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Study of Plants With Allelopathic Potential in the Initial Development of Lettuce

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Abstract

The inappropriate use of herbicides has increased the resistance of weeds; thus, the study of allelopathy becomes of paramount importance. The ability of certain plants to interfere with the metabolism of others by means of substances released into the environment, either by their aerial or roots system, becomes an alternative to combat invasive plants, dispensing with or reducing the use of herbicides. The objective of this work was to evaluate the plant species most sensitive to the allelopathic potential of aqueous extracts. One of the plant species studied was lettuce because it had a rapid response potential, thus showing the benefits obtained through allelopathy.

Keywords: aqueous extract, soil cover plants, weeds

1. Introduction

Crambe inappropriate use of herbicides has increased the resistance of weeds to some classes of these pesticides. As an alternative, studies related to the allelopathic action of plants are useful in the search for new molecules with herbicidal action or growth regulator, generally belonging to classes of secondary metabolites, less harmful to the environment, when compared to synthetic agrochemicals (Magiero et al., 2009).

In this way the investigations of plants with allelopathic activity can be useful in the search of phytotoxins with potential to compose new agrochemicals, being highly important to carry out research in this field to know the mechanisms of action, production and decomposition of allelopathic compounds (Rosado et al., 2009).

Since allelopathy is defined as the direct or indirect inhibitory or beneficial effect of one plant on another, via the production of chemical compounds that are released into the environment (Souza et al., 2006).

In this way, the allelochemicals related to the physiological processes of the plants acting as inhibitors of germination and growth (Mano, 2006). The visible effect of the aleloquímicos on the plants is only a secondary signaling of the effect of these compounds on the germination and the development initially occurring at molecular and cellular level (Ferreira & Áquila, 2000).

In addition to the use of total shoot and roots (Ducca & Zonetti, 2008), some studies have demonstrated the allelopathic effect of different aerial parts tested separately, such as stems, leaves, flowers and fruits (Gatti, Perez, & Lima., 2004).

Some research has shown the effects of aqueous extracts and essential oils on the germination of different species (Alves et al., 2004; Maraschin-Silva & Aqüila, 2006; Souza-Filho, 2006; Piccolo et al., 2007). In that in most species, the allelopathic effect is most evident when using leaf extracts (Souza et al., 2007).

In this way certain plant species have chemical substances that, when liberated in the environment, interfere positively or negatively in the development of other plants. This process is called allelopathy, whose main function is to decrease or eliminate competition for resources. Allelochemicals act by inhibiting seed germination and/or by interfering with the development of seedlings that germinate or grow close to the plant that releases the metabolites; but sometimes a compound that is toxic to one species may not be for another (Rice, 1984; Ferreira & Borghetti, 2004; Fujii & Hiradate, 2007). Thus, it is possible to evaluate the germination and the length of the seedling root to be cultivated.

These compounds are present in different organs of plants and the most impaired biological functions in plants are, among others, growth and photosynthetic activity, and the most common way to determine the allelopathic potential of a plant is the study of the effect of vegetable extract evaluated on seeds or seedlings of cultivated species (Macias et al., 2003; Zeng et al., 2010).

2. Allelopathic Effect on Plants

Allelopathy has been described as a process by which products of the secondary metabolism of a given plant are released, preventing the germination and development of other relatively close plants (Soares & Viera, 2000).

Since the ability of the higher or lower plants to produce chemical substances with direct or indirect action, stimulating or inhibiting, influences the development of the community of plants or microorganisms due to the chemicals released in the environment (Rice, 1984). These substances belong to different categories of compounds, such as phenols, terpenes, alkaloids, polyacetylenes, fatty acids and peptides (Periotto, Perez, & Lima, 2004).

Allelochemicals may be present in all plant tissues including leaves, flowers, fruits, roots, rhizomes, stems and seeds, but the amount and pathway through which they are released differ from species to species (Putnan & Tang, 1986). Therefore, the species present different allelopathic activities in their organs, as already observed Gatti et al. (2010) in *Aristolochia esperanzae* (turkey crop), Souza Filho et al. (2010) in three *Copaifera* species, and Coelho et al. (2011) in *Ziziphus joazeiro* (juazeiro).

In that the allelochemicals are related to the physiological processes of the plants acting as inhibitors of the germination and growth (Bagchi, Jain, & Kumar, 1997; Mano, 2006). The visible effect of allelochemicals on plants is only a secondary signaling of the effect of these compounds on germination and development occurring initially at the molecular and cellular level (Ferreira & Áquila, 2000).

Research in the area of allelopathy may offer opportunities to solve practical problems of agriculture and to contribute to the knowledge of the chemistry and biology of interspecific relationships of plants by bringing alternative solutions to synthetic agrochemicals (Peres et al., 2004) and aiming at a more sustainable and ecological management in agricultural production (Maraschin-Silva & Aqüila, 2006).

In addition to the use of total aerial parts and roots (Delachiave, Rodrigues, & Ono., 1999; Ducca & Zonetti, 2008), some studies have demonstrated the allelopathic effect of different shoot organs, such as stems, leaves, flowers and fruits (Gatti, Perez, & Lima., 2004).

Allelopathic effects are mediated by substances belonging to different categories of secondary compounds. Recent advances in the chemistry of natural products, through modern methods of extraction, isolation, purification and identification, have contributed greatly to a better knowledge of these secondary compounds, which can be grouped in different ways (Ferreira & Áquila, 2000).

Resistance or tolerance to secondary metabolites is a species-specific characteristic, with the most sensitive species being *Lactuca sativa* L. (lettuce), *Lycopersicon esculentum* Miller (tomato) and *Cucumis sativus* L. (cucumber), which are considered plants indicative of allelopathic activity. In order to be indicated as a test plant, the species must have a fast and uniform germination, and a degree of sensitivity that allows expressing the results under low concentrations of allelopathic substances (Gabor & Veatch, 1981; Ferreira & Áquila, 2000).

The allelopathic effects caused in plants are mediated by substances belonging to several secondary compounds such as alkaloids, coumarins and phenols, and can be released by volatilization, leaching of aerial part or waste decomposing in the soil and also by exudation of the roots (Macias et al., 2003; Fujii & Hiradate, 2007).

Plants can produce allelochemicals in all their organs, however their concentration depends on several factors, such as soil, temperature and rainfall, and this production has fundamental importance about self-defense (Macias et al., 2007).

Traditionally, for determination of the allelopathic potential of a plant, the technique of aqueous and organic extracts is initially used. Realised in laboratory and house of vegetation, this technique is a simple and usual, based on the ability to better isolate the allelopathic effect from other interferences (Gomide, 1993).

The most commonly used solvent in the extractions is distilled water, followed by organic solvents of varying degrees of polarity. The use of aqueous extract in allelopathic tests aims to simulate what happens in nature (Medeiros, 1989).

The active principle of medicinal and aromatic plants is mediated by chemical substances belonging to different categories of compounds, such as phenols, terpenes, alkaloids, polyacetylenes, fatty acids, peptides, among others (Periotto, Perez, & Lima, 2004). When these compounds have some inhibitory properties, they can affect the germination of seeds of several species, being the sensitivity of these, variable with the applied concentration (Hruska, Dirr, & Pokorny, 1982).

Research has shown the effects of aqueous extracts and essential oils on the germination of different species (Alves et al., 2004; Maraschin-Silva & Aqüila, 2006; Souza-Filho, 2006; Piccolo et al., 2007). In most species, the allelopathic effect is most evident when using leaf extracts (Souza et al., 2007).

Some plants with allelopathic power such as *Ocimum basilicum* L., popularly known as basil or alfavaca, may be mentioned. It is an aromatic and medicinal plant belonging to the family *Lamiaceae*. The essential oil present has a high amount of linalool (82.64%), according to Blank et al. (2007), being very used in the preparation of perfumes, cosmetics, insect repellents, anti-inflammatory, among others (Teixeira et al., 2002; Rabelo et al., 2003).

As well as *Artemisia annua* L. (*Asteraceae*), which is a highly aromatic herbaceous plant, native to Asia and acclimatized in Brazil. The leaves are abundant sources of artemisinin, a sesquiterpene lactone which, together with its semi-synthetic derivatives, has an effective action against the resistant strains of *Plasmodium* species that cause malaria (Klayman, 1985; Balint, 2001; Who, 2005; Enserink, 2005). *A. annua* also presents action against parasites that affect human and animal health, such as *Coccidia* spp. (Allen, Lydon, & Danforth, 1997), *Leishmania* spp. (Yang & Liew, 1993) and *Neospora caninum* (Kim et al., 2002), as well as anti-cancer activity (Posner et al., 1999; Singh & Lai, 2004; Efferth, 2005; Lai & Singh, 2006).

Bagchi, Jain, and Kumar (1997) also reported the allelopathic activity of artemisinin and its semi-synthetic derivatives, by inhibiting seed germination and the development of monocotyledonous seedlings such as *Hordeum vulgare* and *Secale cereale* and dicotyledons such as *Amaranthus blitum*, *A. annua*, *Lactuca sativa*, *Portulaca oleraceae* and *Raphanus sativus*. In this way, the allelopathic study of different cultures becomes essential, adapting to the one that has the best potentials responsive to the adopted culture.

As can be seen in Tables 1-4 in which the crude extract of *Persea venosa* stem bark significantly inhibited ($p < 0.05$) the germination of corn, soybean, lettuce and radish seeds, and the germination varied significantly inversely proportional to the concentration of this crude extract (Mendes et al., 2013).

Table 1. Percentage of normal and abnormal seedlings, dead and non-germinated lettuce seeds for the five concentrations of *Persea venosa* extract

Concentration (g/L)	Normal seedlings	Abnormal seedlings	Dead seedlings	Non-germinated seeds
0	85.00a*	10.00a	3.00a	2.00a
20	79.00a	15.00b	2.00a	4.00a
40	62.00b	33.00c	2.00a	3.00a
80	10.00c	83.00d	4.00a	3.00a
160	0.00d	93.00d	4.00a	3.00a

Note. *Averages in the column, followed by different letter indicates statistical difference at 5% by the Tukey test.

Table 2. Percentage of normal and abnormal seedlings, dead and non-germinated radish seeds for the five concentrations of *Persea venosa* extract

Concentration (g/L)	Normal seedlings	Abnorml seedlings	Dead seedlins	Non-germinated seeds
0	63.00a*	8.00a	0.00a	29.00cb
20	29.00b	56.00b	0.00a	15.00a
40	5.00c	71.00c	0.00a	24.00b
80	0.00d	73.00c	0.00a	27.00b
160	0.00d	67.00bc	0.00a	33.00c

Note. *Averages in the column, followed by different letter indicates statistical difference at 5% by the Tukey test.

Table 3. Percentage of normal and abnormal seedlings, dead and non-germinated corn seeds for the five concentrations of *Persea venosa* extract

Concentration (g/L)	Normal seedlings	Abnorml seedlings	Dead seedlins	Non-germinated seeds
0	93.00a*	6.97a	0.00a	0.00a
20	85.99a	13.78b	0.00a	0.00a
40	70.47b	29.39c	0.00a	0.00a
80	2.92c	97.00d	0.00a	0.00a
160	0.00d	100.00d	0.00a	0.00a

Note. *Averages in the column, followed by different letter indicates statistical difference at 5% by the Tukey test.

Table 4. Percentage of normal and abnormal seedlings, dead and non-germinated soybean seeds for the five concentrations of *Persea venosa* extract

Concentration (g/L)	Normal seedlings	Abnorml seedlings	Dead seedlins	Non-germinated seeds
0	85.00a*	15.00a	0.00a	0.00a
20	67.00b	33.00b	0.00a	0.00a
40	63.00b	37.00b	0.00a	0.00a
80	43.00c	57.00c	0.00a	0.00a
160	0.00d	100.00d	0.00a	0.00a

Note. *Averages in the column, followed by different letter indicates statistical difference at 5% by the Tukey test.

2.1 Lettuce Plants in Allelopathic Tests

Lettuce is considered the main leafy vegetable crop and consumed vegetable by Brazilians, because its production extends throughout the year and is easily acquired (Oliveira et al., 2004). In 2012, CEAGESP sold 30,188 tonne of lettuce (AGRIANUAL, 2013).

The vegetable crop cultivation areas are characterized by the continuous use of the soil, with several cultural cycles that develop in sequence. Soils are generally fertile with abundant irrigation, and for these reasons, invasive plants predominate in these locations, which exhibit characteristics such as rapid development cycle and high allocation of resources in favor of reproductive structures (Grime, 1979). The presence of these species makes it difficult for farmers to use and manage the soil, which has encouraged the use of herbicides, substantially increased production costs, and caused an imbalance in the ecosystem. However, concern with the environment and quality of life has widely diffused the currents of alternative agriculture, among them organic agriculture.

The organic production system has been growing steadily over the last decade because of a growing demand for organic products. In this context, there are 15.8 million hectares organically managed worldwide. FAO's current estimates indicate an average growth of 15 to 30% per year, which could reach 3.5 to 5.0% of the world food market in 2010, corresponding to sales of US$ 61 to US$ 94 billion in organic food. In Brazil, it is estimated that the area of organic cultivation is around 100 thousand hectares (AGRIANUAL, 2000).

The current changes in global policy with ecological guidelines, the growing demand for organic products in the world, and restrictions imposed by importing countries on quality and food safety have generated the need for studies of alternative techniques to produce vegetables that minimize or eliminate the use of mineral fertilizers and agrochemicals (Fontanétti et al., 2004).

As plants compete for light, water and nutrients, revealing a constant competition among species living in community. This competition contributes to species survival in the ecosystem, and some develop defense mechanisms that are based on the synthesis of certain secondary metabolites released into the environment that will interfere with some stage in the life cycle of another plant (Sampietro, 2001).

In this way, the importance of studies on the allelopathic potential of different crops in agricultural production is highlighted.

It can be observed in Table 5 the initial characteristics of the mulungu aqueous extract, and as it can be observed later in Table 2 that the same independent of the extraction temperature, reduced the percentage and germination speed of lettuce seeds cv. Mônica SF FI and caused a high percentage of seed mortality (Oliveira et al., 2012). It is possible that high toxicity of the aqueous extract of mulungu seeds is due to the presence of allopathic compounds in the seeds, such as the alkaloids erysopine, erysody, erythramine and erythracine which are present in the plant (Castro, 2006).

Table 5. Physical-chemical characteristics of the aqueous extracts of seeds, flowers and bark of tree coral (*E. velutina*), (extracted at 25 and 100 ºC) used in the bioassays to evaluate the allelopathic potential on lettuce seeds. Mossoró, UFERSA, 2009

Aqueous extracts	pH	OP (Mpa × 10^{-2})
Seeds (100 ºC)	5.9	-9.0
Flowers (100 ºC)	5.5	-3.3
Flowers (25 ºC)	5.0	-3.4
Bark (100 ºC)	6.6	-3.6
Bark (25 ºC)	5.6	-3.6
Control	7.1	-2.0

Note. OP = osmotic potencial.

Table 6. Germination and growth of lettuce seedlings in tree coral extracts (*E. velutina*). Mossoró, UFERSA, 2009

Aqueous extracts	PG	PN	PA	GRI × 10^{-1}	SL	CL
	---------------------- % ----------------------			------------------------ mm -------------------------		
Seeds at 100 ºC	6.7b	-	12.0b	0.3c	-	-
Seeds at 25 ºC	13.0b	-	1.0c	0.9c	-	-
Flowers at 100 ºC	100.0a	99.a	0.0c	10.8b	19.3a	27.90a
Flowers at 25 ºC	100.0a	77.0a	22.0b	9.5b	16.9b	21.60b
Bark at 100 ºC	96.0a	63.0b	25.0b	9.7b	13.9c	17.00c
Bark at 100 ºC	93.0a	46.0c	49.0a	11.7b	12.6c	20.58b
Control	100.0a	98.0a	2.0c	14.8a	21.2a	42.40a
CV (%)	13.5	12.5	14.9	16.5	15.6	16.7

Note. PG = percentage of germination; PN = percentage of normal seedlings; PA = percentage of abnormal seedlings; GRI = germination rate index; SL = shoot length; CL = root length. Means followed by the same letter do not differ from each other by the Scott-knott test at the 5% level of significance.

As well as the use of extracts of juazeiro seeds, which also had negative effects on lettuce, in which the germination of lettuce seeds was affected by the concentrations of 75 and 100% of the juice extract of juazeiro, while the concentrations below or equal to 50% provided the same percentage of germination and rate of germination as the control (Table 7). Although they did not affect the percentage of germination, these extract concentrations caused a high percentage of abnormal seedlings, evidencing that the juazeiro seeds extracts have allelopathic effect on the germination of lettuce seeds. The abnormal seedlings showed necrotic primary root ends, absence of epicotyl, negative geotropism, swollen seeds and only radicle (Coelho et al., 2011).

Table 7. Characteristics of lettuce seeds submitted to different concentrations of the juazeiro seed extract. Mosoró, UFERSA, 2008

Concentration of the extract (%)	Germination (%)	Germination rate index	Normal seedlings (%)	Abnormal seedlings (%)
0	95.00a	19.0a	71.25a	23.75b
25	91.25a	18.3a	17.50b	73.75a
50	93.75a	18.7a	7.50c	86.25a
75	8.75b	1.8b	0c	88.78a
100	12.50b	2.5b	0c	12.50bc
CV (%)	18%	12%	23%	22%

As well as the one found by Capobiango, Vestena, and Bittencourt (2009), who mention that the aqueous extracts of kernel seeds (*Joanesia princeps*) reduced and/or inhibited the germination of lettuce, and the reduction was greater with the increase of the concentrations used (Table 8).

Table 8. Allelopathic effect of aqueous extract of kernel seeds (*Joanesia princeps*) on lettuce (*Lactuca sativa* cv. Grand rapids)

Concentration (%)	Germination (%)	Growth (cm)		Germination rate index
		Aerial	Root system	
Controle	100±0.00a	6.9±0.62a	7.9±0.37a	6.5±0.65a
10	72±1.52ab	3.0±0.76b	1.6±0.21b	3.8±0.47b
30	52±1.67b	0.6±0.2a	0.4±0.25c	2.0±0.33c
50	12±0.55c	0±0.00c	0±0.00c	0.5±0.09d
70	0±0.00c	0±0.00c	0±0.00c	0±0.00d
90	0±0.00c	0±0.00c	0±0.00c	0±0.00d
100	0±0.00c	0±0.00c	0±0.00c	0±0.00d
CV (%)	11.73	12.79	15.61	10.69

Note. The means±standard deviation followed by the same letters in the line do not differ significantly by the Tukey test at 5% probability.

2.2 Benefits Achieved Through Allelopathy

The word allelopathy was first used by Hans Molish in 1937 in describing the positive and negative chemical interactions of plants and microorganisms. Allelopathy refers to the positive or negative effects of one plant on another, through the release of chemical compounds (allelochemicals) by leaching of parts of the plant, root exudates, volatilization or leaf decomposition (Ferreira, & Borghetti, 2004).

Allelopathy is defined as a process by which products of the secondary metabolism of a given plant are released, preventing or stimulating the germination and development of other relatively close plants, by the release of substances by the aerial parts, subterraneous or by the decomposition of the vegetal residue (Lorenzi, 2000).

Researches in the area of allelopathy may offer opportunities to solve practical problems of agriculture and to contribute to the knowledge of the chemistry and biology of interspecific relations of plants (Gorla & Perez, 1997), bringing alternative solutions to synthetic agrochemicals (Peres et al., 2004). And aiming at a more sustainable and ecological management in agricultural production (Maraschin-Silva & Aqüila, 2006), through the development of herbicides, growth regulators and pharmaceuticals from natural biomolecules (Bagchi, Jain, & Kumar, 1997).

One of the main studies of the use of allelopathy is the research on natural products for the control of weeds, aiming at reducing the use of synthetic herbicides, preserving the environment, thus contributing to sustainable agriculture (Carvalho, Fontanétti, & Cançado, 2002; Ferreira & Áquila, 2000; Santos et al., 2004).

As the secondary product released by plants called the allelochemical, where nowadays with more advanced studies of allelopathy is known to have specific activities in the plant and environment, such as repellent activities, herbicide selectivity, allelopathy and others (Niemeyer, 1988). It is possible to mention cinmethylin and sorgoleone as allelochemicals with herbicide potentialities (C. N. Souza, I. F. Souza, & Pasqual, 1999).

The allelopathic effects have several uses: to contribute in the search for agricultural pesticides; understand the antagonism of intercropping or successive crops; reduce the use of synthetic herbicides, replacing them with allelopathy; manage and control weeds by rotating crops; adapting seeding systems among species, as well as agroecological systems (Venzon et al., 2005); controlling pests and invasive plants; using dead coverages or companion plants and voluntarily introducing wild species (Mallik & Olofsdotter, 2001).

The allelochemicals, once released into the environment, decisively influence the dynamics of the species that make up the agroecosystems and have been presented as an alternative solution in the search for new sources of herbicides. Thus, to identify species with the capacity to interfere in the germination or growth of other plants represents one of the strategies for the management of weeds in organic crops, with the reduction of the use of herbicides, insecticides and other artificial products used in agriculture (Weir et al., 2004).

Thus, compounds found in plants can be a timely alternative for agriculture in weed control without causing damage to the environment, allowing to obtain products of high quality without the presence of contaminating agents through the so-called bioherbicides (Zeng et al., 2010).

In addition to the physical effects, some plants are used as green fertilizers have allelopathic effects that contribute to the management of invasive plants. Allelopathy is the production of certain compounds by organisms that, when released into the environment, have an inhibitory or stimulatory impact on other organisms (Gliessman, 2000). Allelochemicals can interfere with plant metabolism in several ways, such as plant growth regulators, photosynthesis inhibitors, deregulators of respiration and transport in the cell membrane; and inhibitors of enzymatic and protein activity (Einhellig, 1986). Velvet bean (*Mucuna pruriens*), for example, exerts a strong and persistent inhibitory action on *Cyperus rotundus* (*C. rotundus*) and *Bidens pilosa* (*B. pilosa* L.) (Lorenzi, 1984; Carvalho, Fontanétti, & Cançado, 2002). This was also observed for the jack bean (*Canavalia ensiformes* (L.) DC.) which, even in low planting density, had an inhibitory effect on *Cyperus rotundus* (Magalhães & Franco, 1962).

The presence of weeds in the crop is one of the main problems faced by farmers, raising the cost of production. In places where agriculture is practiced intensively, changes occur in the population of these plants, and the species that best adapt to those conditions predominate (Favero et al., 2001). The interference of these plants in crops of commercial interest is due to the competition for water, light, CO_2 and nutrients and for the allelopathic effect, causing the qualitative and quantitative reduction in the production (Bianchi, 1995).

Thus, several studies of allelopathy have been conducted aiming at the control of weeds. Among them is Eucalyptus, introduced from Australia, but very cultivated in Brazil, which has several species with allelopathic potential (Ferreira & Áquila, 2000). Souto, Gonzalez, and Reigosa (1994) found that residues of *Pinus radiata* D. Don and *Eucalyptus globulus* Labill inhibited the growth and development of lettuce and the allelopathic effect was mainly due to phenolic compounds. Balbinot-Junior (2004) was able to suppress the emergence and growth of *Bidens pilosa* plants by applying aqueous extract of *Mucuna* spp. as a pre-emergence herbicide in pots. *Brachiaria plantaginea* extract inhibited the germination and caused the root system reduction of *Commelina bengalensis* under laboratory conditions (Voll et al., 2004).

Inhibition data on germination and germination rate index of *Brachiaria brizantha*, *Euphorbia heterophylla* and *Ipomoea grandifolia*, after the application of hydroalcoholic extracts of *A. crassiflora*, are presented in Table 8. It was verified that the seed extracts provided total inhibition of germination, and germination rate index of *B. brizantha* and *E. heterophylla*, relative to the control (Table 9). The seeds of *I. grandifolia* that received this extract also showed a significant inhibition in germination (71.8%), and germination rate index (92.1%) (Table 9) (Inoue et al., 2010).

Table 9. Percentage of inhibition in relation to the control, of *A. crassiflora* extracts on germination, and germination rate index of *B. brizantha*, *E. heterophylla* and *I. grandifolia*

Weed	Inhibition in germination (%)			Inhibition at germination rate index (%)		
	Seeds	Leaves	Stem	Seeds	Leaves	Stem
B. brizantha	100.0Aa	53.3Ab	25.0Ac	100.0Aa	50.4Ab	29.6Ac
E. heterophylla	100.0Aa	17.8Bb	11.3Bb	100.0Aa	11.6Bb	12.2Bb
I. grandifolia	71.80Ba	0Cb	0Cb	92.1Ba	0Cb	0Cb
CV (%)	20.1			22.7		

Note. For each variable, averages followed by the same letter, uppercase in the column and lowercase in the row, do not differ by the Scott-knott test at 5% probability.

In this way, the importance of the study of the allelopathic effect on different cultures, in general of fast cycle, for the optimization of the time. As in the study of the allelopathic effect of umbu fruits, in lettuce and black pickle, demonstrated effect on a plant of rapid responsive potential and a weed. Thus, by analyzing the effects caused by the fruit extracts of umbu, significant interaction is observed for percentage of germination, germination velocity and germination speed index, and these effects are more significant in the germination of *Bidens pilosa* seeds than on germination of lettuce seeds (Table 10) (Borella & Pastorini, 2010).

Table 10. Average values of percentage of germination (PG), germination speed (GS) and germination rate index (GRI) of lettuce and *Bidens pilosa* seeds submitted to aqueous extracts of umbu fruits. URI, Frederico Westphalen, RS, 2008

Treatment	Lettuce			*Bidens pilosa*		
	PG (%)	GS (dias)	GRI (dias)	PG (%)	GS (dias)	GRI (dias)
Control	99a*	1.202ns	22.417a	86a	3.620b	6.558a
1%	96a	1.312ns	21.208a	77ab	3.619b	5.995a
2%	90a	1.252ns	20.292a	65b	5.043a	3.420b
4%	66b	1.427ns	13.333b	45c	5.339a	2.195b
8%	26c	1.729ns	4.5410b	0d	0.0c	0.0c

Note. *Means followed by the same letters in the column do not differ by Tukey's test, at 1% probability, ns: not significant.

3. Conclusion

Studies involving plants with allelopathic potential contribute to the knowledge of interspecific relationships of plants. And this information can be used to control weeds and reduce the use of synthetic herbicides.

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