Original Article

ALLELOPATHIC EFFECT OF AQUEOUS EXTRACTS OF DIFFERENT ORGANS OF THREE SUNFLOWER CULTIVARS ON GERMINATION OF RADISH

EFEITO ALELOPÁTICO DE EXTRATOS AQUOSOS DE DIFERENTES ÓRGÃOS DE TRÊS CULTIVARES DE GIRASSOL SOBRE A GERMINAÇÃO DE NABO

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ABSTRACT: This study aimed to evaluate the allelopathic potential of aqueous extracts of different organs of three sunflower cultivars on the germination and initial development of radish. The study was conducted in a Laboratory of Plant Physiology of the Federal University of Santa Maria, Brazil. The design was completely randomized in a three-factor scheme with four replications. The first factor consisted of three sunflower cultivars: Olisun 3, Olisun 5, and Aguará 6. The second factor consisted of different organs: leaves, stems, and roots. The third factor consisted of the extracts concentrations: 0, 25, 50, 75, and 100%. The experimental unit (EU) used was gearboxes with two sheets of germitest paper that were moistened with the extracts. The EUs were placed in BOD germination chamber at 25 °C. Daily count of germinated seeds was performed. The radicle length and hypocotyl were measured on the 10th day. The variables analyzed included germination (G); germination speed index (GSI); radicle length (RL); and hypocotyl length (HL). Sunflowers have allelopathic potential on the radish. The extract concentration of 75% of all organs and cultivars were sufficient to significantly reduce the variables. The allelopathic activity differs between organs (leaves, stems, and roots) and sunflower cultivars. The amount of allelopathic effects vary in the order of root, stem, and then leaf. Extracts from the roots showed the greatest allelopathic effect on germination and initial development on the radish; however, this depends on the cultivar used. Field studies should be performed to verify such allelopathic activities.

KEYWORDS: Allelopathy. Initial growth. *Raphanus sativus. Helianthus annuus* L.

INTRODUCTION

The radish (*Raphanus sativus* L.) has been widely used as winter forage in southern Brazil, preceding crops such as wheat, canola, maize, and soybeans. It is presented as an alternative to keep the soil covered, making difficult the emergence of weeds in the off-season and consequently in the subsequent cultivation. That efficiency is due to its high production of biomass and excellent ground cover (CONCENÇO et al., 2013).

Due to its great use for ground cover and pasture establishment, this species has become an important weed (LAMEGO et al., 2013). Winter and summer crops in Brazil are hindered by the presence of the radish. Especially in canola crops, the radish together with other weeds such as *Lolium multiflorum* L. and *Raphanus raphanistrum* L. compete for water, light, nutrients, and CO_2, and, in some cases, the radish may exhibit resistance to ALS (Acetolactate synthase), inhibiting herbicides (GALON et al., 2015).

The cultivation of canola (*Brassica napus* L.) grows annually in Brazil due to the excellent vegetable oil in its grains for the production of biodiesel. However, the cultivation of this species becomes difficult with the infestation of the radish and the absence of post-emergence herbicides with selectivity for the crop (VARGAS et al., 2011). Also, in the summer crops, the radish is considered an important invasive dicot weed. The presence of radishes in soybean crops may cause major losses in the final grain production (BIANCHI et al., 2011).

Weeds may increase the cost of production and reduce the yield of crops. These plants can become the biggest economic issue if non-chemical methods of weed control are ignored. To have a sustainable production system and an efficient weed management, integrated management should be included in a production system (ASADUZZAMAN et al., 2014).

Allelopathy is considered an excellent alternative for weed control without the use of synthetic chemicals. Allelopathy is defined as the release of a plant allelochemicals or organisms within the environment, which may be beneficial or harmful (NIKNESHAN et al., 2011; SPIASSI et al., 2015). The effect of allelochemicals on the plant can be positive or negative; the recipient plant of such compounds may suffer or be stimulated in their

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initial development (SODAEIZADEH; HOSSEINI, 2012).

The sunflower crop (*Helianthus annuus* L), due to its producing good quality oil and features short cycle, is being grown to predate the winter crop. Furthermore, within sunflowers, there have been more than 200 natural chemical compounds isolated and some have been proven to have allelopathic effects as terpenoids, flavonoids, and alkaloids (VYVYAN, 2002; KAMAL; BANO, 2009). Some studies demonstrate the allelopathic potential of sunflowers on germination and initial development of wheat, rice (BASHIR et al., 2012), maize (MUHAMMAD; MAJEED, 2014), cotton (KANDHRO et al., 2016), and on weeds, such as *Dactyloctenium aegyptium, Trianthema portulacastrum* and *Eleusine indica* (MUBEEN et al., 2012). However, these allelopathic effects have great variability among sunflower cultivars and between the same plant organs.

Thus, if the allelopathic effect of sunflowers on seed germination and initial seedling development of radishes become proved, the sunflower can be grown preceding winter cultivation as an alternative to reduce radish infestation in succeeding crops.

The aim of this study was to evaluate the allelopathic potential of aqueous extracts of different cultivars of sunflower (*Helianthus annuus* L.) and different organs of the plant on the seed germination and initial development of radish seedlings (*Raphanus sativus* L.).

MATERIAL AND METHODS

The experiment was conducted in the Plant Physiology Laboratory of the Federal University of Santa Maria at the campus of Frederico Westphalen, Brazil, RS. The design was completely randomized in a three-factor scheme (3×3×5) with four replications. The first factor consisted of three sunflower cultivars: Olisum 3 (Oli3) Olisum 5 (Oli5), and Aguará 6 (Agu6). The second factor consisted of different organs of the plant for the preparation of aqueous extracts: leaves, stems, and roots. The third factor consisted of different concentrations of the extracts: 0, 25, 50, 75, and 100%.

The sunflowers were grown in 5 L pots filled with organic substrate BIOMIX® and kept in a greenhouse to obtain the raw material. Four plants of each cultivar were kept. Irrigation was performed manually, and it was maintained at 80% of field capacity.

When the sunflower reached a full flowering stage (60 - 70 days after emergence), the leaves, stems, and roots of all plants were collected. Subsequently, they were dried in an air-forced circulation stove at 60 °C for approximately 72 hours until a constant weight was obtained.

For the formulation of the aqueous extracts, the methodology described by Rigon et al. (2012) was used. Sunflowers' leaves, stems, and roots, which were already dry, were ground until they became a powder; then, they were mixed in distilled water with a 1:10 (w/v, 100 g of powder to 1.0 L of distilled water) ratio and stored in a refrigerator for 24 hours at 4 °C. The extracts were filtered with filter paper, which was considered crude extracts (100%). From these, dilutions were made for other extracts at 25, 50, and 75%. For the control (0%), only distilled water was used. After obtaining the extracts, their pHs were measured with the aid of a pH meter. The values varied from 6.0 to 6.5, which are within the limits considered ideal for germination and initial seedling development (BRASIL, 2009).

The radish seeds were obtained in agricultural trade establishments in the region. In the laboratory, the seeds were disinfected with sodium hypochlorite at 2% for 2 minutes and rinsed with running water during the same period and stored in a refrigerator at 4 °C. The materials used and other glassware were sterilized at a temperature of 160 °C for two hours.

Transparent acrylic gearboxes were used as experimental units (EUs) with dimensions 11 × 11 × 4 cm and with two germitest paper at the base, which were humidified in the ratio of 2.5 times their mass (BRASIL, 2009), for each treatment – aqueous extract. For each EU, 50 seeds of the radish were placed with for replicates, totaling 200 seeds per treatment. The gearboxes were sealed with adhesive tape in order to minimize the loss of water, aiming at an appropriate germination. Subsequently, they were placed in a growth chamber type B.O.D. (Biochemical Oxygen Demand) with a controlled photoperiod of 12 hours and temperature at 25 ± 2 °C.

Seed germinations were counted daily until the 10^{th} day. It was considered as a germinated seed when 2 mm of root protrusion was observed. On the last day, the hypocotyl length and radicle length was measured using a digital caliper with data expressed in millimeters (mm).

The variables analyzed included the percentage of germination (G); germination speed index (GSI) using the formula proposed by

Fernandes et al. (2007); radicle length (RL); and hypocotyl length (HL).

The data were submitted to analysis of variance, and when a significance was observed, the averages of the qualitative factor were submitted to Tukey test and the quantitative factor by fitting regression equations, both at 5% error probability using the software SISVAR® (FERREIRA, 2011). The models were selected based on the coefficient of determination, the regression coefficient and on the biological response. For the variable percentage of germination, the transformation $(x+1)^{0.5}$ was used. For the variables with linear and quadratic adjustments, the concentration of response extracts was estimated, which induced a reduction of 50% of the analyzed variable (RE50).

RESULTS AND DISCUSSION

A triple interaction was observed for the variable G. The averages of the germination variable are shown in Table 1. There was a decrease of germination with increasing extract concentration. Using 100% leaf extracts of Oli5 and Agu6 decreased the germination by 75 and 74%, respectively, compared to the controls. Using stem extracts, it was observed that Oli5 extracts inhibited at a higher intensity, reducing radish germination by almost 90%, and root extracts of all cultivars inhibited the germination from 69 % until 80%. By studying the allelopathic effect of sunflower leaves, stems, and roots extracts on wheat and maize, Muhammad and Majeed (2014) noted that leaf extracts inhibited the germination of the species studied at a greater magnitude compared to stems, and roots extracts. However, the authors evaluated the allelopathic effect of different organs of just one sunflower cultivar.

Assessing the organ extracts within each genotype, it can be observed that for Oli3, the roots extract decreased the germination in higher magnitudes (i.e., a reduction of more than 80%) compared to the control. To Oli5, the stem extract and the Agu6 leaves extract decreased this variable to a higher magnitude than controls. These results show great variability in the concentration or presence of different compound allelochemicals among cultivars and organs. These results corroborate with those found by Nikneshan et al. (2011). The authors found differences of allelopathic effect from 8 different cultivars of sunflower on the germination of weed species as *Amaranthus retroflexus* L. and *Hordeum spontaneum* L. According to Alsaadawi et al. (2012), the magnitude of inhibition is dependent on the type of cultivar. Silva et al. (2009) also observed variability in the allelopathic effect of sunflower cultivars. According to Gatti et al. (2004), the amount of allelochemicals and their release by the plant organs are variations that occur from species to species.

Table 1. Mean values ± standard error of the triple interaction among organs, concentrations, and doses for germination variable (G) of radish seeds submitted to different concentrations of aqueous extracts of leaves, stems, and roots of three different cultivars of sunflower: Olisun 3, Olisun 5, and Aguará 6.

Organs	Dose (%)	Cultivars		
		Olisun 3	Olisun 5	Aguará 6
		----------%----------		
leaves	0	70.66 **±3.9** Aa*	70.66 **±3.9** Aa	70.66 **±3.9** Aa
	25	80.00 **±5.6** ABa	75.00 **±5.4** Ba	95.00 **±3.8** Aa
	50	82.00 **±9.0** Aa	81.00 **±9.4** Aa	83.00 **±6** Aa
	75	64.00 **±5.7** Aa	56.00 **±8.9** ABa	44.00 **±9.7** Bab
	100	38.00 **±2.4** Aa	17.00 **±9.0** Ba	18.00 **±6.9** Bb
stems	0	70.66 **±3.9** Aa	70.66 **±3.9** Aa	70.66 **±3.9** Aa
	25	78.00 **±5.1** Aa	69.00 **±6.0** Aa	79.00 **±5.0** Aa
	50	63.00 **±8.2** Ab	57.00 **±8.8** Ab	64.00 **±9.2** Ab
	75	49.00 **±6.4** Ab	35.00 **±8.8** Bb	48.00 **±7.3** Aa
	100	28.00 **±9.7** Aa	9.00 **±2.0** Ba	31.00 **±5.0** Aa
roots	0	70.66 **±3.9** Aa	70.66 **±3.9** Aa	70.66 **±3.9** Aa
	25	75.00 **±3.8** Aa	77.00 **±2.0** Aa	78.00 **±6.9** Aa
	50	58.00 **±4.5** Ab	58.00 **±7.6** Ab	45.00 **±9.0** Ac
	75	28.00 **±7.3** Ac	38.00 **±7.6** Ab	34.00 **±9.2** Ab

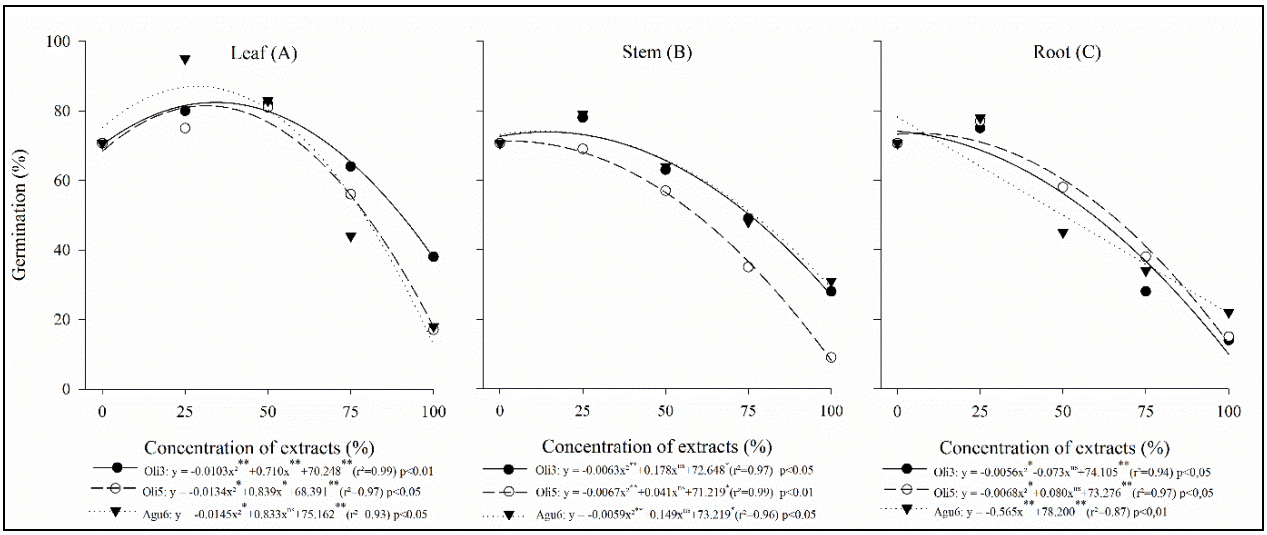
100	14.00 **±5.1** Ab	15.00 **±6.0** Aa	22.00 **±7.6** Aab
CV (%)		8.18	
Average		56.02	

* Means followed by the same lowercase letter in the column, compare organs within cultivar and dose and followed by the same uppercase letter in line compare cultivate within each organ and dose, do not differ by Tukey's test (p <0.05). CV: Coefficient of variation.

Even small concentrations of extracts of all organs and cultivars stimulated the germination. Although the small concentrations of the extracts act as inhibitors, some studies indicate that the allelochemicals can act as stimulants when present in lower concentrations. Gatti et al. (2004), Ghayal et al. (2007), and Rigon et al. (2016) observed stimulation of germination of radishes when a lower concentration of *Aristolochia esperanzae* O. Kuntze extracts, *Cassia uniflora* L. leaves extracts, and *Ricinus communis* leaves extracts were used, respectively.

According to Ghayal et al. (2013), as much the stimulus as the inhibitory effects are both dependent on the concentration of allelochemicals. The authors affirm that the stronger stimulus of an extract on another can be attributed to the presence of different allelochemicals.

In Figure 1, the allelochemical effect can be better analyzed. In Figure 1A, it is noticed that leaf extracts of cultivars Oli5 and Agu6 obtained the ER50 only with 90 and 88.5% of concentration, respectively. The Oli3 extracts (even with 100% of concentration) was not sufficient to reach this reduction. In Figure 1B, stem extracts of the cultivar Oli5 obtained ER50 with 76.3%. Figure 1C shows that all the root extracts obtained ER50 with lower concentrations of 76.9, 80.9 and 75.85 % for Oli3, Oli5, and Agu6, respectively. It showed that roots extracts exhibit greater allelopathic potential, requiring less concentrated to inhibit the germination of radish.



ns, ** and *: non-significant, significant to 1 and to 5% of probability, respectively.

Figure 1. Germination (%) of radish seeds submitted to different concentrations of aqueous extracts of leaves (A), stems (B), and roots (C) of three different cultivars of sunflower: Olisun 3 (Oli3), Olisun 5 (Oli5), and Aguará 6 (Agu6).

Likewise, for the GSI, triple interaction among the factors also occurred. Table 2 shows that this variable was drastically reduced with increasing extract concentrations. Other studies have reported this relationship as well (RIGON et al., 2016). It is also observed that this variable was stimulated when leaf, stem, and root extracts of Agu6 was used in lower concentrations. This occurred since this variable is related to germination, which also obtained stimuli.

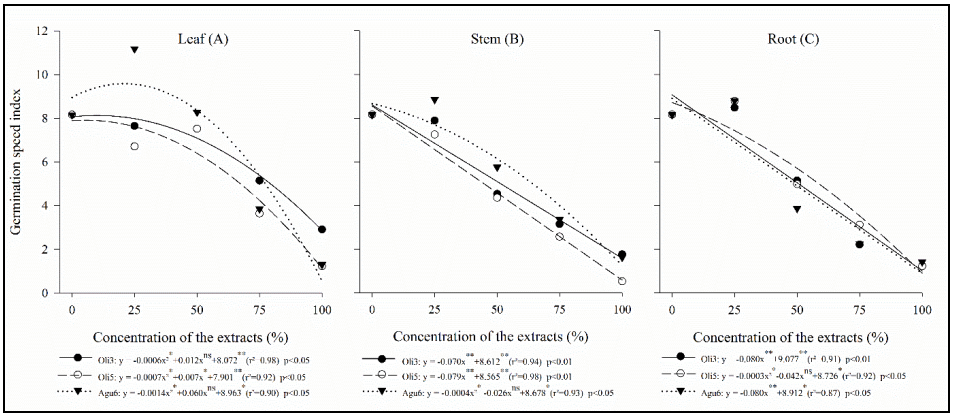
The GSI variable is associated with seed vigor. The importance of this variable is worth noting because the allelopathic effect often does not occur directly in the final seed germination, but on the germination rate, that is, how many days take the seeds to germinate (FERREIRA; BORGHETI (2004). From this, Figure 2 shows that the root and stem extracts compared with the leaf extracts showed a greater reduction of GSI in extracts from 50% of concentration. Also, the quadratic

adjustments show that leaf extracts (Figure 2A) reached ER50 with 93, 80, and 84% of extract concentration, while stem extracts (Figure 2B) reached 64, 56, and 79% and root extracts (Figure 2C) reached 62, 72, and 60%, respectively for Oli3, Oli5, and Agu6.

Table 2. Mean values ± standard error of the triple interaction among organs, concentrations, and doses for germination speed index (GSI) of radish seeds submitted to different concentrations of aqueous extracts of leaves, stems, and roots of three different cultivars of sunflower: Olisun 3, Olisun 5, and Aguará 6.

Organs	Dose (%)	Cultivars		
		Olisun 3	Olisun 5	Aguará 6
leaves	0	8.16 **±0.4** Aa*	8.16 **±0.4** Aa	8.16 **±0.4** Aa
	25	7.65 **±0.7** Ba	6.71 **±0.8** Bb	11.18 **±0.3** Aa
	50	7.52 **±1.8** Aa	7.52 **±0.9** Aa	8.28 **±1.0** Aa
	75	5.14 **±0.8** Aa	3.64 **±0.8** Ba	3.85 **±0.4** Ba
	100	2.91 **±1.2** Aa	1.23 **±0.7** Ba	1.31 **±0.5** Ba
stems	0	8.16 **±0.4** Aa	8.16 **±0.4** Aa	8.16 **±0.4** Aa
	25	7.89 **±1.2** ABa	7.25 **±0.8** Bb	8.86 **±0.8** Ab
	50	4.53 **±0.8** ABb	4.35 **±1.2** Bb	5.76 **±0.8** Ab
	75	3.15 **±1.0** Ab	2.57 **±0.6** Aa	3.36 **±0.6** Aab
	100	1.76 **±0.6** Aab	0.53 **±0.1** Aa	1.63 **±0.2** Aa
roots	0	8.16 **±0.4** Aa	8.16 **±0.4** Aa	8.16 **±0.4** Aa
	25	8.48 **±0.4** Aa	8.79 **±0.2** Aa	8.80 **±0.9** Ab
	50	5.14 **±0.8** Ab	4.98 **±0.5** Ab	3.87 **±0.7** Ac
	75	2.21 **±0.7** Ab	3.12 **±1.0** Aa	2.25 **±0.4** Ab
	100	1.23 **±0.5** Ab	1.22 **±0.4** Aa	1.42 **±0.4** Aa
CV (%)		14.04		
Average		5.41		

* Means followed by the same lowercase letter in the column, compare organs within cultivar and dose and followed by the same uppercase letter in line compare cultivate within each organ and dose, do not differ by Tukey's test ($p < 0.05$). CV: Coefficient of variation.



ns, ** and *: non-significant, significant to 1 and to 5% of probability, respectively.

Figure 2. Germination speed index (GSI) of radish seeds submitted to different concentrations of aqueous extracts of leaves (A), stems (B), and roots (C) of three different cultivars of sunflower: Olisun 3 (Oli3), Olisun 5 (Oli5), and Aguará 6 (Agu6).

For the variable RL, there was a double interaction between organs and doses. Table 3 shows that there was a large reduction in the development of this structure with increasing

concentrations of extracts of all organs. However, stem and root extracts in the lowest concentration (25%) reduced by 90 and 75% of the root length compared to the control, while leaf extracts reduced only by 39%. Some studies mention that the leaves are the organs with the highest concentration of allelochemicals and thus have greater power of inhibiting the development of seedling (SHARMA; SATSANGI, 2013; MUHAMMAD; MAJEED,

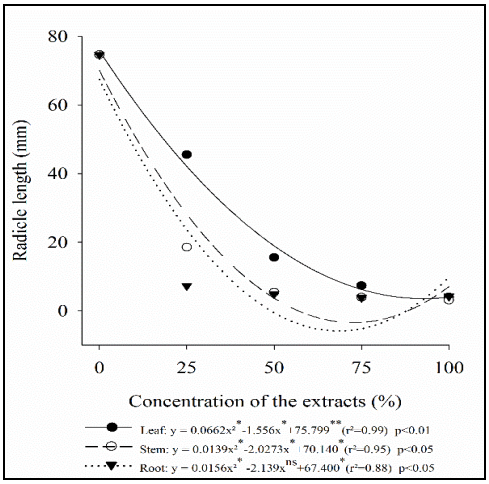
In Figure 3, by adjusting of the equations, root and stem extracts had similar behavior, reaching ER50 with 15.89 and 18.54% of the extract

2014). However, these authors did not work with different cultivars for the formulation of the extracts. When working with extracts of different sunflower cultivars and its organs, root and stem extracts may show variability in the production of allelochemicals due to the genetic load of each cultivar. Thus, some cultivars can be found where the stem or root extracts may present greater allelopathic potential than the leaf extracts. concentrations, respectively. For the leaf extracts, the ER50 reached only 29.02% of concentration.

Table 3. Mean values ± standard error of the interaction between organs and doses for radical length (RL) of radish seedlings submitted to different concentrations of aqueous extracts of leaves, stems, and roots.

Dose (%)	Radicle length (mm)		
	leaves	stems	roots
0	74.66 **±6.6** A	74.66 **±6.6** A	74.66 **±6.6** A
25	45.54 **±9.6** A	18.57 **±5.8** B	7.33 **±2.6** C
50	15.54 **±6.5** A	5.42 **±1.35** B	4.96 **±0.9** B
75	7.36 **±4.0** A	3.96 **±1.4** A	3.85 **±0.5** A
100	4.01 **±2.1** A	3.14 **±0.4** A	4.24 **±0.7** A
CV (%)		22.18	
Average		23.19	

*Means followed by the same letter in the line, compare organs (leaves, stems, roots) within the dose, do not differ by Tukey's test ($p < 0.05$). CV: Coefficient of variation.



ns, ** and *: non-significant, significant to 1 and to 5% of probability, respectively.

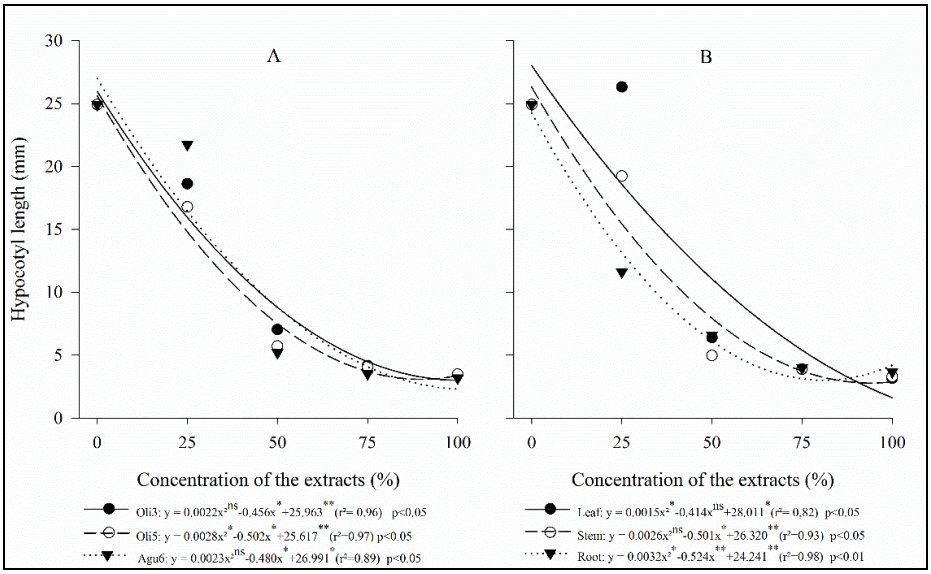
Figure 3. Radicle length (RL) of radish seedlings submitted to different concentrations of aqueous extracts of leaves, stems, and roots.

For the variable HL, there was an interaction between cultivars × doses and organ × doses. The averages of the first interaction are demonstrated in Table 4. It is noted that the extract of Oli5 was the one that reached the highest reduction with lowest extract concentration, reducing development by 32% compared with the control. Some cultivars have higher allelopathic potential due to the presence and higher concentrations of chemical compounds in its structure due to genetics. Figure 4A shows similar behavior between extracts of Oli3 and Agua6, although the extract of Oli5 reached greater reduction, obtaining a ER50 with 35.72, 36.63 and 31.84%, respectively.

Table 4. Mean values ± standard error of the interaction between cultivars and doses for hypocotyl length (HL) of radish seedlings submitted to different concentrations of aqueous extracts of three different cultivars of sunflower: Olisun 3, Olisun 5, and Aguará 6.

Dose (%)	Hypocotyl length (mm)		
	Olisun 3	Olisun 5	Aguará 6
0	24.92 **±2.1** A*	24.92 **±2.1** A	24.92 **±2.1** A
25	18.63 **±6.4** B	16.79 **±5.4** B	21.76 **±6.5** A
50	7.04 **±3.0** A	5.72 **±2.4** A	5.21 **±2.0** A
75	4.17 **±1.5** A	4.08 **±0.9** A	3.53 **±0.8** A
100	3.47 **±0.6** A	3.49 **±0.6** A	3.18 **±0.8** A
CV (%)	20.44		
Average	11.45		

*Means followed by same letter in the line compare cultivars (Olisun 3, Olisun 5 and Aguará 6) within the dose, do not differ by Tukey's test ($p < 0.05$). CV: Coefficient of variation.



ns, ** and *: non-significant, significant to 1 and to 5% of probability, respectively.

Figure 4. Hypocotyl length (HL) of radish seedlings submitted to (A) different concentrations of aqueous extracts of three cultivars: Olisun 3 (Oli3), Olisun 5 (Oli5), and Aguará 6 (Agu6) and to (B) different concentrations of aqueous extracts of leaves, stems, and roots of sunflower.

In the same way, as was the case for RL, Table 5 shows that the magnitude of the reduction of HL was greater when root and stem extracts were used. The reduction using the extract of 25% of concentration was approximately 53.4 and 22.79 %, respectively, for root and stem extracts compared to controls. Leaf extracts in the same concentration stimulated the development of this structure. Rigon et al. (2016) studied the allelopathic effect of aqueous extracts of castor leaves on radishes and noted that extracts at low concentrations stimulate the initial development of seedlings. According to the authors, this occurs as a defense mechanism of the seedlings; it increases cell division, and there is an increased sensitivity of the tissues. With the quadratic adjustments in Figure 4B, the ER50 was achieved with about 27, 33 and 45 % of concentrations for root, stem, and leaf extracts, respectively. Stem and root extracts inhibited the HL variable with a greater intensity, demonstrating they may have a higher concentration of allelochemicals than in leaves.

Table 5. Mean values of the interaction between organs and doses for hypocotyl length (HL) of radish seedlings submitted to different concentrations of aqueous extracts of leaves, stems, and roots.

Dose (%)	Hypocotyl length (mm)		
	leaves	stems	roots
0	24.92 ±2.1 A*	24.92 **±2.1** A	24.92 **±2.1** A
25	26.32 ±5.4 A	19.24 **±5.4** B	11.62 **±4.3** C
50	6.40 ±3.4 A	4.97 **±2.1** A	6.60 **±1.7** A
75	3.88 ±1.5 A	3.90 **±1.0** A	4.00 **±0.9** A
100	3.16 ±0.5 A	3.30 **±0.7** A	3.68 **±0.6** A
CV (%)		20.44	
Average		11.45	

*Means followed by the same letter in the line compare organs (leaves, stems, roots) within the dose, do not differ by Tukey's test ($p < 0.05$). CV: Coefficient of variation.

CONCLUSIONS

Sunflower extracts had allelopathic potential on the germination and initial development of radish seedlings in the studied environment. The extract concentration of 75% of all organs and cultivars were sufficient to significantly reduce the variables analyzed.

The allelopathic activity differs between organs (leaves, stems, and roots) and sunflower cultivars. The amount of allelopathic effects vary in the order of root, stem, and then leaf; however, this depends on the cultivar used.

Field studies should be performed to verify such allelopathic activities.

RESUMO: Este estudo teve como objetivo avaliar o potencial alelopático de extratos aquosos de diferentes órgãos de três cultivares de girassol sobre a germinação e o desenvolvimento inicial de rabanete. O estudo foi realizado em Laboratório de Fisiologia Vegetal da Universidade Federal de Santa Maria, Brasil. O projeto foi inteiramente casualizado, em um esquema trifatorial, com quatro repetições. O primeiro fator consistiu de três cultivares de girassol: Olisun 3, Olisun 5, e Aguará 6. O segundo fator consistiu de diferentes órgãos: folhas, caules e raízes. O terceiro fator consistia nas concentrações dos extratos: 0, 25, 50, 75, e 100%. A unidade experimental (UE) utilizada foi caixas do tipo gerbox, com duas folhas de papel germitest na base, que foram umedecidas com os extratos. As EUs foram colocadas em câmara de germinação BOD a 25 °C. Diariamente após semeadura realizou-se a contagem diária de sementes germinadas. O comprimento da raiz e do hipocótilo das plântulas foram medidas no décimo dia. As variáveis analisadas foram: germinação (G); índice de velocidade de germinação (IVG); comprimento radicular (CR); e comprimento de hipocótilo (CH). Girassóis apresentam potencial alelopático sobre o nabo. A concentração do extrato de 75% de todos os órgãos e cultivares de girassóis foram suficientes para reduzir significativamente as variáveis, em comparação com a testemunha. A atividade alelopática difere entre órgãos (folhas, caules e raízes) e cultivares de girassol. A quantidade de efeitos alelopáticos varia na ordem de raiz, caule, folha. Extratos das raízes apresentam maior efeito alelopático na germinação e desenvolvimento inicial sobre o nabo; no entanto, isso depende da cultivar usada. Estudos a campo devem ser realizados para verificar tais atividades alelopáticas.

PALAVRAS-CHAVE: Alelopatia. Crescimento inicial. *Raphanus sativus*. *Helianthus annuus* L.

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