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ALLELOPATHIC EFFECT OF *Senna alata* GREEN AND DRY EXTRACT ON RICE SEED GERMINATION

ABSTRACT: *Senna alata* (L.) Roxb., Also known as fedegoso, is a weed frequently found in pastures in the Amazon region. Its leaves, besides having medicinal properties, are capable of affecting the germination and development of other plants. The aim of the authors in this work was to evaluate the allelopathic effect of extracts of *Senna alata* on the germination of rice seeds (*Oryza sativa* L.), length and green and dry mass of the aerial part and the root system. The experimental design used was completely randomized in a 2x4 factorial scheme (source of the extract x concentrations). The treatment consisted of two leaf extracts (green and dry) and four concentrations (0; 5; 10 and 20%). It was observed that the germination, green and dry mass of the aerial part and root of rice seedlings, in the medium containing green leaf extract revealed negative effects for the species when compared with the extract from green leaf.

KEYWORDS: Allelopathy, Weed, Fedegoso.

EFEITO ALELOPÁTICO DO EXTRATO VERDE E SECO DE *Senna alata* NA GERMINAÇÃO DE SEMENTES DE ARROZ

RESUMO: *Senna alata* (L.) Roxb., também conhecido como fedegoso, é uma planta daninha frequentemente encontrada em pastagens da região amazônica. Suas folhas além de apresentarem propriedades medicinais são capazes de afetar a germinação e o desenvolvimento de outras plantas. O objetivo dos autores neste trabalho foi avaliar o efeito alelopático dos extratos de *Senna alata* na germinação de sementes de arroz (*Oryza sativa* L.), comprimento e massa verde e seca da parte aérea e do sistema radicular. O delineamento experimental utilizado foi inteiramente casualizado no esquema fatorial 2x4 (fonte do extrato x concentrações). O tratamento consistiu-se de dois extratos de folha (verde e seca) e quatro concentrações (0; 5; 10 e 20%). Observou-se que

a germinação, massa verde e seca da parte aérea e raiz de plântulas de arroz, no meio contendo extrato de folha verde revelaram efeitos negativos para a espécie de quando comparado com o extrato proveniente de folha verde.

PALAVRAS-CHAVE: Alelopatia, Planta daninha, Fedegoso.

EFECTO ALELOPÁTICO DEL EXTRACTO VERDE Y SECO DE *Senna alata* SOBRE LA GERMINACIÓN DE SEMILLAS DE ARROZ

RESUMEN: *Senna alata* (L.) Roxb., También conocida como fedegoso, es una maleza que se encuentra con frecuencia en los pastizales de la región amazónica. Sus hojas, además de tener propiedades medicinales, pueden afectar la germinación y el desarrollo de otras plantas. El objetivo de los autores de este trabajo fue evaluar el efecto alelopático de los extractos de fedegoso sobre la germinación de las semillas de arroz (*Oryza sativa* L.), la longitud y la masa verde y seca de la parte aérea y del sistema radicular. El diseño experimental utilizado fue completamente al azar en un esquema factorial 2x4 (fuente del extracto x concentraciones), con cuatro repeticiones. El tratamiento consistió en dos extractos de hojas (verde y seco) y cuatro concentraciones (0; 5; 10 y 20%). Se observó que la germinación, la masa verde y seca de la parte aérea y la raíz de las plántulas de arroz, en el medio que contenía extracto de hoja verde reveló efectos negativos para la especie en comparación con el extracto de hoja verde.

PALABRAS CLAVES: Alelopatía, Concentraciones, Fedegosa.

INTRODUCTION

Rice (*Oryza sativa* L.) is considered the most economically important product in many developing countries and the growing increase in its consumption imposes on productive sectors the need to seek new techniques that can increase their productive capacity (SANTIAGO et al., 2013).

In different agricultural crops, such as rice, productivity and grain quality can be reduced due to the presence of pests, diseases and weeds, and the latter factor has caused high damage to crops, mainly due to competition for water, light, nutrients and harvest impediments (NKUBA et al., 2016).

Weeds are one of the factors that most influence the growth and yield of upland rice crops, due to competition especially for water, light and nutrients, which can lead to a quantitative and qualitative reduction in production, in addition to increasing harvest costs, drying and processing of grains (RAJ; SYRIAC, 2017).

The presence of weeds, competing with the species of agronomic interest, can cause large reductions in grain yield. In the case of rice cultivation, this loss can reach values close to 100%, in some cases, making the harvest unfeasible. Therefore, the crop is very sensitive to weed interference (CARVALHO et al., 2011).

In addition to the aggressiveness that permeates the reduction in productivity, this species or genus has been reported as a plant that produces allelopathic substances, inhibiting or harming the development of lettuce plants (FERRARI, 2013) and *Mimosa pudica* (RODRIGUES et al., 2010).

The term allelopathy refers to both beneficial and harmful biochemical interactions between plant species, including microorganisms (REIGOSA et al., 2013). Several plants express the allelopathic phenomenon through the exudation of allelochemical substances in the environment (JABRAN et al., 2015). Some species have strong allelopathic potential against other independent plants and whether they are crops or weeds (HARAMOTO; GALLANDT, 2004). However, the concentration of this allelochemical varies in different parts of the plant, it can be in the roots, but also in high concentrations in leaves and branches (FAHEY et al., 2001). To determine the allelopathic potential of a plant, one can initially use the technique of aqueous extracts (SILVA et al., 2018).

Popularly known as pasture forest, *Senna alata* (L.) Roxb. is a weed species that infests cultivated pastures in the Amazon region, constituting a bioeconomic problem that limits the productive development and profitability of agricultural activity. This species belongs to the Leguminosae family, subfamily Caesalpinioideae, probably native to northern South America, has been naturalized and cultivated from the United States to Argentina (ESSIETT; BASSEY, 2013). It is a perennial, shrubby plant with extremely fast vegetative growth, tending to form neat stands. The species is frequent in pasture areas, roadsides and vacant lands, in almost all of Brazil, mainly in humid places (LORENZI, 2000).

The objective of this work was to verify the allelopathic effect of the leaves of the species *Senna alata* (L.) Roxb. on seed germination, length and green and dry mass of shoot and root system of upland rice cultivar Cambara.

MATERIAL AND METHODS

The present work was carried out at the Laboratory of Seed Technology and Weed Science (LaSeM) of the State University of Mato Grosso – UNEMAT, Campus of Alta Floresta.

The experimental design used was completely randomized, in a 2x4 factorial scheme, with four replications each treatment, thus, the treatments consisted of two leaf extracts (green and dry) and four concentrations (0; 5; 10 and 20% w/v) of each extract.

The plant material used came from a population of 20 plants of *Senna alata* (L.) Roxb. that occurred naturally in the urban perimeter of the municipality of Alta Floresta-MT. After collection, the material was placed in kraft paper bags and dried in an oven with forced air circulation, at a constant temperature of 65 °C, for four days. After drying, the material was crushed in a Willey type mill to obtain powder for making extracts from dry leaves. The green leaves were collected in the same place as the previous collection and on the day the experiment was set up, in order to obtain fresh material.

The green leaves, collected from the same plant population on the day the experiment was set up, were chopped into 3.0 cm particles and placed inside beckers with distilled water in each proportion to obtain the study concentrations. The powder from the dry leaves was also mixed in distilled water to obtain the concentrations established as treatments, inside beckers. The crushed dry material and the chopped green leaves were kept for 24 hours to obtain the extract. All containers were sealed with foil and aluminum, so as not to interfere with external conditions, and kept at a constant temperature of 25 ºC.

After this period, each extract was filtered and used to moisten two sheets of germitest paper (substrate), placed in clear acrylic boxes (gerbox), with a volume of 12 mL per box.

Fifty rice seeds were placed to germinate in each box, on substrates that were moistened with different types and concentrations of extracts. The boxes with the seeds were placed in a germination chamber type B.O.D., at a constant temperature of 25 °C and under a photoperiod of 12 hours, for 14 days. The evaluations took place on the fifth day and fourteenth day after the implementation of the experiment, analyzing the germination according to Rules for Seed Analysis (BRASIL, 2009).

On the fourteenth day after application of the treatments, the length of the aerial part and of the root system was evaluated with the aid of a caliper. Then, the aerial part of the root system was separated, and the seeds were included together with the root system. Subsequently, the material was conditioned in an oven with forced air circulation, at a constant temperature of 65 °C, for two days. After drying, the materials were weighed on an analytical balance to obtain the dry mass.

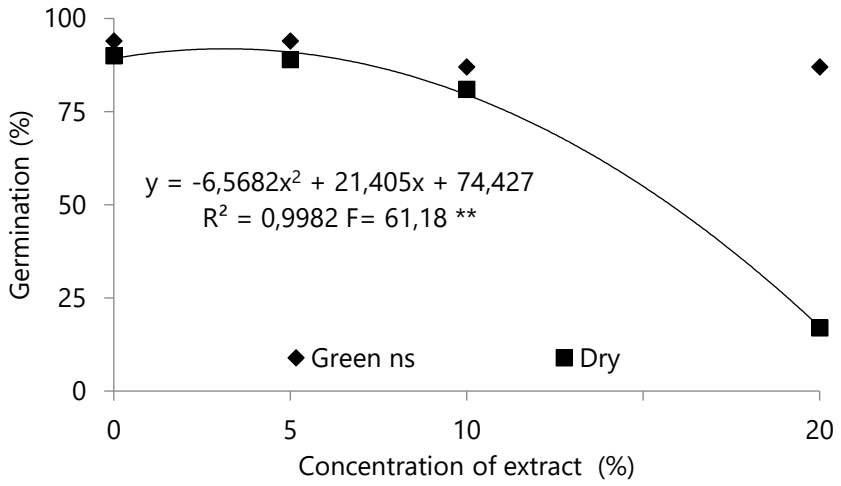
The results were submitted to statistical analysis using the Tukey test at 5% probability with the aid of the Sisvar® Program (FERREIRA, 2014).

RESULTS AND DISCUSSION

The results showed that the interaction between leaf extracts (green and dry) and concentrations significantly interfered with germination, germination speed index, root length, green root mass and shoot and root dry mass. The extracts and isolated concentrations caused significant interference in shoot length and green mass.

In evaluating the percentage of germination, it was observed, as shown in Figure 1, that the dry leaf extract of Senna alata at the maximum concentration studied provided the greatest inhibition, with a negative quadratic behavior ($p<0.01$) and a reduction of 73% in relation to the control treatment. The use of green leaf extract showed no difference in the germination behavior of rice seeds when subjected to different concentrations, remaining with an average value of 91%, thus not affecting the germination process.

Figure 1. Germination of seeds of rice cultivar Cambará at different concentrations of green and dry leaf extracts of *Senna alata* (L.) Roxb.



Source: Prepared by the author.

The drastic reduction in the germination of rice seeds when subjected to a concentration of 20% in the extract of dry leaves may be due to the higher concentration of allelochemicals present in the leaves when they were dry.

Agbagwa et al. (2003) also obtained similar results with *S. alata* extracts on *Celosia argentea* germination, and the germination rate significantly reduced with increasing concentrations. These results also corroborate those observed by Cândido et al. (2010) who found that the semi-purified ethanol-water fraction from shoots of *Senna occidentalis* (L.) at concentrations of 500 and 1000 $mg.L^{-1}$ reduced the percentage of onion germination.

Silva and Santos (2010), who, when analyzing the allelopathic effect of the green leaf extract of *S. obtusifolia* on tomato seed germination, noted that in the first 48 hours the extracts at 100, 70 and 30% showed greater inhibition of germination of seeds, reaching germination less than 2%. In 72 hours, the extracts in proportions of 70 and 100% were the ones that provided greater inhibition of germination, with 36% and 12%, respectively. With 96 hours, the highest concentration of leaf extract provided only 63% germination of seeds,

a reduction of 27% compared to the control treatment.

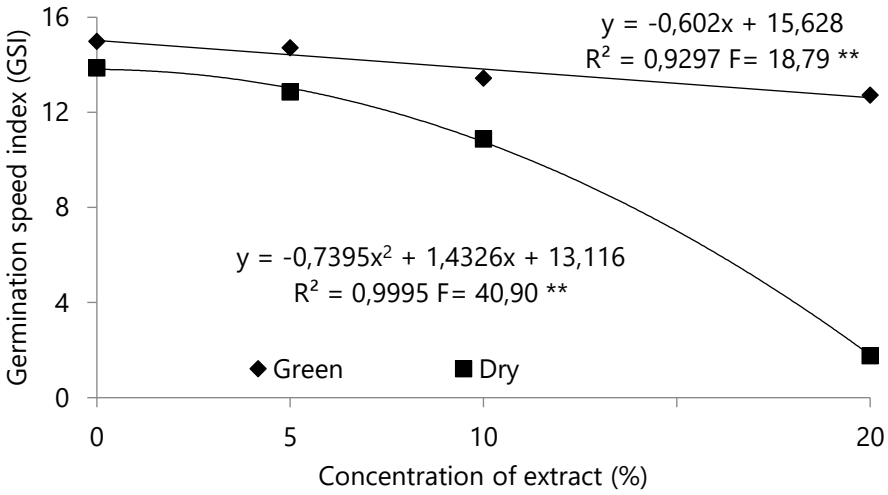
This behavior of high inhibition rate on seed germination of the indicator species caused by the higher concentration of the dry extract of *S. alata* is a result of the inhibition of cell division of the seeds embryonic meristems (AGBAGWA et al., 2003).

Ferreira et al. (2007), studying the allelopathic effect of hydroalcoholic extracts of *S. alata* leaves and flowers, observed that the leaf extract was the one with the highest allelopathic activity, inhibiting weed seed germination above 90% and 70% for weed seed germination. forage, the species *S. obtusifolia* being more sensitive to the effects, followed by *Mimosa pudica*, both presenting, in general, more than 80% of inhibited seeds and the species *Pueraria phaseoloides* presented the greatest resistance to allelopathic action on seed germination.

In the analysis of the germination speed index (GSI) a significant interaction can be observed between the extracts of green and dry leaves of *S. alata* and the concentrations, as shown in Figure 2, and the extract from green leaves of fedegoso presented behavior negative linear ($p<0.01$) with 15% reduction compared to 0% concentration. However, even with a reduction in the germination speed for the different concentrations of the green leaf extract, the germination percentage was not reduced, even at the highest concentration of 20%, where the seeds germinated at 87% slowly, with an GSI of 12.73.

The germination speed index drastically reduced with the use of extract of dry leaves at a concentration of 20%, presenting a negative quadratic behavior ($p<0.01$) as there was an increase in the studied concentrations, with a decrease of 87% in relation to the control treatment. This behavior in reducing seed germination speed (GSI), especially for dry leaf extract, may be due to allelopathic substances having affected seed vigor, significantly reducing germination and speed, with a germination speed index almost 8 times smaller compared to the control treatment.

Figure 2. Germination speed index (GSI) of rice seeds cultivar Cambará at different concentrations of green and dry leaf extracts of *Senna alata* (L.) Roxb.



Source: Prepared by the author.

The GSI is a quantitative measure of germination that relates the number of germinated seeds by the number of sowing days, the higher the GSI, the greater the germination speed, which allows quantifying vigor in seed lots, that is, more seeds germinate in a few days. In this sense, the extract of dry leaves at the maximum concentration studied caused a longer time to start the germination process of rice seeds.

Peres et al. (2010) verified that the crude ethanol extract of the aerial part of S. *obtusifolia* reduced the germination speed index (GSI) of lettuce at all tested concentrations (0, 250, 500 and 1000 mg L^{-1}), observing there was a 39% delay in germination at the maximum concentration in relation to the control, however, this effect was not observed in the final percentage of germination. The crude ethanol extracts of the aerial part of *S. occidentalis* and underground of *S. obtusifolia* and *S. occidentalis* did not influence the germination speed and the germination percentage of the lettuce.

Table 1 and Figure 3 refer to the allelopathic influence of isolated *S. alata* extracts and concentrations on the shoot length of rice seedlings. For the initial growth, the extracts caused changes in the shoot length parameter,

being affected only by the dry leaf extract, which caused a 9.64% reduction in length when compared to the green leaf extract.

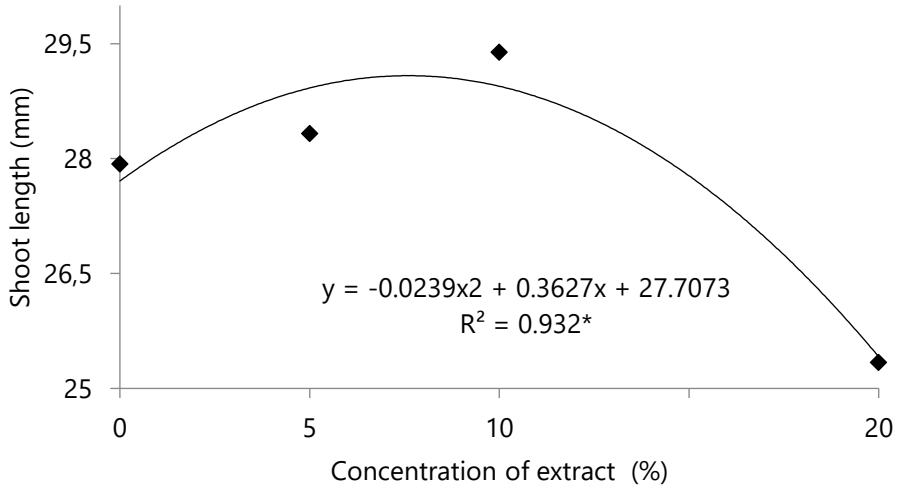
Table 1. Comparison of estimates (%) of shoot length (mm) in green and dry leaf extracts of *Senna alata* (L.) Roxb.

Extract	Shoot length
Green leaf	29,15 a
Dry leaf	26,34 b
C.V. (%)	9,97

Means followed by the same letter do not differ from each other by Tukey's test at 5% probability.

The length of the aerial part was adjusted to quadratic regression ($p<0.05$), with a lower value of 25.34 mm at the maximum concentration, and the maximum point obtained occurred at the percentage of 7.59% with a length of approximately 29 mm (Figure 3). This result can be explained by the effect of allelochemicals present in the leaves that caused the etiolation of the aerial part. Furthermore, it can be observed that the shoot length presented a smaller reduction when compared to the root development.

Figure 3. Shoot length (mm) at different concentrations of leaf extracts of *Senna alata* (L.) Roxb.



Source: Prepared by the author.

Ferreira et al. (2007), when analyzing the allelopathic effect of *S. alata* through hydroalcoholic extracts of leaves and flowers, noted that the leaf extract had a greater allelopathic effect on the development of the hypocotyl of the weed species of *M. pudica* and *S. obtusifolia* and *P. phaseoloid* with 43, 31 and 8% inhibition compared to the control treatment, respectively.

According to Peres et al. (2010), the crude ethanol extract of the shoot of *S. occidentalis* inhibited lettuce root growth (27%) at the highest concentration tested and stimulated hypocotyl growth (21%) at the concentration of 250 mg L^{-1} compared to the control treatment. The crude ethanol extract of the aerial part of *S. obtusifolia* inhibited root growth (38 and 25% at 1,000 mg L^{-1}) and also inhibited the growth of hypocotyl/coleoptiles (28 and 12%, 1,000 mg L^{-1}) of lettuce and onion, respectively.

These results are important, since the accentuated reduction of the root can affect the competitive capacity and the productivity of the plants; and the reduction of the aerial part (hypocotyl/coleoptile) can reduce the plant's ability to compete for light (SILVA et al., 2018). The stimulatory effects can be caused by some substances in low concentrations, while in high concentrations it becomes inhibitory, and in most cases, these substances can affect the permeability of the membrane (PERES et al., 2010). At high concentrations, they can inhibit the absorption of water and nutrients; and those substances in low concentrations can facilitate absorption (REIGOSA et al., 2013).

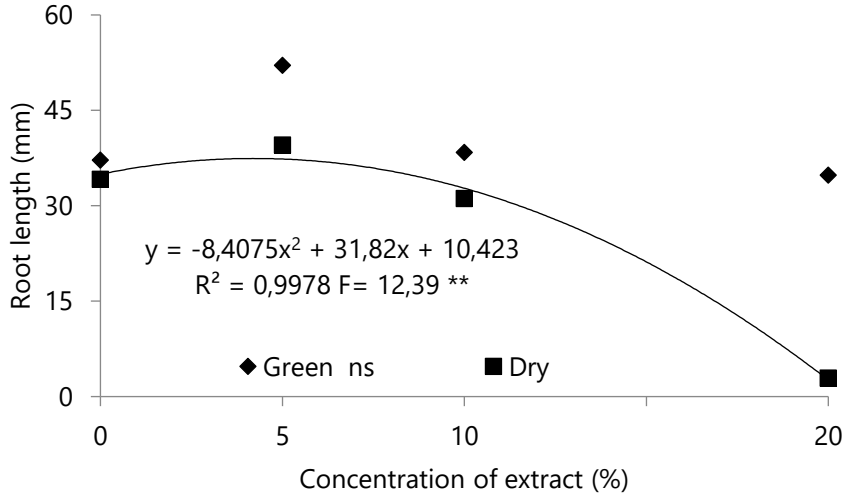
In the root length of rice seedlings, as shown in Figure 4, it was observed that only the green leaf extract showed a difference in length, presenting a negative quadratic behavior ($p<0.01$) as the increase in extract concentrations occurred. The 20% concentration caused a 92% reduction compared to the absence of the extract. This behavior can be attributed to the low concentration of water in the leaves and the higher concentration of allelochemicals, which drastically affected the root length, consequently,

there will be less absorption of water and nutrients by these plants and, consequently, reduction in size and production.

According to Kremer et al. (2018), the reduction of the root system is an important ecological aspect since, with the inhibition of root development, there is a reduction in the competitive pressure of the plant, which favors nearby species and causes their dominance.

This result corroborates those obtained by Cândido et al. (2010), in which they observed that the ethanol-water fraction of the aerial part of S. occidentalis inhibited the root growth of lettuce and tomato at the highest concentrations of 500 $mg.L^{-1}$ and 1000 $mg.L^{-1}$. Agbagwa et al. (2003), also obtained similar results, where they demonstrated that the allelopathic effects of the crude extract of *S. alata* inhibited the radicle growth in *C. argentea*.

Figure 4. Root length (mm) at different concentrations of green and dry leaf extracts of *Senna alata* (L.) Roxb.



Source: Prepared by the author.

Another effect that can possibly be attributed to the presence of allelochemicals, are the morphological changes in the roots, where at a concentration of 5% with both extracts it can be observed that the roots had

longer lengths, but thinner. At 20% concentration with the extract of dry leaves, the roots were extremely smaller and thicker.

These effects corroborate those obtained by Cândido et al. (2010), who observed some stimulus in the growth of the roots, these were thinner, while in inhibition there was thickening, in addition to the absence of absorbent roots.

Soares et al. (2002) also observed that aqueous extracts of legume species show a strong inhibiting effect on the root development of lettuce seedlings, and this result is accompanied by morphological changes in the roots such as thickening, a fact also observed in the present work.

Rodrigues et al. (2010), when analyzing the chemical prospection of compounds produced by *S. alata* and their effect on seed germination and radicle elongation of *Mimosa pudica*, *S. obtusifolia* and *S. alata*, noted that the compounds with allelochemical potential found in leaves, belonging to the class of glycosylated flavonoids, cause intense inhibition, firstly, on the radicle growth and germination of *S. obtusifolia* and *M. pudica*, with little expressive results for the seedling growth and null on the germination of *S. alata*.

Ferreira et al. (2007), studying the allelopathic effect of hydroalcoholic extracts of *S. alata* leaves and flowers, observed that the leaf extract had a greater allelopathic effect on the radicle development of the weed species of *M. pudica* and *S. obtusifolia* and the forage *P. phaseoloide* with an inhibition of 51, 70 and 64% compared to the control treatment, respectively. This behavior was also observed in the present study, where the root length was more inhibited by the extract of dry leaves than the aerial part of rice seedlings.

Table 2 and Figure 5 refer to the allelopathic effect of *S. alata* extracts and concentrations on the green mass aboveground of rice seedlings. For the green mass of the aerial part, it was observed that the dry leaf extracts had a greater reduction in values when compared to the green leaf extract.

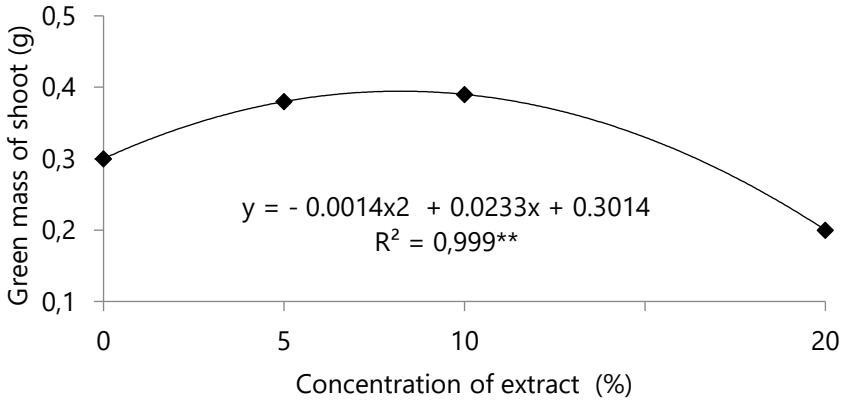
Table 2. Comparison of estimates (%) of shoot green mass (g) in green and dry leaf extracts of *Senna alata* (L.) Roxb.

Extract	Shoot green mass (g)
Green leaf	0,36 a
Dry leaf	0,27 b
C.V. (%)	27,70

Means followed by the same letter do not differ from each other by Tukey's test at 5% probability.

The green mass of the aerial part was adjusted to quadratic regression ($p<0.01$), and as the concentration of the extract increased, there was a decrease for the variable, where the maximum point occurred at the concentration of 8.32%, corresponding to 0.40 g (Figure 5). This result coincides with the data of shoot length, which reached its maximum value at the concentration of 7.59% due to the etiolation of rice seedlings, thus providing a greater green mass of the shoot.

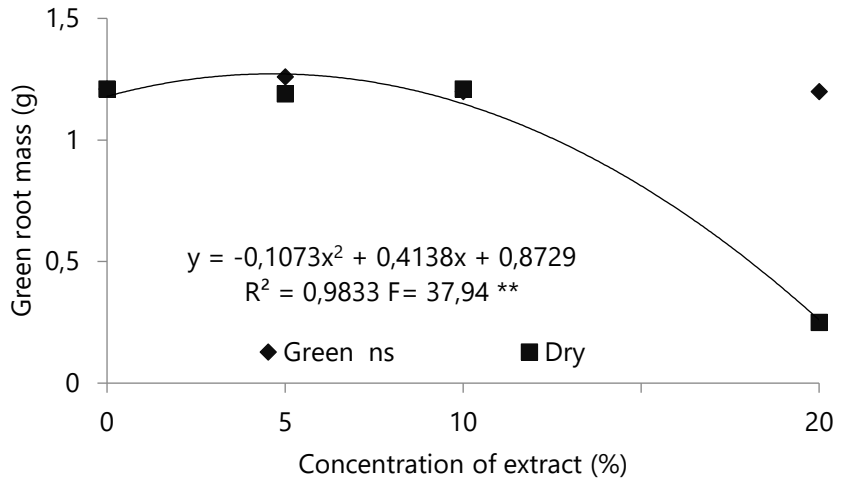
Figure 5. Green mass of shoot (g) at different concentrations of leaf extracts of *Senna alata* (L.) Roxb.



Source: Prepared by the author.

Figures 6, 7 and 8 refer to the allelopathic influence of the interaction between the extracts and concentrations of *S. alata*, on the root green mass and on the shoot and root dry mass of rice seedlings.

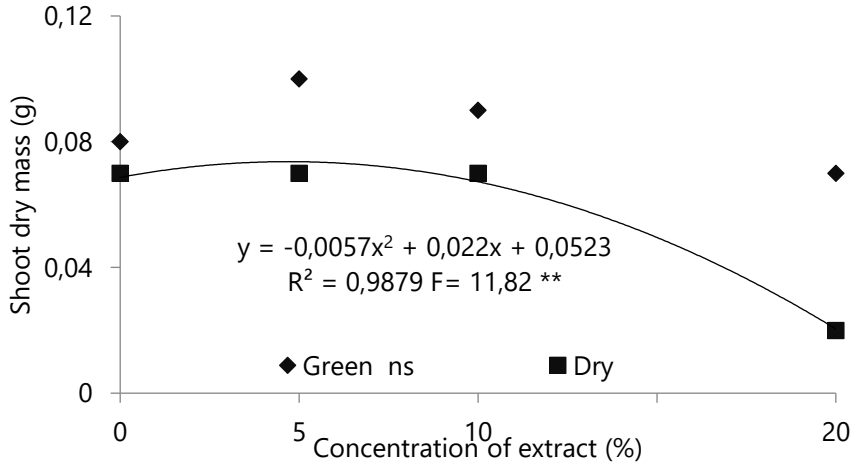
Figure 6. Green root mass (g) at different concentrations of green and dry leaf extracts of *Senna alata* (L.) Roxb.



Source: Prepared by the author.

In the evaluation of the green mass of the root, it was observed that the dry leaf extract of *S. alata* at the maximum concentration studied provided the greatest decrease in mass, with a negative quadratic behavior ($p<0.01$) and maximum point at 4.76 %. The use of green leaf extract showed no difference in the green mass of the root of rice seeds when subjected to different concentrations, remaining with an average value of 1.22 g.

Figure 7. Shoot dry mass (g) at different concentrations of green and dry leaf extracts of *Senna alata* (L.) Roxb.

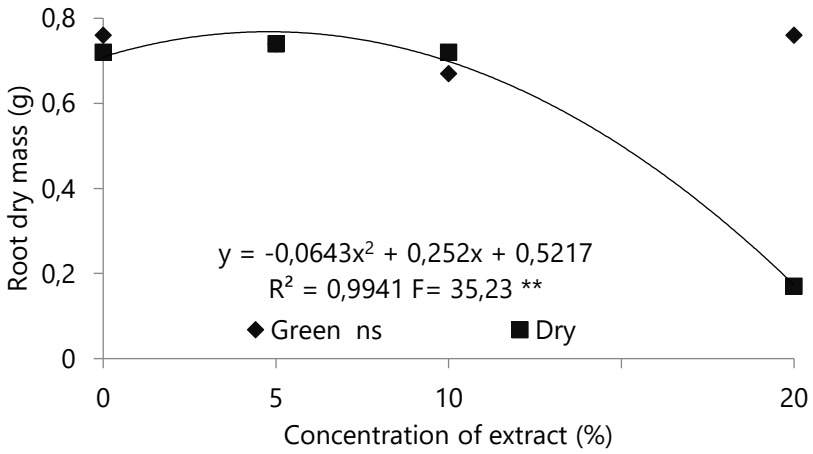


Source: Prepared by the author.

The shoot dry mass had the greatest influence on the concentration of 20% with the dry leaf extract and showed a negative quadratic behavior ($p<0.01$), obtaining a mass of 0.02 g, a value less than 3 times that observed in the concentrations of 0, 5 and 10%. When using the green leaf extract, no significant adjustment for dry mass was verified, however, the highest number occurred in the percentage of 5% (Figure 7).

For root dry mass, a negative quadratic behavior was observed in the dry leaf extract ($p<0.01$) with a drastic reduction in the concentration of 20%, with the maximum point at 4.74%. The green leaf extract at different concentrations showed no significant difference, with a mean value of 0.73 g (Figure 8).

Figure 8. Root dry mass (g) at different concentrations of green and dry leaf extracts of *Senna alata* (L.) Roxb.



Source: Prepared by the author.

According to Rodrigues et al. (2009), *S. alata* presents a high diversity of chemical compounds in all its structures, mainly in its leaves, thus indicating its high allelopathic potential, presenting in the detection of chemical substances classes especially alkaloids, anthraquinones, saponins and tannins in leaf structure. Peres et al. (2010) confirmed that the two species of *S. occidentalis* and *S. obtusifolia*, despite being from the same family and subfamily, showed different behavior in relation to the effects on germination

and growth of the target species, showing that the products of secondary metabolism are species-specific.

Cândido et al. (2010) found that the aerial part of *S. occidentalis* contains chemical substances responsible for interfering with the germination and initial growth of the target species, under study, of eudicots and monocots, which can be useful as a natural herbicide in invasive plant management programs.

Thus, it appears that further research on the allelochemical potential of aggressive plant species such as *S. alata* becomes important within modern agriculture, generating subsidies for the development of new management practices and, as a consequence, improving the performance of cultures (LIMA et al., 2017).

Plants that arise spontaneously, when they are capable of harming or even inhibiting the development of other plants, as is the case of *S. alata*, should be particularly concerned when planning the cultural practices and management strategies to be implemented (LAMEGO et al. al., 2015).

The correct management of these species becomes a bottleneck to achieve high yields under any agricultural practices.

necessary to implement and carry out the research.

CONCLUSION

The dry leaf extract of *Senna alata* causes an allelopathic effect at a concentration of 20% on seed germination and length, green and dry root mass of rice seedlings.

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