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MANAGEMENT OF LEAF SPOTS IN SOYBEAN CULTIVATION WITH FUNGICIDES AT ZERO APPLICATION

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ABSTRACT - Soybean (*Glycine max*) is one of the most important commodities in Brazil. The main factors limiting its production are diseases, with approximately 40 diseases identified in the country, caused by fungi, bacteria, nematodes, and viruses. Foliar spots are common at the beginning of soybean development, and since pathogens can be present from the beginning of cultivation, preventive management is employed with application in the vegetative phase, 30 days after sowing (zero application). This study aims to evaluate the effectiveness of different fungicides from the chemical groups triazoles, strobilurins, multisites, and biological control in controlling foliar spots through zero application. The methodology followed the recommendations of the Ministério da Agricultura, Pecuária e Abastecimento (MAPA-Brazil) according to Normative Instruction No. 13 of 2011, with a randomized block design, 7 treatments, and 5 replications, totaling 35 plots. The treatments, applied 30 days after sowing at the V3 phenological stage, included a control with no application, *Bacillus amyloliquefaciens*, Picoxystrobin + Ciproconazole, Chlorothalonil, *Saccharomyces cerevisiae*, Picoxystrobin + benzovindiflupyr, and Tebuconazole + Trifloxystrobin. Disease incidence and severity, live canopy coverage index, and productivity variables were evaluated. The results demonstrate that Picoxystrobin + Ciproconazole and *S. cerevisiae* were the most effective treatments in reducing foliar disease incidence and severity while enhancing canopy retention and yield. These findings reinforce the importance of integrating chemical and biological control strategies in early disease management, particularly through zero application, to optimize soybean health and productivity.
Keywords: *Glycine max* L., foliar disease, fungal disease management.

MANEJO DE MANCHAS FOLIARES NO CULTIVO DA SOJA COM FUNGICIDAS NA APLICAÇÃO ZERO

RESUMO - A soja (*Glycine max*) é uma das commodities mais importantes do Brasil. Os principais fatores que limitam sua produção são as doenças, com cerca de 40 doenças identificadas no país, causadas por fungos, bactérias, nematoides e vírus. As manchas foliares são comuns no início do desenvolvimento da soja, e como os patógenos podem estar presentes desde o início do cultivo, é empregado um manejo preventivo com aplicação na fase vegetativa, 30 dias após a semeadura (aplicação zero). Este estudo visa avaliar a eficácia de diferentes fungicidas dos grupos químicos triazóis, estrobilurinas, multissítios e controle biológico no controle de manchas foliares mediante aplicação zero. A metodologia seguiu as recomendações do Ministério da Agricultura, Pecuária e Abastecimento (MAPA) conforme a Instrução Normativa n° 13 de 2011, com um delineamento em blocos casualizados, 7 tratamentos e 5 repetições, totalizando 35 parcelas. Os tratamentos, aplicados 30 dias após a semeadura no estágio fenológico V3, incluíram testemunha sem aplicação, *Bacillus amyloliquefaciens*, Picoxistrobina + Ciproconazol, Clorotalonil, *Saccharomyces cerevisiae*, Picoxistrobina + benzovindiflupir e Tebuconazol + Trifloxistrobina. Foram avaliadas a incidência e severidade de doenças, índice de cobertura viva e variáveis de produtividade. Os resultados demonstram que Picoxistrobina + Ciproconazol e *S. cerevisiae* foram os tratamentos mais eficazes na redução da incidência e severidade de doenças foliares, além de promoverem a retenção da cobertura vegetal e o aumento da produtividade. Esses achados reforçam a importância da integração de estratégias de controle químico e biológico no manejo precoce de doenças, especialmente por meio da aplicação zero, para otimizar a sanidade e a produtividade da soja.
Palavras-chave: *Glycine max* L., doença foliar, controle fúngico.

INTRODUCTION

Soybean (*Glycine max*) is one of the most important commodities in Brazil. According to data from CONAB, Brazil is expected to produce around 155.736,5 tons of soybeans in the 2022/23 season, covering an area of 44.031,7 ha cultivated with soybeans, representing a 24% increase compared to the previous season, achieving a historical record in productivity, planted area, and production (CONAB, 2023).

Among the main factors limiting soybean production are diseases. Approximately 40 diseases caused by fungi, bacteria, nematodes, and viruses have already been identified in Brazil. Due to the extensive expansion of soybean cultivation to new areas, leading to monoculture, and the continuous emergence of new pathogens, the

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economic importance of each disease varies from region to region and from year to year, depending on the climatic conditions of each crop season. Annual losses due to diseases are estimated at 15% to 20%, and some diseases can cause losses of up to 100% in production (ALMEIDA et al., 2005).

To minimize production losses in soybeans, it is essential to consider crop planning, identify the main diseases in the region, adopt appropriate management practices, assess weather forecasts, and evaluate the infrastructure of each farm.

One of the diseases that can be observed early in soybean development is Septoria leaf spot, caused by the fungus *Septoria glycines*. Symptoms may appear in the first weeks after emergence, with irregularly shaped spots or small reddish-brown lesions on unifoliate leaves, and under favorable conditions, they can spread to the first trifoliate leaves, causing defoliation. Under high temperatures and humidity, anthracnose (*Colletotrichum* spp.) may occur, which can thrive in dead tissues. Symptoms of anthracnose, such as darkening of veins on leaves, commonly attributed to this disease, may also be caused by other fungi. Anthracnose symptoms can be mistaken for those of target spot, *Cercospora* leaf blight, and stem and pod blight (ALMEIDA et al., 2005; SEIXAS et al., 2020).

Due to the occurrence of pathogens early in the cultivation, chemical control management is employed, using fungicides in the vegetative phase 30 days after emergence, also known as zero application. This approach provides better control of major diseases, yielding positive results in soybean productivity (VYBOROVA; BEZMUTKO, 2023). Therefore, this study aimed to evaluate the effectiveness of different fungicides from chemical groups including triazoles, strobilurins, multisites, and biological control in controlling foliar diseases through zero application.

MATERIAL AND METHODS

The experiment was conducted under field conditions, with seeding on September/2022 and harvesting on February/2023, on a farm located in the western region of Paraná, at an altitude of 320 m. The local soil is classified as red latosol (CURCIO et al., 2021). The region's climate is characterized according to the Köppen classification as *Cfa* (Subtropical Climate, with hot summers). The average temperatures are above 22ºC in summer, and rainfall is well distributed throughout the year. Winter, with infrequent frosts, has an average temperature below 18ºC, and the annual precipitation average is 1.788 mm.

Prior to implementation, soil samples were collected from the area for analysis and soil correction purposes. The soybean cultivar used in the experiment was Brevant 5595 CE, which was industrially treated with Dermacor® insecticide (chlorantraniliprole, 625 g L^{-1}, at 50 mL 100 kg^{-1} of seeds), Fipronil® inseticide (fipronil 250 g L^{-1}, at 100 mL 100 kg^{-1} of seeds), and Rancona T® fungicide (ipconazol 10 g L^{-1}, thiram 350 g L^{-1}, 200 mL 100 kg^{-1} of seeds).

The seeding employed a population of 240,000 plants ha^{-1}, using a PlantiCenter, G4 model, seeder with Titanium system and mechanical seed meter, at a speed of 5 km h^{-1}. The work followed recommendations from the Ministério da Agricultura, Pecuária e Abastecimento (MAPA), employing a randomized block design with 7 treatments and 5 replications, totaling 35 plots. Each experimental plot was established with dimensions of 6.0 m in length by 3 m in width, totaling 18 m² per plot.

The treatments applied in the trial (Table 1) were administered 30 days after seeding, with soybean plants at the V3 stage, using a 20 L electric backpack sprayer Brudden, equipped with an empty conical nozzle and a volume of 150 L ha^{-1}. After 10 days from the zero application, true applications were initiated, with a 14-day interval between them. The spraying was carried out using a Columbia trailed sprayer, with a 20 m boom, green fan nozzle 015, at 120 L ha^{-1}, following the producer's phytosanitary control standard. In the first application, Viovan (Picoxystrobin + Protioconazole) was employed, in the second Vessarya (Picoxystrobin + Benzovindiflupyr) + Status (copper oxychloride), in the third Viovan (Picoxystrobin + Protioconazole) + Unizeb Gold (Mancozeb), and in the fourth application, Aproach Power (Picoxystrobin + Ciproconazole) was applied, maintaining phytosanitary control until crop physiological maturity. In all cases, the label dose was applied, following the manufacturers' recommendations.

TABLE 1 - Treatments employed in the zero application trial at 30 days after seeding, at the V3 development stage.

Treatments	Composition	a.i. (g L^{-1})	c.p. (kg ha^{-1})
Control	Water	0	0.00
Inlayon	*Bacillus amyloliquefaciens*	30	0.25
Aproach Power	Picoxystrobin + Ciproconazole	90 + 40	0.60
Yeast	*Saccharomyces cerevisiae*	15	2.25
Previnil	Chlorothalonil	720	2.00
Vessarya	Picoxystrobin + Benzovindiflupyr	100 + 50	0.60
Nativo[1]	Trifloxystrobin + Tebuconazole	100 + 20	0.60

[1]Treatment was carried out with 400 mL ha^{-1} of mineral oil. Treatments were applied with a spray volume proportional to 150 L ha^{-1} of solution. a.i. = active ingredient, c.p. = commercial product.

Throughout the crop cycle, evaluations of disease incidence and severity were conducted. The first evaluation was performed 30 days after sowing in October/2022, with 5 randomly selected plants per block marked for analysis. After analyzing the incidence of each disease, the second evaluation was carried out at a 14-day interval to quantify their progression.

Disease severity was assessed using diagrammatic scales for diseases affecting the crop, including bacterial blight (*Pseudomonas savastanoi*) and anthracnose (*Colletotrichum dematium* var. *truncata*). For the latter, the severity scale for anthracnose in beans was alternatively employed, adapted for soybean cultivation, as observed in other scientific studies evaluating anthracnose severity in soybeans.

The data on disease incidence and severity were used to calculate the relative disease incidence control (RDIC), relative bacterial blight severity control (RBSC), and relative anthracnose severity control (RASC) compared to the control (Equation 1, 2 and 3).

$$RDIC\ (\%) = 100 - (x.100/Incidence\ Average\ control) \quad \text{(Equation 1)}$$

$$RBSC\ (\%) = 100 - (x.100/BS\ Average\ control) \quad \text{(Equation 2)}$$

$$RASC\ (\%) = 100 - (x.100/AS\ Average\ control) \quad \text{(Equation 3)}$$

Where:

x = observed data for the plot, average control, average value of disease incidence in the control treatment,

BS = average control, average value of bacterial blight severity in the control treatment and

AS = average control, average value of anthracnose severity in the control treatment.

To determine the amount of canopy coverage for live vegetation of the crop, the Canopeo software was used. Thus, a photograph was taken facing downwards of the vegetation in each block. The software assists in monitoring plant progress, which can lead to better decision-making. It can also determine how much crop damage has occurred due to unfavorable weather conditions or even damage caused by agricultural pesticide application.The first evaluation was conducted in November/2022, with plants at the R1 stage, while the second evaluation was carried out after a 53-day interval, in January/2023, with plants at the R5 stage. The evaluated canopy data was used to calculate the relative canopy increment (RCI) (Equation 4).

$$RCI(\%) = (x.100/CMC) - 100 \quad \text{(Equation 4)}$$

Where:

x = observed data for the plot and

CMC = average canopy coverage of the control.

The harvest was conducted manually, 150 days after sowing, using a sickle, sampling the two central rows of each treatment, discarding the initial and final 0.5 m of each row, totaling the harvest of 2 rows of 5m in length, and a harvested area of 2.5 m². In the soybean threshing process, Vencedora brand machine, powered by a Toyama TDE 110E diesel engine, was used. Each threshed plot was placed in packages and labeled for treatment identification.

After threshing, each sample was weighed, and its moisture content was determined. The weighing of the samples was carried out at the Grain Receiving Unit of Cooperativa Lar, located in the São Roque District belonging to the city of Santa Helena (Paraná State, Brazil). Initially, the samples were passed through sieves to remove impurities before being weighed using a triple beam balance scale by J.B. After weighing the samples, a Gehaka® G939 moisture meter was used to measure their moisture content. The productivity parameters analyzed included the number of pods and grains (g). Four plants from the useful area of each plot (Figure 1) were collected, properly separated, and identified. They were then subjected to manual counting afterward.

FIGURE 1 - Collection of plants from each treatment for grain and pod counting. Source: The author's. 2023.

To determine the weight of a thousand seeds, 150 grains per plot were counted and weighed using a precision electronic scale. Therefore, with the production data obtained per plot, the proportion was calculated to obtain productivity in kg ha^{-1} and the number of 60 kg bags ha^{-1}. With the data of bags produced per hectare, the relative increase in bags produced per hectare (IRSP) (Equation 5).

$$IRSP\ (\%) = (x.100/MSPC) - 100 \quad \text{(Equation 5)}$$

Where:

x = observed data for the plot and

MSPC = average value of bags produced by the control treatment per hectare.

The obtained data were subjected to Shapiro-Wilk normality analysis, and when necessary, they were transformed using the square root of (x+1). Afterward, the data were subjected to analysis of variance using Fisher's F-test, and when significant differences were found among treatments, average were compared using the Scott-Knott grouping test. All tests were conducted at a significance level of 10% using the statistical software Sisvar, version 5.7 (FERREIRA, 2019).

RESULTS AND DISCUSSION

In the assessment of disease severity, conducted at 30 days, it was observed that the relative control of bacterial blight severity was higher for plants treated with strobilurin, associated with triazoles or carboxamides, and for yeasts, with Saccharomyces cerevisiae representing such group, followed by Picoxystrobin + Benzovindiflupyr, Tebuconazole + Trifloxystrobin, and then the group containing Picoxystrobin + Cyproconazole. Meanwhile, within the same control group as the witness, treatments with *Bacillus amyloliquefaciens* and Chlorothalonil were observed (Figure 2).

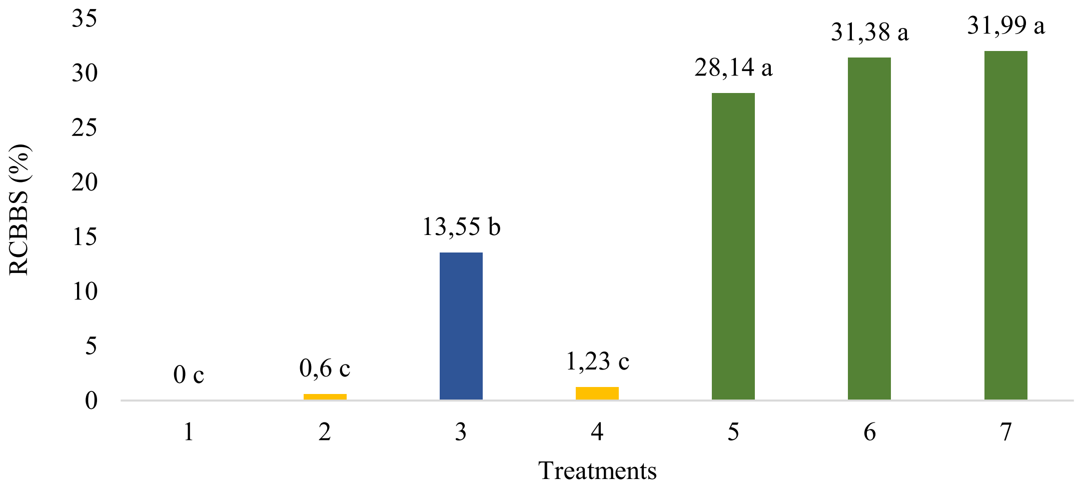

FIGURE 2 - Relative bacterial blight severity control (RCBBS), caused by *Pseudomonas savastanoi*, in soybean plants, subjected to treatments with different fungicides during application 0, at 30 days after sowing, at V3 stage. Note: 1) control, 2) *Bacillus amyloliquefaciens*, 3) Picoxystrobin + Cyproconazole, 4) Chlorothalonil, 5) *Saccharomyces cerevisiae*, 6) Picoxystrobin + Benzovindiflupyr, 7) Tebuconazole + Trifloxystrobin. Average followed by similar letters are statistically similar according to the Scott-Knott test, at 10% probability of error. Coefficient of variation: 31.46%. Average 25.27%.

Regarding the evaluation of disease incidence and severity, the analysis of variance showed significance for all variables, according to the F-test, at a 10% probability of error. The average relative reduction of 30% in bacterial blight on plants sprayed with Picoxystrobin + Benzovindiflupyr (6) and Tebuconazole + Trifloxystrobin (7) was not reported in previous literature consulted for the control of the mentioned bacteriosis (LANNA FILHO, 2015) state that under favorable conditions, the application of copper-based compounds or benzalkonium chloride may be favorable for disease prevention but without any effect on control. In aiming for the control of bacterioses (NASIR et al., 2019) report the effectiveness of mixtures of triazoles and strobilurins in the field against bacterial leaf blight in rice (*Xanthomonas oryzae* pv. *oryzae*), which showed control of 68.63% for the mixture of tebuconazole + trifloxystrobin and 63.67% for azoxystrobin + difenoconazole.

In the case of triazoles, such as tebuconazole, as well as imidazoles, it is known that these have fungicidal action by inhibiting the demethylation in the biosynthesis of fungal membrane sterols (C1, Group 3), while respiratory inhibitors include carboxamides, such as benzovindiflupyr, which affect the inhibition of succinate dehydrogenase (C2, Group 7), and strobilurins, such as picoxystrobin and trifloxystrobin, which are extracellular inhibitors of quinone (C3, Group 11). In this sense (MA et al., 2022), working with the separation of active molecules, report the effect of imidazole alkaloids with potential antibiotic action on bacteria of the genus *Pseudomonas*.

The indirect control effect could also be a probable mode of action observed for some of the tested products, including strobilurins. There are reports of strobilurins acting on processes of inducing resistance in plants, increasing the activity of enzymes such as polyphenol oxidase, peroxidase, phenylalanine ammonia lyase, catalase, chitinase, glucanase, as well as increasing the content of phenols (ARCHANA et al., 2011). For its part, for *S. cerevisiae* (5), the control can be explained by the process of inducing resistance and production of antibiotics, since this biocontroller is a source of Cerevisane (cell wall of *S. cerevisiae*), used in the process of inducing resistance for nonspecific disease control and without direct action on pathogens (BIOSPRINGER, 2023).

The relative control of blister blight of 0.6% for *B. amyloliquefasciens* in the present study, although low, may result from the process of inducing resistance. *Bacillus* mediated induced systemic resistance increases the production of biochemical barriers related to plant resistance (GARCIA et al., 2016). However, induction does not completely inhibit the disease, but it maintains the possibility of associating it with chemical and biological control (ARAUJO et al., 2012).

These results are of great importance, as bacterial blight is considered one of the most common diseases of soybean, and chemical control is limited due to the reduced number of registered products. Control relies on integrated management, where resistant cultivars are constantly used, leading to high selection pressure and population growth of bacteria with resistance (TARAKANOV et al., 2022). In contrast, the relative control of anthracnose severity was superior for Picoxystrobin + Cyproconazole (3), while all other treatments had values similar to the control (Figure 3).

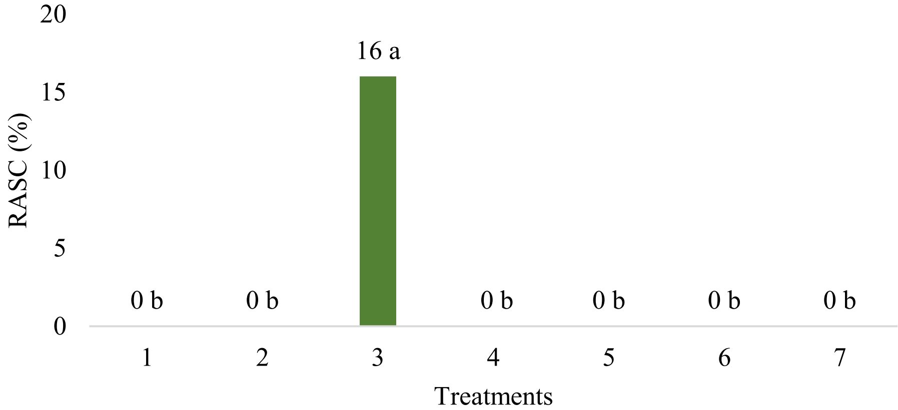

FIGURE 3 - Relative anthracnose severity control (RASC), caused by *Colletotrichum dematium* var. *truncata*, in soybean plants, subjected to treatments with different fungicides during application 0, at 30 days after sowing, at V3 stage. Note: 1) control, 2) *Bacillus amyloliquefaciens*, 3) Picoxystrobin + Cyproconazole, 4) Chlorothalonil, 5) *Saccharomyces cerevisiae*, 6) Picoxystrobin + Benzovindiflupyr, 7) Tebuconazole + Trifloxystrobin. Average followed by similar letters are statistically similar according to the Scott-Knott test at 10% probability of error. Coefficient of variation: 19.12%. Average 2.28%.

In partial agreement with the presented data, the effectiveness of anthracnose control in soybeans has been observed with the use of certain fungicides from the strobilurin group in combination with triazoles, as well as with methyl thiophanate alone or in application sequence with triazoles or strobilurins, and with certain triazoles alone (MEYER and KLEPKER, 2007).

Thun, at 40 days, the disease incidence evaluation was conducted, where the relative disease incidence control showed zero for the control (1) in the isolated group, followed by *B. amyloliquefaciens* (2), and finally, grouped and presenting a better relative disease incidence control rate, Picoxystrobin + Cyproconazole (3), Chlorothalonil (4), *Saccharomyces cerevisiae* (5), Picoxystrobin + Benzovindiflupyr (6), Tebuconazole + Trifloxystrobin (7) (Figure 4).

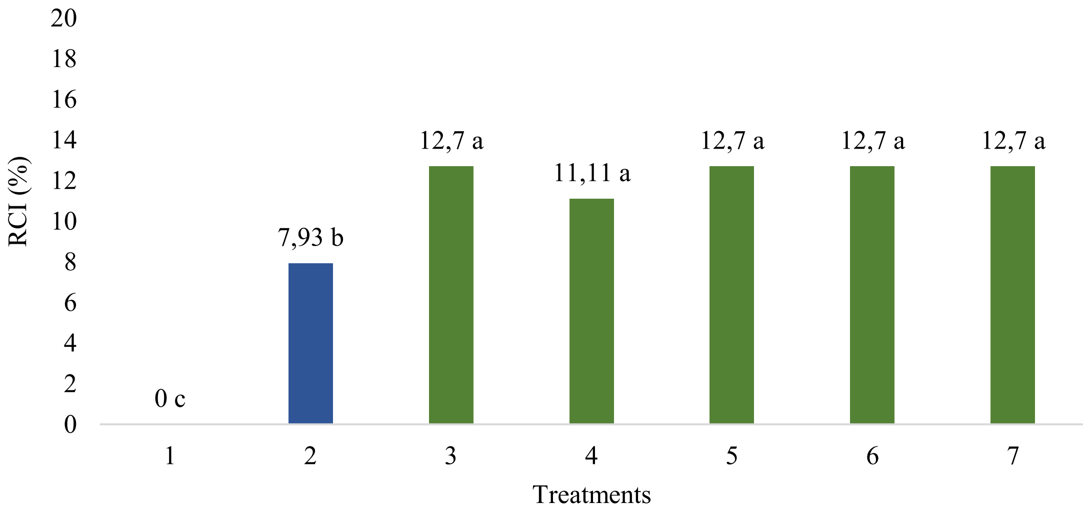

FIGURE 4 - Relative Canopy Increment control (RCI), in soybean plants, subjected to treatments with different fungicides during application 0 at 40 days after sowing, at V3 stage. Note: 1) control; 2) *Bacillus amyloliquefaciens*; 3) Picoxystrobin + Cyproconazole; 4) Chlorothalonil; 5) *Saccharomyces cerevisiae*; 6) Picoxystrobin + Benzovindiflupyr; 7) Tebuconazole + Trifloxystrobin. Average followed by similar letters are statistically similar according to the Scott-Knott test at 10% probability of error. Coefficient of variation: 29.56%. Average 9.97%.

Regardless of the treatment, there was a reduction in the overall disease incidence at 40 days after sowing. This can be explained by the early management at the beginning of the crop in the V3/V4 phenological stages, which is an efficient alternative to reduce damage by pathogens, favoring plants with larger leaf area and greater healthiness (REIS et al., 2014).

Other studies conducted in the form of cooperative trials have demonstrated a reduction in end-of-cycle disease severity from 37% in the control to 22.8% when *Bacillus subtilis* + *Bacillus velezensis* + *Bacillus pumilus* were employed, to 18.2% and 17.6% for chlorothalonil and its association with fludioxonil, 17.2% for mancozeb + azoxystrobin + tebuconazole or mancozeb + difenoconazole + cyproconazole, 16.4% for mancozeb + difenoconazole, and 16.3% for mancozeb + azoxystrobin + protioconazole (GODOY et al., 2022).

The evaluation of soybean vegetative canopy cover showed significance in the analysis of variance according to the F-test at a 10% probability of error for the variables of relative coverage increase at 61 and 114 days after sowing. At 61 days, an average cover of 74.94% was observed, with coverage ranging from 74.24% in the control (1) to 75.44% for picoxystrobin + benzovindiflupyr (6) (Figure 5).

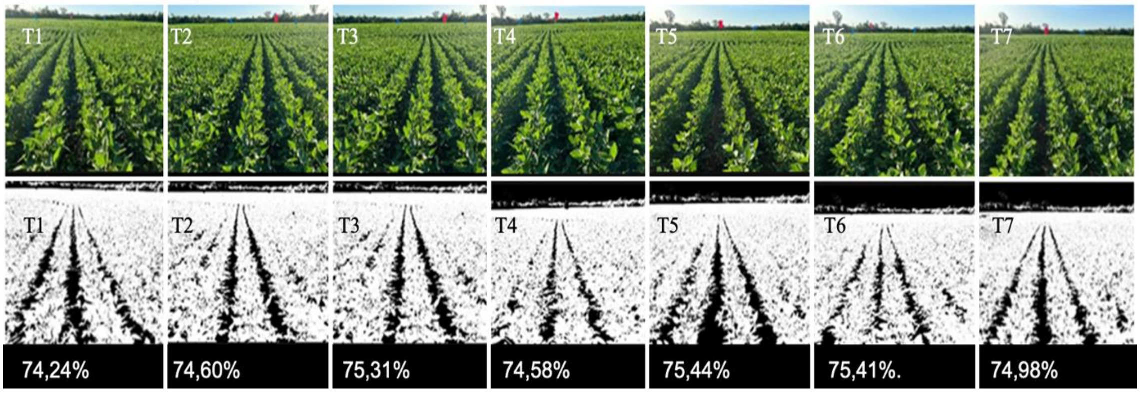

FIGURE 5 - Live vegetative canopy coverage of soybeans at 61 days after sowing, stage R1, and average coverage values presented for each treatment. Note: T1) control, T2) biological treatment (with isolated *Bacillus amyloliquefaciens*), T3) treatment with the chemical group of strobilurins + triazole (active ingredient Picoxystrobin + Ciproconazole), T4) treatment with multisite action (active ingredient Chlorothalonil), T5) biological treatment with natural yeast *Saccharomyces cerevisiae*, T6) treatment with the chemical group of strobilurins + carboxamide (active ingredient Picoxystrobin + Benzovindiflupyr), T7) treatment with the group of triazoles + strobilurins (active ingredient Tebuconazole + Trifloxystrobin). Coefficient of variation: 2.77%. Average: 74.94%.

The relative increase in coverage at 61 days showed higher values for Picoxystrobin + Cyproconazole (3), S. cerevisiae (5), Picoxystrobin + benzovindiflupyr (6), and Tebuconazole + Trifloxystrobin (7). The remaining treatments were grouped together with the control (1) (Figure 6).

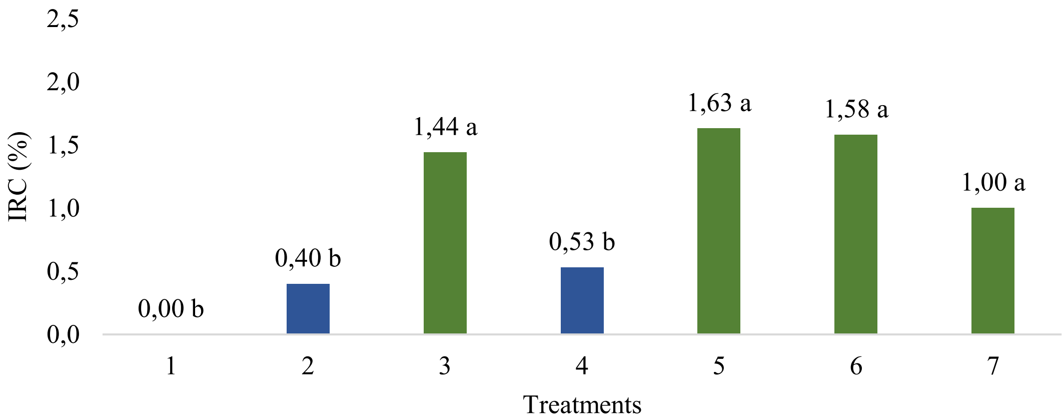

FIGURE 6 - Relative increase in vegetative canopy coverage at 61 days after sowing (IRC), at R1 stage, in soybean plants, subjected to treatments with different fungicides during application 0. Note: 1) control, 2) *Bacillus amyloliquefaciens*, 3) Picoxystrobin + Cyproconazole, 4) Chlorothalonil, 5) *Saccharomyces cerevisiae*, 6) Picoxystrobin + Benzovindiflupyr, 7) Tebuconazole + Trifloxystrobin. Means followed by similar letters are statistically similar according to Scott-Knott test at 10% probability of error. Actual data followed by means transformed by square root of (x+1). Coefficient of variation of square root of (x+1): 18.31%. Average 0.94%.

At 114 days, similar results were observed (Figure 7 and 8). The average canopy coverage at 114 days was 62.91%, ranging from 61.64% for Chlorothalonil (4) to 64.52% for *S. cerevisiae* (5). The data on relative canopy coverage increase showed higher values for Picoxystrobin + Ciproconazole (3) and *S. cerevisiae* (5), which comprised the group with the best results. The other treatments were grouped together with the control (1). Therefore, consistent results were observed for Picoxystrobin + Ciproconazole (3) and S. cerevisiae (5) regarding the maintenance of live vegetative canopy coverage in soybeans in the two evaluations conducted.

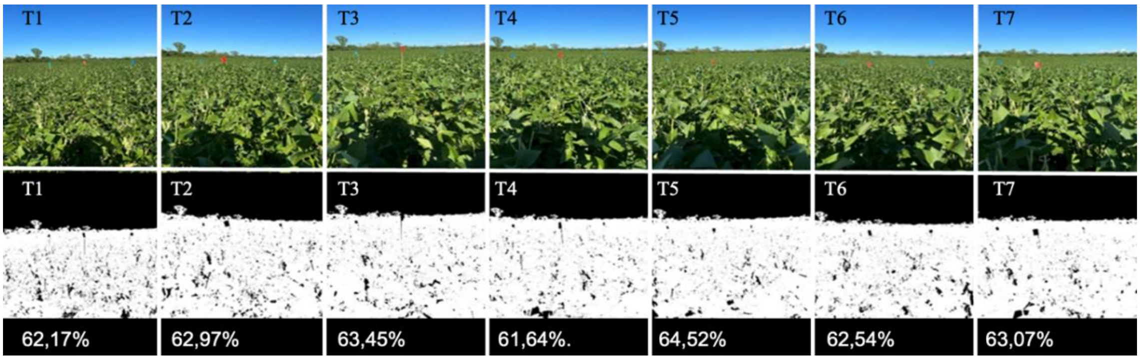

FIGURE 7 - Live vegetative canopy coverage of soybeans at 114 days after sowing, stage R5, and average coverage values presented for each treatment. Note: T1) control, T2) biological treatment (with isolated *Bacillus amyloliquefaciens*), T3) treatment with the chemical group of strobilurins + triazole (active ingredient Picoxystrobin + Ciproconazole), T4) treatment with multisite action (active ingredient Chlorothalonil), T5) biological treatment with natural yeast *Saccharomyces cerevisiae*, T6) treatment with the chemical group of strobilurins + carboxamide (active ingredient Picoxystrobin + Benzovindiflupyr), T7) treatment with the group of triazoles + strobilurins (active ingredient Tebuconazole + Trifloxystrobin). Coefficient of variation: 5.13%. Average: 62.91%.

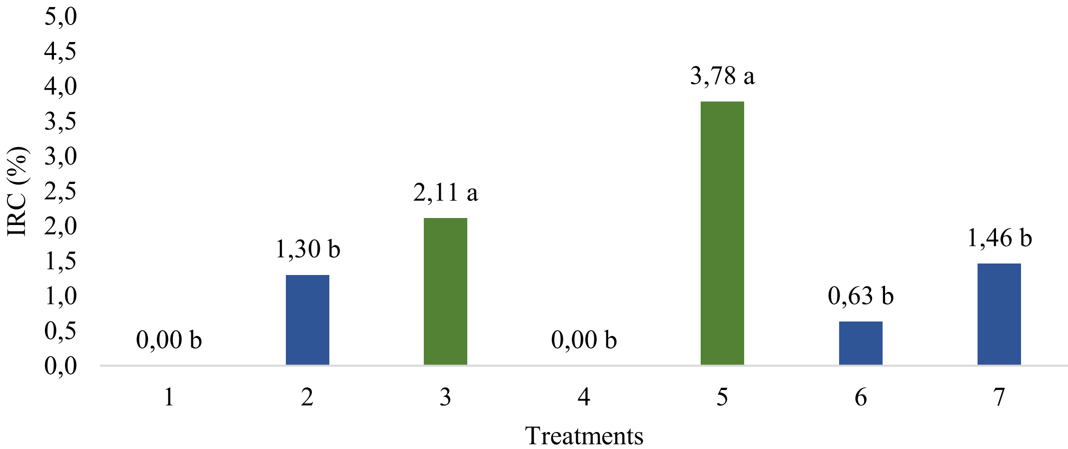

FIGURE 8 - Relative increase in vegetative canopy coverage at 114 days after sowing (IRC), at R5 stage, in soybean plants, subjected to treatments with different fungicides during application 0. Note: 1) control; 2) *Bacillus amyloliquefaciens*; 3) Picoxystrobin + Cyproconazole; 4) Chlorothalonil, 5) *Saccharomyces cerevisiae*, 6) Picoxystrobin + Benzovindiflupyr, 7) Tebuconazole + Trifloxystrobin. Means followed by similar letters are statistically similar according to Scott-Knott test at 10% probability of error. Actual data followed by means transformed by square root of (x+1). Coefficient of variation of square root of (x+1): 31.67%. Average 1.32%.

S. cerevisiae was evaluated for controlling white mold (*Sclerotinia sclerotiorum*), target spot (*Corynespora cassiicola*), and Phytophthora root rot (*Phytophthora sojae*) in soybeans, where *S. cerevisiae* stood out compared to other tested yeasts, showing lower severity and promoting growth (SAAB, 2018). Additionally, the efficacy of fungicides in soybean cultivation indicates that triazoles associated with strobilurins or benzimidazoles showed lower severity compared to the control (GODOY et al., 2007), which is consistent with the data observed in the present trial. Therefore, it can be stated that the use of chemical treatment increased the coverage of live soybean canopy. This factor may be correlated with the previously presented data related to disease occurrence control since lower disease incidence can prolong leaf retention (SILVA et al., 2013).

During the cultivation, meteorological conditions such as temperature and humidity can influence disease occurrence. Therefore, below are the climatological temperature data collected throughout the trial period, according to the AccuWeather climatology website (Figure 9), and rainfall data collected daily using a conventional rain gauge (Figure 10).

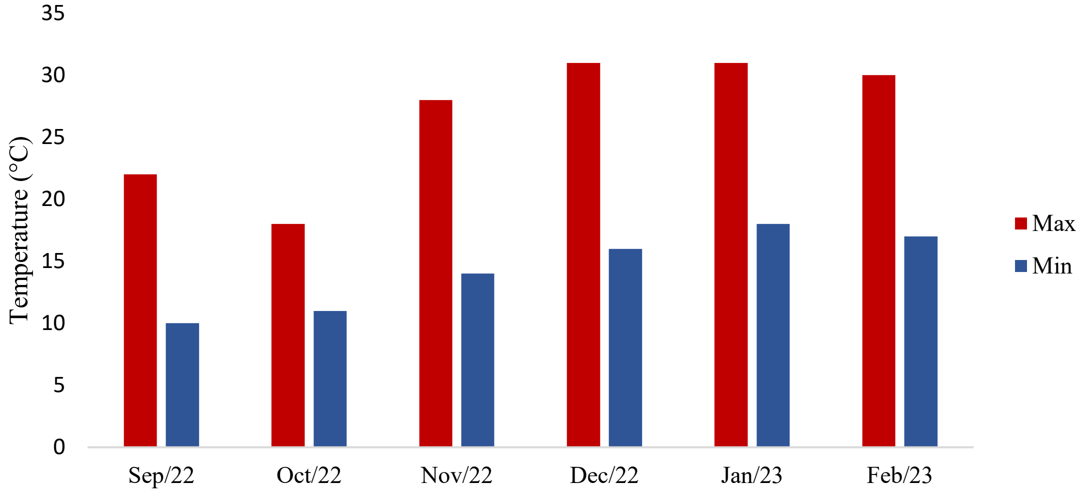

FIGURE 9 - Temperature data for the 2022/23 soybean crops.

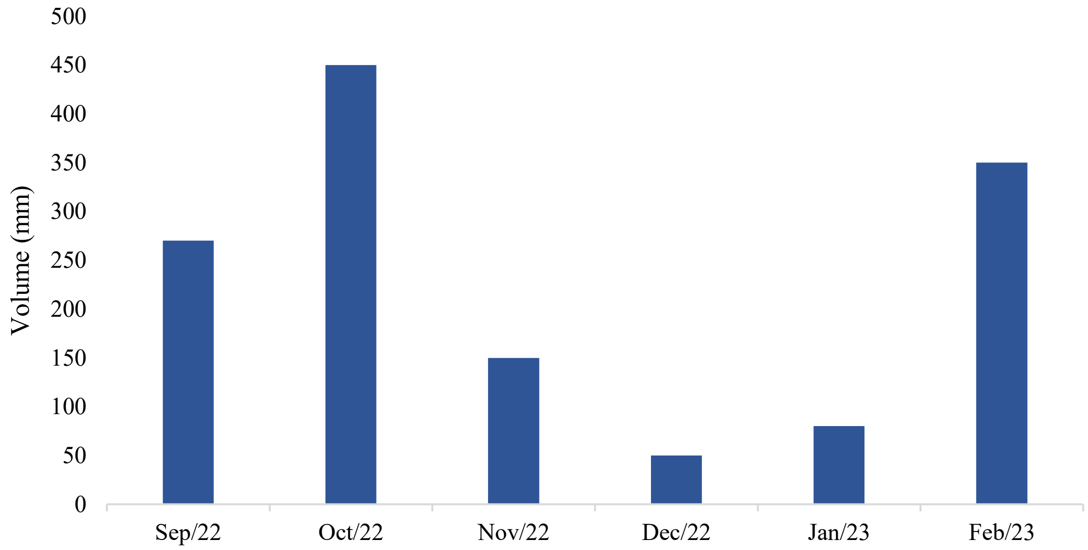

FIGURE 10 - Preciptation data for the 2022/23 soybean crops.

It can be observed that in the months of September and October, we experienced high precipitation and mild temperatures. However, from November to January, temperatures were higher and precipitation was lower. This may have resulted in a reduction in leaf area, damage to grain quality, formation of defective pods, and even a decrease in grain weight. According to Tagliapietra; Zanon (2022), high temperatures above 40°C negatively affect soybean cultivation, especially during the reproductive phase, resulting in damage to flowering, loss of pods, reduction in leaf area, leading to leaf necrosis with symptoms of dry leaves, thus reducing productivity potential. The occurrence of water stress during the grain filling stage also leads to less accumulation of dry matter in the grain, reducing grain size (BAIOCO et al., 2023).

The analysis of variance indicated significance for the treatments in the variables of grain number, pods, and relative productivity increment, while the results were not significant for treatments in the analysis of productivity and wet and dry thousand grain weight. The grain number showed higher values for the control (1), *Bacillus amyloliquefaciens* (2), Picoxystrobin + Ciproconazole (3), Chlorothalonil (4), *Saccharomyces cerevisiae* (5), lower values for Picoxystrobin + benzovindiflupyr (6) and Tebuconazole + Trifloxystrobin (7). However, opposite results were observed for pod number (Figure 11).

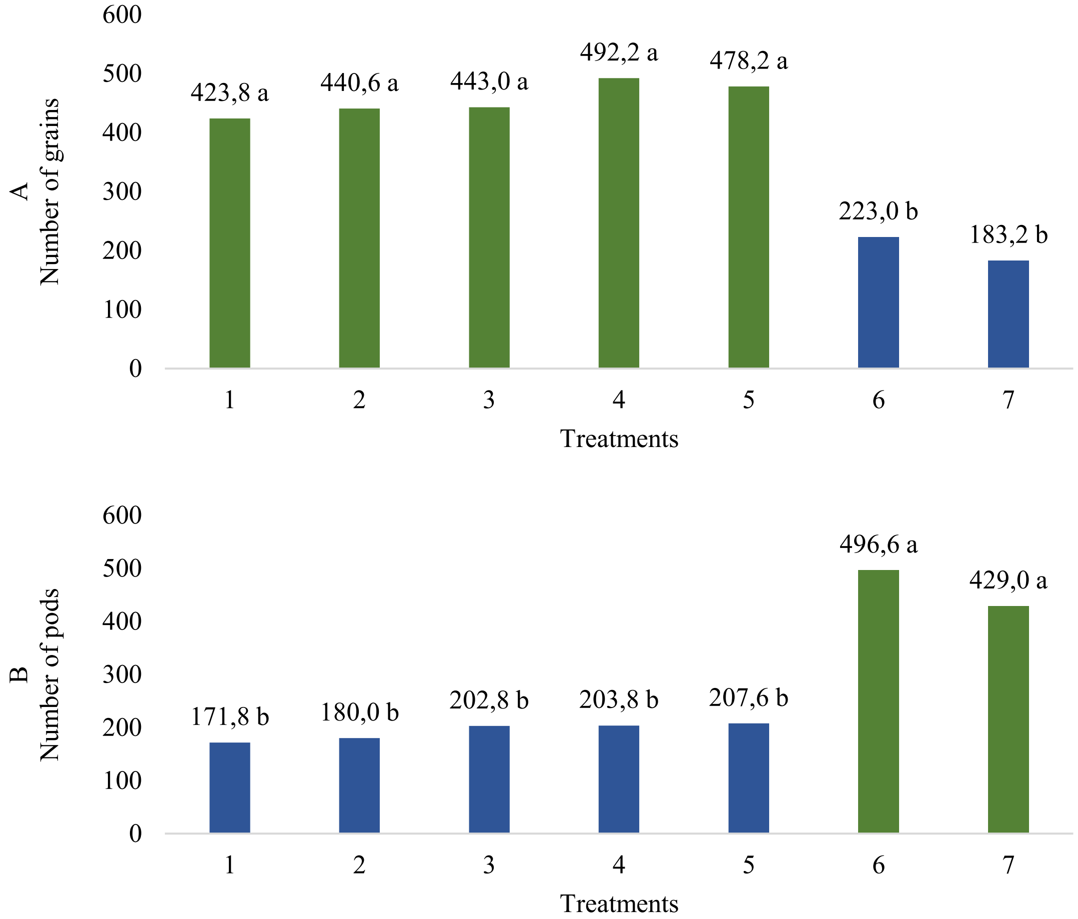

FIGURE 11 - Number of grains (A) and pods (B) of B5595CE soybean subjected to treatments with different fungicides during application 0. Note: 1) control, 2) *Bacillus amyloliquefaciens*, 3) Picoxystrobin + Cyproconazole, 4) Chlorothalonil, 5) *Saccharomyces cerevisiae*, 6) Picoxystrobin + Benzovindiflupyr, 7) Tebuconazole + Trifloxystrobin. Average followed by similar letters are statistically similar according to the Scott-Knott test at 10% probability of error. Coefficient of variation: 18.40%. Average 383.43 grains (A) and 270,22 pods (B).

The mass of one Thousand seeds, on the other hand, did not show significant difference, whether wet or dry (Figure 12), reflecting on productivity (Figure 13). Where the average productivity was 73.60 sacks of 60 kg ha^{-1} of soybeans. This data, in general, showed a small increase for the treatments compared to the control, without significant differences. Therefore, the relative production increase (Figure 14) indicated that *Bacillus amyloliquefaciens* (2), Picoxystrobin + Ciproconazole (3), *Saccharomyces cerevisiae* (5) and Tebuconazole + Trifloxystrobin (7) stood out.

However, in this experiment, considering parameters of health, leaf retention, and productivity, the use of Picoxystrobin + Ciproconazole or *S. cerevisiae* in application zero stood out. It is important to note that previous studies indicate that the weight of a thousand grains shows a strong correlation with severity and defoliation compared to the correlation between productivity (kg ha^{-1}) and severity, indicating that the weight of a thousand grains is more influenced by disease control than productivity, where various factors such as genetics, fertility, pests can impact yield (OTOLAKOSKI et al., 2023).

B. subtilis, *B. pumilus*, and *B. amyloliquefaciens* employed in two initial applications combined with two of fungicides or associated in the four applications resulted in good performance in reducing end-of-cycle diseases, among which anthracnose was evaluated, also observing an increase in productivity (MUNIZ et al., 2023). Still, regarding the benefit of using biologicals, the use of yeasts in controlling fungal diseases and soybean productivity by *S. cerevisiae* was observed by Calixto (2020), similarly to what was observed in the present trial.

Similarly to what was observed for soybeans, in rice cultivation, productivity increases of 1.30% were observed for plants treated with tebuconazole + trifloxystrobin, and productivity increases of 0.47% were observed for azoxystrobin+difenconazole, with also a reduction in bacterial spots at rates above 30% (NASIR et al., 2019). Possibly, increases in productive variables may also result from other processes induced by each specific component. For example, in soybeans, strobilurins have a proven tendency to accumulate more dry matter in flowers, indicating an improvement in the reallocation of photoassimilates to the plant's reproductive system, suggesting that these plants would be prioritizing their production (BASSO et al., 2015).

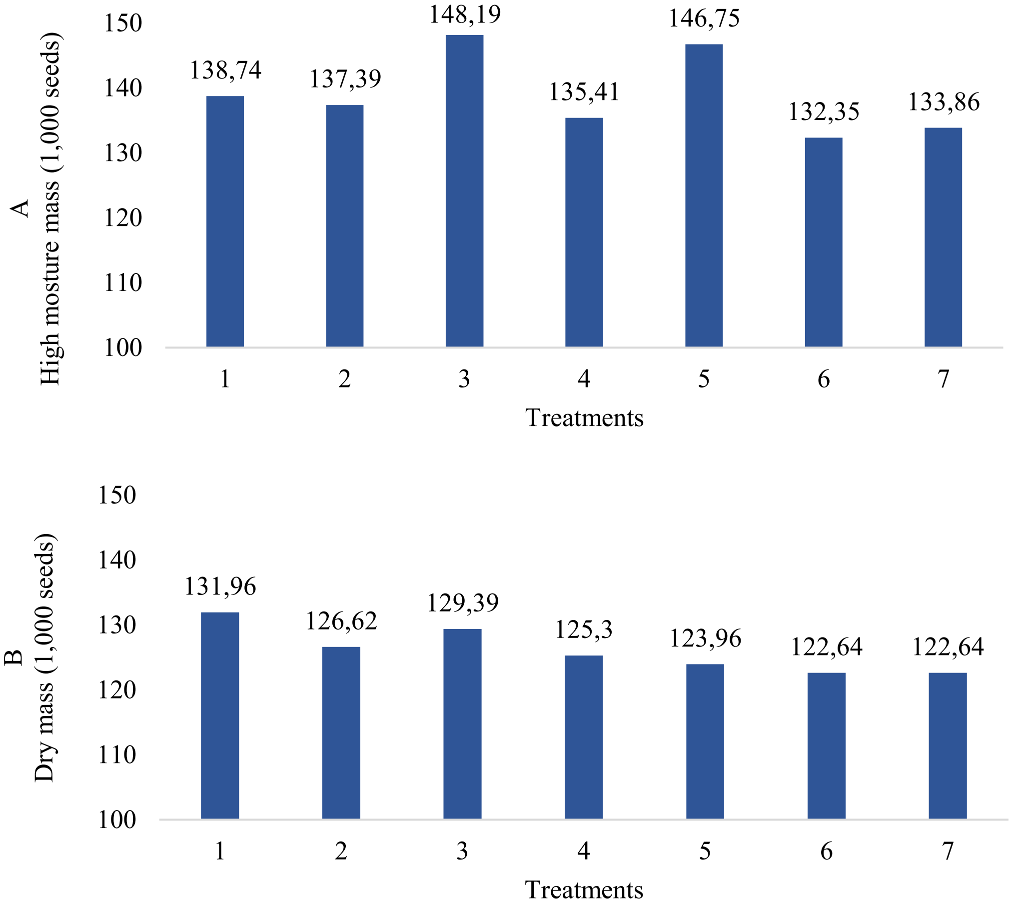

FIGURE 12 - Dry and high mosture mass of one Thousand seeds, of B5595CE soybean, subjected to treatments with different fungicides during application 0. Note: 1) control, 2) *Bacillus amyloliquefaciens*, 3) Picoxystrobin + Cyproconazole, 4) Chlorothalonil, 5) *Saccharomyces cerevisiae*, 6) Picoxystrobin + Benzovindiflupyr, 7) Tebuconazole + Trifloxystrobin. Treatments did not differ significantly according to the F test, at a 10% probability of error. Coefficient of variation: 7.76% (A), 6.28% (B). Average 138.95g (A) and 126.06g (B).

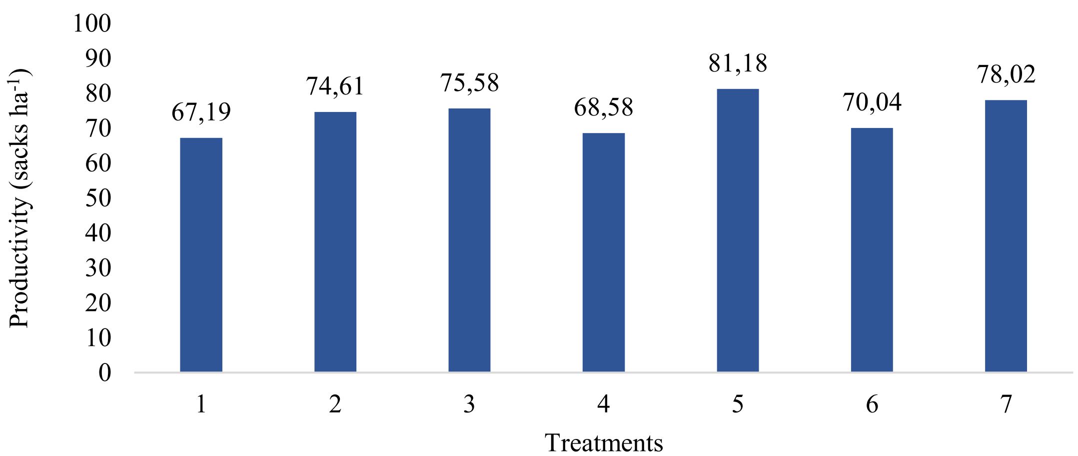

FIGURE 13 - Productivity, in 60 kg bags, of soybean B5595CE, subjected to treatments with different fungicides during application 0. Note: 1) control, 2) *Bacillus amyloliquefaciens*, 3) Picoxystrobin + Cyproconazole, 4) Chlorothalonil, 5) *Saccharomyces cerevisiae*, 6) Picoxystrobin + Benzovindiflupyr, 7) Tebuconazole + Trifloxystrobin. Treatments did not differ significantly according to the F test at a 10% probability of error. Coefficient of variation: 14.22%. Average 73.60 sacks ha^{-1}.

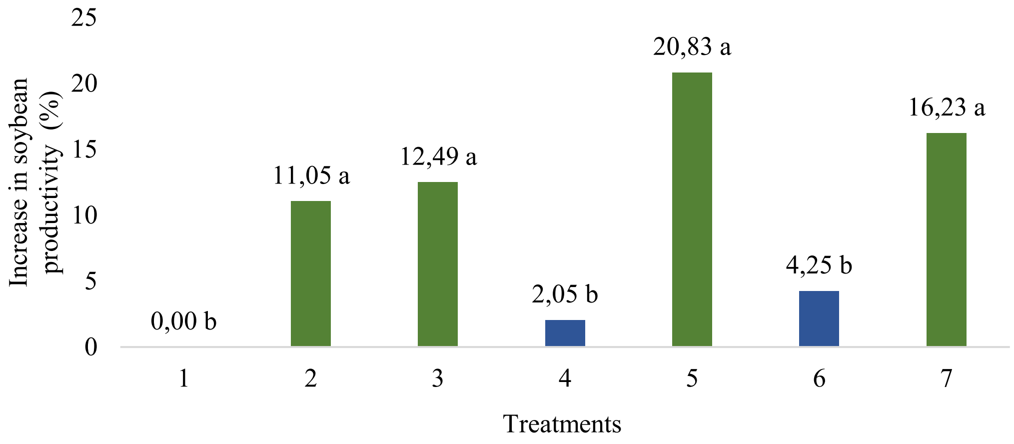

FIGURE 14 - Increase in soybean productivity per hectare (%), of soybean B5595CE, subjected to treatments with different fungicides during application 0. Note: 1) control; 2) *Bacillus amyloliquefaciens*; 3) Picoxystrobin + Cyproconazole; 4) Chlorothalonil, 5) *Saccharomyces cerevisiae*, 6) Picoxystrobin + Benzovindiflupyr, 7) Tebuconazole + Trifloxystrobin. Means followed by similar letters are statistically similar according to Scott-Knott test, at 10% probability of error. Actual data followed by means transformed by square root of (x+1). Coefficient of variation of square root of (x+1): 58.23%. Average 9.54%.

It is important to note that the considerations listed here do not exhaust the study's object, since productivity depends on genotype, health, and climate (BAPTISTA et al., 2021). Observing the control of leaf blight, anthracnose, and overall disease incidence, as well as leaf retention, through the live vegetative cover index and productivity variables, under the conditions of this trial, treatments with Picoxystrobin + Ciproconazole and Saccharomyces cerevisiae stood out compared to the other treatments, being recommended for use in the zero application stage.

It is worth emphasizing the need for continuous research to optimize disease control and genotype responses for sustainable and economic production. This study highlights the effectiveness of Picoxystrobin + Ciproconazole and *Saccharomyces cerevisiae* in improving plant health, leaf retention, and yield. However, productivity is influenced by genetics, environment, and pest dynamics, requiring further studies to refine integrated disease management strategies.

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