

# Survey of the floristic composition and the structure of spontaneous vegetation present at green corn cultivated in organic no-tillage system

Aline Marchiori Crespo<sup>1\*</sup>, Maurício Novaes Souza<sup>2</sup>, Luiz Fernando Favarato<sup>3</sup>, Rogério Carvalho Guarçoni<sup>4</sup>, João Batista Silva Araújo<sup>5</sup>, Otacílio José Passos Rangel<sup>6</sup>, Jacimar Luis de Souza<sup>7</sup>

<sup>1,2,6</sup> Prédio da Pós-Graduação, Instituto Federal do Espírito Santo (IFES), Alegre, ES, Brazil

<sup>3,4,5,7</sup> CPDI, Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural (Incaper), Domingos Martins, ES, Brazil

\*Corresponding author

Received: 25 Sept 2020; Received in revised form: 10 Nov 2020; Accepted: 14 Nov 2020; Available online: 19 Nov 2020

©2020 The Author(s). Published by AI Publications. This is an open access article under the CC BY license

(<https://creativecommons.org/licenses/by/4.0/>).

**Abstract**— *The control of spontaneous plants is one of the biggest challenges faced by organic no-tillage system (NTS). Thus, the use of cultural practices that help on it becomes relevant. The objective of this research was to evaluate the population density, the level of infestation and fresh and dry weight of spontaneous plants community of the green corn cultivated in organic NTS. The trial was conducted in a randomized block design, with six replications and five treatments, consisting of three soil coverings in the organic NTS and organic and conventional systems using intensive soil tillage without covering. For soil covered treatments was used millet as grass specie and sunn hemp as leguminous specie as well as the intercropping between both species. The green corn (AG 1051 hybrid) was sowed at 1.0 m. between rows and 0.20 m. between plants. Infestation, density and fresh weight and dry weight evaluations of spontaneous plants were performed on the V5 (five developed leaves) stage of corn. The use of single millet straw and intercropped straw provided a reduction of the infestation percentage and absolute spontaneous plants density. Both organic and conventional intensive soil tillage systems without covering showed higher relative density for the specie Galinsoga quadriradiata. The highest relative densities in organic NTS were attributed to Amaranthus spp., C. rotundus and Oxalis spp.. The percentage of infestation by spontaneous plants did not reach the level of economic damage in any of the treatments studied since the average productivity of ears without straw had been within the Brazilian average (9,000 to 15,000 Kg ha<sup>-1</sup>).*

**Keywords**— *Crotalaria juncea, Pennisetum americanum, organic farming, weed management.*

## I. INTRODUCTION

“Weed plant” is the most widely term used in studies related to agriculture referring to plants that grow where they are not welcome causing some type of damage. [1, 2] However, these plants do not always bring damage depending on the phase of the crop cycle they germinate, [3] also fulfilling other functions such as contributing to

the biodiversity and dynamics of beneficial insects, [4] serving as plants that indicate the chemical and physical situation of the soil, [5,6] and as soil protective plants, mobilizers or nutrient cyclers. [7] Thus, the term “spontaneous plant” was chosen to be written on this research referring plants that germinate and grow

spontaneously in agricultural environments, but not always being harmful to cultivated plants.

In contrast to the conventional system, the management of spontaneous plants in organic cultivation must be carried out considering those benefits they bring to the agroecosystem. Therefore, rows of spontaneous plants should be kept outside the cultivation area and in the divisions of the cultivation plots. Properly in the organic area cultivation the Normative Instruction – N.I. n. 007 of MAPA, of May 17, 1999 [8] advises that the management should be carried out through diversify techniques such as: a) mechanical means of control; b) biological control; c) inert coverage which does not cause contamination and pollution - at the certifier discretion; d) solarization; e) seeds and seedlings free from invasive plants, use of fresh or dry vegetation cover on the soil; f) crop rotation and g) allelopathy. [7] However spontaneous plants should not be eliminated indiscriminately but rather the level of economic damage caused by the infestation should be defined and the factors that affect a harmful coexistence between spontaneous plants and crops of interest should be understood. [9]

In regards to the management of spontaneous plants, the use of mulch in NTS has been considered as an excellent alternative since if it is well formed and evenly distributed over the soil surface acts physically and mechanically over the bank of seeds of spontaneous plants decreasing its germination rate. [10, 11, 12, 13, 14]

This physical and mechanical control occur by reducing the incidence of light and variation in soil temperature and by inhibiting the germinative process of seeds that have a small amount of reserves in their diaspores. [12, 15, 16] The presence of straw also favors the biological and chemical control of the spontaneous community: a) the first occurs through the population of microorganisms increasing which can destroy the seeds of spontaneous plants [17] and b) the second through the release of allelopathic compounds that can inhibit the growth of the community. [18, 19, 20]

However, the NTS uses in organic agriculture is one of the great challenges for research today because as opposed to the management applied to conventional NTS there are no desiccant herbicides neither post-emergent herbicides recommended for organic agriculture. [9, 21] Therefore is crucial for the management of spontaneous plants in organic agriculture grow plants in the off-season of crops in the form of green manure with grasses and legumes that produce a large amount of straw as well as show allelopathic potential. [15, 22, 23]

Several trials have been performed from North to South of Brazil about the effect of the use of different cover plants in spontaneous plants management in varied commercial cultures. [24, 25, 26, 27, 28, 29, 30]

Working on techniques of agroecological agriculture Gama (2019) [30] evaluated the effect of soil cover plants on the suppression of spontaneous plants and productivity on the sustainable guarana agroecosystem in the state of Amazonas. *Brachiaria ruziziensis*, *Canavalia ensiformis* and *Mucuna deeringiana* were tested. *B. ruziziensis* suppressed 100% of the infesting plants at that area showing excellent soil coverage and high production of phytomass.

Parizotto *et al.* (2018) [27] also using agroecological techniques of cultivation at Santa Catarina State, evaluated the effect of black oats, rye, vetch, and black oats + rye + vetch on spontaneous plant control and the yield on canned cucumbers field. About the spontaneous plants the conclusion was the pre-planting of black oat and rye coverings had the best suppressive effect. In turn, Ferreira (2016) [24] aiming to study the agronomic performance of organic green corn and the population dynamics of spontaneous plants at that area after the green manures cultivation at the Rio de Janeiro state, evaluated the previous cultivation of sunn hemp, black beans pig, black mucuna, sunflower and sorghum, concluding that the cover with sorghum proved to be the most efficient on plant biomass production and spontaneous plants control.

Therefore it must be considered that the efficiency in the management of spontaneous plants is linked to factors such as: a) which type of covering is used; b) the amount of straw is possible to be produced depending on the edaphoclimatic conditions existing; c) if the straw is well distributed on the soil; and d) the composition of the seed bank of spontaneous plants of the area. Thus, it is necessary to establish a broader knowledge of the likely effects of the regular use of cover plants in the rotation or intercropping, [9, 31] for each type of agroecosystem to be studied.

This manner this research aimed to evaluate the population density, the infestation level and the fresh and dry weight of the spontaneous plants community existing on the organic green corn in NTS at mountain region of the Espirito Santo State- Brazil.

## II. MATERIAL AND METHODS

The work was conducted at the Agroecology Reference Unit (ARU) of INCAPER in Domingos Martins-ES, Brazil (20 ° 22 '16.91 "S and 41 ° 03' 41.83" W), at an altitude of

950 m. In this region average maximum temperatures in the warmer range between 26.7 and 27.8 °C and the average minimum temperatures in the cooler months range between 8.5 and 9.4°C. Annual average rainfall is 1,800 mm.

The entire ARU has been cultivated under organic management since 1990 with an area of 2.5 ha subdivided into 15 permanent fields where horticulture experiments are conducted. In the first ten years of research the focus was mainly on the generation of technologies for management of organic compound, of soils and of crops. From the 10th to the 20th year of the project the priority was researches about the planning of organic systems and the generation of soil management technologies that were long-lasting considering the cumulative effects of several years of cultivation. [32]

The general organic management of soils of fields has been carried out through the recycling of biomass using crops rotation also grasses and legumes plants appropriate to supply cultural remainings to the soil; through the application of organic compound inoculated with poultry manure; and practices such as green manure, use of mulch, crop rotation, applications of biofertilizers via soil and leave and other which lead to recycling, mobilization and availability of nutrients. It is worth mentioning that fertilizations with organic compound have been carried out on the basis of 15 t ha<sup>-1</sup> (dry weight) for most crops resulting in an average annual contribution of 22.5 t ha<sup>-1</sup>, considering the average of 1.5 cultivation of vegetables per year, per field. [32] These were the characteristics of the organic compound used in fertilizations from 2009 to 2011: N, P, K, Ca and Mg; 2.0, 1.2, 1.5, 6.0 and 0.6 dag kg<sup>-1</sup>, respectively; Zn, Fe, Mn, Cu and B: 223, 16.1, 804, 50 and 36 mg.dm<sup>-3</sup>; MO: 48 dag.kg<sup>-1</sup>; and C/N: 13/1.

This research was conducted at the 05 field in 720 m<sup>2</sup> of area that is in NTS since 2009.

The field was divided into plots physically isolated by concrete slabs buried at 0.40 m depth where were conducted successive cultivations under summer and winter covering plants as well as intercropping between both. The evaluated species were cabbage on sunn hemp and maize; eggplant on white lupine and black oats; green corn on black oats and white lupine; cabbage on corn and sunn hemp; green corn over corn and sunn hemp; green maize again on white lupine and black oats because the previous field was lost by attack of capybaras; cabbage on white lupine and black oats; and lettuce on black oats, and white lupine.

The trial was conducted from September 2019 to March 2020. The chemical characterization of its soil was

performed before its implementation at a depth of 0-20 cm and it is shown in Table 1.

Table. 1: Means of the chemical characteristics of the soil before the implementation of the trial

Attributes	G	L	G + L	OS	CS
pH H <sub>2</sub> O	6,9	6,8	6,9	6,8	5,4
P (mg dm <sup>-3</sup> )	870,9	975,8	1076,0	971,4	145,3
K (mg dm <sup>-3</sup> )	623,0	445,4	463,0	387,0	197,0
Ca (cmol <sub>c</sub> dm <sup>-3</sup> )	13,2	13,4	14,2	14,6	5,5
Mg (cmol <sub>c</sub> dm <sup>-3</sup> )	3,4	3,5	3,7	3,4	0,8
Al (cmol <sub>c</sub> dm <sup>-3</sup> )	0,0	0,0	0,0	0,0	0,1
H+Al (cmol <sub>c</sub> dm <sup>-3</sup> )	1,7	1,7	1,7	1,6	4,5
SB (cmol <sub>c</sub> dm <sup>-3</sup> )	17,8	18,4	19,3	18,6	6,8
t (cmol <sub>c</sub> dm <sup>-3</sup> )	17,8	18,4	19,3	18,6	6,9
T (cmol <sub>c</sub> dm <sup>-3</sup> )	19,5	20,1	21,0	20,8	11,3
MO (dag kg <sup>-1</sup> )	5,1	5,4	5,5	5,1	3,6
Zn (mg dm <sup>-3</sup> )	33,1	43,0	45,4	45,7	12,9
V(%)	91,2	91,3	92,0	92,3	60,3
Fe (mg dm <sup>-3</sup> )	60,6	57,0	56,4	58,0	134,4
Mn (mg dm <sup>-3</sup> )	96,6	102,5	104,7	102,0	82,7
Cu (mg dm <sup>-3</sup> )	2,1	1,83	1,74	2,0	5,3
B (mg dm <sup>-3</sup> )	0,6	0,4	0,5	0,6	0,3

CS – conventional system without straw; OS – organic system without straw; G – organic NTS with grass straw; L – organic NTS wit legume straw; G + L – organic NTS with grass + legume straws.

It was installed in a randomized block design, with six replications and five treatments, totaling 30 experimental plots with dimensions of 6.0 x 4.0 m, with a total area of 24.0 m<sup>2</sup> and a useful area of 16.0 m<sup>2</sup>. The treatments consisted of three soil coverings in the organic NTS (G - organic NTS with grass straw; L - organic NTS with legume straw; G + L - organic NTS intercropping) and two systems without covering and with tillage system, one organic and the other conventional (OS - organic system without straw; CS - conventional system without straw). For treatments under soil cover were used millet (*Pennisetum americanum*) as the grass specie, sunn hemp (*Crotalaria juncea*) as legume specie and the intercropping between both species.

The cover plants were sown on September 25, 2019 both in single and intercropped crops spaced 0.33 m between rows. The density of seeds in single crops was 29

grams per parcel for millet (12 kg ha<sup>-1</sup>) and 91 grams per parcel for sunn hemp (38 kg ha<sup>-1</sup>). Sowing densities and seed costs were reduced by half in intercropped crops due to planting in alternate rows.

Weeding was carried out between the lines of the cover plants at 18 days after the emergence of corn (DAE) and the irrigation according to observation of visual aspects of the cultures and previous practical experiences of ARU field employees.

The cover crops were mowed with a motorized backpack mower at 82 days after sowing. Samples of these plants were collected using a square measuring 1x1m on a side randomly placed in each experimental plot. Sub-samples were taken from these samples to quantify fresh weight and dry weight. For drying the sub-samples was used an oven with forced air circulation at 65°C for a period of 10 days.

Planting fertilization was performed on the same date that the cover plants were mowed using organic compound at a dose of 17.89 t ha<sup>-1</sup> (dry matter) uniformly distributed by haul over all experimental plots in organic management. These were the characteristics of the compound: N, P, K, Ca and Mg; 2.8, 0.7, 5.0, 3.3 and 0.5 dag kg<sup>-1</sup>, respectively; Zn, Fe, Mn, Cu and B: 151.4, 13014, 455.3, 45.3 and 9 mg.dm<sup>-3</sup>; C:O: 18.4 dag.kg<sup>-1</sup>; and C/N: 6.5. In the plots in conventional cultivation the planting fertilization for corn was carried out with 280 kg ha<sup>-1</sup> of urea according to soil analysis and fertilization recommendation according to the Lime and Fertilization Recommendation System program. [33] There was no application of supplementary fertilization in coverage in the plots in organic cultivation in order to understand the effect of N from straw; nor in the plots in conventional cultivation so that there would be no competitive advantage from this treatment over others.

The suitable for consumption in the form of green maize the hybrid AG 1051 was sown on December 19, 2019 using a special for NTS manual seeder adopting a spacing of 1.00 m between lines and 0.20 m between plants with a density of four seeds per hole. Subsequently it was thinned to one plant per hole recommending a population of 50,000 plants ha<sup>-1</sup>. A greater number of seeds were sown per hole to avoid failures in planting as the presence of birds that feed on seeds and newly emerged plants was found in the area.

Weeding was carried out between the lines of the plots in organic and conventional systems at 23 and 38 DAE corresponding to the V5 and V10 stages of corn according to observation of visual aspects of the culture and previous practical experiences of the URA field employees.

The percentage of soil covered by spontaneous plants was evaluated in the V5 stage of corn. The samples were collected in all experimental units using a Sony Cyber-shot DSC-W690 digital camera (16.1 megapixels) positioned at 1m. above the ground. The percentage of infestation by spontaneous plants was measured by the computer system SISCOB®, developed by Embrapa Instrumentação Agrícola which shows the percentage of soil covered by spontaneous plants in each photograph obtained.

Also in V5 stage of corn using a square measuring 0.50 m on the sides randomly placed in each experimental plot the population density of spontaneous plants was quantified and after this the plants were collected by plucking in order to quantify fresh weight and dry weight also in the V5 stage of corn. The process was repeated four times. In each sample the species of spontaneous plants were identified and counted, as well as the absolute and relative densities were determined in the different treatments. All material in the square was collected, weighed and taken to the forced air circulation oven at 65°C, until reaching constant weight, to determine the total dry matter. Spontaneous plants were weeded manually using a hoe soon after the evaluations were done.

The data on the percentage of soil covered by spontaneous plants were transformed by the function  $y = \arcsen [\sqrt{(x)/(100)}]$ , being submitted together with the characteristics fresh weight and dry weight, to analysis of variance and the means compared by Tukey test  $p > 0.05$  probability.

Principal component analyzes were performed group the five treatments, by means of visual examinations in graphic dispersions. For statistical analysis, the program R [34] was used.

### III. RESULTS AND DISCUSSION

Twelve different species of spontaneous plants belonging to nine botanical families were identified in the experimental area. "Asteraceae" was the family found with the greatest number of times. Lorenzi (2000) [35] highlights that the plants of this family are among the pioneers to establish themselves in recently tillage soils, having from 3000 to 6000 viable seeds per plant, easy dispersion mechanism and seed dormancy in the soil, which can germinate up to five years after its burial.

Both conventional and organic systems without coverings quantified very close values for absolute density as 242 spontaneous plants m<sup>-2</sup> and 229 plants m<sup>-2</sup> respectively.

In the organic systems with cover, there was a reduction in the absolute density of spontaneous plants to 53, 155 and 65 plants.m<sup>-2</sup> for the treatments "soil covered by millet", " sunn hemp" and "intercropping between both species", respectively (Table 2).

Table. 2: Absolute densities of different species of spontaneous plants identified in treatments

Espécies	Absolute Density (plants m <sup>-2</sup> )				
	SC	SO	G	L	G + L
<i>Amaranthus spp.</i>	1.5	2	13	102	31.5
<i>A. absinthium</i>	-	-	6	-	4
<i>C. benghalensis</i>	-	-	-	1	-
<i>C. rotundus</i>	7	12	13	14	16.3
<i>D. sanguinalis</i>	2	2	3	4	1
<i>E. indica</i>	1	1	-	2	-
<i>E. heterophylla</i>	1	1	1	4	2
<i>G. quadriradiata</i>	210	189	-	-	-
<i>Oxalis spp.</i>	7.5	7	1	23	6.8
<i>R. obtusifolius</i>	-	-	2	2.5	2
<i>S. oleraceus</i>	-	-	-	-	-
<i>S. arvensis</i>	12	14.5	-	3	1
<b>Total</b>	<b>242</b>	<b>229</b>	<b>53</b>	<b>155</b>	<b>65</b>

In comparison to a research performed in the same area by Favarato (2014) [31] this present study showed a significant reduction in absolute densities, which in that occasion varied from 96 plants.m<sup>-2</sup> for the treatment soil covered by grass, to 1169 plants.m<sup>-2</sup> for the treatment conventional system. The number of different species found in the area also decreased from 14 to 12 indicating, one more time, the importance of using the no-tillage system in a permanent way

Table 3 shows a higher relative density of the specie *Galinsoga quadriradiata*, both in the conventional system (CS) and in the organic system without straw (OS). This specie has several characteristics that predispose it to a rapid population increase and consequently to a high rate of infestation; including rapid seedling development, ability to flower after a short period of vegetative growth, production of flowers and fruits during the development cycle, production of several generations in a single development cycle, genetic self-compatibility and production of a large number of viable seeds in varying environmental circumstances. [36] And, as it is a positive photoblastic plant, [37] the type of management used in

the systems mentioned had a large contribution to the high rate of infestation of this species, as it includes soil turning with exposure of seeds to solar light.

Table. 3: Absolute densities of different species of spontaneous plants identified in treatments

Species	Relative Density (%)				
	SC	SO	G	L	G + L
<i>Amaranthus spp.</i>	0.6	1	24.9	65.8	48.7
<i>A. absinthium</i>	-	-	12	-	6.2
<i>C. benghalensis</i>	-	-	-	0.6	-
<i>C. rotundus</i>	3	5.4	24.6	9.1	25.3
<i>D. sanguinalis</i>	0.7	1	6	2.6	1.5
<i>E. indica</i>	0.4	0.4	-	1.3	-
<i>E. heterophylla</i>	0.4	0.4	1.9	2.4	3.1
<i>G. quadriradiata</i>	86.9	82.6	-	-	-
<i>Oxalis spp.</i>	3.1	2.9	26.8	14.6	10.5
<i>R. obtusifolius</i>	-	-	3.8	1.6	3.1
<i>S. oleraceus</i>	-	-	-	-	-
<i>S. arvensis</i>	4.9	6.3	-	1.9	1.5

Despite the use of intensive management in soils without mulch there was a low relative density of *Cyperus rotundus* (Table 3). According to Machado *et al.* (2005) [38] and Bangarwa *et al.* (2012), [39] the use of the conventional system favors the propagation and establishment of this specie due to the break in dormancy caused by the division of the tuber chain and the elimination of apical dominance exercised by the distal tubercle. However, in this case, the low density of *C. rotundus* can be attributed to interspecific competition with species of higher relative density present in the area.

In organics NTS were observed higher relative densities of *Amaranthus spp.*, *C. rotundus* and *Oxalis spp.*, respectively (Table 3). The presence of these species in the area can be explained by the high production rate of seeds of the genus *Amaranthus*, as an example we have the specie *Amaranthus retroflexus*, which can produce up to 117 thousand seeds per plant. [40] These seeds, being very light, are easily dispersed by the action of wind and water. [41] In a study carried out by Wilson (1980), [42] seeds of 77 weed species were found in a main irrigation channel, with *Amaranthus retroflexus* having the highest frequency, accounting for 40% of the total seeds. In addition, the presence of straw on the soil favors species that have negative photoblastic germination, such as *Amaranthus*

*caudatus*, as verified by Gutterman et al. (1992) [43] in study related to this specie.

On the other hand *C. rotundus* for having aggressive characteristics of survival and dissemination, is known as one of the most difficult species of spontaneous plants to be controlled that exists whatever the agricultural system work in. [44, 45] However, Vaz de Melo *et al.* (2007) [46] found in their research that in the conventional NTS, with no restrictions on the use of glyphosate for initial desiccation of spontaneous plants, the control of *C. rotundus* was more efficient than in the organic NTS, in that only the use of straw on the soil did not demonstrate efficiency.

In Brazil, the largest number of “shamrock” species belongs to the genus *Oxalis* L. [47] They are aggressive perennial plants, difficult to control, which have vegetative propagation as an exclusive form of dissemination and establishment. [41] Marshall (1987) [48] in a study performed with 3 specific species of the genus *Oxalis*, reports the difficulty of controlling these species using both leaf herbicides and cultural control methods. Jakelaitis (2003), [49] studying the population dynamics of the weed community present in the research area, found that there was a greater accumulation of biomass for the *Oxalis latifolia* in the corn crop in NTS.

No statistical differences were observed between treatments for the fresh weight and dry weight variables (Table 4). However, for the percentage of soil covered by spontaneous plants, the CS and OS treatments showed a higher average than the other treatments, followed by treatment L. The treatments G and G + L had the lowest percentages of covered soil, with no statistical differences between them. These results corroborate those shown in Table 2 and indicate that the use of mulch on the soil reduces both the percentage of infestation and the absolute density of spontaneous plants in the cultivated area. The presence of the cover on the soil reduces not only the luminosity, but also the alternation of temperatures in the soil, in addition to releasing allelochemical compounds during the decomposition of the phytomass resulting in a decrease in the germination rate of several species. [50, 51, 52]

Table. 4: Means of the percentage characteristics of soil covered by spontaneous plants, fresh weight and dry weight.

Treatment	Covered soil (%)	Fresh weight (g)	Dry weight (g)
G	12,57 c	14,07 a	2,22 a
G + L	15,17 c	27,48 a	3,53 a

L	35,72 b	70,47 a	7,89 a
SC	63,36 a	42,21 a	3,95 a
SO	70,76 a	70,45 a	6,13 a
Média <sup>1</sup>	39,52	44,94	4,74
CV (%)	14,45	89,03	86,78

<sup>1</sup>Means followed by the same letter vertically do not differ by Tukey's test at 5% probability.

Trezzi and Vidal (2004) [18] and recently Felito (2020) [53] observed, respectively, a reduction of 41% in infestation and up to 55% in the absolute density of spontaneous plants, comparing areas under cover plants with uncovered control.

Theisen *et al.* (2000) [54] testing the germination of spontaneous plants under covered and uncovered soil concluded that there was a higher incidence of *Brachiaria plantaginea* under uncovered soil and attributed the result to the reduction of the quantity and modification of the quality of the light that reached the seeds caused by the presence of the cover on the ground. Silva (2016) [55] highlights that the increase in the amount of phytomass on the soil, in addition to the physical impediment to the entry of light, also promotes greater regulation of the soil temperature, which provides a decrease in the germination of the specie *Amaranthus deflexus*, since this species is classified as positive photoblastic and also presents a higher emergence rate in bare soil situations where temperature changes.

The use of millet as the grass specie in the composition of straw in organic NTS resulted in good control of the spontaneous community (Table 4) and this can be explained due to its rapid initial growth, covering the soil quickly; [56] due to its general ability to generate a good amount of phytomass, regardless of whether it is grown single or intercropped, as Meschede (2007) [57] also observed in his trial with different types of cover plants; and due to its allelopathic potential. Pereira (2014) [58] concluded in his study that greater control of spontaneous plants was observed in the treatment in which millet was used single, although the treatment that provided the greatest accumulation of dry matter was millet in intercropped between sunn hemp. Carvalho (2012) [59] also found its allelopathic action, since among all the cover plants tested, millet was the one with the highest percentage of control of *Brachiaria brizantha*, *Sida rhombifolia*, and *Emilia sonchifolia*, even having produced only 0.97 t.ha<sup>-1</sup> of phytomass in those conditions, a value considered extremely low.

The graph in Fig. 1 shows the dispersion of the 5 treatments regarding the characteristics percentage of soil covered by spontaneous plants, fresh and dry matter, and the dispersion can be observed based on the coordinates related to the first two main components, CP1 and CP2, that formed 3 distinct groups and that the two components absorbed 99.81% of the variation existing in the original characteristics, with CP1 with 81.69% and CP2 with 18.12%. The first group was formed by treatments G and G + L, the second by treatments CS and OS and finally, the third by treatment L. The results shown in Fig. 1 confirm those presented in Table 4.

It can be seen in the Biplot CP1 x CP2 graph in Figure 1 that the variable that most contributed to CP1 was fresh weight. As expected, a strong correlation was observed between the variables fresh weight and dry weight, according to the acute angles between them. For CP2, the percentage of soil covered by spontaneous plants was the variable that contributed most.

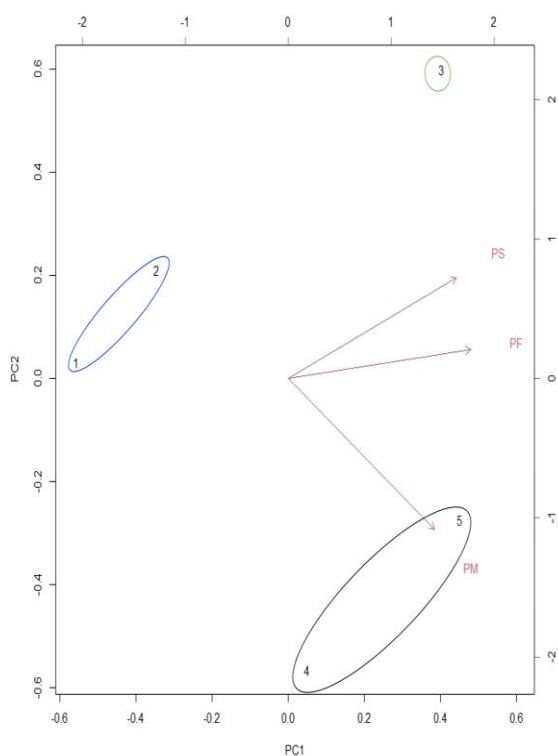


Fig. 1: Dispersion diagram in relation to the first two main components of the five treatments: 1-G; 2-G + L; 3-L; 4-CS; 5-OS; as to the relative density (%).

Characteristics: weed percentage - MT; fresh weight - PF and dry weight - PS

The graph in Fig. 2 shows the dispersion of the 5 treatments in terms of absolute density, and one can

observe the dispersion based on the coordinates related to the first two main components, CP1 and CP2, which formed 3 distinct groups and that the two components absorbed 89.23% of the variation existing in the original characteristics, with CP1 with 56.43% and CP2 with 32.81%. The first group was formed by the CS and OS treatments, the second by the G and G + L treatments and finally, the third by the L treatment.

It can be seen in the Biplot CP1 x CP2 graph in Fig. 2 that the variables that contribute to CP1 are species A, C, G, H, I, J and K. There were also strong correlations between variables A, G and I conform to the acute angles between them. For CP2, B and F were the variables that contributed most.

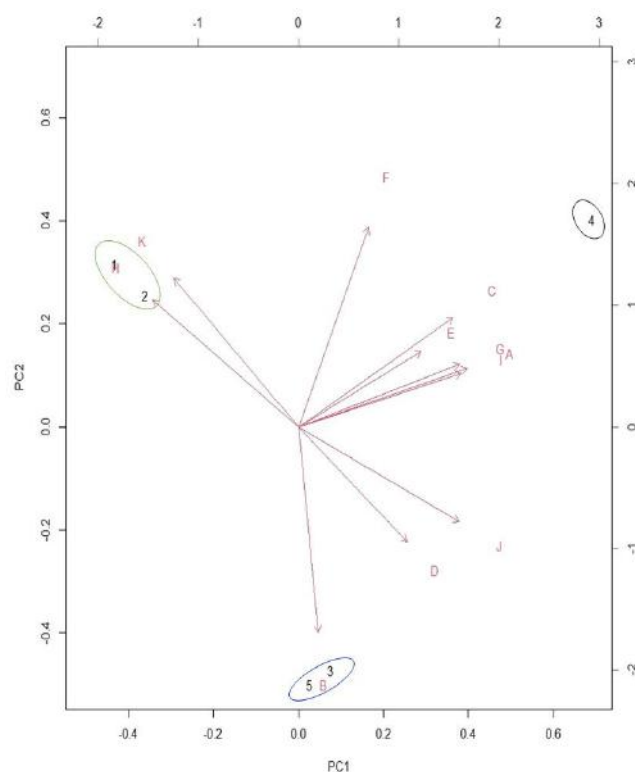


Fig. 2: Dispersion diagram in relation to the first two main components of the five treatments: 1-CS; 2-OS; 3-G; 4-L; 5-G + L, regarding absolute density (plants m<sup>2</sup>).

species: A - *Amaranthus* spp.; B - *A. absinthium*; C - *C. benghalensis*; D - *C. rotundus*; E - *D. sanguinalis*; F - *E. indica*; H - *E. heterophylla*; I - *G. quadriradiata*; J - *Oxalis* spp.; K - *R. obtusifolius*; L - *S. arvensis*.

The graph in Fig. 3 shows the dispersion of the 5 treatments in terms of relative density, and one can observe the dispersion based on the coordinates related to the first two main components, CP1 and CP2, which formed 3 distinct groups and that the two components absorbed 90.56% of the variation existing in the original

characteristics, with CP1 with 63.62% and CP2 with 26.94%. The first group was formed by treatments CS and OS, the second by treatments G and G + L and finally, the third by treatment L.

It can be seen in the Biplot CP1 x CP2 graph in Fig. 3 that the variables that contribute to CP1 are species B, C, D, E, H, I, J and K. There were also strong correlations between variables A, C and F conform to the acute angles between them. For CP2, A, C and F were the variables that contributed most.

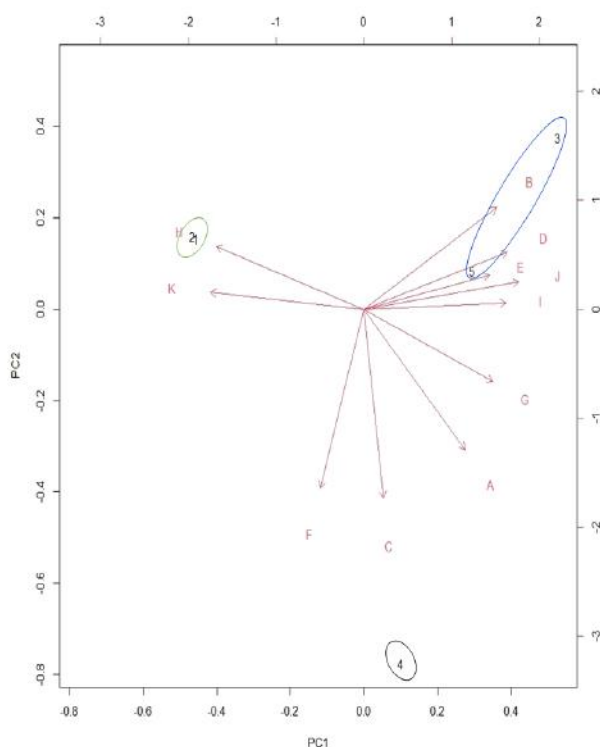


Fig. 3: Dispersion diagram in relation to the first two main components of the five treatments: 1-SC; 2-SO; 3-G; 4-L; 5-G + L, regarding relative density (%)

species: A - *Amaranthus spp.*; B - *A. absinthium*; C - *C. benghalensis*; D - *C. rotundus*; E - *D. sanguinalis*; F - *E. indica*; H - *E. heterophylla*; I - *G. quadriradiata*; J - *Oxalis spp.*; K - *R. obtusifolius*; L - *S. arvensis*.

#### IV. CONCLUSIONS

- The use of single millet straw or intercropped between sunn hemp, in the organic NTS causes a reduction in the percentage of infestation and in the absolute density of spontaneous plants.
- Treatments with intensive soil management systems have a higher relative density for the specie *G. quadriradiata*. The highest relative densities in

organic NTS are attributed to the species *Amaranthus spp.*, *C. rotundus* and *Oxalis spp.*

- The percentage of infestation by spontaneous plants does not reach the level of economic damage in any of the treatments studied, since the average productivity of ears without straw is within the Brazilian average, which is between 9,000 to 15,000 Kg.ha<sup>-1</sup>

#### REFERENCES

- [1] Deuber, R. (2003). *Ciência das plantas infestantes*. Jaticabal, SP: Funep.
- [2] Voll, E., Gazziero, D. L. P., Brighenti, A. M., Adegas, F. S., Gaudêncio, C. A., & Voll, C. E. (2005). *Dinâmica das plantas daninhas e práticas de manejo*. Londrina, PR: Embrapa soja.
- [3] Xavier, L. P. (2019). *Campepinato e agroecologia: construção de uma pesquisa-ação com o uso de adubação verde no manejo de plantas espontâneas*. Master's dissertation, Master's Course in Agroecology and Sustainable Rural Development, Federal University of Fronteira do Sul. Laranjeiras do Sul, PR, Brazil.
- [4] Altieri, M., Silva, E. N., & Nicholls, C. I. (2003). *O papel da biodiversidade no manejo de pragas*. Ribeirão Preto, SP: Holos.
- [5] Machado, L.C.P. (2010). *Pastoreio Racional Voisin: tecnologia agroecológica para o terceiro milênio* (2nd ed.). São Paulo, SP: Expressão Popular.
- [6] Primavesi, A. M. (2016). *Manual do solo vivo: solo sadio, planta sadia, ser humano sadio* (2nd ed rev.). São Paulo, SP: Expressão Popular.
- [7] Pereira, W. , & Melo, W. F. (2008). *Manejo de plantas espontâneas no sistema de produção orgânica de hortaliças*. Brasília, DF: Embrapa Hortaliças.
- [8] Instrução Normativa Nº 007, de 17 de maio de 1999, dispõe sobre normas para a produção de produtos orgânicos vegetais e animais. Retrieved from <http://www.agricultura.gov.br>.
- [9] Darolt, M. R., & Skora, F. Neto. (2002). *Sistema de plantio direto em agricultura orgânica*. Retrieved from <http://www.planetaorganico.com.br>.
- [10] Vidal, R. A., & Bauman, T. T. (1996). Surface wheat (*Triticum aestivum*) residues, giant foxtail (*Setaria faberi*), and soybean (*Glycine max*) yield. *Weed Science*, 44 (5), 939-943.
- [11] Pitelli, R. A., & Durigan, J. C. (2001). Ecologia das plantas daninhas no sistema de plantio direto. In Rossello, R. D. (Coord), *Siembra directa en el Cono Sur* (pp.203-210). Montevideo- Prociur.
- [12] Severino, F. J., & Christoffoleti, P. J. (2001) Efeitos de quantidades de fitomassa de adubos verdes na supressão de plantas daninhas. *Planta Daninha*, 19 (2), pp.223-228.
- [13] Santos, T.R., Galvão, J.C.C., Giehl, J., Coelho, S.P., Campos, S.A., & Mendonça, B.F. (2019, May- Aug). Weed communities in the organic cultivation of fresh maize



- intercropped with legumes and coffee husk. *Revista Facultad Nacional de Agronomía Medellín* (ISSN: 0304-2847. <https://dx.doi.org/10.15446/rfnam.v72n2.68510>).
- [14] Seidel, E.P., Caetano, J.H.S., Karpinski, A.S., & Reis, W. (2019). Residual dry matter, weeds and soil aggregates after winter cover crop. *Journal of Experimental Agriculture International* (<https://doi.org/10.9734/jeai/2019/v32i230100>).
- [15] Monquero, P.A., Amaral, L.R, Inácio, E.M., Brunhara, J.P, Binha, D.P., Silva, P.V., & Silva, A.C. (2009). Efeito de adubos verdes na supressão de espécies de plantas daninhas. *Planta Daninha*, 27 (1), 85-95.
- [16] Yamauti, M.S., Barroso, A. A. M, Giancotti, P.R.F., Squassoni,V.L., Revolti,L.T.M., & Alves, P.L.C.A.(2011). Emergência de plantas daninhas em função da posição da semente e quantidade de palha de cana-de-açúcar. *Scientia Agraria*, 12 (2), 75-80.
- [17] Radosevich, S. R., Holt, J.S., & Ghersa, C. (1997). *Weed ecology: Implications for management* (2nd.ed.). New York, NY: Wiley
- [18] Trezzi, M. M., & Vidal, R.A. (2004). Potencial de utilização de cobertura vegetal de sorgo e milheto na supressão de plantas daninhas em condição de campo: II – Efeitos da cobertura morta. *Planta Daninha*, 22 (1), 1-10.
- [19] Scholberg, J.M.S., Linares, J., Chase, C., McSorley, R., & Fergusson, J. (2006). Integrative Approaches for Weed Management in Organic Citrus Orchards. *HortScience*, 4, 949-954.
- [20] Rosa, D.M., Nóbrega, L.H.P., Lima, G.P., Márcia Maria Mauli, M.M., & Coelho, S.R.M. (2011). Action of dwarf mucuna, pigeon pea and stylosanthes on weed under field and laboratory conditions. *Interciencia*, 36 (11), 841-847.
- [21] Armengot, L., Berner, A., Blanco-Moreno, J., Mäder, P., Sans, F. (2015). *Agronomy for Sustainable Development*. 35(1), 339-346.
- [22] Queiroz, L.R., Galvão, J.C.C., Cruz, J.C., Oliveira, M.F., & Tardin, F.D. (2010, Apr-Jun). Weed suppression and organic green corn production in no tillage system. *Planta Daninha*, 28 (2), 263-270.
- [23] Souza, J. L., & Rezende, P. (2014) *Manual de Horticultura Orgânica*. (3rd ed). Viçosa, MG: Aprenda Fácil.
- [24] Ferreira, J. R. (2016). *Dinâmica de plantas espontâneas e desempenho de milho em sucessão a adubos verdes, sob manejo orgânico*. Master's dissertation, Postgraduate Course in Organic Agriculture, Federal Rural University of Rio de Janeiro, Seropédica, RJ, Brazil.
- [25] Freitas, R. A. (2017). *Controle de plantas espontâneas e aporte de nitrogênio em área cultivada com cafeeiro através do manejo de plantas de cobertura de solo*. Master's dissertation, Postgraduate Course in Organic Agriculture, Federal Rural University of Rio de Janeiro, Seropédica, RJ, Brazil.
- [26] Monteiro, G. F. P. (2018). *Sequestro de carbono e supressão de plantas invasoras por cobertura vegetal*. Doctoral thesis, Postgraduate Course in Tropical Agronomy, Federal University of Amazonas, Manaus, AM, Brazil.
- [27] Parizotto, C., Duarte, T. da S., & Wieth, A.R. (2018, november). Desempenho agrônômico e controle de plantas espontâneas no cultivo do pepineiro em sistema agroecológico. *Annals of Agroecol.* Mato Grosso do Sul, MS. Brasil. Retrieved from <http://cadernos.aba-agroecologia.org.br/index.php/cadernos/article/view/2136/2224>
- [28] Soligo, C. C. (2018). *Produtividade e incidência de plantas espontâneas sob diferentes coberturas de solo no cultivo de alface crespa cv. vera ®*. Monograph to obtain a bachelor's degree. Bachelor's Degree in Agronomy, Federal University of Fronteira do Sul, Laranjeira do Sul, RS, Brazil.
- [29] Araújo, F. C., Nascente, A. S., Guimarães, J. L. N., Sousa, V. S., & Silva, M. A. (2019). Cultivo de plantas de cobertura na produção de biomassa de plantas daninhas. *Annals of XI Congresso Brasileiro de Arroz Irrigado*. Balneário Camboriú., SC. Brazil. Retrieved from <https://ainfo.cnptia.embrapa.br/digital/bitstream/item/201518/1/CNPAF-2019-cbai-asn2.pdf>.
- [30] Gama, L. A. (2019). *Plantas de cobertura no manejo sustentável das infestantes e na produtividade do guaranazeiro (Paullinia cupana var. sorbilis (Mart.) Ducke)*. Doctoral Thesis, Postgraduate Course in Tropical Agronomy, Federal University of Amazonas, Manaus, AM., Brazil
- [31] Favarato, L. F., Galvão, J.C.C., Souza, J.L., Guarçoni, R.C., Souza, C.M., & Cunha, D.N. (2014). Population density and weed infestation in organic no-tillage corn cropping system under different soil covers. *Planta Daninha*, 32 (4), 739-746.
- [32] Souza, J. L. (Ed.). (2015). *Agricultura orgânica: tecnologias para a produção de alimentos saudáveis* (3rd vol.). Vitória, ES: Incaper.
- [33] Prezotti, L.C. (2014). *Sistema de recomendação de calagem e adubação*. Retrieved from <http://www.incaper.es.gov.br/downloads>.
- [34] R Core Team R. (2020). *A language and environment for statistical computing*. Viena, Áustria: R Foundation for Statistical Computing. Retrieved from <https://www.R-project.org>.
- [35] Lorenzi, H. (2000). *Plantas daninhas do Brasil: terrestres, aquáticas, parasitas e tóxicas*. Nova Odessa, SP: Instituto Plantarum.
- [36] Warwick, S. I., & Sweet, R. D. (1983). The biology of Canadian weeds. 58. *Galinsoga parviflora* and *G. quadriradiata* (= *G. ciliata*). *Can. J. Plant Sci.*, 63, 695-709.
- [37] Cauwer, B., Devos, R., Claerhout, S., Bulcke, R., & Reheul, D. (2014, Feb). Seed dormancy, germination, emergence and seed longevity in *G. alinsoga parviflora* and *G. quadriradiata*. *Weed Research*, 54(1), 38-47.
- [38] Machado, A.F.L, Jakelaitis, A., Ferreira, L. R., Agnes, E. L., & Santos, L.D.T. (2005). population dynamics of weeds in no-tillage and conventional crop systems. *Journal of environmental science and health. Part B, Pesticides, food contaminants, and agricultural wastes*,40(1), 119-128.

- [39] Bangarwa, S. K., Norsworthy, Jason. K., & Gbur, E. E. (2012). Effects of shoot clippingsoil disturbance frequency and tuber size on aboveground and belowground growth of purple and yellow nutsedge (*Cyperus rotundus* and *Cyperus esculentus*). *Weed Technology*, 26(4), 813-817.
- [40] Zimdahl, R.L. (1999). *Fundamentals of weed science* (2nd ed.). Fort Collins, EUA: Academic Press.
- [41] Brighenti, A. M., & Oliveira, M. F. (2011). Biologia de plantas daninhas. In: Oliveira, R. S. Jr, Constantin, J., & Inoue, M. H. (Eds.), *Biologia e manejo de plantas daninhas* (pp.1-36). Curitiba: Omnipax.
- [42] Wilson, R. G. (1980). Dissemination of weed seeds by surface irrigation water in Western Nebraska. *Weed Science*, 28, 87-92.
- [43] Gutterman, Y., Corbineau, F., & Côme, D. (1992). Interrelated effects of temperature, light and oxygen on *Amaranthus caudatus* L. seed germination. *Weed Research*, 32, 111-117.
- [44] R. Nishimoto. (2001). Purple nutsedge tuber sprouting. *Weed Biol. Manag.*, 1 (4), 203-208
- [45] Hussain, I., Singh, N.B., Singh, A., & Singh, H. (2017). Allelopathic potential of sesame plant leachate against *Cyperus rotundus* L. *Annals of Agrarian Science*, 15 (1), 141-147.
- [46] Melo, A. I. V., Galvão, J.C.C., Ferreira, L.R., Miranda, G.V., Tuffi Santos, L.D., Santos, I.C., & Souza, L.V. (2007). Dinâmica populacional de plantas daninhas em cultivo de milho-verde nos sistemas orgânico e tradicional. *Planta Daninha*, 25 (3), 521-527.
- [47] Souza, V.C., & Lorenzi, H. (2008). *Botânica Sistemática: guia ilustrado para identificação das famílias de Fanerógamas nativas e exóticas no Brasil, baseado em APG II* (2nd. ed.). São Paulo, SP: Instituto Plantarum.
- [48] Marshall, G. (1987). A review of the biology and control of selected weed species in the genus *Oxalis*: *O. stricta* L., *O. latifolia* H.B.K. and *O. pescaprae* L. *Crop Protection*, 6 (6), 355-36.
- [49] Jakelaitis, A. I., Ferreira, L.R., Silva, A.A., Agnes, E.L., Miranda, G.V., & Machado, A.F.L. (2003). Dinâmica populacional de plantas daninhas sob diferentes sistemas de manejo nas culturas de milho e feijão. *Planta Daninha*, 21 (1), 71- 79.
- [50] Alvarenga, R. C., Cabezas, W. A. L., Cruz, J. C., & Santana, D. P. (2001). Plantas de cobertura de solo para sistema plantio direto. *Informe Agropecuário*, 22 (208), 25-36.
- [51] Rosa, D.M., Nóbrega, L.H.P., Mauli, M.M, Lima, G.P., & Boller, W. (2013, Dec). Weeds suppression and agronomic characteristics of maize crop under leguminous crop residues in no-tillage system. *Tropical and subtropical agroecosystems*, 16 (3), 455-463.
- [52] Coelho, M.E.H., Freitas, F.C.L., Cunha, J.L.X.L., Silva, K.S., Grangeiro, L.C., & Oliveira, J.B. (2013, Apr./June). Coberturas do solo sobre a amplitude térmica e a produtividade de pimentão. *Planta daninha* (ISSN: 0100-8358. <https://doi.org/10.1590/S0100-83582013000200014>).
- [53] Felito, R.A. (2020). *Uso do mulching e sistema de plantio direto no cultivo orgânico de plantas condimentares*. Doctoral Thesis, Horticulture Course, Faculty of Agronomic Sciences, Unesp Campus de Botucatu, Botucatu, SP, Brazil.
- [54] Theisen, G., Vidal, R. A., & Fleck, N. G. (2000). Redução da infestação de *Brachiaria plantaginea* em soja pela cobertura do solo com palha de aveia-preta. *Pesquisa Agropecuária Brasileira*, 35, 753-756.
- [55] Silva, J.B., Pacheco, L.P., Santos, A.S., Francisco Alcântara, F. Neto, Ratke, R.F., & Pette, F.A. (2016, July/Sep.). Plantas de cobertura na supressão do crescimento de *Amaranthus deflexus*. *Rev. Cienc. Agrar.* (<http://dx.doi.org/10.4322/rca.2270>)
- [56] Carvalho, A.M., & Amabile, R.F. (2006). Plantas condicionadoras de solo: interações edafoclimáticas, uso e manejo. In: Carvalho, A.M., & Amabile, R.F. (Eds.), *Cerrado: adubação verde* (pp.2006-369). Planaltina, DF: Embrapa Cerrados.
- [57] Meschede, D.K., Ferreira, A.B., & Ribeiro JR., C.C. (2007) Avaliação de diferentes coberturas na supressão de plantas daninhas no cerrado. *Planta daninha* (ISSN 0100-8358. <https://doi.org/10.1590/S0100-83582007000300005>)
- [58] Pereira, L.C. (2016). *Cultivo orgânico do feijoeiro pelo sistema de plantio direto utilizando milho e crotalaria como cobertura morta*. Master's dissertation, Postgraduate Course in Organic Agriculture, Federal Rural University of Rio de Janeiro, Seropédica, RJ, Brazil.
- [59] Carvalho, W.P. (2012). *Plantas de cobertura no controle de infestantes no sistema orgânico de produção*. Doctoral thesis, Postgraduate Course in Agronomy / Phytotechnics, Federal University of Lavras, Lavras, MG, Brazil