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## Thiamethoxam: An Inseticide that Improve Seed Rice Germination at Low Temperature

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Additional information is available at the end of the chapter

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### 1. Introduction

The discovery of thiamethoxam has opened new perspectives for the Brazilian agriculture, mainly in seed treatment. The molecule was the center of studies by a group of researchers from official agencies and universities, in order to evaluate its mechanism of action.

Researches were made to establish the activity of the active ingredient on the physiology of the plant, when applied the soybean seed treatment. It was observed that seed germination index and seedling vigor were higher than those of plants in plots without seed treatment. It was also found that, under water stress conditions soybean plants from seed treated with thiamethoxam showed better growth, such as increased length and root volume, faster initial development, higher leaf area, height, number of pods and green colored more intense.

The various pesticides used today can be classified into different classes (CASTRO, 2006), such as:

- a. Regulatory Plant or Bio-regulators - organic compounds, non-nutrient, which applied to the plants, at low concentrations promotes, inhibits or modifies some morphological or physiological plant process. The term regulator is restricted to natural or synthetic compounds, applied externally in plants (named exogenous).
- b. Plant Hormones - substances produced by plants, which at low concentrations regulate morphological and physiological processes of the plant. Hormones can move within the plant from the generated to the action site, or be produced at the action site. The term hormone is restricted to products that occur naturally in plants (named endogenous).

Belonging to both the previous classes, there are: auxins, gibberellins, cytokinins, abscisic acid and ethylene. It is considered, for the bio-regulator acts, that it must primarily bind to a receptor on the plasmatic membrane of the cell.

- c. Plants Stimulants or bio-stimulants - mixtures of plant regulators, occasionally along together nutrients, vitamins, amino acids or miscellaneous debris. They exhibit a different stimulatory effect than if application isolated, creating a synergistic effect between regulators. Some examples of bio-stimulants the Stimulate are Promalin and e mixture  $GA_3 + 2,4-D$ .
- d. Bioactivators - complex organic substances, that modify the morphology and physiology of plants and are capable of acting in the synthesis and action of endogenous hormones, leading to increase in productivity. In this class some insecticides fit, such as aldicarb and thiamethoxam, besides of the hydrogen cyanamide.

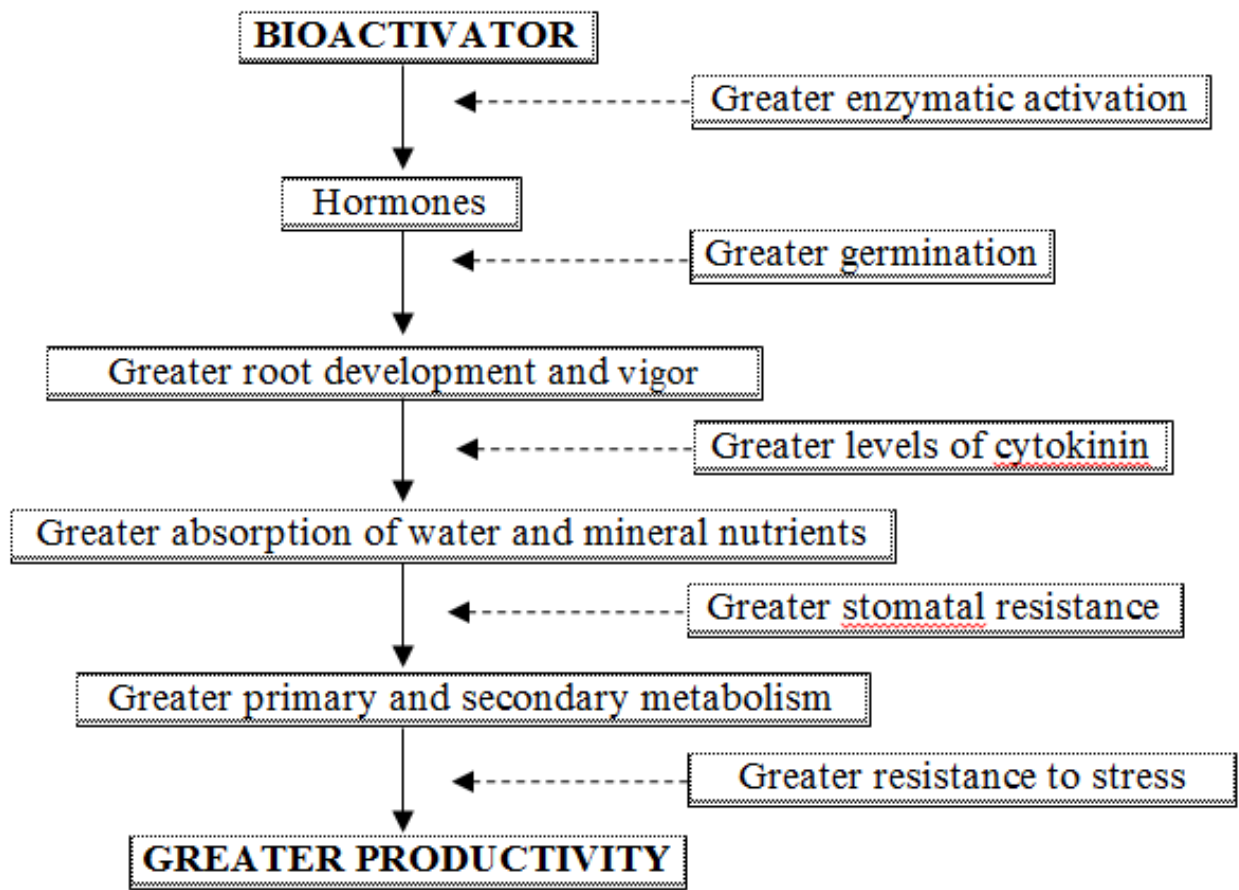


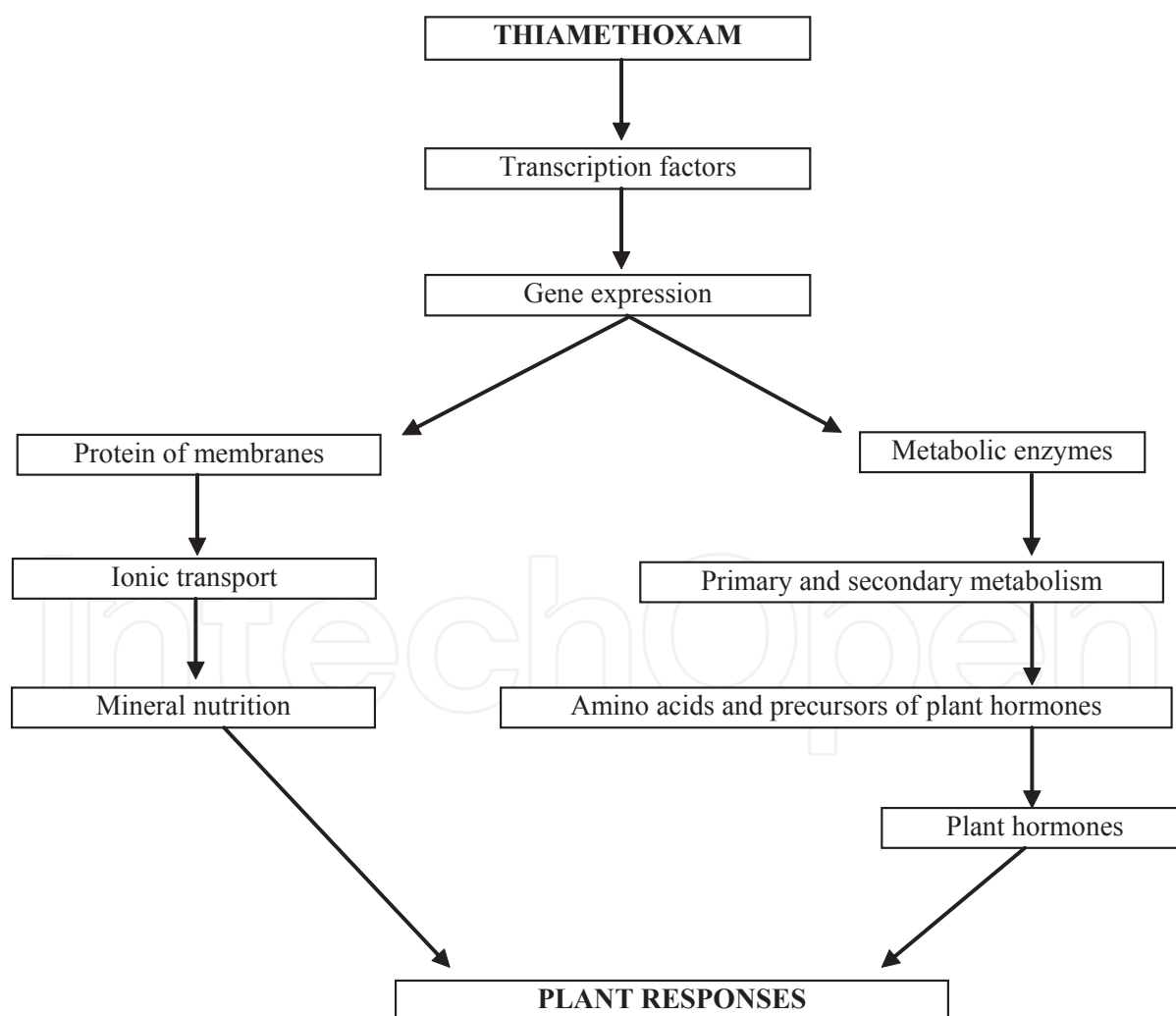
Figure 1. Sequence of events promoted by thiamethoxam (CASTRO, 2006)

Castro (2008), found that the molecule of thiamethoxam is capable of inducing physiological changes in plants. In function of the results obtained, it is concluded that the bioactivator can act in two ways: the first one, is to enable transport proteins from the cell membranes

allowing a greater ionic transport, increasing the mineral nutrition of the plant. This increase in the availability of mineral salts promote positive responses in the development and plant productivity (Figure 1). The second one is related to the higher enzymatic activity caused by thiamethoxam, as the seed level or as the plant one. The highest enzymatic activity would increase both the primary and the secondary metabolism. It would increase the synthesis of amino acids, precursors of new proteins. The plant response to these proteins and hormone biosynthesis could be related to important increases in production (Figure 2).

The bioactivators are organic substances, potentially modifying the morphology and physiology of plants, by acting on the synthesis and action of endogenous hormones and may lead to increases in productivity.

In general, insecticides and fungicides are used to control insects and fungi, respectively. However, it has been found that certain chemicals may also exert actions modifying the morphology and metabolism of plants.



**Figure 2.** Action mode of thiamethoxam in plants (CASTRO, 2006)

Certain insecticides like aldicarb, carbofuran and thiamethoxam, may cause a physiological effect promoting changes in certain processes in plant physiology, such as growth, morphology or plant biochemistry.

The thiamethoxam can be applied in seed treatment, by spraying on leaves of plants or by soil application, being absorbed by the roots. Applied as a seed treatment, the thiamethoxam can promote the expression of the effect by stimulating root growth and increasing germination rate, consequently, reducing the time for field crop establishment.

## **2. Physiological changes in rice seeds exposed to low temperature at germination**

Rice is grown in diverse environmental conditions, but when compared to other cereals such as oats or wheat, is much more sensitive to low temperatures (Mertz et al., 2009). The occurrence of cold weather is one of the major problems when irrigated rice in Rio Grande do Sul - Brazil, is cultivated since the most of the cultivars in use are from tropical origin. The occurrence of low temperatures, together with the susceptibility of the materials used can cause serious damage to the establishment of the crop, reducing the initial stand and consequently favoring the establishment of weeds. The productivity of irrigated rice in Rio Grande do Sul has suffered strong oscillations over the years, caused in part by climatic conditions, where the occurrence of low temperatures has been one of the major determinants factors of this variability at the productivity levels (Mertz et al., 2009).

On the other hand, hormone controllers have received increasingly more attention in agriculture as the crop techniques develop, especially in high value crops. The bioactivators are complex organic substances that can alter the growth, capable to act on the transcription of DNA in plant, gene expression, membrane proteins, metabolic enzymes and mineral nutrition (Castro and Pereira, 2008). The thiamethoxam insecticide has shown positive effects such vigor expression increase, biomass accumulation, high photosynthetic rate and deeper roots (Cataneo, 2008).

The aim of this work was to evaluate the influence of thiamethoxam in the rice crop and the potential benefits that treatment can provide, when rice seeds are subjected to low temperature during germination and emergence.

## **3. Material and methods**

Three rice cultivars where used: two conventional (BR IRGA 417, BR IRGA 424) and one hybrid (Avax R.). The cultivars had the same physiological quality and were evaluated for tolerance to low temperature through the germination test. The seeds were treated with a commercial product containing 35 grams of thiamethoxam active ingredient per liter of product. The treatments were: Treatment 1 - untreated seeds; Treatment 2 - 100ml

of product/100kg of seed; Treatment 3 - 200 ml of product/100kg of seed; Treatment 4 - 300 ml of product/100kg of seed and Treatment 5 - 400 ml of product/100kg of seed, prior to sowing.

The germination test was performed in three replications, eight sub-samples of 50 seeds (400 seeds per replicate) for each cultivar. The seeds were placed to germinate in paper rolls moistened with water equivalent to 2,5 times the weight of the substrate, following the criteria established by the Rules for Seed Testing (Brazil, 2009). Five germination temperatures were used: 25, 20, 18, 15 and 13°C. The germination test at temperatures of 25 and 20°C were performed in the germinator, and at temperatures 18, 15 and 13°C held in BOD. The counting of normal seedlings was performed seven days after sowing for temperatures of 25, 20 and 18°C and at 21 days for temperatures of 15 and 13°C.

#### 4. Results and discussion

According to the results, the rice seeds cultivars BR IRGA 417, BR IRGA 424 and Avax R. treated with thiamethoxam, were superior in all tested temperatures, when compared to the values obtained in the zero dose (without application of thiamethoxam), varying only the intensity of this difference due to the dose used and the temperature.

By observing the data shown in Figure 3, it is found that the treated seeds showed significant increases in germination at different temperatures.

The temperatures of 15°C and 13°C were the most adverse ones, but when the seeds are treated independent from the dose, they showed germination over the zero dose. At the dose of 200 mL/100 kg of seeds at a temperature of 15°C, there was an increase of 21 percentage points, whereas at 13°C this increase was 37 percentage points. At temperatures of 25, 20 and 18°C this increase was on average 7 percentage points when compared with the zero dose.

Figure 4 shows that seeds treated with thiamethoxam at different temperatures had positive additions in relation to the zero dose. The results of this study confirm those obtained by Castro et al. (2007), working with soybeans, and those by Clavijo (2008) working with rice, when claiming that seeds treated with thiamethoxam had their germination accelerated by stimulating the enzymes activity, besides of showing more uniform emergency and stand more uniform and better initial impulse. Also in soybean seeds, Cataneo (2008) observed that thiamethoxam accelerates germination, and induces further development of the embryonic axis. According to the results, rice seeds, cultivars BR IRGA 417, BR IRGA 424 and Avax R. treated with thiamethoxam, were superior in all the tested temperatures, when compared to the values obtained at the zero dose (without application of thiamethoxam), varying only the intensity of this difference due to the dose used and temperature.

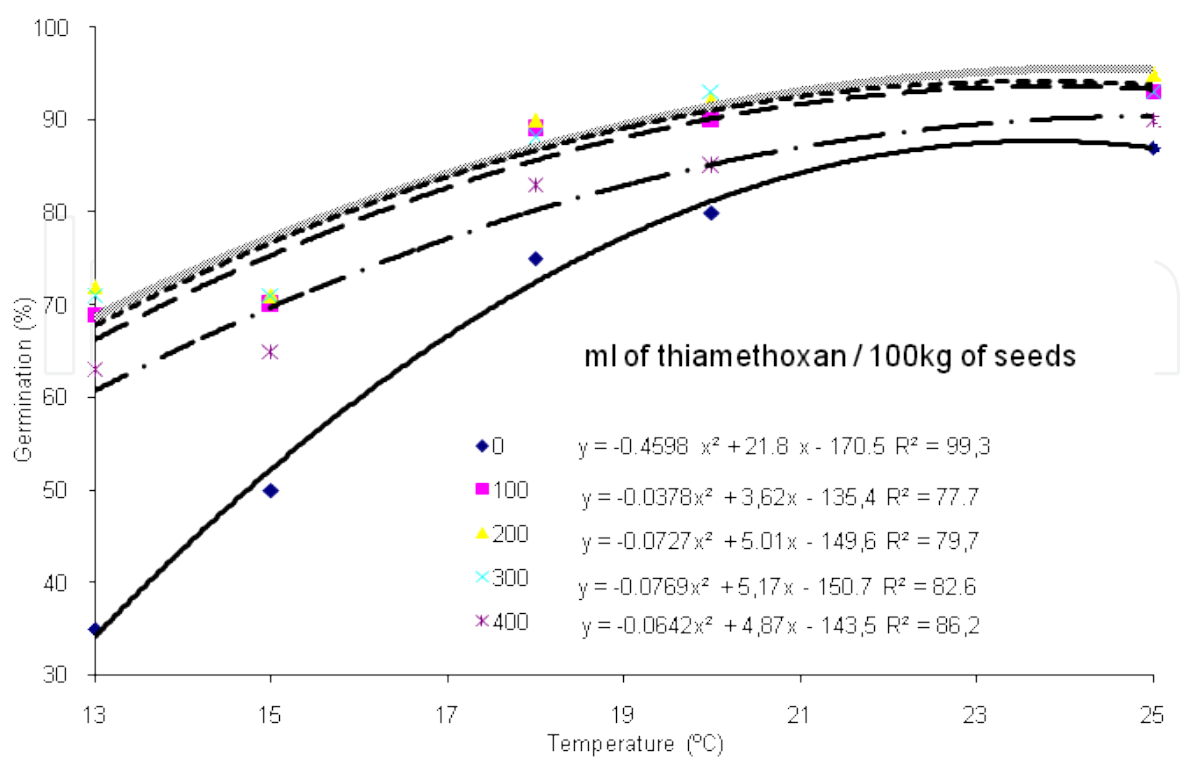


Figure 3. Germination (%) rice seeds, cultivar BR IRGA 417, treated with thiamethoxam at different temperatures.

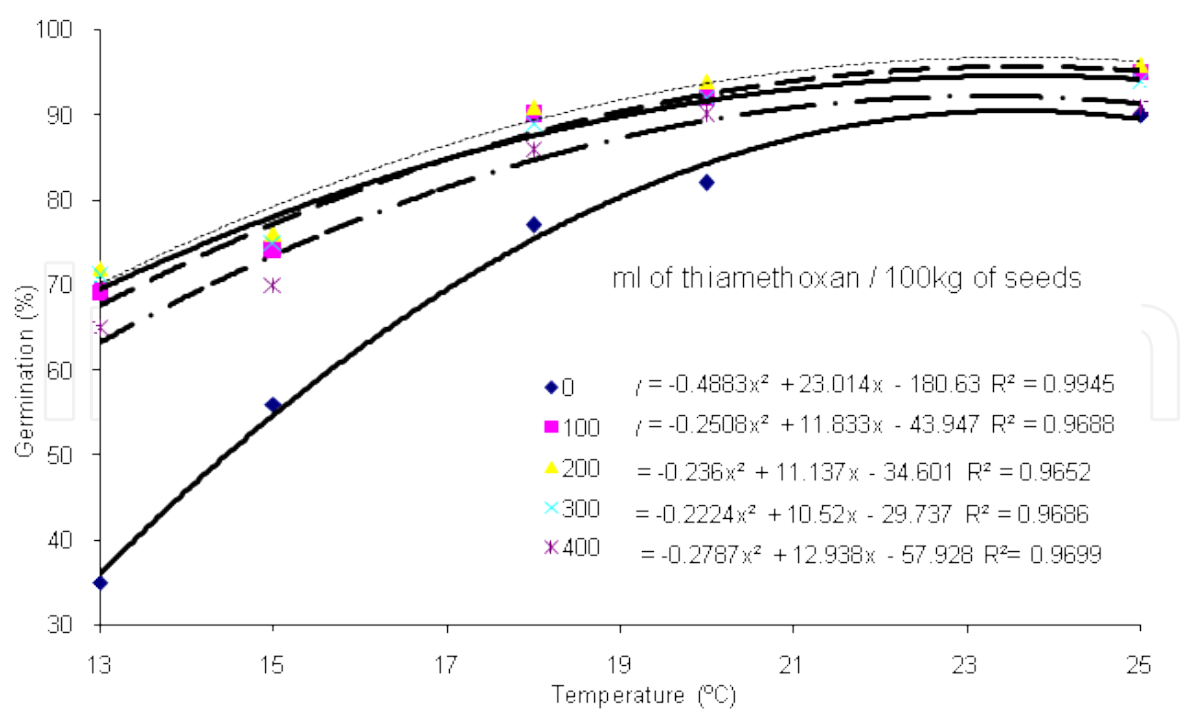
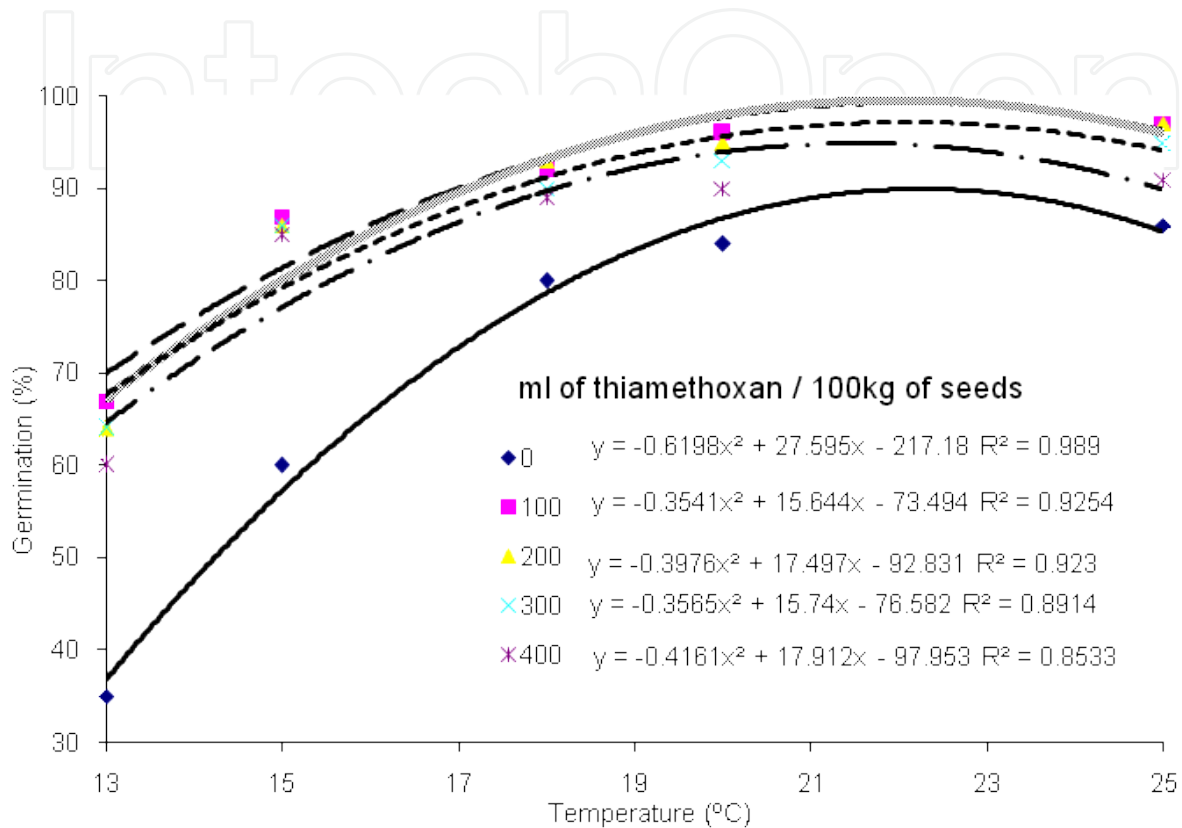


Figure 4. Germination (%) rice seeds, cultivar BR IRGA 424, treated with thiamethoxam at different temperatures.



According to Figure 5, the results of cultivar AVAXI R, hybrid rice seeds when treated with thiamethoxam showed increases in relation to the dose zero. The dose 100mL/100 kg of seeds showed higher increases when compared with other doses at all studied temperatures, being of 28 percentage points at a temperature of 13°C which is the most drastic one, comparing the doses 100mL/100kg of seeds with the zero dose.



**Figure 5.** Germination (%) rice seeds, cultivar Avax R., treated with thiamethoxam at different temperatures.

It was observed that at all temperatures studied with product addition there was an increase in germination of the seeds (Figure 6). In average there were increases reaching up to 8 percent germination at 25 ° C, 12 percentage points at 20 ° C, 17 percentage points at 18 ° C and 34 percentage points in the germination test with temperatures of 15 and 13 ° C when compared with seedlings from untreated seeds. Besides increasing the percentage of germination, there is also the activating effect of the product, with the increase in size of roots and shoots (Figure 7). This increase may provide a more rapid and uniform establishment of the crop. According to Clavijo (2008), the thiamethoxam is transported inside the plant through its cells and activates several physiological reactions like protein expression. These proteins interact with various mechanisms of defense related to the plant stresses, allowing to a better deal with adverse conditions such as drought, low pH, high soil salinity, free radicals, stress by high or low temperature, toxic effects of high levels of aluminum injury caused by pests, winds, hail, attack of viruses and nutrient deficiency



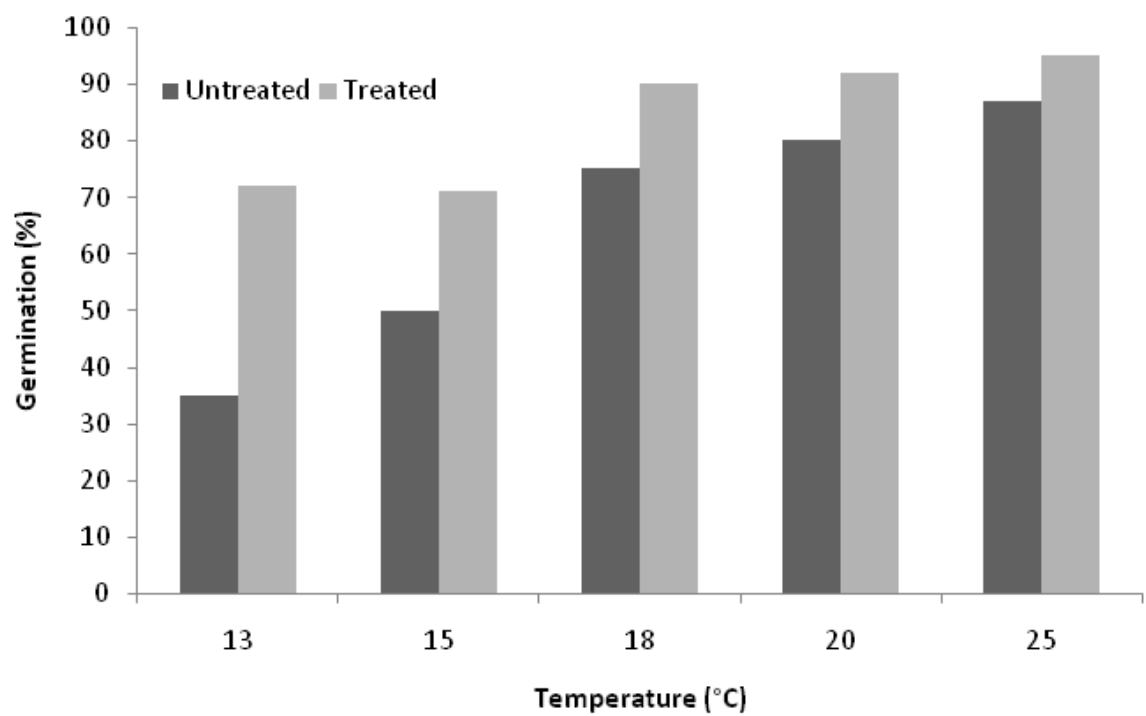


Figure 6. Average germination, cultivar BR IRGA 417, under different doses of thiamethoxam.

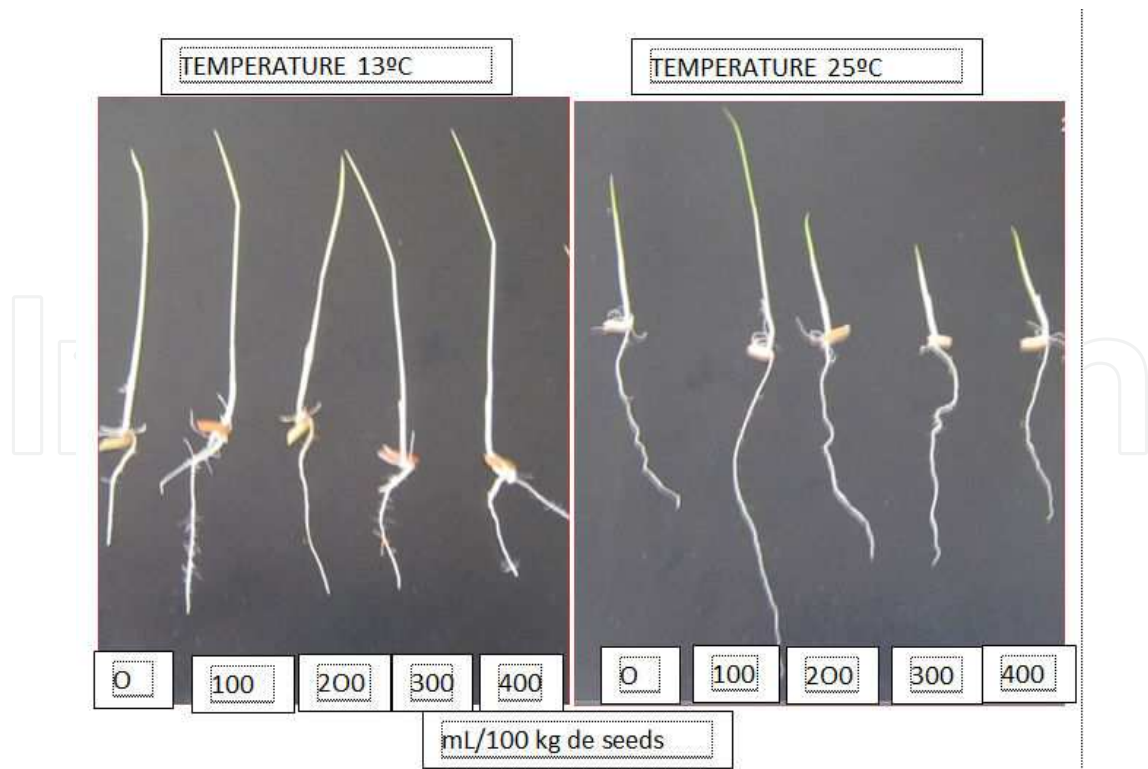


Figure 7. Growth of rice seedlings exposed to different doses of thiamethoxam temperatures of 13 and 25°C

## 5. Conclusion

The rice seed treatment with thiamethoxam positively favors the physiological quality of seeds.

The doses of 100 and 200 mL of product per 100 kg of rice seed are more effective to improve the physiological performance of rice seeds, in temperatures between 13 and 25 °C.

## Author details

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