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Amino Acidsaction on Agrochemicals Applied in Soybean 'BMX Potência RR'

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Abstract

To investigate an agrochemical able to exert effect against stresses caused by fungicides and plant growth regulators (PGR) in soybean, we carried out an essay aiming to test a mixture of amino acids that has potential effect against chemical stress damages in plants. Potted soybean plants were sprayed with a fungicide (3 mL L^{-1}) at V5, R2, and R3 stages and a PGR (30 mg L^{-1}) at V5 stage, with and without amino acids (5 mL L^{-1}),besides application of amino acids isolated, and the check. Therefore, six treatments with six replications were utilized in a randomized blocks design and data were analyzed by the Tukey test ($p<0.05$). The fungicide applied three times in soybean 'BMX Potência RR' reduced the pods and grains dry mass and pods and grains number, increasing the chlorophyll content in the leaves. The fungicide +amino acids reduced the shoot and pods dry mass and grains number, and increased chlorophyll content. The PGR +amino acids reduced the chlorophyll content, shoot dry mass, and pods number.

Keywords: fungicide, plant growth regulator, chemical stress, fungal diseases

1. Introduction

The 2010/11 Brazilian crops of soybean amounted to 75.0 million hectares, producing 60.1 million tons with 3,106.0 kg ha^{-1} of average productivity (Conab, 2011). However, the crop production has been affected by aggravated fungal diseases, causing considerable damage to growers, breeding programs, and therefore tothe country (Sediyama*et al.*, 2005). In Brazil, 34 types of fungal diseases in soybean have been identified (Embrapa, 2010). Among the main diseases, it is the Asian soybean rust, caused by *Phakopsorapachyrhizi*, which has provoked great concerns among growers and technicians. It has spread for all producing regions, mainly after the 2002/03 crop season, posing as a threat to the crop due to the damage caused, besides increased production costs for its control. The most widespread and effective method still used in controlling the Asian soybean rust is the use of fungicides. Among the fungicides most commonly used are mixtures of different groups of strobilurins with triazoles, which have proven effective in controlling the disease (Embrapa, 2010). Characteristic abiotic stress effects of triazole application in plants include reduction in height, increase in stem diameter, and compactness of the plant canopy. The intensity of these changes depends on the triazole, dose and method of application, plant species, and its stage of development. Plants treated with triazole have smaller, but thicker leaves with thicker cuticle. The increase in leaf thickness has been correlated with the increase in the diameter of cells and/or with the presence of additional cell layers (Gao*et al.*, 1988). Abiotic stresses affect negatively the plant growth and productivity, resulting in more than 50% of losses in the production of crops. When under abiotic stress, plants may present wilting and/or necrosis, reduction in leaf area, decreasing number of leaves due the abscission, increased radicular growth, more wax deposition on the leaves, flowers and fruits abortion, poorly developed fruits, and others. However, symptoms can vary with the kind of stress.

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Although the usage and the diversity of these products are increasing, there are controversies on the amino acids utilization in agriculture, once the isolated application has shown few significant effects. Thereby, it is evident the necessity of more information about the amino acids application in crops, mainly when they are under abiotic stresses. One of the problems most faced by the soybean growers is the intense vegetative growth, which causes plants lodging, damaging the harvest and making it difficult. It occurs in function of strong fertilizations aiming production increases, excess of nitrogen, cultivar of excessive indeterminate growth, climate conditions that cause atmospheric turbidity, besides spacing that promotes high density and competition for light, causing plants to get etiolated. All this energy could be allocated for the grains production. In the majority of plants, the apical bud growth inhibits the axillary buds development, phenomenon named apical dominance. Auxin, hormone synthesized in the apical meristems and transported in basipetal direction, is responsible for this phenomenon. Inhibitors of the auxin transport, such as the 2,3,5-triiodobenzoic acid (TIBA), can eliminate the axillary buds suppression (Taizand Zeiger, 2004). This PGR inhibits the basipetal polar transport of the auxin by competing with this hormone for the same binding site of the transporter proteins, localized in the plasmatic membrane (Geldner*et al*., 2001).The TIBA effects, at concentrations of 25, 50, and 75 g L^{-1}, applied at the beginning and the middle of soybean flowering, have been studied. Independently of the concentration applied, the spraying at the middle of flowering promoted higher grains production and also increased the seeds germination and vigor(Rezende, *et al*., 1981). In India, in a field experiment with soybean, foliar applications of TIBA were made at concentrations from 50 to 250 mg L^{-1}.The chlorophyll and nitrogen contents in the leaves were increased with the PGR application. The highest seeds production was obtained with the concentration of 100 mg L^{-1}(Deotale*et al*., 1996). Similar results were obtained in another work (Pankaj*et al*., 2001), in which the TIBA applications at concentrations of 50 and 100 mg L^{-1}permitted the highest total biomass at the harvest and highest seeds production.

According to the literature, the TIBA effects vary, mainly, in function of the concentration and the phenological stage in which it is applied. The application of TIBA (30 mg L^{-1}) in soybean 'BMX Potência RR', at the phenological stage V5, significantly reduced the plants height, making them more compact, without affecting the parameters related to the production(Cato and Castro, 2006). The application of products based on amino acids in wheat caused an increase up 24.13% in the spikes production and 10.73% in the grains yield, once this higher productivity possibly was due to the fact that, during the essay conduction period, there were reduced precipitation and occurrences of low temperatures in the initial stage of the wheat development, which led the author to conclude that the products based on amino acids provide benefits to the wheat crop under adverse conditions of climate. In another study, common bean 'Carioca' plants were submitted to high temperature and radiation stresses, and it may be observed that plants treated with product based on amino acids, 23 days after sowing, had grains number and dry mass increased (Castroand Carvalho, 2013). The mixture of amino acidstested in this study is an organic mineral agrochemical constituted of products from controlled processes of bio-fermentation of the monosodium glutamate production. It combines contents of organic matter (6%) with nitrogen (11%) and potassium oxide (1%) to provide nutritional and physiological equilibrium to the plants. It is recommended 1 L ha^{-1}(0.5 L 100 L^{-1}) water, applied at 30 days after emergence, at pre and post-flowering of soybean (Fertilizantes Ajinomoto, 2012).This mixture has potential to exert effect against stresses caused by the agrochemicals application in the soybean crop. It has been observed that more than 2 sprayings with a fungicide, constituted of cyproconazole + azoxystrobin, efficient against the Asian soybean rust, cause stress in the plant, altering the morphology and coloring of leaves and reducing the crop production potential(Moura*et al*., 2013). It has also been observed that the spraying with TIBA (30 mg L^{-1}), at V4 or V5 stages, modifies the plants architecture, making them more compact, altering the foliar morphology and preventing their lodging (Cato and Castro, 2006). The experiment was carried out to study the action of amino acids applied by foliar sprayings on the development and productivity of soybean submitted to stresses due to the fungicide and PGRutilization.

2. Material and Methods

The experiment was carried out in the Experimental Field of the Biological Sciences Department of Luiz de Queiroz College of Agriculture, University of São Paulo, Piracicaba-SP, Brazil. Plants were grown in pots (20 L) under natural conditions, with substrate of clay, sand, and organic matter (2:1:1).

The soybean 'BMX Potência RR' sowing was made in October of 2012, being the sprayings with the fungicide (3 mL L^{-1}) realized at V5, R2, and R3 stages, with and without amino acids (5 mL L^{-1}). PGR(30 mg L^{-1}) was sprayed at V5 stage, with and without amino acids (5 mL L^{-1}), besides application of amino acids (5 mL L^{-1}) isolated and the check. Therefore, six treatments and six replications were utilized, totaling 36 plots. Each experimental plot was constituted of one pot. The experimental design utilized was randomized blocks and data were analyzed by the Tukey ($p<0.05$) test. The following variables were assessed: indirect chlorophyll content (SPAD index) at 112 days after sowing (DAS), shoot dry mass, pods number and dry mass, grains number and dry mass at 153 DAS, besides electronic microscopy of foliar samples of the treatments at 148 DAS.

3. Results and Discussion

The chlorophyll content (SPAD index) showed more elevated in the plants treated with the fungicide only and with the fungicide + amino acids at 112 DAS, characterizing the "green effect" phenomenon caused by more than 2 sprayings of the triazole + strobirulin, by the Tukey test ($p<0.05$) according to the Table 1.This phenomenon, that could reduce or promote the crop productivity, has been referred as tonic effect of some agrochemicals (Aramaki*et al.*, 2013). Triazoles could increase the amount of chlorophyll per chloroplast without affect the number of chloroplasts in the cells of the leaf (Barnes*et al.*, 1989).Application of strobirulin in soybean reduced the water conductance through stomata closure resulting in lower rates of intercellular CO_2, transpiration, and net photosynthesis. However, strobirulin reduces photosynthesis regardless of the effect on stomata (Nason, 2004). The shoot dry mass (SDM) of soybean 'BMX Potência RR' presented highest at 153 DAS in the plants sprayed with amino acids in relation to those treated with PGR + amino acids, fungicide + amino acids, and fungicide only, according to the Tukey test ($p<0.05$). Amino acids and PGR did not differ from the control (Table 1). This is important because both maintain the production potential of the soybean 'BMX Potência RR', and could be used without causing problem to the crop.

Table 1: Effects of applications of fungicide (azoxystrobin + cyproconazole), plant growth regulator (PGR) (2, 3, 5-triiodobenzoic acid), and amino acids in soybean 'BMX Potência RR' evaluated by the following variables: indirect chlorophyll content (SPAD), shoot dry mass (SDM), pods number (PN), pods dry mass (PDM), grains number (GN), and grains dry mass (GDM).

Treatments	Parameters					
	SPAD	SDM (g)	PN	PDM (g)	GN	GDM (g)
Check	45.95 bc*	93.66 ab	350.33 ab	135.62 ab	803.83 ab	93.19 a
Fungicide	52.87 a	58.28 bc	253.00 c	88.02 c	496.67 c	61.61 b
Fungicide + Amino Acids	54.42 a	46.97 c	285.33 bc	99.97 c	565.33 c	70.55 ab
PGR	46.65 bc	74.64 abc	349.50 ab	115.75 abc	757.83 ab	75.97 ab
PGR + Amino Acids	43.92 c	46.97 c	277.50 c	106.10 bc	648.33 bc	73.66 ab
Amino Acids	47.38 b	95.14 a	396.00 a	114.19 a	904.17 a	96.44 a

*Similar letters in the columns indicate that there was no difference among the means compared by the Tukey test ($p>0.05$).

The pods number (PN) was superior in the treatment with amino acids in relation to the plants sprayed with fungicide, fungicide + amino acids, and PGR + amino acids at 153 DAS, by the Tukey test ($p<0.05$), according to the Table 1. This result showed the capacity of the amino acids, applied isolated, in maintain the production potential of the control and PGR application. The pods dry mass (PDM) harvested at 153 DAS also showed superior in the soybean treated with amino acids, compared to those originated of plants sprayed with fungicide, fungicide + amino acids, and PGR + amino acids, by the Tukey test ($p<0.05$), according to the Table 1. This confirms the maintenance of the production potential of the soybean. Amino acids increased the grains number (GN) at 153 DAS, in relation to the soybean sprayed with fungicide, fungicide + amino acids, and PGR + amino acids, by the Tukey test ($p<0.05$), according to the Table 1, demonstrating the soybean production maintenance by the use of amino acids. It has been verified that other leguminous (common bean) under stress of high temperature and radiation also presented higher grains number when treated with a product composed of amino acids(Castro and Carvalho, 2013).

The grains dry mass (GDM) harvested at 153 DAS showed superior in the soybean treated with amino acids, compared to that sprayed with fungicide, by the Tukey test (5%), according to the Table 1. In this case, we can observe the reduction of the production potential caused by the application of the fungicide isolated and the attenuation of this effect caused by the combination with amino acids.The GDM was also increased in common beans treated with a complex of amino acids, when submitted to high temperature and radiation stress (Castro and Carvalho, 2013). The observation of the morphology of plants treated with the agrochemicals demonstrated a similarity between those ones treated with amino acids and the control. Plants of these treatments had light green and elongated leaves, different of the dark green and oval leaves of those ones sprayed with fungicide and fungicide + amino acids. Leaves of plants treated with PGR and PGR + amino acids also presented certain similarity with those of the treatments with fungicide, however of lower intensity. After all, PGR and the triazole constituent of the fungicide, are classified as plant growth retardants. According to some results, soybean plants treated with TIBA developed a great number of branches and small dark-green colored leaves (Burton and Curley, 1966; Hicks*et al.*, 1967). It was observed that there is a variation in the epicuticular wax content and that this difference also occurs in the wax morphology (Figure 1). The wax variation is more perceptible in the abaxial than in the adaxial face of the leaf. In the control, it was found epicuticular wax of flocculated morphology with high intensity. In the treatment fungicide + amino acids, there was a decrease in the epicuticular wax intensity and in the treatment PGR + amino acids, there was an alteration in the wax morphology, changing from a flocculated aspect to smooth film wax type. It is known that the fungicides application reduces the wax content and also can alter its morphology, which can make the plant more susceptible to diseases, pests, and water stress.

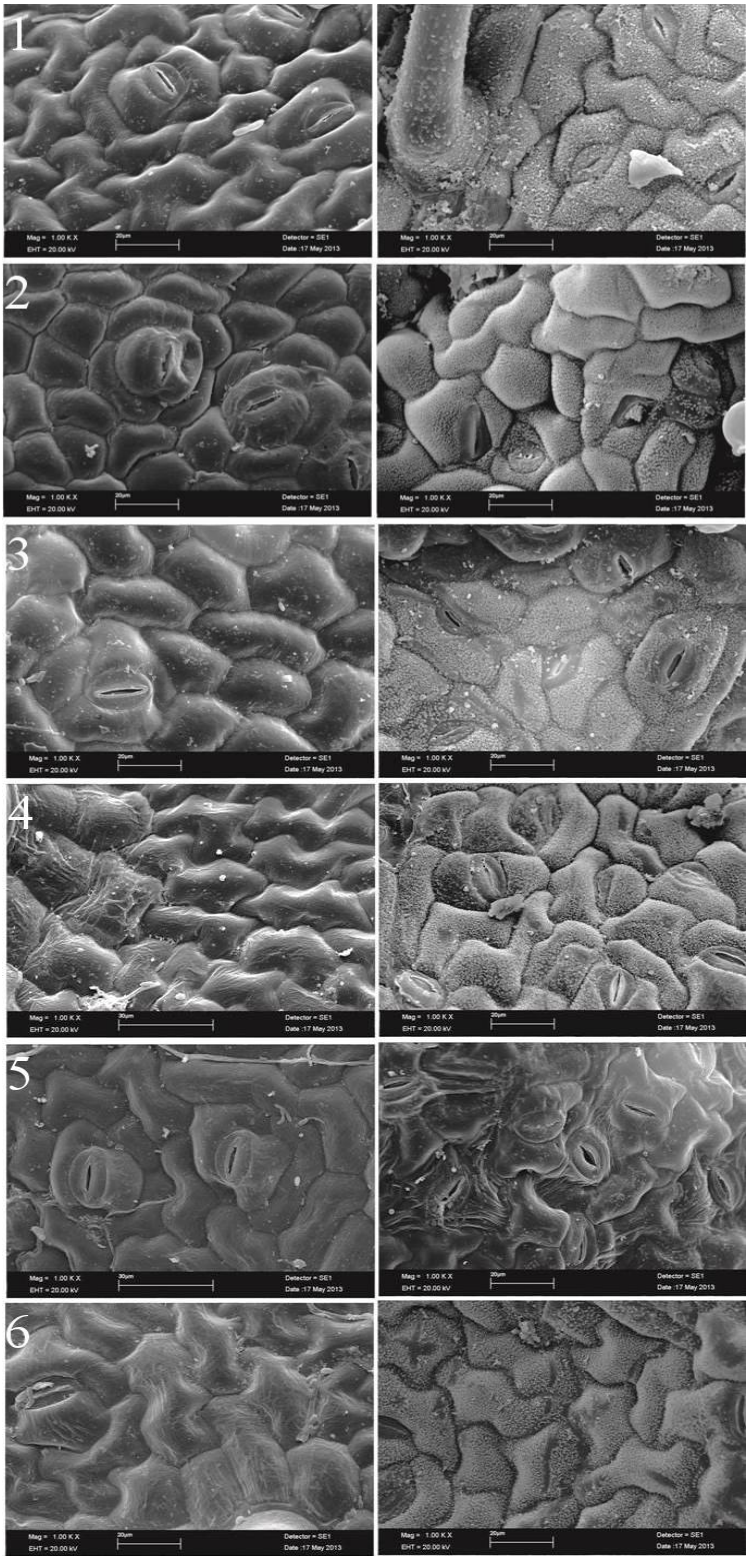

Figure 1: MEV 1000X of the soybean epidermis surface: adaxial (left) and abaxial (right) faces. 1 – Check; 2 – Fungicide; 3 – Fungicide + Amino Acids; 4 – Plant Growth Regulator (PGR); 5 – PGR + Amino Acids; 6 – Amino Acids

4. Conclusion

Fungicideapplication increases chlorophyll content but reduces the production potential of soybean, but this effect might be attenuated with the incorporation of amino acids. The use of amino acids can intensify the action of the PGR.

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