the fall armyworm of corn, reducing the amount of the pest in the sampled period. The time that stood out the most, in relation to the efficiency of each product, was after 24 hours of application, then the 72-hour sampling, showing a possible resistance of the pests to the low residual effect presented by the products.

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