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WEED CONTROL EFFECTS ON SOIL CHEMICAL CHARACTERISTICS

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ABSTRACT – The weed control procedures are known to affect the soil physical attributes and the nutrient amount taken up by weed roots. This work hypothesis is that weed control methods might also affect soil chemical attributes. Four experiments were carried out, three with maize (E-1, E-2 and E-3) and one with cotton (E-4), in randomized complete blocks design arranged in split-plots, with five replications. In E-1 experiment, the plots consisted of two weed control treatments: no-weed control and weed shovel-digging at 20 and 40 days after sowing; and the subplots consisted of six maize cultivars. In the three other experiments, the plots consisted of plant cultivars: four maize cultivars (E-2 and E-3) and four cotton cultivars (E-4). And, the subplots consisted of three weed control treatments: (1) no-weed control; (2) weed shovel-digging at 20 and 40 days after sowing; and (3) intercropping with cowpea (E-2) or _Gliricidia sepium_ (Jacq.) Walp. (E-3 and E-4). In all experiments, after harvest, eight soil samples were collected from each subplot (0-20 cm depth) and composed in one sample. Soil chemical analysis results indicated that the weed control by shovel-digging or intercropping may increase or decrease some soil element concentrations and the alterations depend on the element and experiment considered. In E-2, the weed shovel-dug plots showed intermediate soil pH, lower S (sum of bases) values and higher soil P concentrations than the other plots. In E-4, soil K and Na concentrations in plots without weed control did not differ from plots with intercropping, and in both, K and Na values were higher than in weed shovel-dug plots. Maize and cotton cultivars did not affect soil chemical characteristics.

Key words: _Zea mays_ L., _Gossypium hirsutum_ L., _Gliricidia sepium_ (Jacq.) Walp., _Vigna unguiculata (_L.) Walp.

EFEITOS DO CONTROLE DE PLANTAS DANINHAS SOBRE CARACTERÍSTICAS QUÍMICAS DO SOLO

RESUMO - O controle das plantas daninhas influencia as propriedades físicas do solo e as quantidades de elementos químicos removidos pelas plantas daninhas. Assim, se pode formular a hipótese de que os métodos de controle das plantas daninhas influenciam as características químicas do solo. Quatro experimentos sobre controle de plantas daninhas foram realizados, três com milho (E-1, E-2 e E-3) e um com algodoeiro (E-4), utilizando-se o delineamento experimental em blocos ao acaso com cinco repetições, arranjados em parcelas subdivididas. Em E-1, as parcelas foram dois tratamentos de capinas: sem capina e com capina (aos 20 e 40 dias após o plantio) e as subparcelas consistiram de seis cultivares de milho. Nos outros experimentos, as cultivares foram atribuídas às parcelas: quatro cultivares de milho (E-2 e E-3); e quatro cultivares de algodoeiro (E-4). Nesses experimentos, as subparcelas, foram submetidas aos seguintes tratamentos: sem capina; com capinas; e consorciação com feijão-caupi (E-2) ou gliricídia (E-3 e E-4). Em todos os experimentos, após a colheita, oito subamostras de solo (camada de 0-20 cm) foram retiradas de cada subparcela e a mistura delas (amostra composta) foi submetida à análise química. Concluiu-se que o controle de plantas daninhas, com capina ou através da consorciação, pode aumentar ou diminuir as concentrações de determinados elementos químicos do solo do solo e as alterações dependem do elemento e do experimento considerados. Em E-2, as parcelas capinadas apresentaram pH intermediário, menor valor para a soma de bases e maior teor de P, em relação aos outros tratamentos de capinas. Em E-4, os teores de K e Na nas parcelas sem capina não diferiram daqueles das parcelas com consorciação; e os teores de K e Na de ambos foram superiores ao de solo capinado. As cultivares de milho e algodoeiro não influenciaram as características químicas do solo.

Palavras-chave: *Zea mays* L., *Gossypium hirsutum* L., *Gliricidia sepium* (Jacq.) Walp., *Vigna unguiculata* (L.) Walp.

INTRODUCTION

Weed control methods have been reported to alter the soil physical attributes. When weeds were controlled by shovel-digging or post-emergence herbicides, the soil physical attributes quality were preserved (ALCÂNTARA; FERREIRA, 2000). Nevertheless, the use of rotovators, tillers or cultivators resulted in soil subsurface layer compaction. On the other hand, the continuous pre-emergence herbicide application has caused soil surface crusting and decreased soil organic matter content (ALCÂNTARA; FERREIRA, 2000).

Weed plant residues left over the soil and surface liming increased soil pH and reduced the Al concentration until 20 cm depth (MEDA et al., 2002; YAN; SCHUBERT, 2000). Such effects might be due to the plant residue release of low molecular weight hydrosoluble organic compounds, present on the soil surface before the beginning of microbial decomposition (FRANCHINI et al., 1999). Furthermore, weeds might exhaust soil nutrient reservoir (SREENIVAS; SATYANARAYANA, 1996). Nitrogen uptake by weeds may vary between 32.4 kg ha^{-1} and 52.3 kg ha^{-1}, depending on the method of weed control; P uptake may vary between 4.3 kg (P_2O_5) ha^{-1} and 7.2 kg ha^{-1} and K_2O, 32.1 kg ha^{-1} and 38.9 kg ha^{-1} (SREENIVAS; SATYANARAYANA, 1996). Hence, the initially formulated hypotheses that weed control method can also influence soil chemical attributes may be reasonably feasible.

Herbicides have simplified the weed control procedures and have been extensively used in substitution to the traditional weed control methods, in several regions. However, herbicides are expensive and their excessive use has resulted in resistant weed plant biotypes and environment contamination. The weed control management procedures studied in the past are coming back as interesting practices and they are being subject again of research experiments, including intercropping and the use of more efficient and competitive plant cultivars. Differential genotype ability to suppress weeds was reported for several crop plants such as maize (ROSSI et al., 1996). There are also differences among species and among cultivars within species as to uptake, translocation, accumulation and use of mineral elements (Clark, 1983), what might also change soil chemical attribute.

The objective of this work was to evaluate the effects of weed control methods and cultivars on mineral element composition of soil cultivated with maize and cotton.

MATERIAL AND METHODS

Four experiments (E-1, E-2, E-3 and E-4) were carried out in the Experiment Station *"Rafael Fernandes"*, at the Universidade Federal Rural do Semi-Árido (UFERSA), Mossoró, State of Rio Grande do Norte, Brazil (5º latitude, 37º 20' WGr longitude, 18 m altitude), using sprinkler irrigation. The experimental design was in randomized complete blocks, arranged in split-plots with five replications. Each subplot consisted of four 6.0 m-length rows and the two central rows (5.2 m long) were considered the experimental unity. The soil, a Red Yellow Argisol according to the Brazilian System of Soil Classification (EMBRAPA, 1999), was harrow plowed twice and fertilized with 30 kg ha^{-1} N (ammonium sulfate), 60 kg ha^{-1} P_2O_5 (simple superphosphate) and 30 kg ha^{-1} K_2O (potassium chloride), placed aside and below the seedbed rows. Twenty and fourty days after sowing, 30 kg ha^{-1} N fertilizer (as ammonium sulfate) was sidedressed. Back-sprayers were used for spraying applications and other field procedures were manually managed.

After maize or cotton harvest (about 100 days after sowing), eight soil samples were collected from each subplot, at 0-20 cm depth, using a hand-held soil probe.

E-1 and E-2

The two first experiments were carried out with maize cultivars sowed in the same day in adjacent areas. The previous soil sample chemical analysis results were: pH = 6.8; Ca = 1.80 $cmolc^{-1}dm^{-3}$; Mg = 0.40 cmolc dm^{-3}; K = 0.10 cmolc dm^{-3}; Na = 0.01 cmolc dm^{-3}; Al = 0.00 cmolc dm^{-3}; P = 25 mg dm^{-3}; O.M. = 1.90 g kg^{-1}. Sowing was made in March 23, 2003, using four seeds per hole, spaced 0.4 m x 1.0 m (holes x rows) and 20 days later, the best two plants per hole were left, to give around 50,000 plants ha^{-1}. Pests were controlled using deltamethrin (250 ml ha^{-1}), at 7 and 14 days after sowing, respectively. One hundred days after sowing, corn-cobs were harvested and eight soil samples were collected (0-20 cm depth layer) from each experimental unity, which were composed in one sample for chemical analysis according to EMBRAPA (1999).

In E-1 experiment, the plots consisted of two weed control treatments: no weed control; and shovel digging at 20 and 40 days after sowing. And the subplots consisted of maize cultivars (AG 405, AG 2060, BA 8517, BA 9513, DKB 435 and EX 6005).

In E-2 experiment, the plots consisted of maize cultivars (BA 8512, BA 9012, EX 4001, EX 6004) and the subplots, weed control treatments: no weed control; shovel digging at 20 and 40 days after sowing; and intercropping with cowpea (*Vigna unguiculata* (L.) Walp, 'Sempre Verde' cv), sowed between rows at the same time of maize (four cowpea seeds per hole, holes spaced 1.0 m); after 20 days, the two best cowpea plants were left. After harvest, eight soil samples were randomly collected in each subplot experimental unity and mixed to compose one soil sample for chemical analysis.

E-3 and E-4

In E-3 experiment, four maize cultivars (AG 1051, AG 2060, BRS 2020 and PL 6880) were used and seeded 1.0 m x 0.40 m (2 seedlings per hole were left). In E-4 experiment, four cotton cultivars were used (BRS-Verde, BRS-Rubi, BRS-Safira and BRS-187 8H) and seedlings were spaced 1.0 m x 0.20 m (one seedling per hole), both planted at the same time in adjacent areas. In both experiments, the plots consisted of plant cultivars and the subplots, the weed control treatments: no weed control; shovel digging at 20 and 40 days after sowing; and intercropping with *Gliricidia sepium* (Jacq.) seedlings, planted between rows (1 seedling per hole, spaced 0.50 m apart) at the same time of maize sowing (E-3). Cotton and gliciridia were first seeded in 35 mL-cell-polystyrene trays, in June 14, 2006 (filled with a mixture of 1/3 humus and 2/3 Red Yellow Argisol), and homogeneous seedlings were transplanted to the field to obtain a good plant stand in the field.

In E-3 experiment, the previous soil samples (0-20 cm depth) analyses results were: pH = 7.2; P = 37.44 mg kg^{-1}; K^+ = 0.40 $cmol_c$ dm^{-3}; Ca^{2+} = 5.05 $cmol_c$ dm^{-3}; Mg^{2+} = 0.95 $cmol_c$ dm^{-3}; Al^{3+} = 0.00 $cmol_c$ dm^{-3} and Na^+ = 0.23 $cmol_c$ dm^{-3}.

In E-4 experiment, the previous soil sample analysis results were: pH = 6.70; P = 60.70 mg kg^{-1}; K^+ = 0.21 $cmol_c$ dm^{-3}; Ca^{2+} = 4.20 $cmol_c$ dm^{-3}; Mg^{2+} = 1.60 $cmol_c$ dm^{-3}; Al^{3+} = 0.00 $cmol_c$ dm^{-3}; Na^+ = 0.18 $cmol_c$ dm^{-3}.

After harvest, eight soil samples were randomly collected in each subplot experimental unity and mixed to compose one soil sample. Four equally spaced soil samples were collected between the two central rows (experimental unity) and the other four, from between plants in both rows.

RESULTS AND DISCUSSION

There were no interaction effects between cultivar and weed control methods, for all experiments. For this reason, the data presented is referred to the main treatment effects.

E-1 and E-2

Ten weed species, most gramineae, occurred in E-1 and E-2 experiments (Table 1):

Table 1 – Main weed species identified in the experimental area.

Botanical name	Family
Alternanthera ficoidea (L.) P. Beauv.	Amaranthaceae
Borreria verticilata (L.) G.F.W. Meyer.	Rubiaceae
Cenchrus echinatus L.	Gramineae
Commelina sp. L.	Commelinaceae
Cucumis anguria L.	Cucurbitaceae
Dactyloctenium (L.) Beauv.	Gramineae
Digitaria sanguinalis (L.) Scop.	Gramineae
Melochia pyramidata L.	Sterculiaceae
Phyllanthus niruri L.	Euphorbiaceae
Senna uniflora (P.Mill) Irwin &Barneby	Leguminosae

The maize cultivars used in E-1 experiment did not change the soil chemical attributes. The soil sample analysis results were: pH = 8.35; P = 55.9 mg dm^{-3}; Ca = 4.60; Mg = 2.06, K = 0.40; Na = 0.22; S (sum of bases) = 7.28 $cmol_c$ dm^{-3}. The respective coefficient of variation (CV%) values for the subplots, were: 1.6; 10.4; 23.5; 15.8; 9.1; 6.6 and 24.1. The weed control method also did not change the soil chemical characteristics and the respective CV% values for the plots, were: 3.23; 21.39; 30.90; 25.70; 11.3; 15.5 and 44.2.

The maize cultivars used in experiment E-2 also did not change any soil chemical attributes; the soil sample analysis results were: pH = 8.00; P = 61.6 mg dm^{-3}; Ca = 4.68; Mg = 2.16, K = 0.42; Na = 0.26; S = 7.52 $cmol_c$ dm^{-3}. The respective coefficient of variation (CV%) values for the subplots, were: 1.7; 20.7; 27.9; 21.8; 9.8; 18.4 and 58.3. The weed-shovel-dug plots presented intermediate pH, lower S (sum of bases) values and higher P concentrations than the other two treatments (Table 2). The CV% values for Ca, Mg, K and Na were10.0; 14.8; 14.7 and 9.1, respectively.

Table 2 – Soil chemical characteristics of a Red Yellow Argisol (Embrapa, 1999) after a maize field crop, without and with weed control [shovel-digging or intercropping with cowpea (*Vigna unguiculata* (L.) Walp)] (average of five replications and six maize cultivars)[1]

Weed control	pH	S ($cmol_c\ dm^{-3}$)	P ($mg\ dm^{-3}$)
No control	8.05 a	7.53 a	61.5 b
Shovel-digging	8.01 b	7.43 b	66.4 a
Intercropping	7.97 c	7.61 a	57.1 c
C.V.b (%)	1.0	7.3	22.0

[1] Means followed by a common letter do not differ among themselves by Tukey test ($P \leq 0.05$)

E-3

Sixteen weed species of twelve families were found in E-3 experiment (Table 3). Some species were more frequently found than others, like *Commelina benghalensis* L., for instance, that was found in 93 % of experimental unities; meanwhile *Blainvillea latifolia, Desmanthus virgatus, Melochia pyramidata, Phyllanthus amarus and Senna accidentalis* species were present in only 2% of the area (Tables 3 and 4). This irregular species distribution occurred among blocks, among plots within the same block and among subplots within a plot. Block 2, for instance, presented 62 % of the total species found, compared to block 3, where only 38% of species were present. In block 4, the plot with maize AG 2060 cv presented only 25% of species, but plot with maize PL 6880 cv showed twice this percentage (Table 4).

No effects of cultivars or weed control treatments on soil chemical characteristics were observed. The soil sample chemical analysis results were (average values): pH = 7.19; Ca = 5.48; Mg = 1.77; K = 0.84 and Na = 0.44 $cmol_c\ dm^{-3}$; S = 8.55 $cmol_c\ dm^{-3}$ and P = 104.2 $mg\ dm^{-3}$. The respective CV % values for the plots were 2.2; 22.0; 59.6; 32.3; 21.0; 15.4 and 42.8; and for the subplots, 2.1; 9.4; 24.1; 18.0; 14.5; 5.8 and 28.3.

Table 3 – Occurrence index (ratio between the number of species occurrences and the total number of species in the experimental unit) of the main weed plant species identified in the experimental area, at Mossoró, State of Rio-Grande-do-Norte, Brazil, 2007.

#	Botanical name	Family	Occurrence Index
1	*Acanthospermum hispidum* L.	Compositae	0.03
2	*Alternanthera tenella* Colla	Amaranthaceae	0.66
3	*Amaranthus viridis* L.	Amaranthaceae	0.23
4	*Blainvillea latifolia* (L.f.) D.C.	Compositae	0.02
5	*Cenchrus echinatus* L.	Gramineae	0.12
6	*Commelina benghalensis* L.	Commelinaceae	0.93
7	*Cucumis anguria* L.	Cucurbitaceae	0.73
8	*Desmanthus virgatus* (L.) Willd.	Leg. Mimosoideae	0.02
9	*Ipomoea bahiensis* Willd. Ex Roem et & Schult	Convolvulaceae	0.06
10	*Melochia pyramidata* L.	Sterculiaceae	0.02
11	*Merremia aegyptia* (L.) Urban	Convolvulaceae	0.12
12	*Panicum maximum* Jacq.	Gramineae	0.03
13	*Phyllanthus amarus* Schumach. et Thonn	Euphorbiaceae	0.02
14	*Physalis angulata* L.	Solanaceae	0.03
15	*Senna accidentalis* (L.) Link	Leg. Caesalpinioideae	0.02
16	*Spigelia anthelmia* L.	Loganiaceae	0.08

Table 4 – Weed distribution in the experimental field (numbers correspond to species # in Table 3)

Block 5											
BRS 2020			AG 1051			AG 2060			PL 6880		
Intercrop.[1]	Hoeing	No hoeing	No hoeing	Hoeing	Intercrop.	Intercrop.	No hoeing	Hoeing	Intercrop.	Hoeing	No hoeing
1; 4; 5	1; 2; 4	1; 2; 6; 16	1; 2; 4	1; 4	2; 4	1; 2; 4; 6	1; 2; 4	1; 2; 4; 8	1; 2	4; 13	4; 6
Block 4											
AG 2060			PL 6880			AG 1051			BRS 2020		
Hoeing	No hoeing	Intercrop.	No hoeing	Intercrop.	Hoeing	Hoeing	Intercrop.	No hoeing	No hoeing	Intercrop.	Hoeing
4	1; 2; 4; 6	1; 2; 4; 6	1; 2; 4; 6;14	2; 3; 4; 11	1; 2; 4; 8	2; 6; 8	1; 2; 4; 11	1; 2; 4; 9	1; 2; 4; 11	1; 2; 4; 10	4; 10; 11
Block 3											
AG 1051			PL 6880			BRS 2020			AG 2060		
Hoeing	No hoeing	Intercrop.	Hoeing	Intercrop.	No hoeing	Intercrop.	No hoeing	Hoeing	Hoeing	No hoeing	Intercrop.
1; 4	2; 4; 6	1; 2; 4	1; 4	1; 2; 4; 6	1; 4	1; 4; 6	1; 2; 4; 11	2; 4	4	4	1; 4; 7
Block 2											
AG 1051			BRS 2020			PL 6880			AG 2060		
No hoeing	Hoeing	Intercrop.	No hoeing	Hoeing	Intercrop.	Intercrop.	Hoeing	No hoeing	Hoeing	Intercrop.	No hoeing
1; 2; 4	1; 4; 12	1; 2; 4	2; 4; 5; 7	1; 4; 15	1; 2; 4	1; 2; 4; 5	1; 2; 4; 8	2; 4; 7	1; 4; 7; 8	1; 2; 4; 6; 11	2; 4; 7
Block 1											
AG 2060			BRS 2020			AG 1051			PL 6880		
Intercrop.	Hoeing	No hoeing	Intercrop.	No hoeing	Hoeing	No hoeing	Hoeing	Intercrop.	No hoeing	Hoeing	Intercrop.
1; 2; 4; 6	1; 4	1; 2; 3; 4	1; 4; 5	1; 2; 4; 6; 7	1; 2; 4	1; 2	1; 2; 4; 13	1; 2; 4	2; 4	1; 4; 11	2; 4; 6; 7

[1] Intercrop. = intercropping with *Gliricidia sepium*

E-4

Twelve weed plant species were found in E-4 experiment (Table 5), most of them of Gramineae family. Some weeds occurred more frequently than others like *Commelina benghalenis* L., for instance, that was present in 81.3% of the experimental unities, meanwhile, *Merremia aegyptia* (L.) Urban and *Turnera ulmifolia* L. species were only found in 2% of the experimental unities (Tables 5 and 6). The species distribution was not homogeneous in the field areas and varied among blocks, among plots within the same block and among subplots in the same plot. For instance, 83.3% of the species was found in block 1, meanwhile only 50% was found in block 4. And in block 2, 25% of the species was found in the plot cultivated with BRS Verde and twice this percentage in the plots cultivated with BRS Safira and BRS Rubi (Table 6).

No effects of cotton cultivars or weed control treatments on the soil chemical characteristics were observed, except for the soil K and Na concentrations. Soil K did not differ between no-weed control (0.54) and intercropping (0.51) treatments, but both K contents were higher than the soil K content in shovel-dug plots (0.46). Similar results were observed for soil Na concentrations: soil-Na in plots with intercropping (0.67) was similar to soil-Na in no-weed-control plots (0.66) and both were higher than soil-Na contents found in shovel-dug plots (0.59). The soil samples chemical analyses results collected after harvest were (in average): pH = 7.49; Ca = 5.46; Mg = 2.29; K = 0.50; and Na = 0.64 $cmol_c\ dm^{-3}$; S = 7.36; and P = 70.16 mg dm^{-3}. The respective CV % values for the plots were 3.4; 15.5; 30.2; 16.8; 17.1; 14.8; and 42.6 and for the subplots, 3.8; 6.7; 18.1; 11.2; 10.2; 6.0; and 21.2.

Although differences among plant cultivars are well-known as to the uptake (WU et al., 2007), translocation (ARAO et al., 2003), accumulation CHEN et al., 2007), assimilation (CABA et al., 1993) and use (HEBBERN et al., 2005) of mineral elements, in the present experiment, the studied cultivars did not affect the soil chemical attributes. The environment condition variations can influence the plant physiological mechanisms of nutrient uptake and such variations might mask or misinform the cultivar effects on the evaluated chemical characteristics.

In the present work, soil chemical element concentrations were observed to increase or decrease with the weed control treatment, depending on the element and experiment. Such variations have been also observed by other researchers. For instance, during a long-time experiment (three years) to evaluate three weed control methods, no differences among treatments were observed in the first year, between the soil biomass C concentrations, organic matter and total nitrogen, but these variables were significantly different among treatments during the two following years (YANG et al., 2007).

Variations among treatments and experiments might be due to several factors, as for instance, when the weeds are cut and not removed from the plot (this might represent nutrient addition to the soil, since soil samples were collected from the plots only 60 days after).

Variation was also observed in the weed species distribution in the experimental area, once some species were observed to occur more frequently than others. Mycorrhiza formation is one factor involved that might explain the soil chemical differences found between plots with and without weed control (YANG et al., 2007). Maize association with mycorrhiza is known to benefit roots in the acquisition of relatively immobile nutrients like P, Cu and Zn (LIU et al., 2000). Besides, root exudates might influence not only nutrient acquisition, but also plant growth and soil ecology (BERIN et al., 2003).

Table 5 – Weed plant species occurrence in E-4 experiment

#	Botanical name	Family	Occurrence index (%)	#	Botanical name	Famíly	Occurrence index (%)
1	*Alternanthera tenella Colla*	Amaranthaceae	56.3	7	*Dactyloctenium aegyptium* (L.) Beauv	Gramineae	8.3
2	*Amaranthus viridis* L.	Amaranthaceae	29.2	8	*Ipomoea bahiensis* Willd. ex Roem. et & Schult	Convolvulaceae	22.9
3	*Cenchrus echinatus* L.	Gramineae	6.3	9	*Merremia aegyptia* (L.) Urban	Convolvulaceae	2.1
4	*Chloris virgata* Sw.	Gramineae	4.2	10	*Panicum maximum* Jacq.	Gramineae	6.3
5	*Commelina benghalenis* L.	Commelinaceae	81.3	11	*Spermacace verticillata* L.	Rubiaceae	10.4
6	*Cucumis anguria* L.	Cucurbitaceae	45.8	12	*Turnera ulmifolia* L.	Turneraceae	2.1

Source: Data obtained from experiments carried out at Experiment Station “Rafael Fernandes”, Universidade Federal Rural do Semi-Árido – UFERSA.

Table 6 – Weed plant distribution in the experimental area (numbers are referred to species # in Table 5)

Block 4											
BRS-Rubi (reddish brown fibers)			BRS-Verde (greenish fibers)			BRS-187 8H (white fibers)			BRS-Safira (brown fibers)		
Hoeing	No hoeing	Intercrop.[1]	No hoeing	Intercrop.	Hoeing	Hoeing	Intercrop.	No hoeing	No hoeing	Intercrop.	Hoeing
1; 2; 5; 11	1; 2; 5; 6	1; 5	1; 2; 6	1; 5	5	1; 5	1; 5; 6	5; 6; 8	1; 5; 6, 8	1; 2; 5	1; 5
Block 3											
BRS-187 8H (white fibers)			BRS-Verde (greenish fibers)			BRS-Safira (brown fibers)			BRS-Rubi (reddish brown fibers)		
Hoeing	No hoeing	Intercrop.	Hoeing	Intercrop.	No hoeing	Intercrop.	No hoeing	Hoeing	Hoeing	No hoeing	Intercrop.
1; 5	2; 5; 6	5	5; 7	1; 5	1; 2; 6; 11	1; 5; 6	1; 5; 6; 8	1; 5; 6	5	1; 2; 3; 5	1; 2; 5; 8
Block 2											
BRS-187 8H (white fibers)			BRS-Safira (brown fibers)			BRS-Verde (greenish fibers)			BRS-Rubi (reddish brown fibers)		
No hoeing	Hoeing	Intercrop.	No hoeing	Intercrop.	Hoeing	Intercrop.	Hoeing	No hoeing	Hoeing	Intercrop.	No hoeing
5; 8	5; 6	1; 5; 6; 8	5; 10	2; 5; 6; 8	5; 6; 8; 9	1; 5; 6	1; 5	1; 5; 6	5	1; 2; 3; 5; 6	2; 3; 7
Block 1											
BRS-Rubi (reddish brown fibers)			BRS-Safira (brown fibers)			BRS-187 8H (white fibers)			BRS-Verde (greenish fibers)		
Intercrop.	Hoeing	No hoeing	Intercrop.	No hoeing	Hoeing	No hoeing	Hoeing	Intercrop.	No hoeing	Hoeing	Intercrop.
1; 2; 5	1; 6; 7	1; 5; 6; 8; 11	1; 6; 8; 10	2; 5; 6; 8; 11	-	6	-	2; 4; 5; 10	4; 7; 11	5	5; 12

[1] Intercrop. = intercropping with *Gliricidia sepium*

An important aspect to consider about data variation is that the plant species involved in the experiments would interact during the nutrient acquisition process. In general, higher nutrient contents would be supposed to occur in plots with cut weeds, because no competition for nutrients between maize and weeds would take place and also because the left over decomposing weeds would return nutrients to the soil. In the two other treatments, nutrient removal would be supposed to occur by maize + weeds or maize + leguminosae + weeds roots absorption. This hypothesis would only be true if interactions between species would not exist (not considering the interactions with microorganisms). In other words, when more than one plant species, crop or weed is present in the same plot, the soil nutrient removal is not equal to the sum of each individual species nutrient removal when growing isolated. For instance, Sreenivas and Satyanarayana (1996) observed that maize grown without weeds, removed 186, 28 and 163 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. But, when maize was grown in the presence of weeds, the nutrient removal was correspondent to 78; 74; and 79% of the original values, respectively. The inverse was observed with the weed nutrient removal, that is, in the plots with no-weed cutting, nutrient removal corresponded to 52, 10 and 39 kg ha^{-1} (N, P_2O_5 and K_2O, respectively). With weed cutting, the values corresponded to 62%, 50% and 100 % of the estimated values without weed cutting (SREENIVAS; SATYANARAYANA, 1996). Similar results were reported in rice (Chaudhury et al., 1995) and wheat (DAS; YADURAJU, 1999). Moreover, weeds were observed to remove more nutrients in monocroppings than in intercroppings (SUBBAIAH et al., 1997). Such differentiated behavior might be due mainly to interactions among the species root systems. Maize root system was less developed in the presence of weeds (THOMAS; ALLISON, 1975), and probably, the weed root system would also be less developed in the presence of crop plants. Hence, a smaller crop root system, due to the presence of weeds, would be less efficient in nutrient uptake. For instance, more efficient plants in P acquisition are able to modify the root structure, increasing the root system size. And a greater root biomass would explore a greater soil volume (WOUTERLOOD et al., 2004). Similarly, thinner roots, with higher number of root-hairs, and longer hairs can increase the root surface area for P uptake (HORST et al., 1993).

CONCLUSIONS

It was concluded that weed control by shovel-digging or intercropping, may increase or decrease soil element concentrations, depending on the element or the experiment considered. In E-2, the shovel-dug plots presented intermediate soil pH, lower S (sum of bases) values and higher soil P concentrations, compared to the two other treatments. In E-4, soil K and Na concentrations in plots without weed control did not differ from those with intercropping, and both treatments presented higher K and Na concentrations than the weed shovel-dug plots.

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