

Management of Soil Mulch in Weed Suppression and Sugarcane Productivity

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Abstract

The soil mulch is an agricultural practice that can benefit soil fertility and can be effective in suppressing weeds. The objective this research was to evaluate the mulching from legumes in weed control and sugarcane (first harvest/cut) productivity, comparing the results with the conventional application of herbicides. This research was carried out under field conditions. Five legumes were managed in two ways to form the soil cover: (1) mechanical topple, and (2) chemically desiccated. To compare the results, used treatments with herbicides applied in pre and pre + post emergence. The soil mulch from mechanical topple of *Crotalaria spectabilis*, *C. juncea*, *C. ochroleuca*, *C. breviflora* and *Cajanus cajan* presented lower efficiency in suppressing weeds than the treatment with herbicides applied in pre + post-emergence, however, were more efficient in controlling weeds in relation to the use of herbicides in pre-emergence, a fact observed at 60 days of sugarcane cultivation.

Keywords: *Crotalaria* spp., *Cajanus cajan*, Sugarcane (first harvest/cut), soil mulch

1. Introduction

In Brazil, the sugarcane as one of the crops which more agrochemicals are used, especially herbicide. Among the main damages caused by agrochemicals, we can mention destruction of soil microbiota balance (Mueller & Senseman, 2015), contamination of the water table, surface or underground; air contamination; death of insects and natural enemies and numerous diseases, including kidney diseases and cancers, are correlated with increased herbicide use in crops (Samsel & Seneff, 2013).

One alternative to control weed's in sugarcane that can reduce the use of herbicides is the formation of mulching over the soil. Plants of the Leguminosae family with high productivity of biomass can be cultivated and managed to form the cover. This practice interferes in infestation and establishment of weeds by physical, chemical and biological means (Teixeira et al., 2014). In the State of Alagoas, Northeastern Region of Brazil, the most used legumes in the renewal area of sugarcane, are of the genus *Crotalaria* and the species *Cajanus cajan* (popular name: bean-guandu-dwarf) (Silva et al., 2016). Among the benefits provided by this practice are increment in macro and micronutrients (Oliveira et al., 2017); increase in organic matter (Garcia-Franco et al., 2015); increase in nitrogen availability (Santos et al., 2017) and nutrient recycle (Sharifi et al., 2014). In addition to these benefits to soil fertility, the soil mulch from legumes can suppress weeds (Gomes et al., 2014; Mhlanga et al., 2015).

When legumes topple on the soil surface, without incorporation, they negatively interfere in the germination of positive photoblastic seeds, those that require light for germination (Yamauti et al., 2011). *Tridax procumbens* seeds, for example, are photoblastic positive; don't germinate without the presence of light and therefore the infestation of this weed is intensely reduced in the crops with soil cover (Guimarães et al., 2002).

Another effect of soil cover is the physical barrier that hinders the survival of seedlings of weeds with small quantities of reserves in the diaspores (seed dispersal structures). Often the reserves are not sufficient to ensure

the survival of the seedlings in the process of their emergence through the mulching of the soil, since the germination until it has access to the light to initiate the photosynthesis, then these weeds suppress (Monquero et al., 2009).

In view of all the aforementioned aspects and the possibility of using mulch as a component inside the integrated weed management, serving as an alternative method in detriment to the use of herbicides, the objective of this research was to evaluate the efficiency of the soil mulch as of five legumes in weed control and sugarcane (first harvest/cut) productivity, comparing the results with herbicide efficiency.

2. Materials and Methods

This research was conducted under field conditions at Farm Santa Luzia, lot 31, Cansanção de Sinimbu Sugarcane Industry, Jequiá da Praia, AL (Figure 1). During the experiment, the accumulated rainfall was 1416 mm and the average temperature was 25.7 °C. The soil of the experimental area is a Distrocoesal Yellow Argisol (Embrapa, 2013). It's an area of renewal of sugarcane plantation, which for more than 20 years has been cultivated with sugarcane.

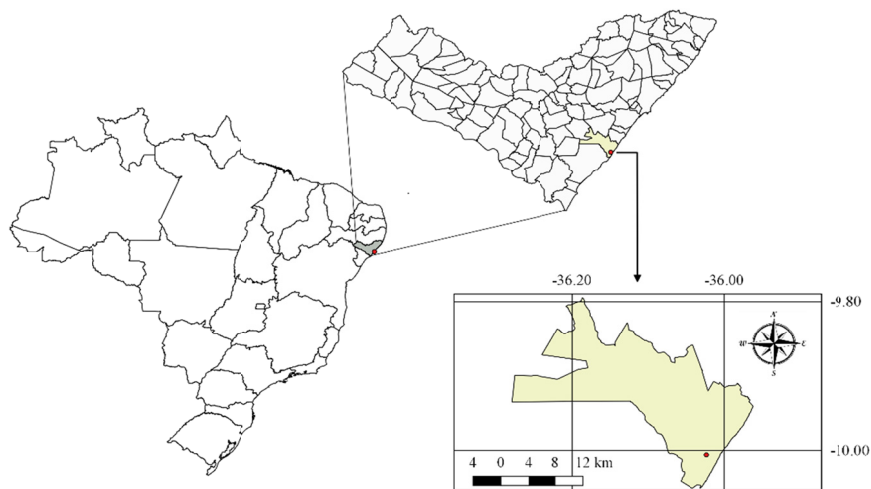


Figure 1. Location of the experimental area

The experiment was a $2 \times 6 + 2$ factorial design. The two factors were the soil mulch and the management of this mulch, besides two additional treatments. Were six kind of mulches: *C. spectabilis*, *C. juncea*, *C. ochroleuca*, *C. breviflora*, *Cajanus cajan* and without soil mulch from legumes. On the other hand, the two treatments were without herbicides and with herbicides.

For evaluate the suppression of weeds, five legumes seeded on September 1, 2011 and cultivated until December 20, 2011, period that the biomass was determined for the formation of mulch. The other plots remained covered with spontaneous vegetation. The management of this soil mulch done in two ways: (1) topple over the ground with the support of a tractor that tractioned a metal bar breaking the stem of the plants, or (2) the same species desiccated with herbicides. Therefore, the soil mulch formed by two managements: mechanical topple (mechanical management) or desiccation with herbicides (chemical management).

The chemical management of legumes performed as follows: for chemical desiccation, herbicides with post-emergence and pre-emergence used in the mix (200 g paraquat + 960 g metribuzin + 1066 g diurom + 134 g hexazinone per hectare). For the additional treatment 1 only a post-emergence herbicide (200 g of paraquat per hectare) used to desiccate *C. spectabilis*. For the additional treatment 2, pre-emergence herbicides applied directly on the soil without mulch after planting the sugarcane (960 g of metribuzin + 1066 g of diurom + 134 g of hexazinone per hectare) (Table 1). After 10 days of application of the herbicides, the planting grooves opened in the experimental area and the sugarcane planting, variety RB 92579, spaced in 1.0 m between lines.

Table 1. List of treatments and respective descriptions

Treatments (N°)—Soil Mulch (SM) and Management (M)	Description	
	Dry mass (t ha ⁻¹)	Herbicide (dose) (g ha ⁻¹)
<i>Mechanical Management—Mechanical Topple</i>		
<i>C. spectabilis</i> (1)	6.0	-
<i>C. juncea</i> (3)	6.5	-
<i>C. ochroleuca</i> (5)	6.5	-
<i>C. brevisflora</i> (7)	1.0	-
<i>Cajanus cajan</i> (9)	6.5	-
Without Soil Mulch (11)	-	-
<i>Chemical Management—Desiccation with Herbicide (Mix PRE and POST)</i>		
<i>C. spectabilis</i> (2)	6.0	
<i>C. juncea</i> (4)	6.5	
<i>C. ochroleuca</i> (6)	6.5	Paraquat (200) + Metribuzin (960) + Diurom (1066)
<i>C. brevisflora</i> (8)	1.0	+ Hexazinone (134)
<i>Cajanus cajan</i> (10)	6.5	
Without Soil Mulch (12)	-	
<i>Two additional Treatments</i>		
1 = <i>C. spectabilis</i> + post-emergence (13)	6.5	Paraquat (200)
2 = Without Soil Mulch + pre-emergence (14)	-	Metribuzin (960) + Diurom (1066) + Hexazinone (134)

During two seasons: at 30 and 60 days after planting (DAP), evaluated the effects of mulching on weed suppression between the lines of sugarcane plantation. Evaluated also two variables in the weeds: phytomass and plant density, using a methodology adapted from the square inventory (Braun-Blanquet, 1950), which based on the use of a square of 1.0 × 1.0 m, randomly placed inside the crops, however in this experiment a rectangle 0.5 × 1.0 m used, randomly placed in each experimental plot. At 12 months of cultivation, the sugarcane harvested and the data of agricultural productivity (TCH) and industrial yield (TPH) obtained.

The statistical design used was a randomized block design with four blocks and experimental plots of 6 m × 8 m. The collected data submitted to analysis of variance and the means tested by the Scott-Knott grouping test up to 5% probability. The calculations performed using Assistat version 7.7 beta (Silva and Azevedo, 2016).

Contrasts (C) also performed between some treatments, obtained by the t test in the Scheffé method: C1 (1 vs 13) corresponding to the contrast between *C. spectabilis* with mechanical toppe and *C. spectabilis* desiccated with post-emergence herbicides; C2 (1 + 3 + 5 + 7 + 9 vs 11) corresponding to the contrast between the five legumes submitted to the mechanical toppe and the treatment without cover and without herbicides; C3 (2 + 4 + 6 + 8 + 10 vs 12) corresponding to the contrast between chemically desiccated legumes and treatment with just herbicides and without soil cover; C4 (1 + 3 + 5 + 7 + 9 vs 14) corresponding to the contrast between the five legumes submitted to the mechanical toppe and the additional treatment of pre-emergence herbicides and C5 (1 vs 14) corresponding to the contrast between *C. spectabilis* and the additional treatment of herbicide application in pre-emergence.

3. Results and Discussion

There was a significant effect of the interaction between soil mulch and management, for dry mass production and weed density at 30 and 60 DAP (Tables 2 and 3). At 30 DAP the suppression efficiency of *C. spectabilis* mulch, has passed from 27% with toppe to 33% with post + pre herbicides, but there was no difference. Contrast C1 indicates that there was also no difference in relation to the additional treatment 1, only with post emergence herbicide. Observed from the above exposed that the common residual effect in pre-emergent herbicides may not be observed at 30 days in weed suppression in sugarcane (Table 2).

Table 2. Influence of management soil mulch on the production of dry mass and weed density in the area, 30 days after planting sugarcane, Sugarcane Industry Sinimbu, AL

Soil Mulch (N°)	Weeds 30 days after planting sugarcane					
	Dry Mass (g m ⁻²) [%]			Density of plants (plants m ⁻²)		
	Mechanical Manangement	Chemical Manangement	Average	Mechanical Manangement	Chemical Manangement	Average
<i>C. spectabilis</i> (1 and 2)	22 [27] bA	20 [33] aA	21	32 bA	14 bA	23
<i>C. juncea</i> (3 and 4)	18 [40] bA	15 [50]aA	17	211 aA	11 bB	111
<i>C. ochroleuca</i> (5 and 6)	20 [33] bA	11 [63]aB	16	58 bA	6 bB	32
<i>C. breviflora</i> (7 and 8)	26 [13] aA	11 [63]aB	19	46 bA	12 bB	29
<i>Cajanus cajan</i> (9 and 10)	32 [0]aA	15 [50]aB	24	46 bA	32 bA	39
Without Soil Mulch (11 and 12)	30 [0] aA	10 [67] aB	20	53 bA	71 aA	62
Average	25	14		74	24	
<i>Additional treatments</i>						
<i>C. spectabilis</i> + POST (13)	28 [7]			147		
Without Soil Mulch + PRE (14)	20 [33]			146		
Contrasts (C)	Dry Mass			Density of plants		
C1 (1 vs 13)	-1.67			-7.75**		
C2 (1+3+5+7+9 vs 11)	-2.18*			2.22*		
C3 (2+4+6+8+10 vs 12)	1.50			-4.83**		
C4 (1+3+5+7+9 vs 14)	1.43			-5.84**		
C5 (1 vs 14)	0.66			-7.65**		
General Average	20.09			63.25		
CV %	26.41			33.34		

Note. Average followed by equal letters, lowercase in the column and uppercase in the line, don't differ by Scott-Knott test up to 5% probability. ** Significant up to 1% probability; * significant up to 5% probability; ns not significant up to 5% probability; (C) contrasts obtained by the t test, [] the brackets bring the percentage efficiency of weed control in relation to the treatment without cover and with mechanical management.

High infestation of one or some weed species is an undesirable condition in which losses occur only for the interest crop. However, the correct management doesn't search the total eradication of weeds, only search to diminish the denser populations (Varella & Rocha, 1999). In the additional treatment 2, pre-emergence herbicides, the weed density was significantly higher (146 plants m⁻²) in relation to the treatment without mulch and without herbicides at 30 DAP. However, the opposite occurred with the dry mass of weeds (Table 2). This shows that plant density shouldn't be analyzed apart from the dry mass of weeds; this could lead to wrong conclusions about the suppressive effect of soil mulch (Oliveira & Freitas, 2008).

Table 3. Influence of management soil mulch on the production of dry mass and weed density in the area, 60 days after planting sugarcane, Sugarcane Industry Sinimbu, AL

Soil Mulch (N°)	Weeds 30 days after planting sugarcane					
	Dry Mass (g m ⁻²) [%]			Density of plants (plants m ⁻²)		
	Mechanical Manangement	Chemical Manangement	Average	Mechanical Manangement	Chemical Manangement	Average
<i>C. spectabilis</i> (1 and 2)	19 [93] cA	17 [93] bA	18	6 cB	29 dA	18
<i>C. juncea</i> (3 and 4)	14 [95] cA	22 [92] bA	18	4 cB	112 aA	58
<i>C. ochroleuca</i> (5 and 6)	20 [92] cA	17 [93] bA	19	19 bB	39 cA	29
<i>C. breviflora</i> (7 and 8)	120 [54] bB	216 [17] aA	168	30 bB	45 cA	38
<i>Cajanus cajan</i> (9 and 10)	13 [95] cA	27 [90] bA	20	12 cB	27 dA	19
Without Soil Mulch (11 and 12)	260 [0] aA	18 [93] bB	139	144 aA	76 bB	110
Average	74	53		36	55	
<i>Additional treatments</i>						
<i>C. spectabilis</i> + POST (13)	16 [94]			100		
Without Soil Mulch + PRE (14)	205 [21]			121		
Contrasts (C)	Dry Mass			Density of plants		
C1 (1 vs 13)	0.14			-13.61**		
C2 (1+3+5+7+9 vs 11)	-16.14**			-24.12**		
C3 (2+4+6+8+10 vs 12)	3.01**			-4.79**		
C4 (1+3+5+7+9 vs 14)	-12.15**			-19.84		
C5 (1 vs 14)	-10.44**			-16.57**		
General Average	70.48			54.70		
CV %	35.73			17.95		

Note. Average followed by equal letters, lowercase in the column and uppercase in the line, don't differ by Scott-Knott test up to 5% probability. ** Significant up to 1% probability; * significant up to 5% probability; ns not significant up to 5% probability; (C) contrasts obtained by the t test, [] the brackets bring the percentage efficiency of weed control in relation to the treatment without cover and with mechanical management.

At 60 DAP of sugarcane cultivation, the soil mulch from *C. juncea* with mechanical topper overcame by almost 15 times the capacity to control weeds in relation to herbicides in pre-emergence (Table 3). The main effects of soil mulch on weed suppression are cited in Oliveira Neto et al. (2011): the physical barrier causes mechanical resistance to the emergence of weeds, prevents the light that interferes in the germination of positive photoblasts weed seeds, and this management of mulch requires a minimum soil cultivation that contributes to the maintenance the weed seeds dormancy on the soil.

The main weeds occurring in the area belonged to the family Poaceae: *Eragrostis ciliares*, *Eleusine indica* and *Dactyloctenium aegyptium*. However, other species also stood out: *Emilia coccinea* (Asteraceae) and *Mollugo verticillata* (Molluginaceae).

The weed density at 60 DAP was significantly higher in treatments that received herbicides compared to soil mulch with mechanical topper (Table 3). Although herbicides provide intense control of weeds, other species of the soil seed bank may be establishing in the crop area (Timossi et al., 2011). There was an interaction effect of the factors studied for culms production per hectare (TCH) and industrial yield (TPH) of sugarcane (Table 4).

Table 4. Influence of soil mulch on Agricultural Productivity [tons of culm per hectare (TCH)] and Industrial Yield [tons of sugar per hectare (TPH)] of sugarcane, at 12 months of cultivation, Sugarcane Industry Sinimbu, AL

Soil Mulch (N ^o)	Agricultural Productivity and Industrial Yield of Sugarcane					
	TCH (t ha ⁻¹)			TPH (t ha ⁻¹)		
	Mechanical Manangement	Chemical Manangement	Average	Mechanical Manangement	Chemical Manangement	Average
<i>C. spectabilis</i> (1 and 2)	116 aB	153 aA	134	18 aB	24 aA	21
<i>C. juncea</i> (3 and 4)	92 bB	136 aA	114	14 bB	21 bA	18
<i>C. ochroleuca</i> (5 and 6)	101 aA	115 bA	108	15 bB	18 cA	16
<i>C. breviflora</i> (7 and 8)	89 bB	114 bA	101	13 bB	17 cA	15
<i>Cajanus cajan</i> (9 and 10)	107 aA	111 bA	109	17 aA	17 cA	17
Without Soil Mulch (11 and 12)	84 bB	135 aA	109	13 bB	20 bA	17
Average	98	128		15	20	
<i>Additional treatments</i>						
<i>C. spectabilis</i> + POS (13)	116			18		
Without Soil Mulch + PRE (14)	97			15		
Contrasts	TCH			TPH		
C1 (1 vs 13)	0.09			0.39		
C2 (1+3+5+7+9 vs 11)	2.57*			2.69*		
C3 (2+4+6+8+10 vs 12)	-1.37			-0.98		
C4 (1+3+5+7+9 vs 14)	0.60			0.74		
C5 (1 vs 14)	2.29*			2.51*		
General Average	112.06			17.22		
CV %	10.75			11.28		

Note. Average followed by equal letters, lowercase in the column and uppercase in the line, don't differ by Scott-Knott test up to 5% probability. ** Significant up to 1% probability; * significant up to 5% probability; ns not significant up to 5% probability; (C) contrasts obtained by the t-test.

The agricultural productivity (TCH) was significantly higher for treatments with soil mulch from *C. spectabilis*, *C. ochroleuca* and *Cajanus cajan* with mechanical tople, in relation to the uncovered area, in the option of mechanical management. This productivity increase isn't only related to the efficiency of suppressing weeds of the soil mulch, since the coverage of *C. juncea* with tople had the same suppression efficiency at 60 DAP as the mulch's cited (Table 3). However, it hasn't now presented the same agricultural productivity. Another research verified that the root system of the legumes: *C. spectabilis*, *C. ochroleuca* and *Cajanus cajan*, are very extensive and deep, in the formation of the soil mulch the decomposed roots of the legumes serve as biopores in the soil, that allow greater infiltration and availability of water for sugarcane cultivated in the same area, which would justify the increase of agricultural productivity (Cerqueira, 2011) (Table 4).

The use of herbicides in the formation of mulch seemed to contribute to a faster mineralization in the stage of decomposition of mulch in *Crotalaria spectabilis*, for example, this would justify the increase of productivity with the use of herbicides (Tables 3 and 4), because the suppression of weeds presented the same efficiency for the two treatments. Boer et al. (2008) also observed that when the soil cover was managed with chemical desiccation, an increase in the decomposition velocity of the vegetal remains occurred, causing a greater availability of nutrients to the soil, which would favor the production of the sugarcane under the herbicide management.

The absence of weed control until the 60 days of sugarcane cultivation, in the treatment without soil mulch and without herbicides, reduced the sugar production per hectare by 35%, in relation to the control with herbicides (pre and post), also reduced by 45% compared to treatment of soil mulch from *C. spectabilis* with herbicides. The treatments without soil mulch and without herbicides presented agricultural losses and losses of industrial yield around 35% (Table 4).

4. Conclusion

The soil mulch from *C. spectabilis*, *C. juncea*, *C. ochroleuca*, *C. breviflora* and *Cajanus cajan* was less efficient in suppressing weeds than the treatment with herbicides applied in pre-emergence + post-emergence.

On the other hand, they were more efficient in the control of weeds in relation to the use of herbicides in pre-emergence, fact observed at 60 days of sugarcane cultivation.

Soil mulch from *C. spectabilis* showed the same weed control efficiency and the same effect on sugarcane (first harvest/cut) productivity, both with mechanical management and with additional management with post-emergence herbicides.

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