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Scientifc Article
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Branches of *Gliricidia sepium* used as mulch for weed control in corn[1]

Cobertura do solo com ramos de *Gliricídia sepium* no controle de plantas daninhas em milho

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ABSTRACT - Mulching using crop residue reduces the growth of weeds and increases the yield of various crops. The aim of the present study was to evaluate the effects of *Gliricidia sepium* branches, used as mulch, on weed control, and on grain yield in corn. A randomized block design was used, with split plots and five replications. The cultivars, 30F35H and AG 1051, were grown in the plots, and the following treatments applied in the subplots: no weeding, two weedings, and mulching with 10, 20 or 30 t ha^{-1} (fresh weight) gliricidia branches. The mulch material was applied between the sowing furrows after sowing the corn. Increasing the amount of gliricidia branches caused a linear reduction in weed growth, and increased growth and yield in the corn. Weed growth was less with two weedings than with mulching. Corn yield when carrying out two weedings was equivalent to yields obtained using mulch. There was no difference between cultivars for weed growth nor for growth or grain yield of corn. Maximum growth and grain yield in corn are obtained with the application of 22.0 and 25.6 t ha^{-1} gliricidia branches respectively, in both cultivars.

Key words: *Zea mays*. Number of branches. Corn yield. Weed growth. Hoeings.

RESUMO - A cobertura do solo com resíduos vegetais reduz o crescimento das plantas daninhas e aumenta o rendimento de diversas culturas. O objetivo do presente trabalho foi avaliar os efeitos de doses de ramos de *Gliricidia sepium,* como cobertura do solo no controle de plantas daninhas e no rendimento de grãos do milho. Utilizou-se o delineamento de blocos casualizados com parcelas subdivididas e cinco repetições. As cultivares 30F35H e AG 1051 foram cultivadas nas parcelas e nas subparcelas foram aplicados os seguintes tratamentos: sem capinas; duas capinas; e cobertura do solo com 10, 20 ou 30 t ha^{-1} (massa fresca) de ramos da gliricídia. O material de cobertura do solo foi aplicado após a semeadura do milho entre os sulcos de semeadura. O aumento da dose de ramos de gliricídia reduziu linearmente o crescimento das plantas daninhas e aumentou o crescimento e o rendimento do milho. O crescimento das plantas daninhas foi menor com a realização de duas capinas do que com a cobertura do solo. O rendimento do milho com a realização de duas capinas foi equivalente aos rendimentos obtidos com a cobertura do solo. Não houve diferenças entre cultivares no que se refere ao crescimento das plantas daninhas, nem quanto ao crescimento e rendimento de grãos do milho. Crescimento e rendimento de grãos máximos do milho são obtidos com aplicações de 22,0 e 25,6 t ha^{-1} de ramos de gliricídia, respectivamente, em ambas cultivares.

Palavras-chave: *Zea mays.* Doses de ramos. Rendimento do milho. Crescimento de plantas daninhas. Capinas.

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INTRODUCTION

Corn (*Zea mays* L.) is probably grown in all the municipalities of the Brazilian semi-arid region. In this region, in large companies and where cultivation includes irrigation, weed control is carried out with herbicides. In small businesses, cultivation takes place under rainfed conditions, and weed management is carried out by weeding using a hoe. Weeding is strenuous, expensive and time-consuming, however there is no prospect of weeding being widely replaced by herbicides. Most farmers in the semi-arid region are poor and illiterate, and lack technical assistance. This situation can limit the use of herbicides. Furthermore, climate conditions, especially the often-reduced rainfall with poor distribution over time and space, can also limit herbicide use. As a result, there is interest in alternative methods of weed management, including the use of mulching.

Some studies have shown that a mulch of tree branches controls weeds and increases the yield of corn and other crops (MASHINGAIDZE *et al*., 2012; MULVANEY; PRICE; WOOD, 2011; RAJASHEKARAPPA; BASAVARAJAPPA; PUTTAIAH, 2013; SILVA *et al*., 2015). For example, Silva *et al*. (2015) evaluated the effects of mulching using the branches of four tree species, and found that carrying out two weedings was more effective than mulching in reducing weed growth. However, weeding and mulching gave similar green-ear and grain yields. In this study, 30 t of branches were applied per hectare.

There is great interest in applying smaller amounts of branches as mulch, because the collection and distribution of branches is strenuous. Although less strenuous than weeding, the application of fewer branches has several advantages, including the benefit of extending the application over larger areas. Moreover, there is the possibility of an interaction between the amount of branches and the cultivars.

It is also interesting that mulching using tree branches be associated with the adoption of some type of agroforestry system. There are two reasons for this interest. Firstly, it would facilitate collection and placement of the branches, and secondly, would favor the improvement of semi-arid soils, which are often exploited by itinerant agriculture. Studies of alley farming including corn have shown improvements in the soil, a reduction in weeds, and an increase in corn yield (BERTALOT *et al*., 2010; QUEIROZ *et al*., 2010). The use of gliricidia (*Gliricidia sepium* (Jacq.) Steud) in agroforestry systems in Brazil has been noted for over 30 years (BAGGIO, 1984).

The aim of the present study was to evaluate the effects of using gliricidia branches as mulch on weed control, and on grain yield in two corn cultivars.

MATERIAL AND METHODS

The experiment was carried out from May to September 2016 on the Rafael Fernandes Experimental Farm in the district of Alagoinha, located at 5°11’ S and 37°20’ W at an altitude of 18 m.

According to the Gaussen bioclimatic classification, the climate in the region is type 4ath, strongly thermoxeroquimenic, i.e. hot tropical with a long season of seven to eight months of severe drought (ALVARES *et al*., 2013). The maximum mean air temperature in the region is between 32.1 and 34.5 °C and the minimum between 21.3 and 23.7 °C, with June and July being the warmest months; the mean annual rainfall is around 825 mm. Insolation increases from March to October, with an average of 241.7 h. The maximum relative humidity reaches 78% in April, with a minimum of 60% in September. The soil in the experimental area is classified as a Red-Yellow Argisol (PVA) according to the Brazilian Soil Classification System (EMBRAPA, 2013).

Chemical analysis of the soil in the experimental area showed: pH = 6.80 (H_2O); OM = 4.60 g kg^{-1}; P = 23.1 mg dm^{-3}; K+ = 191.6 mg dm^{-3}; Na = 90.0 mg dm^{-3}; Ca^{2+} = 2.10 $cmol_c$ dm^{-3}; Mg^{2+} = 1.10 $cmol_c$ dm^{-3}; Al^{3+} = 0.00 $cmol_c$ dm^{-3}; H+Al = 0.50 $cmol_c$ dm^{-3}; SB = 4.08 $cmol_c$ dm^{-3}; CEC = 4.58; ESP = 9%.

The soil of the experimental area was harrowed twice and fertilized at planting with 40 kg of N ha^{-1} (ammonium sulfate), 80 kg P_2O_5 ha^{-1} (simple superphosphate) and 40 kg K_2O ha^{-1} (potassium chloride). The fertilizers were applied by hand to furrows located to the side of and below the sowing rows. The corn was sown by hand on June 23, 2016, using four seeds per hole at a spacing of 1.0 m x 0.4 m. The remaining nitrogen (80 kg ha^{-1} as ammonium sulfate) was applied as cover, at two different periods, in equal amounts immediately following each weeding (20 and 40 days after sowing). The plants were thinned twenty days after sowing, leaving the two largest plants in each hole. Therefore, after thinning, the experiment had a programmed planting density of 50,000 plants ha^{-1}.

The experiment was carried out employing sprinkler irrigation. Irrigation was for two hours a day at an irrigation frequency of one day. The experimental plots were arranged perpendicular to the line of sprinklers. The required daily water depth for corn (5.6 mm) was calculated considering the effective depth of the root system to be 0.40 m. The time of irrigation was based on the water retained in the soil at a potential of 0.40 Mpa. Irrigation began after planting, and was suspended 20 days before harvesting the dry corn.

An experimental design of randomized complete blocks was used, with split plots and five replications. The experimental units consisted of three rows of corn plants, 6 m in length and spaced 1.0 m apart. The working area was considered as occupying the central row, discarding the plants from the first hole at each end of the central row when harvesting. The cultivars, 30F35H and AG 1051, were grown in the plots, and the following treatments applied in the subplots: no weeding, two weedings (20 and 40 days after sowing the corn), and mulching with 10 t ha^{-1}, 20 t ha^{-1} or 30 t ha^{-1} (fresh weight) gliricidia shoots. The mulch material consisted of leaves and parts of the stem (diameter approximately 1.0 cm or less). Mulching was carried out to the side of the sowing furrows after sowing the corn in order to distribute the mulch uniformly throughout each experimental unit.

Of the three rows in the working area, one was used at random to evaluate the yield of baby corn, and the other to evaluate the green-ear yield, the results of which are presented in another article. The third working row was used to evaluate grain yield.

The mature ears were harvested 123 days after sowing, when the grain had a water content of around 15 to 20%. At the time of harvesting the mature ears, the plant height, ear insertion height, total number of ears, number of grains per ear, 100-grain weight and grain yield were evaluated.

Plant height and ear insertion height were measured on all the plants in the working row of each experimental unit. Plant height was considered the distance from ground level to the insertion point of the highest leaf blade. In the case of prolific plants, ear insertion height was measured from ground level to the base of the highest ear.

The number of grains per ear was obtained from 10 randomly chosen ears by multiplying the number of rows of grain by the number of grains in one row chosen at random in each ear. The 100-grain weight was estimated based on the weight of the grain from the ears used to evaluate the number of grains. The grain yield was corrected (wet basis) for a moisture content of 15%.

After harvesting, two plants were collected at random from different holes and cut close to the ground. After being weighed, the plants were ground in a forage maker, and a sample of approximately 300 g of the ground material was placed in a forced-circulation oven set to 75 °C, to constant weight. This allowed the shoot dry matter of the corn to be estimated. After harvesting the two corn plants, all the weeds found in an area of 0.8 m^2 were collected from the central part of each experimental unit. The collected weeds were identified and, using a similar procedure to that used on the two corn plants, the shoot dry matter of the weeds was estimated. The weeds found in each experimental unit were identified to allow the occurrence index of each species to be calculated, defined as the ratio between the number of experimental units in which the species occurred and the total number of experimental units in the experiment.

The data were subjected to analysis of variance. The mean values for the cultivars were compared by F-test and those for the methods of weed-control by Dunnett's test at 5% probability. In applying Dunnett's test, the treatment with two weedings was considered the control. The SISVAR v5.3 software (FERREIRA, 2010) was used in the statistical analysis. The data of the quantitative treatments (amounts of mulch) were also subjected to regression analysis using the Table Curve 2D software (JANDEL SCIENTIFIC, 1992).

RESULTS AND DISCUSSION

The list of weed species that were present in the experimental plots at the time the corn was harvested is shown in Table 1. Although 21 species were found, *Cenchrus echinatus* L. and *Digitaria* sp. were considered the most important as they occurred in 94 and 76% of the experimental units respectively. *C. echinatus*, an herbaceous grass, is considered one of the six most-aggressive weed species in modern agriculture (DAN *et al*., 2011). It is a highly competitive species, and can cause direct and indirect damage to crops (DAN *et al*., 2011; MACHADO *et al*., 2014). Species of *Digitaria* sp. are considered problematic in more than 60 countries, being able to infest more than 30 crops (CAMPOS *et al*., 2016). Infestations of at least some species of *Digitaria* sp. can result in losses of up to 70% in corn yield (HUGO *et al*., 2014).

The analysis of variance showed an effect, from the methods of weed control only, on the growth of weeds occurring in the experiment evaluated after harvesting the corn (Table 2). Weed growth in plots that received two weedings was less than the growth in plots with no weedings, and in plots that received a mulch of gliricidia branches (Table 3). Regression analysis showed that weed growth decreased linearly with the increasing applications of gliricidia branches (Table 3).

The results of applying mulch to reduce weed growth can be divided into direct and indirect effects, although the two types of effect cannot always be completely separated. Direct effects are those that act directly on the seeds or seedlings of the weeds. Indirect effects are those that act on the seeds or seedlings of the weeds through their influence on the attributes and properties of the soil (BEZUIDENHOUT; REINHARDT; WHITWELL, 2012; CHAUHAN; ABUGHO, 2013; PENNY; NEAL, 2003).

Mulch can act as a physical barrier that can reduce the germination and emergence of weeds (CHAUHAN; ABUGHO, 2013; TEASDALE; MOHLER, 2000).

Table 1 - Occurrence index (ratio between the number of experimental units where the species occurred and the total number of experimental units) for weed species in the experiment

Botanical name	Common name	Family	Occurrence index (%)
Adenocalymma marginatum	Cipó-vaqueiro	Bignoniaceae	42
Amaranthus viridis	Caruru	Amaranthaceae	40
Astraea lobata	Erva-de-rola	Euphorbiaceae	2
Blainvillea dichotoma	Picão	Asteraceae	4
Borreria verticillata	Vassourinha	Rubiaceae	24
Cenchrus echinatus	Capim carrapicho	Poaceae	94
Commelina benghalensis	Trapoeraba	Commelinaceae	2
Cucumis anguria	Maxixe	Cucurbitaceae	18
Dactyloctenium aegyptium	Capim-pé-galinha	Poaceae	28
Desmodium glabrum	Rapadura de cavalo	Leguminosae	2
Digitaria sp.	Capim-colchão	Gramineae	76
Eragrostis sp.	Barba-de-bode	Poaceae	2
Euphorbia asarifolia	Salsa-brava	Euphorbiaceae	18
Herissantia crispa	Malva branca	Malvaceae	12
Ipomoea bahiensis	Jitirana	Convolvulaceae	16
Jacquemontia sp.	Amarra-cachorro	Convolvulaceae	10
Neojobertia candolleana	Cipó-de-Jacu	Bignomiaceae	8
Panicum maximum	Capim Tanzânia	Poaceae	4
Physalis angulata	Camapum	Solanaceae	2
Solanum agrarium	Baba	Solanaceae	2
Turnera subulata	Flor-do-Guarujá	Turneraceae	4

Table 2 - Summary of the analysis of variance of the data for shoot dry matter in weeds, and plant height, ear-insertion height, shoot fresh matter and shoot dry matter in corn cultivars, in response to methods of weed control[1]

Source of variation	DF	Weed material (kg ha^{-1})	Height (corn)		Shoot material after harvesting the corn (kg ha^{-1})	
			Plant	Ear insertion	Fresh	Dry
		Mean square				
Blocks	4	3490 ^{ns}	194 ^{ns}	207 ^{ns}	3139137 ^{ns}	170404 ^{ns}
Cultivars (C)	1	899 ^{ns}	959 ^{ns}	3495 **	63799808 *	1167086 ^{ns}
Residual (a)	4	3664	198	60	5226047	623750
Control (P)	4	66451 **	511 *	262 *	28274613 **	2682229**
C x P	4	2899 ^{ns}	66 ^{ns}	67 ^{ns}	15121317 **	939250 ^{ns}
Residual (b)	32	2533	145	68	2941302	483899
Overall mean		182	190	103	8812	3699

[1]ns; *; **: not significant; significant at 5% and significant at 1% respectively by F-test. DF = degrees of freedom

Table 3 - Mean values for shoot dry matter in weeds occurring in plots of corn cultivars, and for plant height, ear-insertion height, shoot fresh matter and shoot dry matter in corn cultivars, in response to methods of weed control

Weed control	Weed dry matter (g m^{-2})	Height (corn) (cm)		Shoot material (corn) (kg ha^{-1})		
		Plant	Ear insertion	Fresh		Dry
	Cultivar	Cultivar	Cultivar	Cultivar		Cultivar
	Both	Both	Both	30F35H	AG 1051	Both
Double weeding	41	193	104	11602	6676	3995
Mulch of gliricidia branches (t ha^{-1})						
0	246 *	179 ^{ns}	95 ^{ns}	6294*	5651*	2788 *
10	223 *	189 ^{ns}	104 ^{ns}	8774*	9523*	3765 ^{ns}
20	210 *	194 ^{ns}	106 ^{ns}	10284	8371*	4001 ^{ns}
30	189 *	197 ^{ns}	108 ^{ns}	12754	8193*	3945 ^{ns}
Cultivar						
30F35H	178 A	195 A	95 B	-	-	3852 A
AG 1051	186 A	186 A	111 A	-	-	3546 A
CV_{plots}	33.3	7.4	7.5	25.9	21.4	
$CV_{subplots}$	27.7	6.3	8.0	19.5	18.8	

Regression Analysis: characteristics (y) per amount of mulch (x, t ha^{-1})

Characteristic	Cultivar	Equation	R^2
Shoot dry matter (weeds)	Both	$y = 244.8 – 1.8x$	0.99
Plant height (corn)	Both	$y = 178.8 + 3.3x^{0.5}$	0.99
Ear-insertion height (corn)	Both	$y = 95.4 + 2.\ 4x^{0.5}$	0.99
Shoot fresh matter (corn)	30F35H	$y = 6393 + 208.9x$	0.99
	AG 1051	$y = 10025.5 - 66.5x - 4374.6\ e^{-x}$	0.98
Shoot dry matter (corn)	Both	$y = 2810.4 + 114.5x - 2.6x^2$	0.99

[1]Mean values followed by an asterisk in a column differ from the mean value obtained with two weedings at 5% probability by Dunnett's test. [2]The parameters of each equation are significant at 5% probability by t-test

It is likely that mulching also influences these characteristics by reducing the temperature and light that reach the seeds and seedlings (PENNY; NEAL, 2003). Allelochemicals released by the mulch can also directly affect weed germination and emergence (BEZUIDENHOUT; REINHARDT; WHITWELL, 2012). Although 15 compounds with allelochemical activity were identified in gliricidia (RAMAMOORTHY; PALIWAL, 1993), coumarins were considered the main allelopathic compounds of the species (TAKEMURA *et al*., 2013). Coumarins form a group of secondary metabolic compounds, originating in the shikimic acid pathway, and widely distributed in the families Apiaceae, Rutaceae, Asteraceae and Fabaceae, having a phytotoxic, fungitoxic, insecticide, nematicide and antibacterial effect (RAZAVI, 2011).

Mulching influences the temperature and moisture content of the soil (FARZI *et al*., 2017; ZEGADA-LIZARAZU; BERLINER, 2011). The chemical characteristics and soil biota are also affected (TU *et al*., 2006) when the mulch starts to decompose (HALDE; ENTZ, 2016). It is also likely that, with decomposition of the mulch, the allelopathic effects continue to occur in the soil (SODAEIZADEH; RAFIOLHOSSAINI; DAMME, 2010).

The direct and indirect effects depend on the species of weed and on various other environmental factors (TEASDALE; MOHLER, 2000). For the weeds, this means that some species may benefit, and others be damaged by mulching. This difference in effect suggests that some weed species will not be completely eliminated, and that other species will be eliminated slowly. This explains the difference between the effects of weeding (which quickly and completely eliminates most weeds) and the effects of mulching.

There was an effect on plant height from the methods of weed control only (Table 2). Plant height increased with the increasing amount of gliricidia branches applied to the soil, but there was no difference between carrying out two weedings and applying the mulch (Table 3). A similar fact occurred with ear-insertion height (Tables 2 and 3); however, for this characteristic, there was also an effect from the cultivars, where the AG 1051 cultivar was superior to 30F35H (Table 3).

There was an effect from the cultivars (C), methods of weed control (P) and the C x P interaction on shoot fresh matter in the corn (Table 2). For the 30F35H cultivar, the increase in the amount of gliricidia branches resulted in growth similar to that achieved when carrying out two weedings. This also occurred with the AG 1051 cultivar, but in this case, the increase in growth with the greater amount of gliricidia branches differed from the growth achieved when carrying out two weedings (Table 3). This difference in behavior may be associated with the higher water content of the 30F35H cultivar (with a longer cycle), since, in terms of shoot dry matter, only the methods of weed control had an effect (Table 2); in this case, the lack of mulching resulted in smaller growth than achieved with the two weedings, however increases in the amount of gliricidia branches applied to the soil resulted in growth similar to that obtained with the weedings (Table 3).

An effect was seen from the cultivars (C), methods of weed control (P) and C x P interaction on the number of ears (Table 4). In the 30F35H cultivar, the lack of weedings gave a similar result to that obtained when carrying out two weedings (Table 5). Also, in this cultivar, mulching resulted in a greater number of ears than obtained with the two weedings. In fact, for the 30F35H cultivar there was an increase in the number of ears with the increasing amount of gliricidia branches (Table 5). In the AG 1051 cultivar, the lack of weedings and the application of mulch were inferior to the two weedings, with the exception of the 10 t ha^{-1} application of gliricidia branches. There was no effect on this cultivar from the amount of gliricidia branches (Table 5).

On the number of grains per ear, the only effect was from the methods of weed control (Table 4), where, with respect to this characteristic, only the treatments with no weedings were inferior to those with two weedings (Table 5). The 30F35H cultivar was superior to AG 1051 for the number of grains per ear. There was no effect from the two treatment groups under study on the 100-grain weight (Tables 4 and 5).

For grain yield, the only effect was from the methods of weed control (Table 4). The lack of weedings gave a lower yield than obtained with the two weedings only (Table 5), i.e. there was no difference between carrying out the two weedings and applying the mulch. Also, there was no difference between cultivars for grain yield; the yield increased with the increasing amount of gliricidia branches applied to the soil (Table 5).

Applying the mulch caused a linear reduction in weed growth (Table 3). However, weed growth when carrying out two weedings was less than seen with mulching (Table 3). On the other hand, grain yield was the same whether weeding or mulching (Table 5). Similar results to those reported in the present study were obtained by other authors (SILVA *et al*., 2015). It is likely that the increase in grain yield obtained by mulching, seen in the present study, do not result only from weed control. Several authors have found that mulching can result in improvements in the physical, chemical and biological properties of the soil (AWOPEGBA; OLADELE; AWODUN, 2017; RICO HERNÁNDEZ; NAVARRO

Table 4 - Summary of the analysis of variance for production-component and grain-yield data in corn cultivars, in response to methods of weed control [1]

Source of variation	DF	Number of ears ha^{-1}	Number of grains ear^{-1}	100-grain weight	Grain yield (kg ha^{-1})
		Mean square			
Blocks	4	30152466 ^{ns}	2741 ^{ns}	16.6 ^{ns}	3280837 ^{ns}
Cultivars (C)	1	175125613 *	72124 *	1.1 ^{ns}	31531329 ^{ns}
Residual (a)	4	11271128	3760	5.1	4590725
Control (P)	4	34634586 *	17805 **	1.1 ^{ns}	8191679 **
C x P	4	40495207 **	910 ^{ns}	2.2 ^{ns}	727246 ^{ns}
Residual (b)	32	9214221	1709	6.0	1295877
Overall mean		46619	524	33.4	7670

[1]ns; *; **: not significant; significant at 5% and significant at 1% respectively by F-test. DF = degrees of freedom

Table 5 - Mean values for production-component and grain-yield data in two corn cultivars, in response to methods of weed control[1]

Weed control	Total number of dry ears		Number of grains per ear	100-grain weight (g)	Grain yield (kg ha^{-1})
	Cultivar		Cultivar		
	30F35H	AG 1051	Both		
Double weeding	46107	48446	550	33.57	8586
Mulch of gliricidia branches (t ha^{-1})					
0	45513	41523 *	460 *	33.61 ^{ns}	6283 *
10	50000 *	46154	514 ^{ns}	32.90 ^{ns}	7285 ^{ns}
20	50000 *	41846 *	525 ^{ns}	33.72 ^{ns}	8105 ^{ns}
30	50833 *	45769 *	572 ^{ns}	33.27 ^{ns}	8092 ^{ns}
Cultivar[2]					
30F35H	-	-	562 a	33.26 a	8464 a
AG 1051	-	-	486 b	33.56 a	6876 a
CV_{plots}	7.2	11.7	6,7	27.9	
$CV_{subplots}$	6.5	7.9	7,3	14.8	

Regression Analysis: characteristics (y) per amount of mulch (x, t ha^{-1})[3]

Characteristic	Cultivar	Equation	R^2
Total number of mature ears	30F35H	$y = 50277.7 – 4764.8\ e^{-x}$	0.97
	AG 1051	$y = 43823$	-
Number of grains per ear	Both	$y = 215454.1 + 3592.5x$	0.95
100-grain weight	Both	$y = 33.63$	-
Grain yield	Both	$y = 6262.6 + 113x – 0.1x$	0.99

[1]Mean values followed by an asterisk in the columns differ from the mean value obtained with two weedings at 5% probability by Dunnett's test. [2]Mean values followed by the same letter do not differ at 5% probability by F-test. [3]The parameters of each equation are significant at 5% probability by t-test

PEDREÑO; GÓMEZ LUCAS, 2016; KUMAR *et al*., 2014; MOURA *et al*., 2017; YORDANOVA, 2017; TU; TOAN, 2017). As an example, it was found that mulching decreased soil resistance to root penetration, which increased nitrogen uptake (MOURA *et al*., 2017). In addition, mulching reduced temperature variation and water loss in the soil (RICO HERNÁNDEZ; NAVARRO PEDREÑO; GÓMEZ LUCAS, 2016; YORDANOVA, 2017). Mulching increased the levels of organic carbon, nitrogen, phosphorus, potassium and exchangeable cations in the soil (AWOPEGBA; OLADELE; AWODUN, 2017; KUMAR *et al*., 2014). Tu and Toan (2017) found mulching caused an increase in the number of soil bacteria, actinomycetes and fungi. These improvements, not evaluated in the experiment on which this study was based, may have occurred, and would help to explain, together with weed control, the greater growth (Table 3) and yield of the corn (Table 5).

It is important to remember that carrying out the two weedings resulted in weed residue. This residue may have contributed to an increase in corn yield by improving the physical, chemical and biological properties of the soil, similar to that described for the mulch (MAJUMDER; SHUKLA; ARUNACHALAM, 2008). It should also not be forgotten that the residue, whether from the mulch or the weeds, may have an allelopathic effect, beneficial or harmful, on the corn.

Increasing the amount of gliricidia branches caused a decrease in the shoot dry matter weight of the weeds, as per the equation shown in Table 3. The minimum value (189.4 g m^{-2}) was achieved with the application of 30 t ha^{-1} gliricidia branches. For the other characteristics under evaluation (Tables 3 to 5), a rise in the amount of gliricidia branches led to increases (Table 6). For most of these characteristics, the maximum value was obtained with the application of 30 t ha^{-1} gliricidia branches, showing that greater amounts would allow further increases in these characteristics. However, for shoot dry matter and grain yield in the corn, the maximum values were obtained with 22.0 and 25.6 t ha^{-1} gliricidia branches respectively, indicating that greater amounts would reduce growth and yield in the corn (Table 6).

Table 6 - Values for the independent variables (x) and respective values for the dependent variables (y), according to the fitted equations

Amount of gliricidia branches (t ha^{-1}, x)	Cultivar	Corn characteristic	Maximum (y)
30.0	Both	Plant height	197
30.0	Both	Ear insertion height	109
30.0	30F35H	Shoot fresh weight	12660
4.2	AG 1051		9861
22.0	Both	Shoot dry weight	4080
30.0	30F35H	Total number of mature ears	50278
	AG 1051		-
30.0	Both	Number of grains per ear	569
-	Both	100-grain weight	-
25.6	Both	Grain yield	8193

CONCLUSIONS

1. Increasing the amount of gliricidia branches linearly reduced weed growth and increased growth and yield in the corn. Maximum growth and grain yield in the corn are obtained with applications of 22.0 and 25.6 t ha^{-1} gliricidia branches respectively in both cultivars. Weed growth was less with two weedings than with mulching. Corn yield with two weedings was equal to the yield obtained with mulching;
2. There was no difference between cultivars for weed growth or for grain growth and yield.

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