PLANTA DANINHA

SOCIEDADE BRASILEIRA DA CIÊNCIA DAS PLANTAS DANINHAS

<http://www.sbcpd.org>

ISSN 0100-8358 (print)
1806-9681 (online)

Article

Cover Crops in the Weed Management in Soybean Culture

Culturas de Cobertura no Manejo de Plantas Daninhas na Cultura da Soja

SÃO MIGUEL, A.S.D.C.[1]*
PACHECO, L.P.[1]
SOUZA, E.D.[1]
SILVA, C.M.R.[1]
CARVALHO, Í.C.[1]

ABSTRACT - The objective of this work was to evaluate the effect of cover crops on weed suppression in no-tillage soybean production systems in Rondonopolis, Mato Grosso. The experiment was carried out in an experimental area and consisted of the evaluation of nine cover treatments and soil management in a randomized complete block design. The treatments were: NT fallow, CT fallow, *Crotalaria spectabilis*, *Crotalaria breviflora*, maize + *Crotalaria spectabilis*, *Pennisetum glaucum*, *Urochloa ruziziensis*, *Cajanus cajan*, sunflower + *Urochloa ruziziensis*, *Stylosanthes*, *Vigna unguiculata*, *Urochloa brizantha*, maize + *Urochloa ruziziensis*. The evaluations were carried out before the desiccation for soybean sowing in the crops (10/23/2014) and (09/21/2015), before the post-emergence of soybean (09/12/2014) and (12/11/2015) and in the second season (12/06/2015). The useful area was 5 x 5 m and all weeds were counted and identified, but only the four species with the largest population were collected. The weeds evaluated were: *Digitaria horizontalis*, *Digitaria insularis*, *Porophyllum ruderale* and *Tridax procumbens*. Fallow treatments presented higher weed populations in relation to the others, in all periods of evaluation. *Digitaria horizontalis* presented the highest phytomass production in most seasons. The production systems with *Urochloa ruziziensis*, *Pennisetum glaucum*, *Crotalaria spectabilis* and intercropped with maize + *Urochloa ruziziensis*, sunflower + *Urochloa ruziziensis* and maize + *Crotalaria spectabilis* were the best alternatives for integrated weed management, reducing the incidence and increasing control of the main species that were detected during the conduction of the experiment.

Keywords: *Glycine max*, no-till system, weed community, suppression.

RESUMO - O objetivo deste trabalho foi avaliar o efeito de culturas de cobertura na supressão das plantas daninhas em sistemas de produção de soja sob plantio direto, em Rondonópolis, Mato Grosso. O experimento foi realizado em área experimental e consistiu na avaliação de nove tratamentos de cobertura e manejo do solo em delineamento de blocos casualizados. Os tratamentos foram: pousio PD, pousio PC, ***Crotalaria spectabilis****,* ***Crotalaria breviflora****, milho +* ***Crotalaria spectabilis****,* ***Pennisetum glaucum****,* ***Urochloa ruziziensis****,* ***Cajanus cajan****, girassol +* ***Urochloa ruziziensis****,* ***Stylosanthes****,* ***Vigna unguiculata****,* ***Urochloa brizantha*** *e milho +* ***Urochloa ruziziensis****. As avaliações foram realizadas antes da dessecação para semeadura da soja nas safras (23/10/2014 e 21/09/2015), antes da pós-emergência da soja (09/12/2014 e 12/11/2015) e na safrinha (12/06/2015). A área útil foi de 5 x 5 m, e foram contabilizadas e identificadas todas as plantas daninhas, porém somente as quatro espécies com maior densidade populacional foram coletadas. As plantas daninhas avaliadas foram:* ***Digitaria horizontalis****,* ***Digitaria insularis****,* ***Porophyllum ruderale*** *e* ***Tridax procumbens****. Os tratamentos com pousio apresentaram maior população de plantas daninhas em relação aos demais, em*

*** Corresponding author:**
<andressadallacort@hotmail.com>

Received: November 29, 2016
Approved: April 26, 2017

Planta Daninha 2018; v36:e18172534

[1] Universidade Federal de Mato Grosso (UFMT), Rondonópolis-MT, Brasil.

Doi: 10.1590/S0100-83582018360100072

todas as épocas de avaliação. ***Digitaria horizontalis*** *apresentou a maior produção de fitomassa na maioria das épocas de avaliação. Os sistemas de produção com* ***Urochloa ruziziensis****,* ***Pennisetum glaucum, Crotalaria spectabilis*** *e os consórcios com milho +* ***Urochloa ruziziensis****, girassol +* ***Urochloa ruziziensis*** *e milho +* ***Crotalaria spectabilis*** *foram as melhores alternativas para o manejo integrado de plantas daninhas, por reduzirem a incidência e aumentarem o controle das principais espécies que foram detectadas durante a condução do experimento.*

Palavras-chave: *Glycine max*, sistema plantio direto, comunidade infestante, supressão.

INTRODUCTION

Soybean is one of the oleaginous plants of major interest in the world and its development is often affected by various factors, among them weeds, which compete with soybean for water, light and nutrients, causing reduced grain yields and difficulties in harvesting (Pittelkow et al., 2009). The species known as Jamaican crabgrass (*Digitaria horizontalis*), sourgrass (*Digitaria insularis*), *couvinha* (*Porophyllum ruderale*) and coatbuttons (*Tridax procumbens*) are difficult to control in soybean, maize and millet crops (Pittelkow et al., 2009; Meschede et al., 2007; Martins et al., 2016). As a result, there is a need for techniques that can be used to assist in the chemical control of integrated weeds management.

The no-tillage cropping system (NT) is an effective soil management alternative for weeds suppression by means of the phytomass produced by cover plants. The species of cover plants used in the production systems need to establish quickly and produce adequate amounts of phytomass to cover the soil. Maize growing systems intercropped with *U. ruziziensis P. glaucum* and *Cajanus cajan* have a phytomass production capacity of 10,000 to 16,000 kg ha^{-1} (Carneiro et al., 2008; Pacheco et al., 2013; Queiroz et al., 2016). Single crops with *Pennisetum glaucum*, *Urochloa ruziziensis* and *Crotalaria spectabilis* or intercropped with annual cultures can be effective in suppressing the infesting community.

In the NT system, weeds control is achieved by the phytomass of cover plants, which acts as a physical barrier to the passage of sunlight and makes weeds' seed germination and seedlings growth difficult (Borges et al., 2013). Cover crops also have allelopathic effects on weeds, in their seeds or seedlings, through root exudation or during phytomass decomposition, interfering with the plants growth and development (Borges et al., 2013). Some studies with sorghum identified allelopathic action of this species, which has high phytotoxic activity as photosystem II inhibitors, acting similarly to the triazine group of herbicides (Czarnota et al., 2003; Santos et al., 2012).

Furthermore, an even bed of plant cover on the soil is capable of diminishing weeds infestations and improving the soil structure and fertility (Cosdta et al., 2015). To promote these improvements, the cover species in *cerrado* lands need to adapt to the biome edaphoclimatic conditions and produce large amounts of phytomass. Therefore, knowing the behavior of each cover plants species is necessary for an optimal production in monocropping, crop rotation or intercropping farming systems (Meschede et al., 2007) as well as for weeds control. This study aimed to evaluate the cover plants' effectiveness in suppressing weeds in no-till soybean production system.

MATERIAL AND METHODS

The experiment was carried out in 2013/2014, 2014/2015 and 2015/2016 crop years at the Federal University of Mato Grosso - UFMT, Campus of Rondonópolis (16°27'75" S and 54°34'55" O and altitude of 292 meters). The soil in the area is Dystrophic Oxisol (Embrapa, 2006), whose chemical and physical attributes are described on Table 1. The climate, according to Köppen classification, is Cwa, with well-defined dry and rainy seasons, the rainy season beginning in October and ending in May (Souza et al., 2013). Precipitation rates and mean maximum and minimum air temperatures during the experiment conduction are described in Figure 1.

Table 1 - Physicochemical attributes of Dystrophic Oxisol prior to the experiment's establishment

Depth	pH	O.M.	P	K	Ca	Mg	Al	H+Al	CEC	V
	($CaCl_2$)	(g kg^{-1})	(mg dm^{-3})		($cmol_c$ dm^3)					(%)
00-10 cm	4.1	17.6	5.4	55	0.5	0.2	1.2	6.8	7.6	11.0
10-20 cm	4.0	19.9	1.4	49	0.2	0.1	1.4	7.2	7.6	5.6
20-40 cm	4.1	13.7	0.2	31	0.3	0.1	1.3	6.2	6.7	7.2

P = available phosphorus; exchangeable K^+, Ca_2^+ and Mg_2^+; H+Al = potential acidity; CEC = cation exchange capacity at a pH value of 7.0; V = base saturation; O.M. = organic matter. P: extraction method of Mehlich-1.

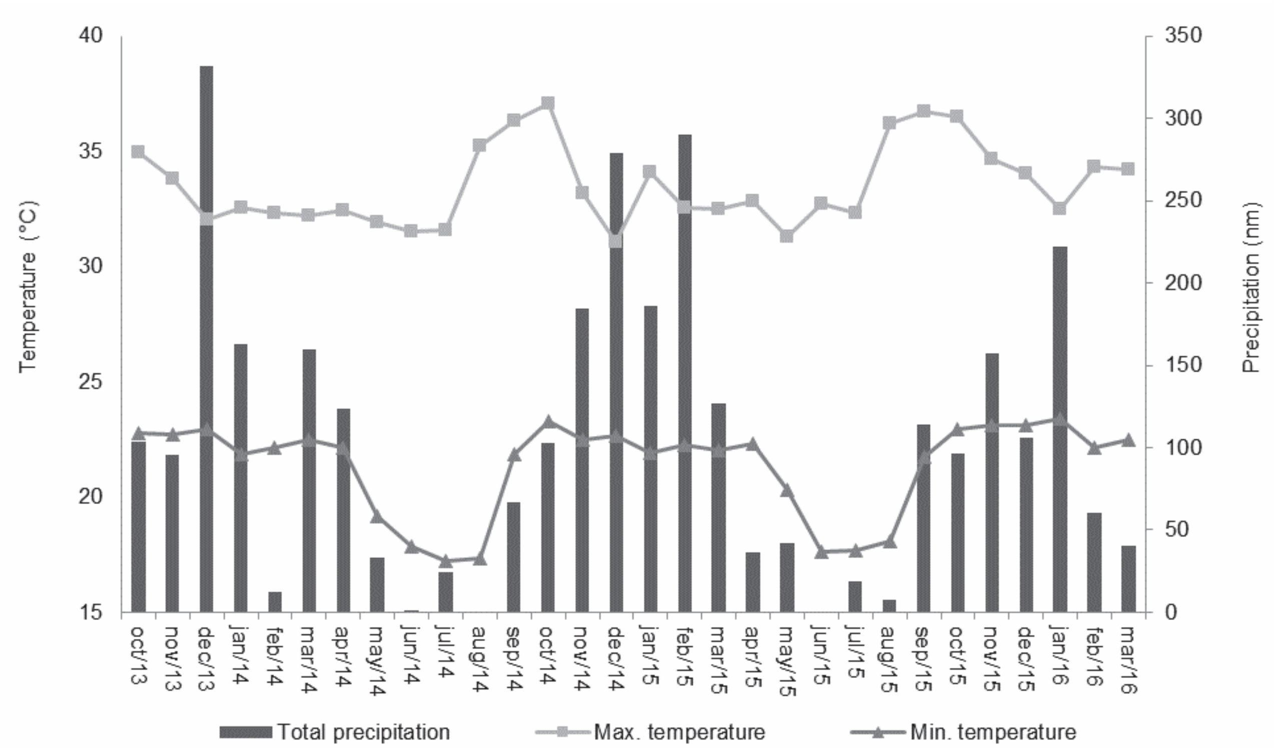

Figure 1 - Monthly and accumulated precipitation and minimum and maximum average air temperatures during the conduction of the experiment in Rondonópolis-MT.

Prior to the experiment installation, the area was cleared, followed by plowing and harrowing and manual roots removal. On Oct 08, 2013, liming was applied to the area (4,000 kg ha^{-1}) with Filler lime (PRNT: 99.02%), incorporated with a plow and harrow. The experiment was implemented in a randomized block design with nine treatments (Table 2) and four replications. Each experimental plot was 7 m wide x 9 m long.

In all production systems, soy was cultivated in two crop seasons. After being harvested, the second season began, when annual cereal crops were grown (60,000 maize plants ha^{-1}, 55,000 sunflower plants ha^{-1}, 160,000 *Vigna unguiculata* plants ha^{-1}) and the following cover plants: *Pennisetum glaucum* (18 kg ha^{-1}), *Urochloa ruziziensis* and *Urochloa brizantha* (15 kg ha^{-1} with 60% of cultural value), *Crotalaria breviflora* (17 kg ha^{-1}), *Crotalaria spectabilis* (15 kg ha^{-1}), *Cajanus cajan* (40 kg ha^{-1}) and *Stylosanthes capitata* + *S. macrocephala* (8 kg ha^{-1}), as described in Table 2. The systems with single cover crops were implemented with spacing of 0.45 m between rows; in the intercropping systems, annual crops (maize and sunflower) were implemented with spacings of 0.45 m, and the intercropped cover crops were sowed in between rows. All systems during the second season were sowed and fertilized manually. As can be seen in Table 2, some treatments (S4, S7, S8 and S9) had rotation of species sowed between the 2014 and 2015 second seasons, for systems diversification. Fallow treatments (S1 and S2) are the controls.

Table 2 **-** Characterization of production systems for sowing second season soybean seeds and after 2014/15 and 2015/16 harvests

Systems	2014 Second season	2015 Second season
S_1:	NT fallow	NT fallow
S_2:	CT fallow	CT fallow
S_3:	*Crotalaria spectabilis*	*Crotalaria spectabilis*
S_4:	*Crotalaria breviflora*	Maize + *C. spectabilis*
S_5:	*Pennisetum glaucum* ADR 8010	*Pennisetum glaucum* ADR 300
S_6:	*Urochloa ruziziensis*	*Urochloa ruziziensis*
S_7:	*Cajanus cajan*	Sunflower + *U. ruziziensis*
S_8:	*Stylosanthes capitata* + *S. macrocephala*	*Vigna unguiculata*
S_9:	*Urochloa brizantha* cv. Marandu	Maize + *U. ruziziensis*

NT - No-till system; CT- Conventional till system with plow + harrow.

The soybean cultivar TMG 132 RR was sowed in November 2013, with spacing of 0.45 m between rows and density of 12 plants m^{-1}. After the soybean harvest, the cover crops of the 2013/2014 crop year were sowed. In the beginning of the 2014/2015 crop, in October, all cover crops were desiccated using glyphosate herbicides (5 L ha^{-1}) and 2.4-D (1.5 L ha^{-1}). Afterwards, the soybean cultivar ANTA 82 RR was sowed on the remaining plant residues deposited on the soil, with a distribution of 29 plants m^{-1} and spacing of 0.45 m between rows. Soybean was harvested in February 2015, and again cover crops were sowed manually. The soybean cultivar used in 2015/16 was TMG 1175 RR, with a density of 25 plants m^{-1}. In 2015/16 crop, soybean was sowed on Oct. 29, 2015 and harvested on Feb. 16, 2016.

The fertilization used in soybean in both crop seasons was 120 kg ha^{-1} of P_2O_5 and 22 kg ha^{-1} of N, via monoammonium phosphate in the sowing grooves, and 100 kg ha^{-1} of K_2O via potassium chloride, half of it scattered over during pre-sowing and the rest when the soybean was in the V4 phenological stage. For all soybean plantations, the seeds were inoculated with liquid inoculant (Cell Tech HC® Nitragin) at a dosage of 150 mL of inoculant per 50 kg of seeds, exhibiting a bacterial concentration of $3x10^9$ CFU per mL, with *Bradyrhizobium japonicum* bacteria (SEMIA 5079 and 5080). In the annual crops sowed during the second season (maize, *V. unguiculata* and sunflower), fertilizations were made as recommended by Souza and Lobato (2004), while in the parcels of land where single crops of cover plants were grown, no fertilizers were used.

The evaluations were carried out before desiccation for soybean sowing in the 2014/2015 (Oct. 23, 2014) and 2015/2016 crop years (Sept. 21, 2015), prior to application of the selective herbicide in post-emergence of soybean in 2014/2015 (Dec. 09, 2014) and 2015/2016 (Nov. 12, 2015) and in the second season (June 12, 2015). In each parcel, a 5 x 5 m of useful area was assessed, where all weed species were counted and identified, but only the four species with the largest population amount were collected for phytomass determination. The four species were cut close to the ground and dried in a forced-circulation oven at 65 °C during 72 hours; subsequently, manual cleaning of residues was made to remove adhered soil and obtain dry phytomass. Soybean grains yield was assessed by harvesting the plants in two 2 meter long rows, expressed in kg ha^{-1} (standardized at 13% moisture).

The main weeds evaluated in the experimental area were Jamaican crabgrass (*Digitaria horizontalis*), sourgrass (*Digitaria insularis*), *couvinha* (*Porophyllum ruderale*) and coatbuttons (*Tridax procumbens*). The parameters used for the main weeds were density (plants m^{-2}), phytomass (kg ha^{-1}), incidence:

$$\frac{Population\ of\ evaluated\ species}{Total\ population} x\,100$$, expressed in percentage, and control effect:

$$\frac{Population\ of\ evaluated\ species\ x\,100}{Average\ of\ treatement\ with\ the\ highest\ population} - 100$$, also expressed in percentage.

The results were subjected to analysis of variance, with data transformed by equation “X+1, except for the control treatment; means were compared by Scott-Knott’s test at 5%, using SISVAR 5.4 software (Ferreira, 2008).

RESULTS AND DISCUSSION

The studied cover crops had an influence on weeds development (Table 3). *D. horizontalis* was the species that exhibited the highest population density among the assessed weed species. Edaphoclimatic conditions with rising temperature and rains are ideal conditions for breaking the dormancy of this seed and, consequently, its development, suppressing other species (Andrade et al., 2000).

In the evaluation prior to the desiccation of the area in 2015 (Sept 21, 2015), *D. horizonthalis* plants were not counted because they had already senesced due to water stress occurred in this period (Figure 1) and for not actually representing the situation of the species. These results are confirmed in the evaluation conducted during the 2015/2016 crop (Nov.12, 2015), so that after the rains, *D. horizonthalis* was present in the area. The other species did not appear in the evaluations, probably because of the production systems, which, by means of the cover crops phytomass control or the characteristics of each species, they may have been dormant for a while, awaiting better conditions for germination.

P. ruderale and *T. procumbens* weeds were more numerous in the fallow area than in the treatments with cover crops (Table 3), which indicates that there is a greater proliferation of these species when there is no control by the cover crops phytomass. Rizzardi and Silva (2014) studied management strategies to prevent the emergence of weeds in soybean crop, and Martins et al. (2016) in maize crop, reported that in fallow areas, managed with or without chemical control, contribute to the proliferation and a more difficult control of weeds. *T. procumbens* was found in fallow areas at all times, and in the evaluation at the time of desiccation for planting soybean, it was found in the area with *P. glaucum*. Cover crops phytomass exerts interspecific inhibition on weeds species (Meschede et al., 2007), either by the physical suppression effect or by the allelochemicals released by the plant matter in decomposition or produced by the roots of photosynthetically active crops.

In the conventional till (CT) fallow system, incorporation of plant residues reduced the density of infesting species in most of the soybean pre- and post-emergence evaluations, when compared to the NT fallow treatments (Table 3). Results obtained by Pacheco et al. (2016) in rice production system in the state of Piauí corroborate the temporary effectiveness of this management practice in the early stage of crop development.

It is worth noting that in the off-season evaluation, the CT fallow system exhibited higher counts of the species studied, except for *D. insularis,* which has a slower cycle and, therefore, did not exhibit a great number of individuals of this species (Table 3). It is known that weeds control by conventional tillage, when soil is turned over, is temporary, only by the time that soybean is sowed. In addition, with soil mechanical agitation, the seeds bank has more stimulus to germinate and emerge, resulting in a greater density of weeds in the off-season. So, the use of this technique is not recommended because it causes an increased infestation and increased seeds bank in the area over time.

The use of *U. ruziziensis* as cover crop promoted a lower incidence of weeds in most of the times and species evaluated (Table 3). These results were obtained because this cover species is able to produce a great amount of phytomass. Pacheco et al. (2016) obtained, in dry rice cultivation systems with *U. ruziziensis*, amounts between 10,800 and 12,500 kg ha^{-1} of phytomass for weeds control. Cover crops with this characteristic are vitally important for the integrated management of weeds, because it reduces weed infestations and the use of herbicides.

Gomes Jr. And Christoffoleti (2008) and Monquero et al. (2009) reported that the amount of phytomass produced by cover crops can interfere with the process of germination of weed seeds by reducing the soil temperature. This favors proliferation of soil micro- and mesofauna, which feeds on the seeds or colonizes them, and can also prevent the passage of light that is required for cellular histodifferentiation of positive photoblastic species. Mondo et al. (2010) examined four species of the genus *Digitaria* and found that *D. horizontalis* has positive photoblastism, differently from *D. insularis*, which exhibited negative photoblastism, which explains the high density of *D. horizontalis* in the area.

Table 3 **-** Density and phytomass of four weeds at different times and cropping systems for growing soybean. Mato Grosso, 2014/2015 and 2015/2016

System	Oct 23, 2014		Dec 09, 2014		June 12, 2015		Sept 21, 2015		Nov 12, 2015	
	Density (m^{-2})	Phytomass (kg ha^{-1})	Density (m^{-2})	Phytomass (kg ha^{-1})	Density (m^{-2})	Phytomass (kg ha^{-1})	Density (m^{-2})	Phytomass (kg ha^{-1})	Density (m^{-2})	Phytomass (kg ha^{-1})
	Digitaria horizontalis									
S_1:	11.55 a	136.64 a	8.72 a	15.63 a	17.44 a	1171.21 a	--	--	91.53 a	183.66 a
S_2:	11.49 a	150.13 a	4.31 a	5.56 a	22.13 a	1454.44 a	--	--	56.50 b	142.82 a
S_3:	0.00 b	0.00 b	3.92 a	4.12 a	0.05 b	1.07 b	--	--	28.75 c	71.39 b
S_4:	0.27 b	12.18 b	4.39 a	8.63 a	0.05 b	3.38 b	--	--	8.65 d	21.79 b
S_5:	0.44 b	10.01 b	0.97 a	1.26 a	0.00 b	0.00 b	--	--	8.85 d	17.37 b
S_6:	0.00 b	0.00 b	0.64 a	0.41 a	0.00 b	0.00 b	--	--	14.45 d	32.49 b
S_7:	0.00 b	0.00 b	2.10 a	8.73 a	3.07 b	93.25 b	--	--	43.90 b	170.91 a
S_8:	0.00 b	0.00 b	0.24 a	0.07 a	0.00 b	0.00 b	--	--	29.75 c	69.57 b
S_9:	0.19 b	0.97 b	6.36 a	7.58 a	0.00 b	0.00 b	--	--	10.19 d	25.31 b
VC (%)	17.4	43.78	45.98	61.99	31.6	61.09	--	--	29.77	35.92
	Digitaria insularis									
S_1:	--	--	--	--	0.16 a	16.67 a	0.57 a	31.81 a	--	--
S_2:	--	--	--	--	0.09 a	18.05 a	0.37 a	16.98 a	--	--
S_3:	--	--	--	--	0.08 a	6.92 a	0.42 a	2.87 b	--	--
S_4:	--	--	--	--	0.00 a	0.00 a	0.05 b	0.89 b	--	--
S_5:	--	--	--	--	0.00 a	0.00 a	0.11 b	2.74 b	--	--
S_6:	--	--	--	--	0.00 a	0.00 a	0.00 b	0.00 b	--	--
S_7:	--	--	--	--	0.00 a	0.00 a	0.00 b	0.00 b	--	--
S_8:	--	--	--	--	0.00 a	0.00 a	0.03 b	0.83 b	--	--
S_9:	--	--	--	--	0.00 a	0.00 a	0.00 b	0.00 b	--	--
VC (%)	--	--	--	--	4.8	92.5	10.64	66.43	--	--
	Porophyllum ruderale									
S_1:	1.52 a	18.87 a	--	--	0.51 b	47.41 b	0.14 a	2.31 a	--	--
S_2:	0.89 b	13.95 a	--	--	0.88 a	106.48 a	0.32 a	13.05 a	--	--
S_3:	0.07 c	0.38 b	--	--	0.22 c	5.43 c	0.01 a	0.21 a	--	--
S_4:	0.00 c	0.00 b	--	--	0.00 c	0.00 c	0.00 a	0.00 a	--	--
S_5:	0.60 b	22.61 a	--	--	0.06 c	0.43 c	0.09 a	0.55 a	--	--
S_6:	0.00 c	0.00 b	--	--	0.00 c	0.00 c	0.00 a	0.00 a	--	--
S_7:	0.00 c	0.00 b	--	--	0.03 c	0.35 c	0.00 a	0.00 a	--	--
S_8:	0.00 c	0.00 b	--	--	0.02 c	0.35 c	0.00 a	0.00 a	--	--
S_9:	0.00 c	0.00 b	--	--	0.00 c	0.00 c	0.00 a	0.00 a	--	--
VC (%)	12.6	45.76	--	--	5.25	60.59	7.12	72.32	--	--
	Tridax procumbens									
S_1:	0.53 a	4.05 a	--	--	0.14 a	31.73 a	0.24 a	11.65 a	--	--
S_2:	2.51 a	51.70 a	--	--	0.15 a	32.98 a	0.16 a	11.15 a	--	--
S_3:	0.00 a	0.00 a	--	--	0.00 b	0.00 b	0.00 b	0.00 b	--	--
S_4:	0.00 a	0.00 a	--	--	0.00 b	0.00 b	0.00 b	0.00 b	--	--
S_5:	0.00 a	0.00 a	--	--	0.00 b	0.00 b	0.03 b	0.57 b	--	--
S_6:	0.00 a	0.00 a	--	--	0.00 b	0.00 b	0.00 b	0.00 b	--	--
S_7:	0.00 a	0.00 a	--	--	0.00 b	0.00 b	0.00 b	0.00 b	--	--
S_8:	0.00 a	0.00 a	--	--	0.00 b	0.00 b	0.00 b	0.00 b	--	--
S_9:	0.00 a	0.00 a	--	--	0.00 b	0.00 b	0.00 b	0.00 b	--	--
VC (%)	36.83	153.38	--	--	3.88	105.71	5.1	73.51	--	--

Systems: S_1- NT fallow; S_2- CT fallow; S_3- *Crotalaria spectabilis*; S_4- *C. breviflora* (2014) and maize + *C. spectabilis* (2015); S_5 *P. glaucum* ADR 8010 (2014) and ADR 9010 (2015); S_6- *U. ruziziensis,* S_7- Pigeon beans (2014) and sunflower + *U. ruziziensis* (2015); S_8- *Stylosanthes* Campo Grande (2014) and cowpea bean (2015); S_9- *U. brizantha* (2014) and maize + *U. ruziziensis* (2015). Evaluations: Oct 23, 2014 – Prior to desiccation for growing soybean in 2014/15; Dec 09, 2014 – Prior to application of selective herbicide at soybean post-emergence in 2014/15; June 12, 2015 – Second season; Sept 21, 2015 – Prior to desiccation for growing soybean in 2015/16; Nov 12, 2015 – Prior to application of selective herbicide at soybean post-emergence in 2015/16. Means followed by same letters in column do not differ statistically from each other by the Scott-Knott's test ($P<0.05$).

D. horizontalis exhibited a higher phytomass production compared to the other species in most of the evaluation periods in all treatments (Table 3). The fast growth and development of this species makes it capable of accumulating phytomass very quickly to cover the soil surface, which results in more competition with other species and soybean plants if there is no proper control. Pittelkow et al. (2009) observed that high weed infestations affect the number of pods per plant, grain yield and reduced accumulation of dry matter during the soybean cycle, and the damages were higher as the weeds infestation levels increased.

P. ruderale, *T. procumbens* and *D. insularis* exhibited lower accumulation of phytomass because of lower population density (Table 3). These weeds have low individual weights and a slow development stage, which results in more time to accumulate phytomass, propagate and increase their populations. The highest weeds phytomass amount was found in the fallow area, due to the lack of phytomass of cover crops to exert control on the development of these species. In a study conducted in Cáceres-MT, Meschede et al. (2007) found similar results for fallow, obtaining high weeds phytomass values.

With respect to incidence, the highest value found was 11.1% for *D. insularis* in the evaluation that preceded desiccation for soybean sowing (2015/2016) in the area with *C. spectabilis*. In the other evaluations, the highest incidences were found for *D. horizontalis* (Table 4), which exhibited the highest infestation rate in all treatments for having a high seeds germination rate and fast establishment, which becomes a control problem.

Machado et al. (2006) reported that *D. insularis* has slow initial growth and this can diminish its competition with the other weed species, but it may become the dominant species if the herbicide dosage is not sufficient to control it. This trait of the species is confirmed by the data found in the evaluation conducted before management desiccation (Sept 21, 2015), when chemical control had not been used yet, and *D. insularis* exhibited high incidence and dominance over the other species.

Concerning the control variable, the treatments that influenced most in the reduction of weeds germination or growth were single *U. ruziziensis* and maize + *U. ruziziensis* intercropping with 100% of control in most of the periods and species investigated (Table 4). The high amounts of phytomass and slow decomposition of *U. ruziziensis* exerted a suppressive effect on the weeds in the off-season and part of the growing season, contributing to the integrated management of weeds in the *cerrado* by reducing the use of herbicides. Pacheco et al. (2011) stated that grasses like *U. ruziziensis* and *U. brizantha* are potential cover crops to be grown in the second season cropping systems in the *cerrado*, due to their high phytomass production, with values over 8,000 kg ha^{-1}.

The treatments with *P. glaucum*, *C. spectabilis* and *V. unguiculata* also exhibited high rates of control, reaching 100% in some evaluations. In the off-season evaluation, it was possible to observe *D. horizonthalis* phytomass reduction and population density in these treatments compared to the previous evaluations (Table 4). Results obtained by Meschede et al. (2007) corroborate the results of the present study, in which *P. glaucum* and *C. spectabilis* exhibited the smallest number of weeds per m^2, which indicates a greater control of these cover crops on weeds. These cover crops release secondary metabolites, also called phytotoxins, which are able to prevent the seeds germination, cause a suppressive effect on the seedlings and, finally, develop injuries in the plants' structure and physiology, which may cause the weeds death (Golisz et al., 2008).

With respect to the sunflower + *U. ruziziensis* and maize + *C. spectabilis* intercropping, high rates of control of weeds were also found at the dates of evaluation (Table 4). These data indicate the importance of intercropping in NT management systems, as well the diversity of species to be used as cover crops, so that the spectrum of suppressive effects on weeds may be enlarged, thus contributing to the integrated management of weeds with reduced applications of chemicals.

Alsaadawi et al. (2011), in experiment conducted in southern Bagdad, Iraq, extracted various allelopathic substances from sunflower, which were able to control weeds and also add nutrients to the soil, improving its fertility. Erasmo et al. (2009), in a study carried out in Jaboticabal-SP, observed a reduction of 60% of dry matter of *D. horizontalis'* roots by incorporating 30 g dm^{-3} of *C. spectabilis* biomass to the soil.

Table 4 - Incidence and control of four weed species at different times and cropping systems for growing soybean. Mato Grosso, 2014/2015 and 2015/2016

System	Oct 23. 2014		Dec 09. 2014		June 12. 2015		Sept 21. 2015		Nov 12. 2015	
	Incidence (%)	Control (%)	Incidence (%)	Control (%)	Incidence (%)	Control (%)	Incidence (%)	Control (%)	Incidence (%)	Control (%)
	Digitaria horizontalis									
S_1:	17.81 a	76.41 b	22.54 a	0.00 b	14.81 a	80.30 b	--	--	21.85 a	0.00 d
S_2:	13.45 a	0.00 c	16.57 a	87.64 a	17.55 a	0.00 c	--	--	16.95 a	84.56 c
S_3:	0.00 b	100.00 a	20.48 a	88.76 a	1.47 b	99.94 a	--	--	18.95 a	92.14 b
S_4:	10.38 a	99.44 a	15.31 a	87.41 a	5.00 b	99.94 a	--	--	18.86 a	97.63 a
S_5:	3.50 b	99.10 a	20.52 a	97.22 a	0.00 b	100.00 a	--	--	17.14 a	97.58 a
S_6:	0.00 b	100.00 a	9.00 a	98.16 a	0.00 b	100.00 a	--	--	23.85 a	96.05 a
S_7:	0.00 b	100.00 a	11.65 a	93.98 a	16.44 a	96.53 a	--	--	21.10 a	88.00 c
S_8:	0.00 b	100.00 a	10.00 a	99.31 a	0.00 b	100.00 a	--	--	13.60 a	91.87 b
S_9:	14.71 a	99.61 a	19.47 a	81.76 a	0.00 b	100.00 a	--	--	18.00 a	97.21 a
VC (%)	56.33	1.80	46.7	12.19	44.81	4.57	--	--	16.79	5.06
	Digitaria insularis									
S_1:	--	--	--	--	0.13 a	0.00 b	5.23 a	0.00 c	--	--
S_2:	--	--	--	--	0.07 a	85.93 a	3.58 a	83.77 b	--	--
S_3:	--	--	--	--	2.35 a	87.50 a	11.10 a	81.58 b	--	--
S_4:	--	--	--	--	0.00 a	100.00 a	6.66 a	97.80 a	--	--
S_5:	--	--	--	--	0.00 a	100.00 a	5.00 a	95.17 a	--	--
S_6:	--	--	--	--	0.00 a	100.00 a	0.00 a	100.00 a	--	--
S_7:	--	--	--	--	0.00 a	100.00 a	0.00 a	100.00 a	--	--
S_8:	--	--	--	--	0.00 a	100.00 a	5.00 a	98.68 a	--	--
S_9:	--	--	--	--	0.00 a	100.00 a	0.00 a	100.00 a	--	--
VC (%)	--	--	--	--	34.14	12.62	63.03	11.91	--	--
	Porophyllum ruderale									
S_1:	0.02 b	0.00 d	--	--	0.00 b	85.51 c	0.02 a	88.67 c	--	--
S_2:	0.01 b	84.95 c	--	--	0.00 b	0.00 d	0.02 a	0.00 d	--	--
S_3:	0.02 b	98.84 a	--	--	0.14 a	93.75 b	0.05 a	99.22 a	--	--
S_4:	0.00 c	100.00 a	--	--	0.00 b	100.00 a	0.00 a	100.00 a	--	--
S_5:	0.05 a	90.13 b	--	--	0.03 b	98.29 a	0.05 a	92.97 b	--	--
S_6:	0.00 c	100.00 a	--	--	0.00 b	100.00 a	0.00 a	100.00 a	--	--
S_7:	0.00 c	100.00 a	--	--	0.00 b	99.14 a	0.00 a	100.00 a	--	--
S_8:	0.00 c	100.00 a	--	--	0.02 b	99.43 a	0.00 a	100.00 a	--	--
S_9:	0.00 c	100.00 a	--	--	0.00 b	100.00 a	0.00 a	100.00 a	--	--
VC (%)	0.73	2.35	--	--	1.74	3.53	1.86	1.74	--	--
	Tridax procumbens									
S_1:	1.04 a	94.44 b	--	--	0.10 a	76.66 b	2.80 a	0.00 d	--	--
S_2:	2.78 a	0.00 c	--	--	0.11 a	0.00 c	1.65 a	84.11 c	--	--
S_3:	0.00 a	100.00 a	--	--	0.00 b	100.00 a	0.00 b	100.00 a	--	--
S_4:	0.00 a	100.00 a	--	--	0.00 b	100.00 a	0.00 b	100.00 a	--	--
S_5:	0.00 a	100.00 a	--	--	0.00 b	100.00 a	1.34 a	96.61 b	--	--
S_6:	0.00 a	100.00 a	--	--	0.00 b	100.00 a	0.00 b	100.00 a	--	--
S_7:	0.00 a	100.00 a	--	--	0.00 b	100.00 a	0.00 b	100.00 a	--	--
S_8:	0.00 a	100.00 a	--	--	0.00 b	100.00 a	0.00 b	100.00 a	--	--
S_9:	0.00 a	100.00 a	--	--	0.00 b	100.00 a	0.00 b	100.00 a	--	--
VC (%)	40.99	0.77	--	--	3.11	1.05	34.99	1.08	--	--

Systems: S_1- NT fallow; S_2- CT fallow; S_3- *Crotalaria spectabilis*; S_4- *C. breviflora* (2014) and maize + *C. spectabilis* (2015); S_5 *P. glaucum* ADR 8010 (2014) and ADR 9010 (2015); S_6- *U. ruziziensis,* S_7- Pigeon beans (2014) and sunflower + *U. ruziziensis* (2015); S_8- *Stylosanthes* Campo Grande (2014) and cowpea bean (2015); S_9- *U. brizantha* (2014) and maize + *U. ruziziensis* (2015). Evaluations: Oct 23, 2014 – Prior to desiccation for growing soybean in 2014/15; Dec 09, 2014 – Prior to application of selective herbicide at soybean post-emergence in 2014/15; June 12, 2015 – Second season; Sept 21, 2015 – Prior to desiccation for growing soybean in 2015/16; Nov 12, 2015 – Prior to application of selective herbicide at soybean post-emergence in 2015/16. Means followed by same letters in column do not differ statistically from each other by the Scott-Knott's test (P<0.05).

The lowest rates of weeds suppression were found in the fallow treatments (Table 4). This was due to the absence of cover crops to exert control on weeds, which, without the inhibitory effect of cover crops, proliferate in fallow treatments, and therefore increases the seeds bank for the next crops, which makes control more difficult.

With regard to soybean yields, there was as a significant effect of the systems only in 2015/2016 (Table 5). The system with *Crotalaria spectabilis* exhibited better results compared to the other systems, with high control of weeds, among other factors. This weeds control minimized interspecific competition for resources and contributed to higher yields of soybeans. In the fallow systems, the absence of cover crops associated with the management system resulted in lower soybeans yields. Management with spontaneous plant species and mechanical agitation of soil showed, since the early stages of soybean growth, a high density of weeds and, consequently, more competition between the crop and the infesting community.

Table 5 **-** Yields of soybean grown in rotation with annual crops and cover crops sown in second season in nine different cropping systems in 2014/2015 and 2015/2016

Cropping systems	2014/2015	2015/2016	Soybeans yield (kg ha^{-1})	
			Crop year 2014/2015	Crop year 2015/2016
S_1:	Soybean-NT Fallow	Soybean-NT Fallow	2763^{ns}	1889 C
S_2:	Soybean-CT Fallow	Soybean-CT Fallow	2837	2276 B
S_3:	Soybean-*C. spectabilis*	Soybean-*C. spectabilis*	4059	2686 A
S_4:	Soybean-*C. breviflora*	Soybean-Maize + *C. spectabilis*	4054	2155 B
S_5:	Soybean-*P. glaucum*	Soybean-*P. glaucum*	3349	2347 B
S_6:	Soybean-*U. ruziziensis*	Soybean-*U. ruziziensis*	3373	2273 B
S_7:	Soybean-*Cajanus cajan*	Soybean-Sunflower + *U. ruziziensis*	3660	2301 B
S_8:	Soybean-*Stylosanthes capitata* + *S. macrocephala*	Soybean-*V. unguiculata*	3170	2425 B
S_9:	Soybean-*U. brizantha*	Soybean-Maize + *U. ruziziensis*	2560	2051 C
VC (%)			24.26	7.67

Means followed by same letters in column do not differ from each other by the Scott-Knott's test at 5% probability level. ^{ns} not significant by the F test at 5% probability.

The cropping systems with *U. ruziziensis*, *P. glaucum*, *C. spectabilis* and intercropping with maize + *U. ruziziensis,* sunflower + *U. ruziziensis* and maize + *C. spectabilis* are good alternatives to assist integrated weeds management, by reducing the incidence and increasing the control of *D. horizonthalis*, *D. insularis*, *P. ruderale* and *T. procumbens*, detected in soybean growing systems during the conduction of the experiment in the *cerrado* region in Rondonópolis-MT. The system with *C. spectabilis* results in higher soybeans yield. With this integrated management, costs with herbicides applications, use of implements and fuel are reduced, besides incorporating phytomass to the system, making NT farming system an efficient method in managing agricultural farming systems.

ACKNOWLEDGEMENTS

The authors are thankful to the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for the MD scholarship granted to the first and fourth authors. To the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the financial support (Universal Call no. 14/2012 – Project no. 484801/2012-0) and for the productivity scholarships granted to the second and third authors. To the *Fundação AGRISUS* – Agricultura Sustentável (Project no. 1604/15) for the financial support.

REFERENCES

Alsaadawi I.S. et al. Integration of sunflower (*Helianthus annuus*) residues with a pre-plant herbicide enhances weed suppression in broad bean (*Vicia faba*). **Planta Daninha**. 2011;29:849-59.

Andrade A.C.S. et al. Germinação de sementes de jenipapo: temperatura, substrato e morfologia do desenvolvimento pós-seminal. **Pesq Agropec Bras.** 2000;35:609-15.

Borges W.L.B., Freitas R.S., Mateus G.P. Plantas de cobertura no controle de plantas daninhas. **Pesq Tecnol.** 2013;10:1-5.

Carneiro M.A.C. et al. Produção de fitomassa de diferentes espécies de cobertura e suas alterações na atividade microbiana de solo de cerrado. **Bragantia**. 2008;67:455-62.

Costa N.R. et al. Atributos do solo e acúmulo de carbono na integração lavoura-pecuária em sistema plantio direto. **Rev Bras Cien Solo**, 2015;39:852-63.

Czarnota M.A., Rimando A.M., Weston L.A. Evaluation of root exudates of seven sorghum accessions. **J Chem Ecol.** 2003;29:2073-83.

Empresa Brasileira de Pesquisa Agropecuária – Embrapa. **Sistema brasileiro de classificação de solos**. 2ª.ed. Brasília: 2006. 306p.

Erasmo E.A.L. Efeito de extratos de adubos verdes sobre *Lactuca sativa* e *Digitaria horizontalis*. **Bragantia**. 2011;70:529-37.

Ferreira D.F. Sisvar: um programa para análises e ensino de estatística. **Rev Cien Sympos**. 2008;636-41.

Golisz A., Sugano, M., Fujii, Y. Microarray ex-pression profiling of *Arabidopsis thaliana* L. in response to allelochemicals identified in buckwheat. **J Exper Bot.** 2008;59:3099-109.

Gomes JR., F.G.; Christoffoleti P.J. Biologia e manejo de plantas daninhas em áreas de plantio direto. **Planta Daninha**, 2008;26:789-98.

Machado A.F.L. et al. Análise de crescimento de *Digitaria insularis*. **Planta Daninha**. 2006;24:641-7.

Martins D., Gonçalves C.G., Silva Junio A.C. Coberturas mortas de inverno e controle químico sobre plantas daninhas na cultura do milho. **Rev Cienc Agron.** 2016;47:649-57.

Meschede D.K.; Ferreira, A.B.; Ribeiro Jr., C.C. avaliação de diferentes coberturas na supressão de plantas daninhas no cerrado. **Planta Daninha**. 2007;25:465-71.

Mondo V.H.V. et al. Efeitos da luz e temperatura na germinação de sementes de quatro espécies de plantas daninhas do gênero *Digitaria*. **Rev Bras Sementes**. 2010;32:131-7.

Monquero P.A. et al. Efeito de adubos verdes na supressão de espécies de plantas daninhas. **Planta Daninha**. 2009;27:85-95.

Pacheco L.P. et al. Produção de fitomassa e acúmulo e liberação de nutrientes por plantas de cobertura na safrinha. **Pesq Agropec Bras.** 2011;46:17-25.

Pacheco L.P. et al. Produção de fitomassa e acúmulo de nutrientes por plantas de cobertura no cerrado piauiense. **Bragantia**. 2013;72:237-46.

Pacheco L.P. et al. Sistemas de produção no controle de plantas daninhas em culturas anuais no Cerrado Piauiense. **Rev Cienc Agron.** 2016;47:500-8.

Pittelkow F.K. et al. Interferência de plantas daninhas na cultura da soja transgênica. **Global Sci Technol.** 2009;02:38-48.

Queiroz R.F. de et al. Maize intercropped with *Urochloa ruziziensis* under no-tillage system. **Pesq Agropec Tropical**. 2016;46:238-44.

Rizzardi M.A., Silva L. Manejo de plantas daninhas eudicotiledôneas na cultura da soja Roundup Ready®. **Planta Daninha**. 2014;32:683-97.

Santos I.L.V.L. et al. Sorgoleone: benzoquinona lipídica de sorgo com efeitos alelopáticos na agricultura como herbicida. **Rev Arq Inst Biol.** 2012;79:135-44.

Souza D.M.G.; Lobato, E. **Cerrado:** correção do solo e adubação. Planaltina: Embrapa Cerrados, 2004. 416p.

Souza A.P. et al. Classificação climática e balanço hídrico climatológico no estado de Mato Grosso. **Nativa**, 2013;1:34-43, 2013.