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The effect of velvet bean (*Mucuna cinerea)* extract on seedling growth of winter cereals

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Some plants can have a beneficial or harmful effect on the germination and growth of other plants. This is known as the allelopathic effect. The objective of this study was to evaluate the effect of different doses of velvet bean (*Mucuna cineruim)* aqueous extract on germination and initial seedling growth of three winter cereals: white oat (*Avena sativa*), rye (*Secale cereale*) and wheat (*Triticum aestivum*). The experimental design was a completely randomized design, with four replications of five doses of aqueous extract (0, 5, 10, 15 and 20%). Of the three cereals, rye had the greatest allelopathic effect on the test variables in the different aqueous extract concentrations, while the white oat had the highest mean germination time. Negative effects of velvet bean on the growth of wheat were observed only in the applications of high doses. It can be concluded that velvet bean exhibits great allelopathic potential to control the germination and seedling growth of the cereals. This effect was primarily observed in the white oat and rye under the applications of higher extract doses.

Key words: Velvet bean, *Avena sativa*, *Secale cereale*, *Triticum aestivum*, germination, aqueous extract.

INTRODUCTION

The velvet bean (*Mucuna cinerea*) is a climbing legume that is used as a cover crop and is significant for its biomass production and adaptability to diverse soil conditions (Ribas et al., 2010). The velvet bean can also prevent the multiplication of plant-parasitic nematodes that cause great damage to crops (Sakai et al., 2007). They added that the velvet bean is one of the main crops used in the production of green manure in Brazil, due to its high productivity and the low cost of production.

In a crop rotation scheme, the velvet bean may be used prior to winter crops. Where, wheat (*Triticum aestivum*), white oat (*Avena sativa*) and rye (*Secale cereale*) are winter cereals belonging to the Poaceae family. These three cereals have great economic importance in Brazil and are used in crop rotation systems to produce grain. They are cultivated primarily in the southern region of Brazil where the climate is more conducive to growth.

Few studies had explored the allelopathic effect of

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cover crops that precede winter crops in organic or conventional production systems. Therefore, studies are necessary to investigate the interaction of these crops with other plants in the production system, especially those that precede the crop.

In the environment, plants compete for light, water, space and nutrients. Thus, there is constant competition between species, which contributes to the survival of some species in an ecosystem and the development of defence mechanisms by other species based on the synthesis of secondary metabolites that are released into the environment and that interfere with some stage in the life cycle of another plant (Sampietro, 2002).

Other study, detected that the released secondary metabolites, which are released into the environment, may inhibit or stimulate the germination and/or growth of other plants that are relatively close, characterizing the allelopathic effect where one plant has an effect on another (Soares and Vieria, 2000). Resistance or tolerance to secondary metabolites is a species-specific characteristic, and more sensitive plants are considered as indicators of allelopathic activity (Alves et al., 2004).

While, the possibility of developing beneficial or unfavourable allelopathic effects between crops is of agronomic interest, especially in terms of crop rotation and intercropping (Silva et al., 2013). These findings may contribute to the development of adequate management and the determining of suitable species for crop rotation or for the use of cover crops (Bonfim et al., 2013).

On the other hand, there are numerous records of the allelopathic influence on crop rotation, as observed with wheat, black oat and rye. Although these crops did not reduce the germination of summer crops, they affected the growth of corn, soybean and bean plants (Ferreira and Aquila, 2000). In other study carried out with velvet bean showed an allelopathic effect on some species of weeds, such as black sting (Teixeira et al., 2004).

Therefore, the aim of the study was to evaluate the effect of applying velvet bean aqueous extract on the germination and seedling growth of three winter cereals: white oat, rye and wheat.

MATERIALS AND METHODS

The experiment was conducted in the Seed Analysis Laboratory of the Federal University of Technology of Paraná (UTFPR), Campus Dois Vizinhos, between April and June 2015.

The aqueous extract was prepared by collection of the aerial part of velvet beans during the grain-filling period. The plants were dried in a semi-enclosed greenhouse under ambient conditions of temperature and humidity until constant weight was obtained. Subsequently, the material was ground in a knife mill, packed in plastic bags and stored in a cold chamber until use.

The experimental design was a completely randomized design with four replications. The treatments consisted of five doses of velvet bean aqueous extract (0, 5, 10, 15 and 20%), and distilled water was used for the dilutions. The 0% concentration represented the control treatment that received only distilled water. Each replication included 100 seeds of oats, rye and wheat, which were used disinfected in 5% hypochlorite solution for 3 min. The seeds were then sown on two sheets of Germitest paper and another sheet was used to cover the seeds, which were then rolled and dampened with 60 mL of aqueous extract.

On the other hand, preparation of the highest concentration (20%) of aqueous extract (20 g of extract in 1 L of distilled water) was used. After dilution, the liquid was filtered and the remaining dilutions were carried out for the other concentrations. The treatments were conditioned in an incubator (BOD) at a constant temperature of 21±1°C, with no photoperiod in accordance with the recommendations of the Rules for Seed Analysis (RSA) (Brasil, 2009).

The germination percentage (G), germination speed index (GSI), mean germination time (MGT) and average speed of germination (ASG) were calculated daily. At the end of the test, the germination percentage, the length of the radicle (LR), aerial part length (APL), and radicle and shoot dry mass (DM) were determined. While, the G was calculated daily by counting the number of germinated seeds for seven days after germination began. The criterion applied to determine seed germination was morphological, that is the emergence of the radicle was considered as the defining factor (Ferreira and Aquila, 2000). The G was calculated using the formula $G = (N/100) \times 100$, where N = Number of seeds germinated at the end of the test. Whereas the GSI was calculated according to the equation proposed by Maguire (1962): $GSI = G1/N1 + G2/N2 + ... + Gn/Nn$, where G1, G2, ... Gn = number of normal seedlings from the first until the seventh day of counting, N1, N2, ..., Nn = number of days of sowing.

The radicle and shoot length were determined using a graduated ruler and all germinated seedlings were measured in each replication. Subsequently, the radicle and shoot samples were conditioned in a forced ventilation oven at 50°C until constant weight was obtained.

The MGT was calculated by formula $MGT = (\Sigma n_i t_i)/\Sigma n_i$, where ni = number of seeds sprouted per day; ti = time; i = 3 to 9 days; and ASG was calculated using formula *ASG = 1/mean germination time in days.*

The percentages were transformed using sine-arc $\sqrt{x}/100$ for the normalization of its distribution. The results were submitted to analysis of variance (ANOVA) and the effect of the regression treatments was verified using ASSISTAT statistical software (Silva and Azevedo, 2009), at 5% probability of error.

RESULTS AND DISCUSSION

The velvet bean extract had a negative effect on the rye, white oat and wheat, and caused a low germination percentage (G) and low germination speed index (GSI). The mean germination time (MGT), average speed of germination (ASG), radicle length and dry mass of the radicle and shoot were also negatively influenced.

However, the increase in the extract dose resulted in the reduction of the germination percentage (G) in all winter cereals (Figure 1). Where, the rye had the lowest germination percentage at the highest dose, with only 3.25% in comparison with the control group that had a G of 88.5%, showing a decrease of 96.32%. While, the wheat had a G of 22.25% and the white oat showed 47% of germinated seeds at the highest dose. Similar findings were reported by Erasmo et al. (2004), who conducted a study in which a different species of velvet bean (Mucuna pruriens) was investigated, and a reduction in the number

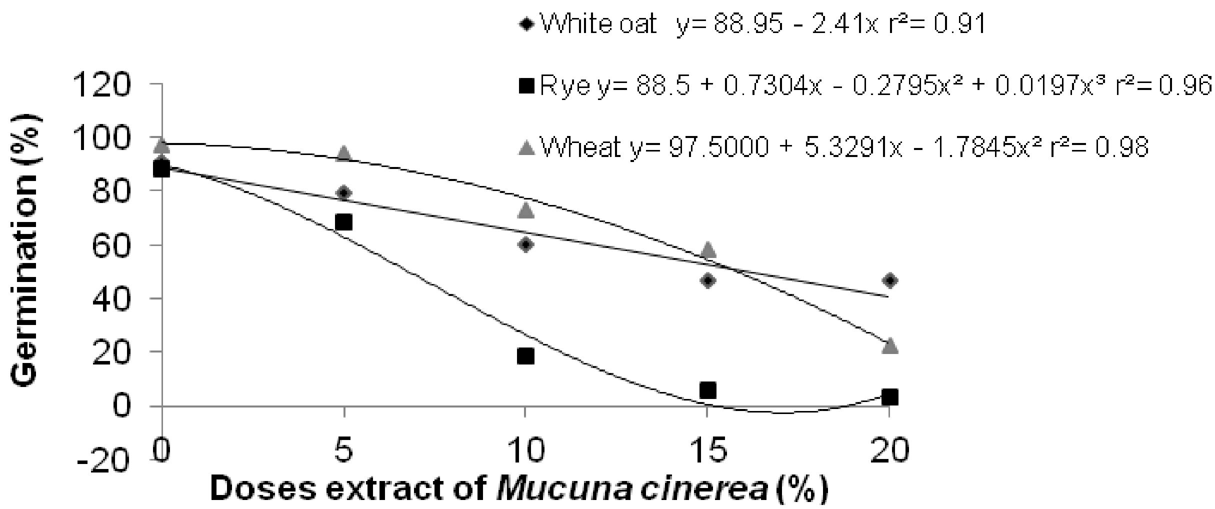

Figure 1. Germination percentage of winter cereals submitted to different doses of velvet bean aqueous extract.

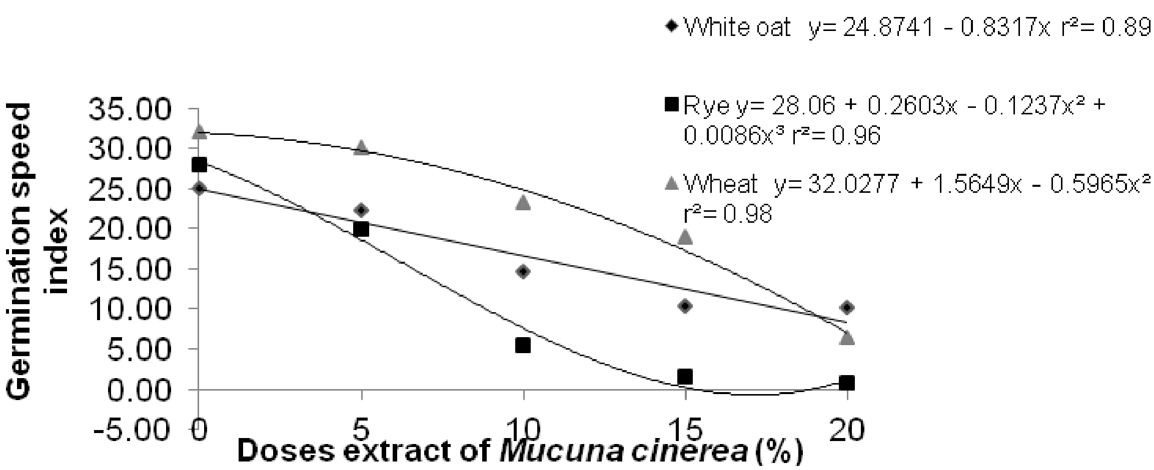

Figure 2. Germination speed index of winter cereals submitted to different doses of velvet bean aqueous extract.

of weeds confirmed the control potential of this species.

Currently, the germination speed index (GSI) also decreased for the three cereals (Figure 2) in relation to an increase in extract concentration. Similar to the G, rye was the crop that had the lowest GSI (0.83), followed by wheat (6.43) and oats (10.28). In comparison with the control group, the reductions were 96.97, 20.07 and 59.12%, respectively for each culture at the highest extract dose.

In the present study, the mean germination time (MGT), which represents the number of days required for seed germination, increased for all tested crops (Figure 3). Where, more days were required for the germination process to begin in the winter cereals. Therefore, the allelopathic qualities of the velvet bean delay the growth of these cereals. Oats were the most affected and, at an extract dose of 20%, germination started at 5.11 days^{-1}, while the time for the control group was 3.94 days^{-1}. While, the rye germination began at 4.30 days^{-1} for the highest extract dose. Little difference in MGT was observed in wheat for the different extract doses. This result may be related to an adaptive or physiological characteristic of the culture, as the species that establishes itself first in the environment has advantages in the competitive process. The competitive ability of a species is related to the efficient use of resources in the surrounding environment (Rizzardi et al., 2001). The delay or irregularity in germination is detrimental, as the seed is exposed in the field for long and is, thus, vulnerable to the attack of fungi, unfavourable climatic conditions such as drought, predation and interference in pre-germination phase, thereby having less capacity to

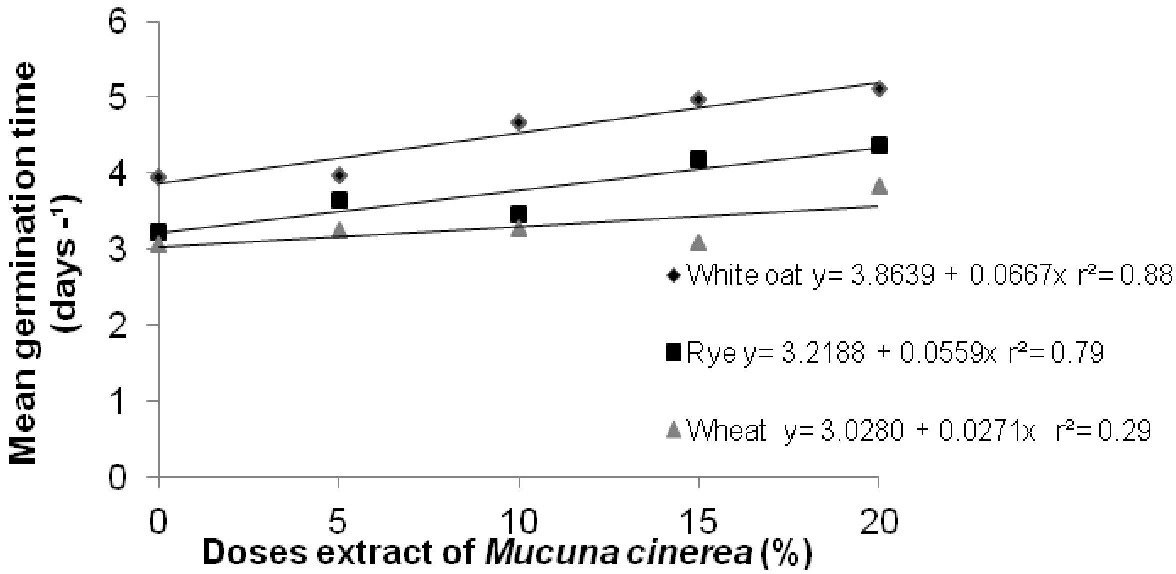

Figure 3. Mean germination time of winter cereals submitted to different doses of velvet bean aqueous extract.

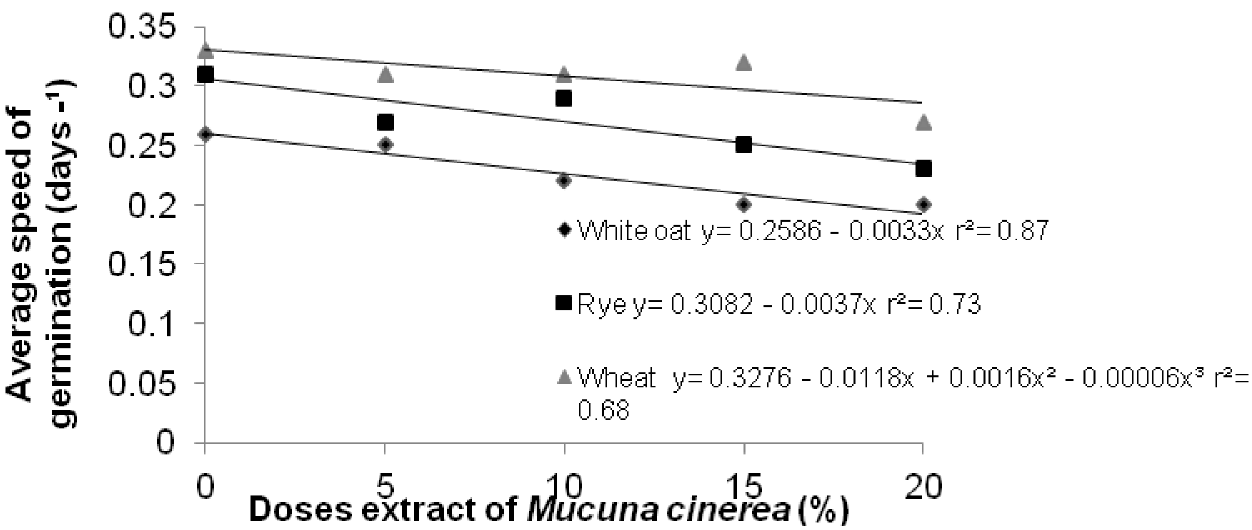

Figure 4. Average speed of germination of winter cereals submitted to different doses of velvet bean aqueous extract.

compete for environmental resources (Alencar et al., 2016).

In the present work, the average speed of germination (ASG) (Figure 4) is calculated from the MGT. Thus, as the mean germination time for the crops decreased with the application of the extract doses, the ASG also decreased. In the field, this may mean that the crops have a low competition power with weeds, thereby reducing the plant resistance and resulting in low grain production at the end of the crop cycle. According to Ferreira and Aquila (2000), the allelopathic effect is often not the final percentage of germination time, but of germination speed.

Regarding, the tested variables of seedling growth, the rye was the most affected by the velvet bean extract, and in the 20% dose there was no root growth (Figure 5), thereby demonstrating the strong allelopathic effect of the velvet bean on the crop. The reduction in root growth has a negative influence on crop growth, as it becomes more vulnerable to lodging and water stress, and thus lowers productivity.

The white oat also showed a reduction in radicle length (Figure 5), comparing the control treatment (7.27 cm) with the 20% dose (3.5 cm), showing a reduction of

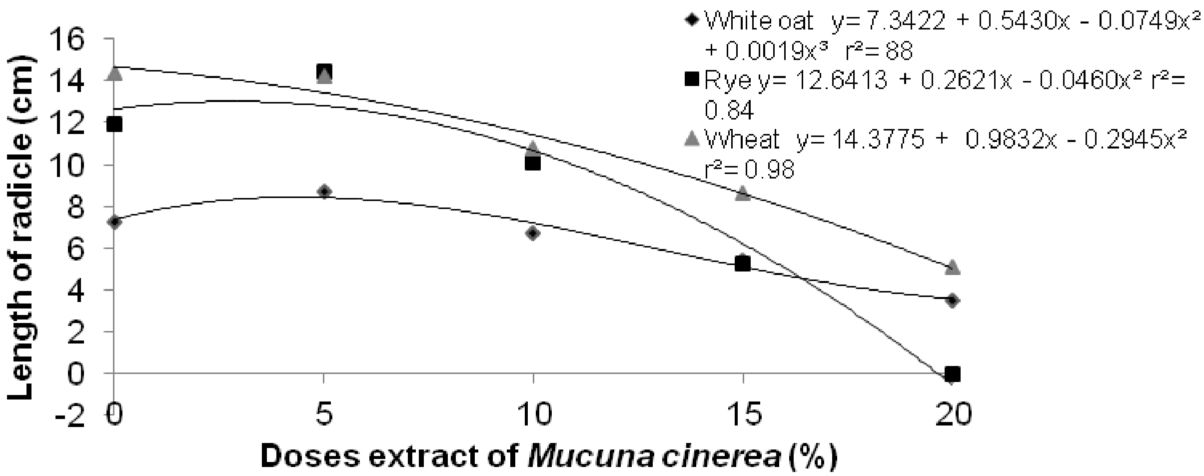

Figure 5. Length of radicle of winter cereals submitted to different doses of velvet bean aqueous extract.

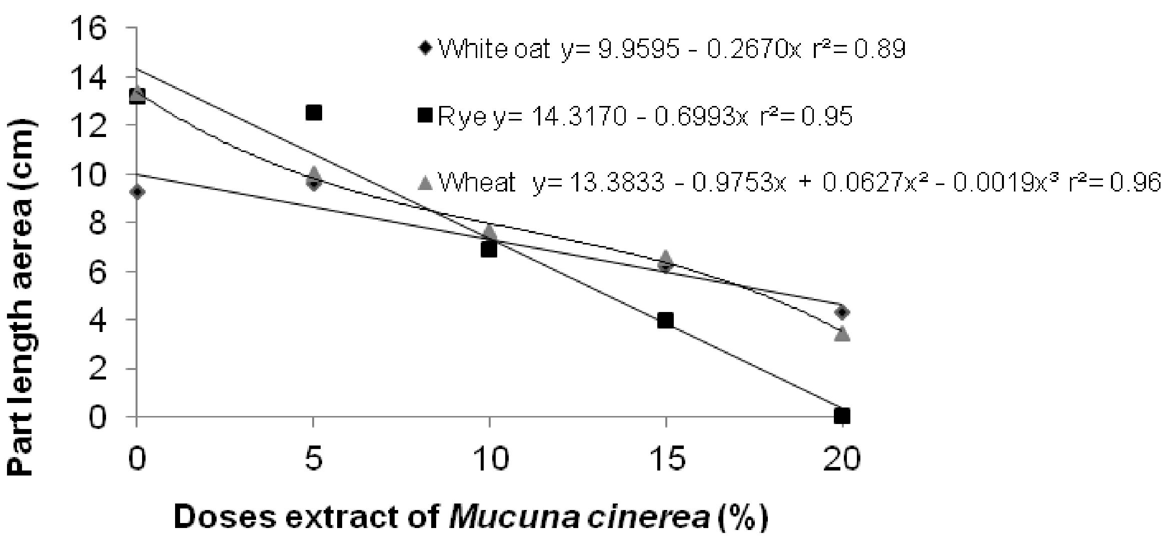

Figure 6. Aerial part length of winter cereals submitted to different doses of velvet bean aqueous extract.

51.85%. Wheat had a significantly reduced radicle length at the 10% (10.78 cm) dose, which may signify that in the field the development of the crop may be inhibited depending on the amount of dry matter mass present in the soil. The rapid root development of a crop after germination is a characteristic that can lead to a high establishment speed and, subsequently, the competitive advantage during the critical period of competition. According to Ferreira and Aquila (2000), germination is less sensitive to allelochemicals than seedling growth.

Results similar to what was observed concerning the radicle length were also recorded in the aerial part length of the cultures.

Also, rye had no aerial part development at the highest dose tested (20%) (Figure 6). The wheat gradually decreased its aerial part length area as the extract dose increased, where the control group was 13.32 cm and the 20% dose was only 3.46 cm. The oats also had their aerial development inhibited; however, when compared with the other cultures, the oats developed even in the highest applied dose and showed only a slight reduction. Based on the decrease of area growth the plant will have a smaller photosynthetically active leaf area, therefore the production of photo-assimilates will be lower, which will result in productivity losses.

The present findings on the shoot length and radicle reported that they were directly influenced by the dry mass of the crops, since both variables are correlated. No seedling growth occurred in the rye at the highest dose (20%); consequently, the dry mass values of the

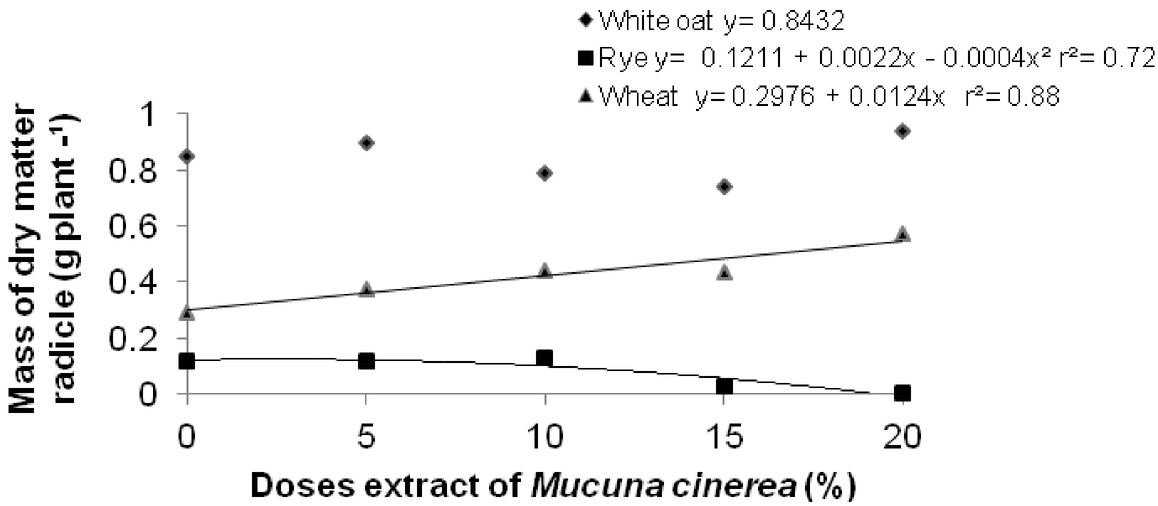

Figure 7. Mass of dry matter radicle of winter cereals submitted to different doses of velvet bean aqueous extract.

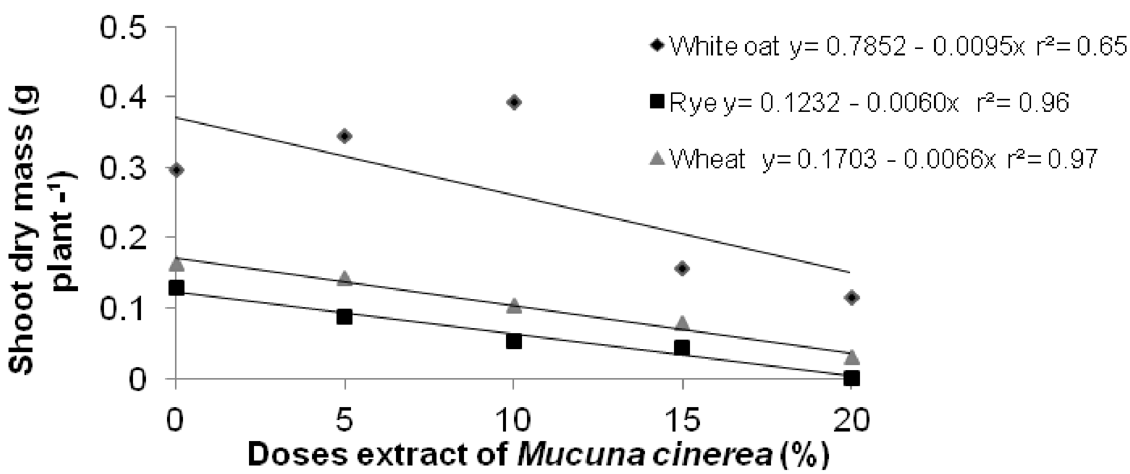

Figure 8. Shoot dry mass of winter cereals submitted to different doses of velvet bean aqueous extract.

radicle (Figure 7) and aerial part (Figure 8) were not obtained. In comparison to the control group, there was an increase in dry mass of the radicle in the wheat (Figure 7). This increase can be explained either by stimulation of the extract or by the presence of a greater amount of reserves in the endosperm, which decreased as the dose of the applied extract increased, having a reduction of 81.9% of the control group to the 20% dose. For the white oat, the results of the dry mass of the radicle did not exhibit a difference between the doses tested and in the aerial dry mass, reduction occurred mainly in the higher doses (15 and 20%). Therefore, for each culture and tested dose of velvet bean extract, a response occurred and the most significant reductions occurred when the highest doses were applied.

Conclusion

From the foregoing results it could be conclude that the velvet bean exhibited great allelopathic potential that affects all variables of germination and seedling growth of the three winter cereals.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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