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Article

Allelopathic potential of Cover Crops in Control of Shrubby False Buttonweed (*Spermacoce verticillata*)

*Potencial Alelopático de Plantas de Cobertura no Controle da Vassourinha-de-Botão (**Spermacoce verticillata**)*

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ABSTRACT - Searching for alternatives to deal with weeds without the exclusive use of herbicides can increase the sustainability of agricultural production in the Amazon region. This study aimed to evaluate the allelopathic potential of cover crops on the weed shrubby false buttonweed (*Spermacoce verticillata* L.). Three straw levels (1; 2.5 and 5 mg cm^{-2}) of thirteen cover crops (*Cajanus cajan*, *Canavalia ensiformis*, *Crotalaria juncea*, *C. ochroleuca*, *C. spectabilis*, *Mucuna aterrima*, *M. cinereum*, *Pennisetum glaucum*, *Sorghum bicolor*, *S. sudanense*, *Urochloa brizanha* cv. Xaraés, *U. brizantha* cv. Piatã and *U. ruziziensis*) were assessed on germination and initial growth of weed and lettuce. We carried out two experiments (weed and lettuce) in a factorial scheme (cover crops x straw levels) with additional treatment (control without straw) in a completely randomized experimental design, with four replicates. The straw of the cover crops inhibited the germination and initial growth of the target plants. The highest straw levels promoted 44.0 and 78.8% reductions in radicle length in relation to the lowest dose (1 mg cm^{-2}), for lettuce and *Spermacoce verticillata*, respectively. The highest sensitivity to allelochemicals occurred on the radicle. The major suppressive effects on weed germination were promoted by *Cajanus cajan*, *Urochloa brizanha* cv. Xaraés, *Mucuna cinereum*, *M. aterrima*, *Canavalia ensiformis*, *Crotalaria juncea*, *C. spectabilis* and *U. ruziziensi*s. Cover crops use is an integrated practice management to control *Spermacoce verticillata* under no-tillage system.

Keywords: allelopathy, crop control, leguminous, sandwich method, straw.

RESUMO **-** *A busca por alternativas no manejo de plantas daninhas sem a utilização exclusiva de herbicidas pode contribuir para aumento da sustentabilidade na produção agrícola na região Amazônica. Objetivou-se neste estudo avaliar o potencial alelopático de plantas de cobertura, sobre a planta daninha vassourinha-de-botão (**Spermacoce verticillata** L.). Três níveis de palhada (1; 2,5 e 5 mg cm^{-2}) de treze plantas de cobertura (**Cajanus cajan**, **Canavalia ensiformis**, **Crotalaria juncea**, **C. ochroleuca**, **C. spectabilis**, **Mucuna aterrima**, **M. cinereum**, **Pennisetum glaucum**, **Sorghum bicolor**, **S. sudanense**, **Urochloa brizanha** cv. Xaraés, **U. brizantha** cv. Piatã e **U. ruziziensis**) foram avaliados, sobre a germinação e o crescimento inicial da planta daninha e da alface. Dois experimentos foram instalados (planta daninha e alface) em esquema fatorial (plantas de cobertura x níveis de palhada) com tratamento adicional (testemunha sem palhada) em delineamento experimental inteiramente casualizado, com quatro repetições. As palhadas das plantas de cobertura inibiram a germinação e o crescimento inicial*

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das plantas alvo. Os maiores níveis de palhada promoveram reduções de 44,0 e 78,8% no comprimento da radícula em relação à menor dose (1 mg cm^{-2}), para a alface e para a vassourinha-de-botão, respectivamente. A maior sensibilidade aos aleloquímicos foi observada sobre a radícula. Os maiores efeitos supressivos na germinação da planta daninha foram promovidos pelo ***Cajanus cajan****,* ***Urochloa brizanha*** *cv. Xaraés,* ***Mucuna cinereum****,* ***M. aterrima****,* ***Canavalia ensiformis****,* ***Crotalaria juncea****,* ***C. spectabilis*** *e* ***U. ruziziensis****. A utilização de plantas de cobertura em área de cultivo sob plantio direto representa uma prática de manejo integrado no controle da* ***Spermacoce verticillata****.*

Palavras-chave: alelopatia, controle cultural, leguminosa, método sandwich, palhada.

INTRODUCTION

Weeds compete for different resources with agricultural crops, and the management of these plants is necessary to minimize production losses (Castro et al., 2001; Almeida et al., 2015). In the management of these plants, chemical method predominates by applying herbicides. These products promote imbalances in agroecosystems, when used improperly, such as the increase of resistant biotypes and contamination of water bodies and soil (Takano et al., 2016).

An alternative to weed management is the use of conservationist systems that use succession, intercropping and crop rotation strategies. In addition to protecting and improving soil quality and increasing crop productivity, generation of straw reduces weed infestation (Lopes and Guilherme, 2016; Martins et al., 2016). Straw on the soil, from cover crops, can act by the physical impediment and competition by natural resources to the germination of weeds (Gomes et al., 2014) or by the release of substances inhibiting germination and/or weed growth (Lamego et al., 2015). These substances, called allelochemicals, derive from secondary metabolites and may promote negative effects on weed physiology as well as influence population dynamics in whole agroecosystems (Zhang et al., 2016). Physiological conditions influence these allelochemicals, such as nutritional and phenological stages, and the conditions of the environment where the plants are grown (Cecchin et al., 2017). Thus, studies of factors influencing the production and release of allelochemicals should be carried out in order to promote allelopathy as a non-conventional control resource for pest management in agricultural systems (Kobayashi and Ikato-Noguchi, 2015).

The sandwich method, proposed by Fujii et al., (2003, 2004) is one of the tools used to identify the allelopathic potential of plants in laboratory. This method consists in depositing dry biomass (straw) of the potentially allelopathic species between two layers of agar and seeds of a bioindicator plant. Lettuce (*Lactuca sativa*) is the most used species as a bioindicator plant, due to its sensitivity to allelochemicals (Ferreira and Aquila, 2000; Reigosa et al., 2013). The allelopathic potential is verified by assessing the germination of the sensitive plant and the target weed by measuring initial growth parameters, such as the radicle and hypocotyl length of the seedlings.

Among weeds of great economic importance in the Americas, the shrubby false buttonweed (*Spermacoce verticillata* L.) stands out as one of the species with high frequency in native pasture areas and in grain production areas in no-tillage system (Lorenzi, 2008). It is a species with high capacity to generate infestations in arable areas and difficult to control, even with using herbicides (Miléo et al., 2016).

Allelopathic cover crops may have an effect on the germination and growth of weed seedlings aiming at controlling them. Thus, this study aimed to evaluate the allelopathic potential of different cover crops on the weed shrubby false buttonweed.

MATERIAL AND METHODS

Shoot of cover crops were cultivated and collected as plant material in an experimental area (8°47’53" S 63°51’02" W and 87 m altitude), located in Porto Velho, Rondônia. Since 2014, the area is occupied with an experiment that evaluates different cover crops in succession to maize, consisting of the following species: *Cajanus cajan*, *Canavalia ensiformis*, *Crotalaria juncea*, *Crotalaria ochroleuca*, *Crotalaria spectabilis*, *Mucuna aterrima*, *Mucuna cinereum*, *Pennisetum glaucum*, *Sorghum bicolor*, *Sorghum sudanense*, *Urochloa brizanha* cv. Xaraés, *Urochloa brizantha* cv. Piatã and *Urochloa ruziziensis* (Passos et al., 2017).

According to Köppen, the regional climate is Aw, tropical hot and wet, with average annual temperature of 25.6 °C. The average annual precipitation is 2,200 mm, with rainy season from October to May, and dry season from June to September (Alvares et al., 2013). The region shows potential annual evapotranspiration of 1,455 mm (Cunha and Shöffel, 2011). The soil of the site is a typical Oxisol; Table 1 shows its chemical attribute characterization.

Table 1 - Chemical attributes of the experimental collection area of the vegetal material of the cover crops, 0 to 20 cm depth. Porto Velho, Rondônia, 2014. Porto Velho, Rondônia, 2014

pH	OM	P	K	Ca	Mg	H+Al	Al	CEC	m	V
(H_2O)	(kg^{-1})	(mg dm^{-3})	($cmol_c$ dm^{-3})					(%)		
5.05	38.36	7.13	0.20	2.67	1.96	10.77	1.59	15.61	27.81	30.25

pH in water 1: 2.5; organic matter (OM) by wet digestion; P and K determined by methods Mehlich I; Ca, Mg and Al exchangeable extracted at KCL 1 mol with L^{-1}.

In this study, we used shrubby false buttonweed, as a target species and lettuce (*Lactuca sativa* cv. Veneranda) as a bioindicator (Ferreira and Aquila, 2000; Reigosa et al., 2013). The lettuce seed lot was obtained in the local market. For the tests, we evaluated the cover crops effect on seeds and seedlings of the tested species; the seeds presented 100% germinative potential. *Shrubby false buttonweed* seeds were collected by beating the inflorescences in a paper bag, manually removing the immature seeds with a diaphanoscope, selecting only the viable seeds. Seed collection was performed near the experimental area, at coordinates 08°47’40" S 63°50’50" W longitude and 95 m altitude.

To obtain the straw, the cover crops shoot were collected at the flowering phenological stage, by manual cutting at 5 cm from the soil. The species were identified and stored in paper bags, placed in a drying oven at 45 °C for 72 hours, and then manually ground with scissors, pistil and mortar.

For each cover crop, three amounts of straw (10, 25 and 50 mg per well) and a control treatment with no straw (agar only) were evaluated by sandwich method, proposed by Fujii et al. (2003). Bioassays took place on Multi-well plastic plate with six wells with 10 cm^2 and 10 cm^3 area and volume, respectively (Fujii et al., 2004). We prepared an agar suspension (Himedia) at 5% (m v^{-1}). Agar was pre-autoclaved for 15 minutes at 120°C. Then we added 5 mL agar suspension to the well and, after solidification, the straw levels were set (10, 25 and 50 mg). After this, a further 5 mL agar suspension was added over the plant material (straw), which, after solidification, received five seeds of shrubby false buttonweed or lettuce cypselas. After sowing, the plates were encapsulated in film plastic and stored in a B.O.D.-type germination chamber at alternating temperatures of 20-30 °C, and a light, 16-hour photoperiod for the *Shrubby false buttonweed* (Ferreira and Rosa, 2009), and in the absence of light radiation for lettuce cypselas at 20 °C (Fujii et al., 2004).

All seeds germinated within four days after sowing. Therefore, at four days after sowing were recorded germinated seed counts and radicle and hypocotyl length measurements, expressed as percentage and millimeter, respectively. From the results, we evaluated the ratio of radicle by hypocotyl (R/H) and ratio of hypocotyl by radicle (H/R). The initial growth parameters were measured in all seeds with a digital caliper.

The experimental design was a completely randomized design, in a 13 x 3 factorial scheme with additional treatment, with four replications (13 species of cover crops x 3 straw levels) as well as a control treatment (agar only). Values were submitted to analysis of variance; with statistical significance for the treatments, the means were submitted to the Tukey test ($p<0.05$) for the cover crops and polynomial regression for straw levels. Dunnett test ($p<0.05$) evaluated the effects of each cover crop and straw levels with the additional treatment. For the analysis, we used the computer program R (R Core Team, 2014).

RESULTS AND DISCUSSION

Cover crops influenced the weed shrubby false buttonweed, except for only the H/R ratio variable (Table 2). Regarding the bioindicator plant, the effects were verified only on radicle lengths and R/H ratio. As for the straw levels, these affected all the variables for the shrubby false buttonweed, whereas for lettuce only the radicle length variables and the relationships between the radicle and hypocotyl lengths were affected. No interaction effect was observed between the factors.

Among the initial plant growth and development parameters, germination has been shown to be the least sensitive to allelopathic substances (Formagio et al., 2010). On the other hand, radicle is one of the parts with greater sensitivity to allelochemicals (Reigosa et al., 2013), as observed in the results found in this work. Oliveira et al., (2015), also observed this effect when testing brachiaria, sunflower and sorghum extracts on lettuce seeds, found no effect on germination, but a decrease of root system and formation of normal seedlings.

Radicle sensitivity to allelopathic effect may occur due to the direct contact with the allelochemicals in the studied straws. As the first structure to appear after germination, the roots are exposed to allelochemicals, facilitating the absorption and action of allelopathic substances in the early stages of development (Zhang et al., 2016), thus interfering directly with cell division, compromising radicle elongation (Ferreira and Aquila, 2000) or even death of tissues (Cecchin et al., 2017). Chlorogenic acid, ferulic acid, catechin and p-anisic acid, all phenolic compounds, are reported as having a significant effect on the plant root system, acting on membrane stability and lignin synthesis with growth impairment of this plant organ on weeds (Carvalho et al., 2014; Cecchin et al., 2017). These results are important indicators of the allelopathic potential of cover crops, since sharp root reduction can affect the competitive capacity and the negative effect of the weed on the agricultural crop (Almeida et al., 2015).

Table 2 - Summary of analysis of variance of germination percentage (G), mean hypocotyl (H) and radicle (R) length, hypocotyl radicle (R/H) and inverse ratio (H/R) in shrubby false buttonweed and lettuce seedlings, under cover crop effect at different straw amounts. Porto Velho, Rondônia, 2015

Source of variation	Medium Square					
	DF	G (%)	H (mm)	R (mm)	R/H	H/R
Shrubby false buttonweed						
Cover (C)	12	1939.44**	0.60*	1.17*	0.58**	0.64
Straw level (N)	2	13742.82**	6.54**	8.33*	4.06**	2.38**
C*N	24	395.56	0.17	0.18	0.20	0.35
Factorial	38	1585.59**	0.64**	0.92**	0.52**	0.55
Additional x Factorial	1	17300.01**	2.60**	47.60**	14.68**	0.88
Error	120	588.30	0.27	0.23	0.16	0.36
VC (%)		69.17	62.93	60.84	59.12	71.11
Factorial mean		33.39	0.81	0.70	0.63	0.86
Lettuce						
Cover (C)	12	331.62	15.41	14.94*	0.11*	0.29
Straw level (N)	2	1020.51	3.09	84.40**	1.18**	4.24**
C*N	24	331.62	10.00	7.04	0.05	0.20
(Factorial)	38	367.88	11.34	13.60*	0.12*	0.44**
Additional x Factorial	1	175.51	1.55	75.12**	0.71**	0.98
Error	120	395.00	9.91	6.47	0.06	0.24
VC (%)		24.61	38.50	38.33	29.72	35.49
Factorial mean		80.51	8.15	6.48	0.82	1.41

**, * significant by F Test at 1% and 5% level of significance, respectively.

Cover crops promoted a suppressive effect on germination of the shrubby false buttonweed seeds (Table 3), especially by *Cajanus cajan*, *Urochloa brizanha* cv. Xaraés, *Mucuna cinereum*, *Mucuna aterrima*, *Canavalia ensiformis*, *Crotalaria juncea*, *Crotalaria spectabilis* and *Urochloa ruziziensis*. These results are in accordance with those found by Petter et al. (2015), who observed the initial growth of *Digitaria insularis,* on straw of cover crops cultivated under greenhouse conditions, found that *Cajanus cajan*, *Mucuna aterrima* and *Urochloua brizantha* show the ability to suppress the species evaluated.

Table 3 - Effect of cover crops on germination (G), hypocotyl length (H), radicle length (R), hypocotyl radicle ratio (R/H) and inverse ratio (H/R) on seeds and seedlings of shrubby false buttonweed. Porto Velho, Rondônia, 2015

Cover crop	Means				
	G (%)	H (mm)	R (mm)	R/H	H/R
Sorghum sudanense	58.54 a*	1.26 a*	1.52 a*	1.22 a	0.88 a
Pennisetum glaucum	47.50 ab*	1.12 ab*	1.10 ab*	0.87 ab*	1.07 a
Sorghum bicolor	46.45 ab*	0.91 ab*	0.80 bc*	0.77 ab*	1.14 a
Crotalaria ochroleuca	44.37 ab*	0.97 ab*	0.67 bc*	0.57 b*	1.10 a
Urochloa brizantha cv. Piatã	37.08 ab*	0.97 ab*	0.72 bc*	0.68 ab*	1.29 a
Urochloa ruziziensis	32.91 ab*	0.74 ab*	0.51 bc*	0.40 b*	0.84 a
Crotalaria spectabilis	30.00 ab*	0.70 ab*	0.60 bc*	0.53 b*	0.66 a
Crotalaria juncea	28.54 ab*	0.67 ab*	0.52 bc*	0.53 b*	0.85 a
Canavalia ensiformis	27.70 ab*	0.62 ab*	0.47 bc*	0.48 b*	0.71 a
Mucuna aterrima	22.91 b*	0.59 ab*	0.42 c*	0.46 b*	0.75 a
Mucuna cinereum	22.70 b*	0.45 b*	0.36 c*	0.56 b*	0.44 a
Urochloa brizanha cv. Xaraés	20.83 b*	0.82 ab*	0.76 bc*	0.61 b*	0.75 a
Cajanus cajan	14.58 b*	0.74 ab*	0.66 bc*	0.51 b*	0.73 a
Mean	33.39	0.81	0.70	0.63	0.86
Control	100	1.61	4.17	2.57	0.39

Means followed by the same letter do not differ in the columns, at 5% level of significance by the *Tukey test* ($p<0.05$). * Averages followed by asterisks differ significantly from the control, at 5% probability, by Dunnett test ($p<0.05$).

There was root system reduction of lettuce seedlings promoted by the cover crops *Canavalia ensiformis*, *Urochloa ruziziensis*, *Mucuna aterrima*, *Mucuna cinereum*, *Urochloa brizantha* cv. Piatã (Table 4). In studies with hydroalcoholic extracts of shoot, roots and seeds and crude extracts of Jack bean seeds (*Canavalia ensiformis*) promoted an allelopathic inhibitory effect on germination and stretching of the radicle of weeds *Mimosa pudica, Urena lobata, Senna obtusifolia and Senna occidentalis* directly proportional to the concentration of the evaluated extract (Souza Filho, 2002). The production of an allelochemical, and consequently its allelopathic effect, is associated with the physiological plant conditions, such as nutritional and phenological stages and environmental conditions where plants are cultivated (Kobayashi and Ikato-Noguchi, 2015; Cecchin et al., 2017). Therefore, straw use of cover crops with allelopathic effect may represent a strategy of less economic and environmental impact for the control of some weeds than the use of synthetic herbicides.

These results differ from those obtained by Carvalho et al. (2014), which evaluated aqueous extracts from *Cajanus cajan*, *Canavalia ensiformes*, *Sorghum bicolor*, *Pennisetum glaucum*, *Crotalaria anagyroides* and *Avena strigosa*, observed significant effects of *Canavalia ensiformes* extracts on seeds and seedlings of lettuce. The absence of seed germination reduction of lettuce seeds can be attributed to the intrinsic characteristics of the species tested as cover crop, since each species submitted to a type of allelochemical shows specific and different reactions (Silva et al., 2009). In addition, environmental conditions may influence the gene expression of secondary metabolites significantly, interfering with the ability of plants to express their allelopathic potential (Souza Filho, 2002; Cecchin et al., 2017; Zhang et al., 2017).

The allelopathic potential of cover crops was dependent on the amount of straw and expressed on the development and growth of the weed *Spermacoce verticillata*; notably on germination and radicle, respectively (Table 5). The highest straw levels, 50 and 25 mg, promoted a 65.8 and

Table 4 - Effect of cover crops on germination (G), hypocotyl (H) length, radicle (R) length, hypocotyl radicle ratio (R/H) and inverse ratio (H/R) on seeds and seedlings of lettuce. Porto Velho, Rondônia, 2015

Cover	Means				
	G (%)	H (mm)	R (mm)	R/H	H/R
Cajanus cajan	70.00 a	8.41 a	6.35 a	0.74 a*	1.42 a
Canavalia ensiformis	70.00 a	6.74 a	3.79 b*	0.61 a*	1.82 a
Crotalaria juncea	80.00 a	8.28 a	6.94 a	0.91 a	1.30 a
Crotalaria ochroleuca	76.66 a	11.37 a	8.19 a	0.73 a*	1.48 a
Crotalaria spectabilis	70.00 a	7.11 a	7.25 a	1.09 a	1.03 a
Mucuna aterrima	76.66 a	7.81 a	4.99 b*	0.60 a*	1.76 a
Mucuna cinereum	86.66 a	6.69 a	5.16 b*	0.76 a*	1.49 a
Pennisetum glaucum	86.66 a	9.65 a	8.72 a	0.94 a	1.19 a
Sorghum bicolor	83.33 a	7.95 a	6.44 a	0.83 a	1.38 a
Sorghum sudanense	86.66 a	10.64 a	8.55 a	0.79 a	1.30 a
Urochloa brizanha cv. Xaraés'	90.00 a	8.57 a	7.49 a	0.90 a	1.19 a
Piatã	90.00 a	6.41 a	5.96 b	0.90 a	1.55 a
Urochloa ruziziensis	80.00 a	6.32 a	4.4 b*	0.75 a*	1.44 a
Mean	80.51	8.15	6.48	0.81	1.41
Control	100	9.03	13.06	1.47	0.69

Means followed by the same letter do not differ in the columns at 5% level of significance by the *Scott-Knott* test ($p<0.05$). * Averages followed by asterisks differ significantly from the control, at 5% probability, by Dunnett test.

Table 5 - Effect of straw levels of cover crops on germination (G), hypocotyl (H) length, radicle (R) length, hypocotyl radicle ratio (R/H) and inverse ratio (H/R) on seeds and seedlings of lettuce and shrubby false buttonweed. Porto Velho, Rondônia, 2015

Attribute	Shrubby false buttonweed					
	50 mg	25 mg	10 mg	Control	Equation	R²
G	16.88*	33.94*	49.38*	100	-0.7992x + 5.045	0.9869
H	0.45*	0.84*	1.15	1.63	-0.0173x + 1.3037	0.9940
R	0.33*	0.65*	1.13*	4.2	-0.0193x + 1.2492	0.9347
R/H	0.37*	0.59*	0.93*	2.57	-0.0135x + 1.0116	0.9307
H/R	0.62	0.96	1.01	0.39	-0.0101x + 1.1507	0.9328
	Lettuce					
G	76.15	77.69	87.69	100	ns	
H	7.76	8.25	8.43	9.03	ns	
R	4.56*	6.74*	8.14	13.06	-0.0893x + 9.0092	0.9997
R/H	0.59	0.82	1.02	1.47	-0.0106x + 1.1101	0.9894
H/R	1.84	1.35	1.04	0.69	0.02x + 0.8445	0.9998

* Averages followed by asterisks differ significantly from the control, at 5% probability, by the Dunnett test.

31.3% decrease, respectively, in the germination percentage in relation to 10 mg level. However, even with the least amount of straw deposited on the weed seeds, a decrease in germination of 50.6% occurred in relation to control treatment, without cover crops. Among the straw quantities evaluated, the 50 mg showed the greatest suppressive effect on the weed.

In no-tillage system, there is a soil disturbance in the sowing furrow, which can cause high rate of weed emergence in the place. To turn and break up topsoil in the sowing row favors seed exposure to light and temperature alternations, which are fundamental factors for the germination of some weeds (Ferreira and Rosa, 2009). Suppression of weed germination represents a low cost and less environmental impact strategy than usual practices such as the use of herbicides, promoting greater economic and environmental sustainability to agroecosystems (Martins et al., 2016).

Soil cover is one of the main premises for the success of no-tillage systems due to its physical and chemical both effect for soil protection (Lopes and Guilherme, 2016) and for weed management. Sorghum, millet and brachiaria are among the most used cover crops in no-tillage system (Kobayashi and Ikato-Noguchi, 2015; Lamego et al., 2015; Martins et al., 2016).

Cover crops, used as an effective method to control weed germination, has been pointed out by several authors. Castro et al., (2001) point out the importance of the appropriate choice of production system, involving the insertion of forage plants of the brachiaria group in succession to the summer crop as a weed control strategy for grain production. These authors observed a control efficacy of 97.7% in relation to treatment with no cover crops and the fallow use in the off-season.

Among cover crops, sorghum (*Sorghum bicolor*) is one of the most studied plants in weed control, with notorius allelopathic activity and whose allelochemical is generically called sorgoleone (Santos et al., 2012; Gomes et al., 2015). On the other hand, *Urochloa brizantha*, currently used to generate forage and straw in Integrated Crop-Livestock systems, was tested on the development of cress, lettuce, *Phleum pretense* and *Lolium multiflorum*, with promising results for weed inhibition (Kobayashi and Ikato-Noguchi, 2015). In some studies, *Urochloa ruziziensis* could control *Cenchrus echinatus* (Silva et al., 2015).

Shrubby false buttonweed is one of the most frequent weed species in the Amazon, with high capacity to interfere negatively in several crops by competing for nutrients (Fontes and Tonato, 2016; Miléo et al., 2016). The effects on hypocotyl alongation were pronounced and the highest amounts of straw, 50 and 25 mg, promoted a decrease of 70.0 and 27.0%, respectively, in the hypocotyl length of the seedlings in relation to the amount of 10 mg of straw.

Cajanus cajan, *Urochloa brizanha* cv. Xaraés, *Mucuna cinereum*, *M. aterrima*, *Canavalia ensiformis*, *Crotalaria juncea*, *C. spectabilis* and *U. ruziziensi* used as cover crops in no-tillage systems represent a strategy to establish an integrated weed management plan to control the shrubby false buttonweed.

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