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Physiological Performance of White Oat Seeds Treated with Phosphite-based Products

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Authors' contributions

This work was carried out in collaboration among all authors. Author DLRM conducted the experiment, data collection and statistical analysis, wrote the protocol and wrote the manuscript. Author IMSL conducted the experiment and data collection. Authors LA, MJGV and GEM would write and assist in the preparation of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: White oats are considered one of the most important cereals in the world. Currently, fertilizers based on phosphorus and silicon are being studied as inductors of resistance in the treatment of seeds, since they have as advantages such as low costs and excellent absorption by plants. The effects of seed treatment with phosphite resistance inducers are still unknown, being necessary the study in relation to interact with the seed at the time of twinning.

Study Design: The experimental design used was completely randomized, with four replications, two commercial products based on phosphite FullTec Mais and Ultra Plus and five doses.

Place and Duration of Study: The work was conducted at the Didactic Laboratory of Seed Analysis of the Faculty of Agronomy Eliseu Maciel of the Federal University of Pelotas (UFPel), Pelotas-RS, in 2019.

Methodology: White oat seeds were used, produced in the 2018/2019 agricultural kharif and treated with commercial products based on FullTec Mais and Ultra Plus phosphites, in five doses: 0; 1.0; 2.0; 3.0; 4.5 mL for each 100 kg of seeds. The variables evaluated were first germination

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count (CP), germination (G), shoot length (CA), root length (CR), total length (CT), accelerated aging (EV) and total dry mass (MST). The data expressed as a percentage were subjected to analysis of variance to verify the effect of treatments. Then, the Duncan means test (P=0.5) was performed, for the discrimination between the treatment means. Statistical analyzes were performed using the R Core Team (2020).

Results: The results showed that the FullTec Mais product stimulates the physiological performance of white oat seeds for the variables first germination count (CP), germination (G) and shoot length (CA), with a dose of 2 mL of the product per 100 kg of seeds that showed the highest expression. For the Ultra Plus product at a dose of 1 mL of the product per 100 kg of seeds it is more efficient in the accelerated aging test (EV), for the other variables it did not show significant differences.

Conclusion: It is possible to use phosphite-based micronutrients in seed treatment, without causing physiological damage to the seed during the twinning process.

Keywords: Vigor; Avena sativa L.; fertilizers; micronutrients.

1. INTRODUCTION

White oats (*Avena sativa* L.) is considered one of the most important cereals, occupying the sixth place in production worldwide [1]. It stands out as one of the main options for cultivation in the cold season, being a technically and economically viable alternative for cultivation.

In Brazil, the cultivation of oats is expanding, with an estimated production of 917.3 thousand tons, 1.5% above the previous year [1]. The excellent performance of oats in recent years is largely due to the use of seeds of high physical, physiological, sanitary and genetic quality, as well as the adoption of seed treatment techniques with insecticides, nematicides, fungicides, nutrients and inoculant [2].

In this sense, oats, together with annual ryegrass (*Lolium multiflorum* Lam.), are the most cultivated winter forage species and of greatest economic importance in the State of Rio Grande do Sul [3].

In this culture, the use of chemical fungicides in seed treatment is widespread. In addition to the chemical treatment of seeds, it has been presenting problems in the management of diseases, the most important being the resistance of several fungi to the molecules of the main fungicides. This fact makes chemical control vulnerable as the main tool in the control of phytopathogens [4]. In this context, new technologies are being used in the management of diseases and among them is the induction of resistance. Which, consists of the activation, by biotic or abiotic agents, of defenses present in the plant, giving it protection to a wide spectrum of microorganisms [5].

Seed treatment represents less than 0.5% of the cost of installing the crop according to [6], in addition to providing protection to the seeds and providing an additional guarantee for the establishment of the same. Seed treatment can ensure an adequate stand, vigorous plants, delay in the onset of epidemics and increased yield. It presents immediate benefits (cost of the process is less than the gain in yield) and medium / long term (balanced production system) [7].

Currently, phosphorus- and silicon-based fertilizers are cited in the literature as resistance inducers [8]. Phosphites have the advantages of low cost and excellent absorption by plants [9]. In the treatment of soybean seeds, these products have been shown to activate plant defense routes, such as chitinase and β 1,3 glucanase [10]. As for oats, there are no reports in the literature of its use in seed treatment, either alone or in association with fungicides.

Phosphite-based resistance inducers, in commercial formulations, are already used in foliar application, although so far it has effects on the treatment of unknown seeds, thus requiring research related to their interaction with seeds at the time of twinning, in seedlings and pathogens.

Therefore, the objective of this study was to verify the dose of greater efficiency of the product based on phosphites on the physiologica quality of white oat seeds.

2. MATERIALS AND METHODS

The work was conducted at the Didactic Laboratory of Seed Analysis of the Faculty of Agronomy Eliseu Maciel of the Federal University of Pelotas (UFPel), Pelotas-RS, in 2019.

White oat seeds were used, produced in the 2018/2019 agricultural season and treated with commercial products based on FullTec Mais and Ultra Plus phosphites, in five doses: 0; 1.0; 2.0; 3.0; 4.5 mL for each 100 kg of seeds.

The syrup (product plus distilled water) was applied, with the aid of a graduated pipette, to the bottom of a transparent plastic bag and spread over the walls of the bag up to a height of 15 cm. The syrup volume used was 0.6 L per 100 kg of seeds, for all doses evaluated, varying the concentration of the product, 250 grams of seeds were used per bag and treatment. After the treatment, the seeds were stored in a cold chamber until the tests were set up.

The effects of treatments were assessed using the following parameters:

2.1 Germination

It was out in four repetitions of 50 seeds for each sample, placed on germination paper substrate " *germitest* ", previously moistened in water using 2.5 times the dry paper mass, and kept at 25ºC. the count was performed at 10 days after sowing. The evaluations were carried out according to the Rules for Seed Analysis [11], and the results were expressed in percentage of normal seedlings.

2.2 First Germination Count

It was performed together with the germination test, with normal seedling counting performed 5 days after sowing and the results expressed as a percentage of normal seedlings.

2.3 Accelerated Aging

A gerbox was used with a horizontal metallic screen fixed in the middle position. 40 ml of distilled water were added to the bottom of each gerbox, and the seeds of each treatment were distributed over the screen in order to cover the surface of the screen, constituting a single layer. Then, the boxes containing the seeds were covered and placed in a BOD type incubator, at 41ºC, where they remained for 72 hours [12]. After this period, the seeds were submitted to the germination test, as previously described. In parallel, the water content of the seeds was determined before and after aging, using the greenhouse method at 105 ± 3ºC / 24 h, in order to monitor the procedures used in the test.

2.4 Total, Root and Aerial Length of the Seedling

Ten samples of 20 seeds from each treatment were distributed in rolls of paper towels moistened with distilled water in a proportion of 2.5 by 1 mL of distilled water per dry mass in grams and kept in a germinator at 25ºC, for five days [13]. A line was drawn on the moistened paper towel in the upper third, in the longitudinal direction, where the seeds were placed directing the micropyle downwards. The length of primary root and seedlings considered normal [11] was determined at the end of the fifth day, with the aid of a millimeter ruler and the results expressed in centimeters per seedling of the aerial, root and total portions.

2.5 Dry Mass of Plants

The determination of the dry matter mass was obtained by discarding the residual endosperm from the aerial parts of the seedlings. After seedling length measurements, the material for each repetition was packed in paper bags, previously identified and taken to a greenhouse maintained at 80ºC, for 24 hours [13]. After cooling in a desiccator, each repetition had its mass determined. The average results obtained were expressed in milligrams per seedling.

2.6 Cold Test

The test was conducted according to the methodology proposed by Círo and Vi eira [14], with four repetitions of 50 seeds, in rolls with two sheets of GERMITEST® paper moistened with 2.5 times its weight of water distilled. After sowing, the rolls were packed inside plastic film bags, sealed with rubber alloys and kept in BOD regulated at 10ºC, for seven days. After this period, the rolls were removed from the plastic bags and transferred to a Mangelsdorf germination chamber, where they were kept at a temperature of 25ºC and after another 5 days to then count normal seedlings. The results were expressed as a percentage of vigor.

2.7 Statistical Analysis

The experimental design used was completely randomized, with four replications. The data expressed as a percentage were subjected to analysis of variance to verify the effect of treatments. Then, the Duncan means test (P = 0.5) was performed, for the discrimination between the treatment means. Statistical analyzes were performed with the aid of the R Core Team [15].

3. RESULTS AND DISCUSSION

The analysis of variance (Table 1) showed that the phosphites had an effect for the variables first germination count (CP), twinning (G) and shoot length (CA), in the four doses evaluated for the Fulltec Mais product.

For the second product tested Ultra Plus , it is worth mentioning that for the variables first germination count (CP), twinning (G), shoot length (CA), root length (CR), total length (CT) and total dry mass (MST), indicated that there was no significant difference between the tested doses, it was demonstrated that the seed treatment did not harm the germination, which obtained results between 95% and 98%, indicating the possibility of being used for the seed treatment in the tested doses (Table 1). These data differ from those obtained by Gonçalves et al. [16], testing phyto-stimulating fertilizers on wheat seeds.

The influence of the tested doses against the evaluation of vigor for the Fulltec Mais product, was more evident in the variable length of aerial part than for the length of the roots and dry matter accumulation of the seedlings that did not present significant differences.

In work carried out by Espindola [17] on soybean seeds using the Ultra Plus product, they found an increase in the dry mass of the root system of soybean plants. Likewise, Oliveira [18], when evaluating the effect of potassium phosphite applications via root through nutritive solution, on soybean cv. Conquest, registered an increase of about 36% in the aerial part mass of plants that received phosphite application.

Although Ultra Plus is used commercially for foliar application, its use in this test in treatment of seeds did not negatively affect their germination when used alone, providing similar germination to other products.

In the first germination count (CP) (Fig. 1), it is verified that, from the zero dose there was an increase in the values, with an increase in the phosphite dose reaching a maximum point when reaching the 2 mL dose of the product per 100kg of seed. From that point, it decreases as the dose of the product increases. Likewise Avelar et al. [19], evaluating the physiological quality of corn seeds, verified increases in germination and vigor of seeds produced in the subplots that received seed treatment with micronutrient formulations (Zn, Mo and B). However, data by Rosa et al. [20], observed more significant differences in vigor, compared to germination, in treated and stored corn seeds.

Analyzing Fig. 2 gives germination (G), it can be seen depending on the doses of FullTec Mais used in the study, there was a greater expression in the germination values with increased dose reaching a maximum point when reaching the dose of 2 mL of product per 100 kg of seed, after reaching that point the germination decreases in the dose of 3mL, and reaching the dose 4.5 ml had again an increase.

Regarding the maximum point in relation to the zero dose, it increased by 2 percentage points. Data that differ from those obtained by Gonçalves et al. [16], who found no significant differences between the doses tested on wheat seeds. According to Ribeiro and Santos [21], the

Table 1. Mean square first germination count (CP), germination (G), shoot length (CA), root length (CR), total length (CT), accelerated aging (EV) and total dry mass (MST) of two commercial products in the treatment of white oat seeds

			Medium Square						
Product		**Gl**	**PC**	**G**	**CA**	**CR**	**CT**	**EV**	**MST**
Fulltec Mais	Dosis	4	34.80*	5.30*	0.35*	0.30^{ns}	0.44^{ns}	15.30^{ns}	0.000044^{ns}
	Residuo	15	21.80	2.80	0.12	0.59	1.14	17.70	0.00005
	Media General	-	93.30	97.80	9.31	12.13	21.44	88.20	0.09
	CV (%)	-	5.00	1.71	3.86	6.36	4.99	4.77	7.89
Ultra Plus	Dosis	4	6.30^{ns}	6.70^{ns}	0.11^{ns}	0.36^{ns}	0.12^{ns}	46.30**	0.000064^{ns}
	Residuo	15	19.60	10.20	0.18	0.48	0.73	10.73	0.00009
	Media General	-	92.20	96.10	9.20	12.26	21.47	89.30	0.092
	CV (%)	-	4.80	3.32	4.67	5.67	3.99	3.66	10.44

*CV= Coefficient of variation *= significant at 5% level of probability, ns= non-significant* application of micronutrients to seeds and their transfer to seedlings, during the germination process and their initial development, allows to partially and, in some cases, fully meet the needs of the plant.

As can be seen in Fig. 3, the oat seeds treated with FullTec Mais the base phosphite presented to the shoot length. The length showed maximum expression at the dose of 2 mL of product per kg of seeds. The maximum efficiency that the product allowed for an increase of up to 0.56 cm in the length of the aerial part, compared to the seeds that had not been treated. Work carried out by [16], for the production of biomass, in wheat seeds treated with FullTec Mias had significant differences in the length of the aerial part, which increased by 7 cm. As found in soy Tavares et al. [22], and in carrot Almeida et al. [23], the development of the roots increases the absorption of mineral nutrients, increasing the leaf area and the expression of the vigor of the plants.

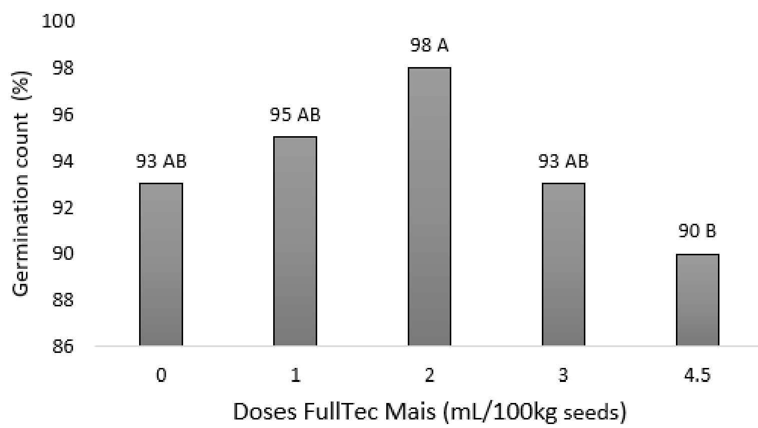

Fig. 1. Normal seedlings in the first germination count of white oat seeds treated with the commercial product FullTec Plus based on phosphite and five doses (0.0; 1.0; 2.0; 3.0; 4.5 m / kg)

Test Duncan: P <0.05; equal letters do not differ significantly from each other

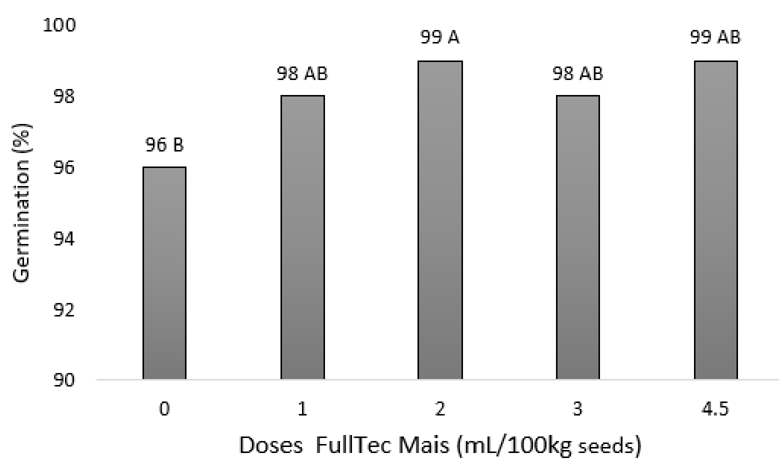

Fig. 2. Germination of white oat seeds treated with the commercial product FullTec Mias based on phosphite and five doses (0.0; 1.0; 2.0; 3.0; 4.5 mL / kg)

Test Duncan: P <0.05; equal letters do not differ significantly from each other

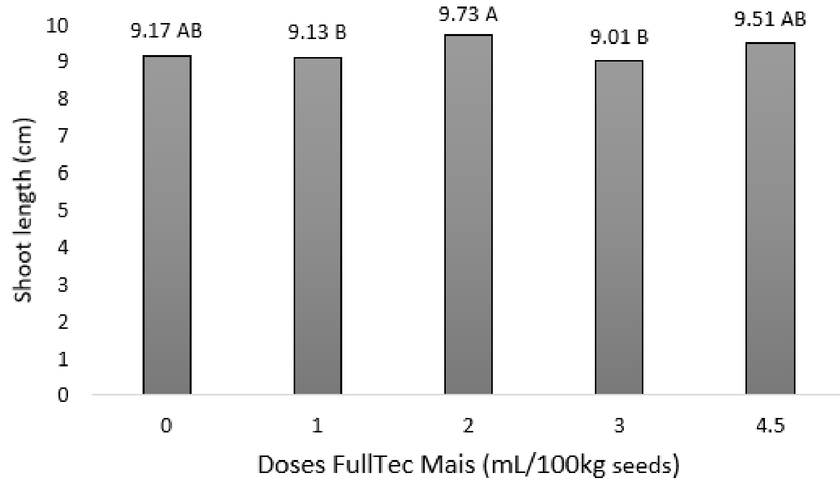

Fig. 3. Length of aerial part of white oat seedlings from seeds treated with the commercial product FullTec Mais based on phosphite and five doses (0.0; 1.0; 2.0; 3.0; 4.5 m / kg)
Test Duncan: P <0.05; equal letters do not differ significantly from each other

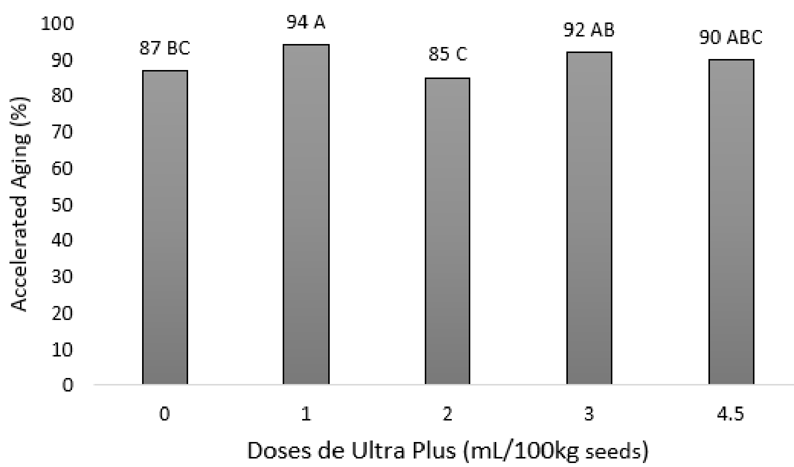

Fig. 4. Accelerated aging in white oats from seeds treated with the commercial product Ultra Plus based on phosphite and five doses (0.0; 1.0; 2.0; 3.0; 4.5 m / kg)
Test Duncan: P <0.05; equal letters do not differ significantly from each other

According to Hampton and Goolbear [24], they state that vigor tests are reliable, as they can estimate the performance of seeds in the field in more detail. Thus, the results of accelerated aging (EA) for the Ultra Plus product indicate that there was a small decrease in the vigor values of the treated seeds (Fig. 4) at a dose of 2 mL per 100 kg of seeds in relation to the control. The dose that had the best expression was the dose of 1 mL per 100 kg of seeds in relation to the control. In the other dose, there is no increase in the vigor values of the treated seeds. Muller [10], found that potassium phosphite applied to soybean seeds, demonstrated an EA of 27%, low compared to the results of this study.

4. CONCLUSION

The results obtained in this work allow us to conclude that it is possible to use phosphite-based micronutrients in seed treatment, without causing physiological damage to the seed during the twin oat twinning process.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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