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ACTION OF DWARF MUCUNA, PIGEON PEA AND STYLOSANTHES ON WEED UNDER FIELD AND LABORATORY CONDITIONS

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SUMMARY

The quality and allelopathy properties of dwarf mucuna, dwarf pigeon pea and stylosanthes as cover crops on corn and weed species were evaluated. Seeds were sown in October 2007, with a control treatment, in 20 plots of 4×5m, with five replicates. Weed population was determined 30 and 60 days after sowing. At 90 days, plants were mowed and the residues left to remain on the plot. Fresh and dry mass of the cover crops were determined and the allelopathic potential of aqueous extract of their aerial part was tested. The extract was chemically characterized and applied on seeds of weeds

and corn. The experimental design was completely randomized and averages compared by the Scott-Knott test at 5% significance. The cover crops showed to be effective in the control of weeds. The highest values in fresh and dry mass were obtained for dwarf pigeon pea, followed by dwarf mucuna; fresh mass increased 72 and 34%, respectively, compared to the control. The extract with dwarf mucuna affected arrowleaf sida germination. The use of green manure in the summer or between harvests ensures that crop rotation is carried out properly and warrants its benefits.

Introduction

Leguminous species and others used as vegetal mulching may result in the release and addition of chemical substances to the system. These substances, known as allelochemicals, may have a positive or harmful effect on other species. This phenomenon, termed allelopathy (Rice, 1984) is species-specific, and may inhibit the growth of weeds and cultivated plants. It must be observed when a new vegetal mulching is introduced in the handling of soil and crops. Allelopathy has been recognized as an important ecological and agricultural mechanism, acting in the succession, formation of communities and crop produc-

tivity (Yunes and Calixto, 2001).

The study of plants with allelopathic activity represents an alternative to the intensive use of pesticides in crops, decreasing environmental pollution. However, interactions between cover plants and cultures, mainly regarding weed control, both by allelopathic effects and physical effects of the mulching, have not been sufficiently studied. The acquired knowledge can help in adequate planning of crop rotation. Bhowmika and Inderjit (2003), Weih *et al.* (2008), and Meksawat and Pornprom (2010) highlight the possibility of allelopathic activity as an alternative measure to the use of chemical control in order to suppress

weeds in the agroecosystem or to reduce pesticide usage.

Crop rotation can also be an efficient agricultural practice in the control of weed plants, due to changes in the selection pressure. Tillage sequences reduce the seed bank, providing different competition models, allelopathy and disturbances in the soil (Severino and Christofoleti, 2001b; Borkert *et al.*, 2003).

The use of soil coverage plants has been a strategy capable of increasing the sustainability of agroecosystems, bringing benefits to the cultures of economic interest, to the soil and to the environment, showing itself as an economically viable and ecologically sustainable alterna-

tive (Gama-Rodriguês *et al.*, 2007).

The species cultivated for mulching must be compatible with the demands of the agricultural system. According to Meschede (2006), a proper use of mulch can provide control of weed plants by allelopathy, the alteration of thermal regimes, incidence of light and physical barriers to emergence, and also increase rain water retention, soil humidity, organic matter content, microbial activity, predation and overcoming of seed dormancy.

The higher efficiency of leguminous species as vegetal mulch (cover plants) is due to the fact that, in symbiosis with *Rhizobium*- and *Bradyrhizobium*-type bacteria, nitro-

KEYWORDS / Allelopathy / Cover Crops / Green Manure / No-Tillage / Weed /

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ACCIÓN DE MUCUNA ENANA, HABICHUELA Y ESTILOSANTES SOBRE PLANTAS INVASORAS EN CONDICIONES DE CAMPO Y LABORATORIO

Danielle Medina Rosa, Lúcia Helena Pereira Nóbrega, Gislaïne Piccolo de Lima, Márcia Maria Mauli y Sílvia Renata Machado Coelho

RESUMEN

La calidad de la mucuna enana, habichuela y estilosantes, como cobertura vegetal sobre maíz y especies invasoras fue evaluada. La siembra fue en octubre de 2007, con un testigo, en 20 parcelas de 4x5m, cinco repeticiones. A los 30 y 60 días después de la siembra, fue calculada la población de plantas invasoras. A los 90 días, las plantas fueron segadas y los residuos permanecieron sobre la parcela. Masa fresca y seca de las coberturas fueron determinadas y probadas cuanto al potencial alelopático del extracto acuoso de la parte aérea, siendo este caracterizado químicamente y aplicado sobre semillas de especies invasoras y maíz. El diseño experimental de ese ensayo fue completamente aleatorio con promedios com-

parados por el Scott-Knott prueba a 5% de probabilidad. Las plantas de cobertura presentaron eficiente control de plantas invasoras. Los mayores valores encontrados de masa fresca y seca fueron para la habichuela, seguida de mucuna enana, con una diferencia porcentual en relación al testigo de 72 y 34% de aumento en la cantidad de masa fresca, respectivamente. El extracto con mucuna enana afectó negativamente la germinación de guanxuma; habichuela y estilosantes no afectaron ninguna de las especies. La opción del uso de adobo verde en el verano o fuera de temporada de cosecha, puede garantizar la rotación de culturas más adecuadas, trayendo ventajas al sistema de cultivo.

AÇÃO DE MUCUNA ANÃ, FEIJÃO GUANDU ANÃO E ESTILOSANTES SOBRE PLANTAS INVASORAS EM CONDIÇÕES DE CAMPO E LABORATÓRIO

Danielle Medina Rosa, Lúcia Helena Pereira Nóbrega, Gislaïne Piccolo de Lima, Márcia Maria Mauli e Sílvia Renata Machado Coelho

RESUMO

A qualidade da mucuna anã, feijão guandu anão e estilosantes, como cobertura vegetal sobre milho e espécies invasoras foi avaliada. A semeadura foi em outubro de 2007, com uma testemunha, em 20 parcelas de 4x5m, cinco repetições. Aos 30 e 60 dias após a semeadura, foi levantada a população de plantas invasoras. Aos 90 dias, as plantas foram roçadas e os resíduos permaneceram sobre a parcela. Massa fresca e seca das coberturas foram determinadas e testadas quanto ao potencial alelopático do extrato aquoso da parte aérea, sendo este caracterizado químicamente e aplicado sobre sementes de espécies invasoras e milho. O delineamento experimental desse ensaio foi inteiramente casualizado com médias comparadas

por o Scott-Knott teste a 5% de probabilidade. As plantas de cobertura apresentaram eficiente controle de plantas invasoras. Os maiores valores encontrados de massa fresca e seca foram para o feijão guandu anão, seguido de mucuna anã, sendo a diferença percentual em relação à testemunha de 72 e 34% de aumento na quantidade de massa fresca, respectivamente. O extrato com mucuna anã afetou negativamente a germinação de guanxuma; feijão guandu anão e estilosantes não afetaram nenhuma das espécies. A opção de uso de adubação verde de verão ou na entressafra, pode garantir a rotação de culturas mais adequada, trazendo vantagens ao sistema de cultivo.

gen from the air is fixed in sufficient quantities, so that their needs are satisfied and excess generates for the following crop (Ambrosano *et al.*, 2005).

Severino and Christoffoleti (2001a) reported that the phytomass of green manure, incorporated to the soil or placed on its surface reduces the population of weed plants. Thus, knowing about these possible effects allows its usage in rotation systems or in consortia with cultures, in the context of integrated handling of weed plants (Erasmus *et al.*, 2004). The effects of some green manures are related to the release of allelopathic substances during residue decom-

position; the allelopathic effect may occur both during the crop cycle and in subsequent crops (Teixeira *et al.*, 2004; Espíndola *et al.*, 1997).

Tokura and Nóbrega (2006) evaluated the allelopathic potential of *Triticum* spp., *Avena strigosa*, *Pennisetum glaucum*, *Raphanus sativus* and *Brassica napus* mulches on the development of weed plants in the field. They concluded that among the species found, *Brachiaria plantaginea* was the one that showed the highest allelopathic potential, and *Chenopodium album* L the lowest. The vegetal mulches that presented a better control, in comparison to the total

amount of weed plants present in the experimental area, were *A. strigosa*, *B. napus*, *R. sativus* and *P. glaucum*.

There is a need for establishing new weed plant control paradigms, which should, at the same time, be efficient in their control, protect the interests of society and, furthermore, they should not contaminate natural resources (Souza Filho *et al.*, 2005). In this sense, vegetal mulching significantly decreases the intensity of area infestation by weed plants and modifies the composition of the weed population, being capable of reducing or eliminating the use of pesticides. The aim of the present work was to evaluate

the quality and the allelopathic potential of dwarf mucuna, pigeon pea and stylosanthes vegetal mulch on corn culture and weed species.

Materials and Methods

Experimental conditions

The experiment was carried out in an agricultural field, in western Paraná, Brazil, in the municipality of Braganey, during the 2007/2008 agricultural year. The area is located at 24°49'03"S and 53°07'11"W, and 643masl. The local soil is classified as eutrophic Red Latosol. Average annual rainfall is 1600mm and an aver-

age annual temperature of 20°C. The area was cultivated under a no-tillage system with a succession of soybean (*Glycine max*) and wheat (*Triticum vulgare*) for ~10 years.

The leguminous species dwarf mucuna (*Mucuna deeringiana* (Bort.) Merr), pigeon pea (*Cajanus cajan* L.) and stylosanthes (*Stylosanthes capitata* and *S. macrocephala*) were sowed with ~20, 50 and 70 seeds per m², respectively, in October 2007, in 4×5m plots, with 1m spacing between the plots. The sowing of the leguminous species was done by throwing, and they were incorporated to the soil with a hoe, without use of manure. There were four treatments, three leguminous ones and a control fallow.

At the beginning of the blossom stage, in January 2008, the cover plants were cut close to the soil and samples were collected for the preparation of aqueous extracts in the laboratory and for the determination of fresh and dry mass. The rest was weeded mechanically, in such a way that the straw remained on the plot related to the treatment.

A metal board of 0.50×0.50m, totalizing an internal area of 0.25m², was randomly thrown, four times, inside each plot and the vegetal mulch included was collected. Next, subsamples were gathered, forming a single sample. The fresh mass was determined just after the cut, and the dry mass after drying in an air circulation greenhouse at 60°C, for 48h. The results of fresh and dry mass were extrapolated to kg·ha⁻¹.

The percentage of dry mass present in the total fresh mass was calculated as

$$\%DM = \frac{DM}{FM} \times 100$$

where % DM: dry mass percentage, DM: dry mass value found for the leguminous species, and FM: fresh mass value found for the leguminous species.

The control mass was the mass of spontaneous vegetation (weeds), and the variation of mass production in relation to the control was calculated as

$$\% \Delta = \frac{T_n \cdot 100}{T_0}$$

where %Δ: mass production variation in relation to the control, T_n: mass production in the treatment, and T₀: mass production in the control. The results were expressed as percentages.

The relation between fresh mass and dry mass was obtained from the equation

$$FM/DM = \frac{FM}{DM}$$

where FM/DM: relation between fresh and dry mass, FM: fresh mass obtained, and DM: dry mass obtained.

Amount of weed

The amount of weeds was evaluated during the culture of the leguminous species, at 30 and 60 days after sowing. The gathering of data consisted of four random samplings, by plot, with a random throwing of metal frame boards as described above, totalizing an internal area of 0.25m². The weed plants found within the board were counted and separated in long and broad leaves, apart from the count and specific identification of the *Ipomoea* sp., *Sida rhombifolia* L. and *Bidens pilosa*.

The percent reduction in the treatments in relation to the control was calculated with the equation

$$\%RED = 100 - \left(\frac{T_n \cdot 100}{T_0} \right)$$

where %RED: percent reduction, T_n: number of weed plants found in treatment n, and T₀: number of weed plants found in the control.

Aqueous extract of plants

The aqueous extract was prepared with fresh leaves of dwarf mucuna, pigeon pea and stylosanthes collected in the field, at blossom stage for

the first two species and at vegetative stage for the third, since this last species entered the blossom stage at a different period. Fresh leaves, collected the same day as the test was performed, were milled in a blender until the mixture became homogeneous, in a 1/3 (weight/volume) proportion of leaves and distilled water, respectively. This solution was placed in a refrigerator for 48h and then filtered through filter paper. The pH, electrical conductivity, extract yield and refractive index of the extract solution were established according to the recommendation of the Adolfo Lutz Institute (2008), with one replicate for each treatment. The analyses were carried out at the Seed and Plant Evaluation Laboratory (LASP), Technological and Exact Sciences Center (CCET), Universidade Estadual do Oeste do Paraná, *campus* Cascavel.

The laboratory experiment was set in germination boxes (Gerbox-type) with two sheets of filter paper. The filter paper was moistened with 13ml of extract solution (~2.5 times the paper weight), at concentrations of 0; 1; 2.5; 5; 10 and 20%, and constituted the substratum on which were placed for germination 10 corn seeds or 25 seeds each of *Ipomoea* sp., *Sida rhombifolia* L. and *Bidens pilosa*, in accordance with MAPA (2009) observations. The germinators were kept at 25°C and the permanence time differed depending on the species, with nine days for corn and the *Ipomoea* sp. seeds, 13 days for *B. pilosa* and 16 days for *S. rhombifolia*.

At the end of the experiment, the seedlings were rated as normal, abnormal, hard seeds and dead. The results were expressed in percentage, as in MAPA (2009).

Experimental design and data analysis

The experimental design was entirely randomized, with five replicates per treat-

ment in the field and four replicates each at the laboratory. For the laboratory-based allelopathy tests, a flame ionization detector was used in the factorial scheme 4×6 (4 leguminous species × 6 concentrations). The results were subjected to variance analysis and the mean comparison was accomplished by the Scott-Knott test at 5% probability, with the support of the SISVAR software (Ferreira, 2000).

Results and Discussion

In the analysis of type and amounts of weeds during the development of leguminous plants, it was observed that for the narrow or long-leaved weeds, *Ipomoea* sp. and *S. rhombifolia*, there was no statistical difference, while among the large or broad-leaved species, *B. pilosa* stood out as the most common.

In the evaluation performed 30 days after sowing of the leguminous plants dwarf mucuna, pigeon pea and stylosanthes there was no statistical differences among the treatments. But in the evaluation at 60 days after sowing the control showed a significantly higher value for long-leaved species when compared to the other treatments, showing that this type of mulch indicating that cover crops controlled these species (Table I).

After 30 days from sowing, the highest reduction in relation to the control (42%), among invading species was found to be in the treatment with stylosanthes. Dwarf mucuna, on the other hand, led to the lowest reduction (20%) at 30 days after sowing and the highest reduction (55%) at 60 days. Pigeon pea showed values between intermediate treatments in both evaluations.

Fernandes *et al.* (1999) studied the phytomass of green manure and the control of weed plants as a response to population densi-

TABLE I
NUMBER OF WEED PLANTS PER-m² AND REDUCTION (%) IN THE THREE TREATMENTS IN RELATION TO THE CONTROL, DURING DEVELOPMENT OF DWARF MUCUNA, PIGEON PEA AND STYLOSANTHES, 30 AND 60 DAYS AFTER SOWING

Evaluation	30 days			60 days		
	Long leaf	<i>B. pilosa</i>	% reduction	Broad leaf	<i>B. pilosa</i>	% reduction
Control	45 a	7 a	0	40 a	7 a	0
Dwarf mucuna	36 a	5 a	20	18 b	2 a	55
Pigeon pea	34 a	5 a	24.4	19 b	6 a	52.5
Stylosanthes	26 a	5 a	42.2	26 b	4 a	35
Variation coeff. (%)	21.69	63.43	-	15.91	45.86	-
General mean	35	5	-	26	5	-
F values	1.50ns	0.17ns	-	7.27*	1.27ns	-

Averages followed by the same letter, in a column, do not differ from each other by the Scott-Knot test at 5% probability. The presented data were gathered from the original observations, followed by the letters obtained in the mean comparison with transformation into $\sqrt{x+0.5}$.

ties of leguminous species, and the largest inhibitions occurred in the plots of *Mucuna aterrima* and *Canavalia ensiformis*. Erasmo *et al.* (2004) evaluated at 15, 30, 45 and 60 days after the implantation of cover crops of pigeon pea and the mucunas *M. aterrima* and *M. pruriens*; they reported that the two later species significantly reduced the number and the dry mass of the population of weeds in all the evaluations, whereas *C. cajan* showed the highest interference over the 45 days after the implantation. Penteadó (2007) also indicated mucuna and pigeon pea as mulch or cover crops for the soil, as a way to suppress weed plants.

According to Severino and Christoffoleti (2001a), the phytomass of green fertilizers incorporated to the soil or on the surface, reduces the populations of weeds; these same authors, in another paper, studying a seed bank of invading plants in a soil where manure had been spread, reached the conclusion that the use of the leguminous species *C. juncea*, *C. cajan* and *Arachis pintoi* significantly reduced the infestation of weed plants, mainly of *Brachiaria decubens*, *Panicum maximum* and *B. pilosa*. Concerning the weed *B. pilosa*, the leguminous species *C. cajan* and *C. juncea* stood out (Severino and Christoffoleti, 2001b).

As for the influence of cover crops over *B. pilosa*, Correia *et al.* (2006), studying the cover crops *Sorghum bicolor* × *S. sudanense*, *Pennisetum americanum*, *Eleusine caracana* and *Brachiaria brizantha* for the formation of straw at the emergence of weeds, observed that the specific composition and the population densities of the infesting communities were influenced by the dead coverage systems of production. The number of emerged plants of *B. Pilosa*, *Araganthus* spp., *Commelina benghalensis*, *Leucas martinicensis* and grass-like (narrow) leaves was inhibited by the covers, whereas for *Chamaesyce* spp. the residues contributed for an increase of emergence.

According to Erasmo *et al.* (2004) the interference of cover plants on weed species happens for two reasons: the allelochemical factor, available in a higher quantity in decomposing individuals and the volume of deposited vegetable material.

Table II shows the averages for fresh and dry mass (kg·ha⁻¹) of the aerial part of plants in the cases of control, dwarf mucuna, pigeon pea and stylosanthes treatments. The variation of fresh mass produced under the different treatments can be appreciated. The highest value (8.1kg·ha⁻¹) was that of pigeon pea, followed by dwarf mucuna. The differ-

ence in relation to the control for these two species represents an increase of 72 and 34% in the quantity of fresh mass. In turn, stylosanthes had the lowest value, even lower than the control.

When dry mass is analyzed, it can be seen that the pigeon pea, just as for the fresh mass, showed the highest value, whereas the dwarf mucuna showed a reduction, being equivalent to the control. Alcántara *et al.* (2000) studied the *C. Cajan*, *Crotalaria juncea* and pasture in the recovery of soil fertility, and also found that the biggest production of dry mass by the aerial part, as well as the biggest contribution in nutrient supplies, was that of *C. Cajan*.

Stylosanthes presented the lowest quantity of dry mass

among the treatments employed, well below the control. Heinrichs *et al.* (2005) reported a reduced development for *C. cajan*, *Crotalaria spectabilis* and *M. deeringiana*, with a production of green phytomass lower than that generated in the control treatment, made up of spontaneous plants. Among the studies on green manures by these authors, *Canavalia ensiformis* stood out, reaching values of up to 290% higher than the control.

Borkert *et al.* (2003) claimed that the pigeon pea is an option for covering the soil in summer/fall, and that it is able to produce, in consortium with corn, amounts of dry mass higher than 2Mg·ha⁻¹. In some cases, it produced even more than 10Mg·ha⁻¹, when cultivated in isolation in fertile soils and with good climate conditions. In the present study the species reached around 8Mg·ha⁻¹. Favero *et al.* (2001) found around 5.5Mg·ha⁻¹ for pigeon pea; these same authors found values ~6Mg·ha⁻¹ for black mucuna, similar as found for dwarf mucuna in this work.

Stylosanthes was unable to establish a good soil cover, possibly because the edaphoclimatic conditions that predominated in the study area may have influenced the capacity for phytomass production, and also because the species did not

TABLE II
MEAN FRESH AND DRY MASS, DIFFERENCE (%) BETWEEN TREATMENTS AND CONTROL, AND FRESH MASS / DRY MASS RATIO OF THE AERIAL PARTS OF DWARF MUCUNA, PIGEON PEA AND STYLOSANTHES AND THE SPONTANEOUS PLANTS IN THE CONTROL (FALLOW)

Evaluation	Fresh mass		Dry mass		FM/DM	
	(kg·ha ⁻¹)	(%)	(kg·ha ⁻¹)	(%)	%DM	Relation
Control	4.702 c	100	452 b	100	10	10/1
Dwarf mucuna	6.307 b	134	488 b	108	8	13/1
Pigeon pea	8.083 a	172	1.131 a	251	14	7/1
Stylosanthes	1.975 d	42	272 c	60	14	7/1
Variation coef. (%)	11.88	-	3.63	-	-	-
General mean	5267	-	585	-	-	-
F values	68.65*	-	69.19*	-	-	-

Averages followed by the same letter, in the column, do not differ from each other by the Scott-Knot test at 5% probability. The dry mass data presented were gathered from the original observations, followed by the letters obtained in the mean comparison with the Box-Cox transformation.

reach the blossom stage on the field.

In studies about the accumulation of nutrients in the foliar limbo of guandu and stylosanthes, Silveira *et al* (2005) reported that the pigeon pea produced more dry mass and, in general, showed more accumulation of nutrients than stylosanthes, up to about 100 days of age. In this work, the leguminous species were tilled 90 days after sowing, and stylosanthes might need some more time to reveal its potential.

Braz *et al.* (2006), studying plants for mulching in wheat crops, reported productions of dry mass of 3494kg·ha⁻¹ for stylosanthes, and of 5507kg·ha⁻¹ for pigeon pea, values that are lower than those encountered in this work for pigeon pea, but higher than that for stylosanthes, which are of 8083 and 1975kg·ha⁻¹, respectively.

The difference found in the percentage value in relation to the control for the dry mass of pigeon pea is higher than the results for fresh mass, with an increase of 151% in the amount of fresh mass, whereas dwarf mucuna showed a less evident increase for the fresh mass, corresponding to 8%. Stylosanthes showed a 40% reduction in dry mass, lower than the reduction of fresh mass, which was 58% in relation to the control (Table II).

As for the percentage of dry mass found in the vegetal tissues (% DM) and the relation fresh/dry mass (FM/DM) showed in Table II, it can be seen that the dwarf pigeon pea and stylosanthes showed similar values, around 14% for the DM percentage, and a 7:1 FM/DM relation, respectively, even though both species presented an accentuated difference in the previously analyzed aspects. The dwarf mucuna showed a lower percentage of dry mass, even in relation to the control. However, this species led to the highest FM/DM relation among the

TABLE III
PHYSICO-CHEMICAL CHARACTERISTICS AQUEOUS EXTRACT OF THE AERIAL PART OF DWARF MUCUNA, PIGEON PEA AND STYLOSANTHES

Characteristic	Dwarf mucuna	Pigeon pea	Stylosanthes
Electrical conductivity (µS·cm ⁻¹)	1.980	1.884	1.937
°Brix	1	1	2
Refraction index	1.3345	1.3345	1.333
pH	4.94	6.09	5.37
Extract yield (mg·ml ⁻¹)	0.23	0.32	0.21

treatments, followed by the control. This fact indicates that the species has a smaller amount of solids in the tissues and, possibly, a faster decomposition.

Calegari (2008), studying the percentage of nutrients in the dry mass, reported that dwarf mucuna is composed of 2.85-3.35% of nitrogen in the dry mass, and pigeon pea of 1.02-2.04%. The data presented herein compensates the fact that dwarf mucuna shows a lower percentage of dry mass in relation to pigeon pea, which happens because it contains less nitrogen in its tissues.

Menezes and Leandro (2004), studying the mucuna rajada (*Stizolobium dierrigianum*) and the gray mucuna (*Stizolobium muriens*), found final productions of phyto-mass higher than 5.0Mg·ha⁻¹. These values are higher than those found in this work. It is worth mentioning that the dif-

ferences in dry mass yield among the leguminous plants, no matter where they are, may be related to the edapho-climatic conditions.

The dry mass of the control, in which the plants indigenous to the place formed the soil cover, was quantified, because it also plays the role of a soil mulch. Favero *et al.* (2001) claimed that these species can promote the same effects of soil mulching, biomass production and nutrients cycling as that of the species introduced or cultivated for green manure.

Table III shows the values corresponding to the physico-chemical characteristics of the aerial part aqueous extracts of the three leguminous plants studied. The characterization of the vegetal extracts utilized in allelopathy bioassays is important to reach a conclusion about the biological effects observed (Carmo *et al.*, 2007). Among the physico-

chemical characteristics, the evaluation of pH and osmotic potential is fundamental when one does not know the composition in sugars, amino acids, organic acids, ions and other molecules, as extreme values of both pH and osmotic potential can act on the seeds and/or the seedlings and thus mask the allelopathic effect (Ferreira and Aquila, 2000). In the present work, the osmotic potential of the extract solution was not measured, but the amount of soluble solids (°Brix) is related to the content of sugars and amino acids.

As for the pH values, it can be seen that the aqueous extract of dwarf mucuna aerial parts showed an acid pH, whereas pigeon pea showed a moderately acid pH. Lower pH values can mean lower microbial development, which warrants a higher stability of the extract.

According to Ferreira and Borguetti (2004), controlling the pH of the extracts concentration is important because substances such as sugars, amino acids and organic acids may remain in the extracts, and they interfere with the ionic concentration and are osmotically active. Both the germination and development of plants are affected in a negative way only in conditions in which the environment is either extremely alkaline (Souza Filho *et al.*, 1997).

Correia *et al.* (2005), studying the extract from leaves, stems and roots of hybrids of *Sorghum bicolor*, deduced that the pH and electrical conductivity values reported can be considered to be out of the damaging limits to germination and seedlings' development. The values found by these authors for pH 4.5-6.0 are similar to those found in the present study. Carmo *et al.* (2007), in tests about the allelopathy of *Oco-*

TABLE IV
SUMMARY OF VARIANCE ANALYSIS OF THE GERMINATION PERCENTAGE OF SEEDS SUBJECTED TO APPLICATION OF THE AERIAL PART AQUEOUS EXTRACTS OF THE LEGUMINOUS SPECIES DWARF MUCUNA, PIGEON PEA AND STYLOSANTHES AT 0; 1; 2.5; 5; 10 AND 20%

Concentrations (%)	Parameters	F	General means (%)	Coeff. of variation (%)
<i>Zea mayz</i>	Leguminous	1.43 ns	99.61	2.73
	Concentrations	0.91 ns		
	Leg. x Conc.	0.91 ns		
<i>Ipomoea purpurea</i> L.	Leguminous	0.27 ns	77	7.17
	Concentrations	0.95 ns		
	Leg. x Conc.	1.01 ns		
<i>Sida rhombifolia</i>	Leguminous	5.30 *	36.55	35.10
	Concentrations	0.70 ns		
	Leg. x Conc.	0.51 ns		
<i>Bidens pilosa</i> L.	Leguminous	0.25 ns	46.18	13.05
	Concentrations	2.13 ns		
	Leg. x Conc.	0.67 ns		

* Significant, ns: Non-significant

tea odorifera aqueous extracts, found pH values between 5.7 and 6.8 for extracts of plant components. These authors claim that the values they found are in a range that is not considered to interfere with the ability to germinate of *S. bicolor* seeds, and these values are very close to the ones found in this work. Periotto *et al.* (2004), in studies on the allelopathic effect of *Andira humilis* Mart ex Benth over lettuce and radish, also measured the solution pH; they found pH values ~5 and claimed that germination is not affected at this pH.

The highest yield of extracts was obtained from the pigeon pea, therefore corresponding to the results of electric conductivity, in which the pigeon pea showed the lowest value (Table III). That happens because the yield of the extracts can be related to a higher concentration of active ingredients in the extract, and the electrical conductivity is diminished in the presence of solutes in the solution. Dwarf mucuna and stylosanthes showed similar values for extract yield. Analyzing the electric conductivity of the extracts, it can be seen that dwarf mucuna showed the highest value, followed by the stylosanthes. The physico-chemical characteristics generally present similar values, mainly for °Brix and refractive index. This is probably due to the fact that the plant extracts of dwarf mucuna, pigeon pea and stylosanthes are similar, as these three species belong to the *Fabaceae* family.

Table IV shows the variance analysis data related to the percentage of germination of corn, *Ipomoea* sp., *S. rhombifolia* and *B. pilosa* seeds, subjected to aqueous extracts of the aerial part of dwarf mucuna, pigeon pea and stylosanthes, at concentrations of 0; 1; 2.5; 5; 10 and 20%. According to the F

TABLE V
PERCENT GERMINATION OF SEEDS OF CORN, *B. pilosa*, *Ipomoea purpurea* AND *S. rhombifolia* SUBJECTED TO EXTRACTS OF DWARF MUCUNA, PIGEON PEA AND STYLOSANTHES AT VARIOUS CONCENTRATIONS

Treatments		<i>Z. mays</i>	<i>B. pilosa</i>	<i>I. purpurea</i>	<i>S. rhombifolia</i>
		%			
Leguminous	Dwarf mucuna	100 a	46 a	78 a	28 a
	Pigeonpea	100 a	54 a	75 a	38 b
	Stylosanthes	98 a	44 a	78 a	43 b
Extract concentrations	0	100 a	51 a	76 a	29 a
	1	100 a	44 a	76 a	37 a
	2.5	100 a	48 a	82 a	33 a
	5	100 a	47 a	75 a	39 a
	10	99 a	49 a	79 a	46 a
	20	98 a	37 a	74 a	35 a

Averages followed by the same letter, in the column, do not differ from each other by the Scott-Knot test at 5% probability. The presented data were gathered from the original observations followed by the letters obtained in the mean comparison with transformation into \sqrt{x} .

values, the data of germination percentage is significant only for the leguminous factor, the *Sida rhombifolia* seeds.

Table V shows the means for germination percentage of corn, *Ipomoea* sp., *S. rhombifolia* and *B. pilosa* seeds for the leguminous and extract concentration factors. There was a statistical difference among the studied leguminous species for the *S. rhombifolia* seeds, and the dwarf mucuna extract showed the lowest invader germination percentage.

The extract concentrations utilized did not result in statistical differences among the species studied. There were no significant differences between the legume species for the corn, *B. pilosa* and *S. rhombifolia*, and neither among the concentrations of aqueous extracts of these plants on the allelopathic potential. That may be due to the low concentrations of the extracts applied in this experiment, or even to the inexistence of allelopathic effects among these species, apart from other factors. The effect was also verified in the result of natural products, the chemical compounds of which may have been rapidly degraded. However, care must be applied in interpreting the data of this experiment, as it may not match the reality of the cultivated areas.

Carvalho *et al.* (2002) studied the allelopathic potential of the jack bean (*Canavalia ensiformes*) and of the black mucuna (*Stilozobium aterrimum*) in controlling nutsedge (*Cyperus rotundus*) in a greenhouse. They concluded that the aqueous extract of the black mucuna reduced the amount of green mass and dry matter of the aerial part, of the root, and the emergence velocity index, besides establishing the number of nutsedge tubercles, characterizing a possible allelopathic effect. But the aqueous extract of jack beans stimulated growth of the nutsedge aerial part and increased the emergence velocity index, making also evident a possible allelopathic effect that is beneficial for the nutsedge. This further shows that the allelopathic effect may vary according to the studied species.

In studies carried out on the allelopathic potential and the control of weed plants by the use of perennial herbal leguminous species, the extract of the pinto peanut (*Arachis pintoi*), tropical kudzu (*Pueraria phaseoloides*), the purple bush bean (*Macropitilium atropurpureum*) and of the spontaneous vegetation (with predominance of *Panicum maximum*) over the seeds of lettuce, carrot and cucumber test plants, the purple bush bean extract stood out from the others by signifi-

cantly reducing the germination of the seeds of all of the test plants (Embrapa, 2000).

Conclusion

Leguminous plants had a higher influence on weed community, and the control showed the highest infestation values, offering an alternative for the integrated handling of the species in a no-till farming system. Moreover, in the field they showed adequate mulching of the soil. However, in the laboratory, the extract of the plants did not have effect over the corn, but only over *Sida rhombifolia* (a weed), guaranteeing the advantages in using this plant for soil cover.

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