EFFECTS OF WEED "REESTABLISHMENT" AFTER HOEING ON CORN YIELDS[1]

Efeitos do "Pegamento" das Plantas Daninhas, Após a Capina, Sobre os Rendimentos do Milho

SILVA, P.S.L.[2], OLIVEIRA, A.C.[3], OLIVEIRA, O.F.[4], FREITAS, F.C.L.[5] and SANTOS, T.S.[6]

ABSTRACT - Some growers and researchers sustain the idea that regrowth or root setting of some weeds may occur after hoeing, with detrimental effects over corn. The objective of this study was to evaluate the effects of weed removal from the field, removal after each hoeing, and corn intercropped with gliricidia on weed control and corn yield values. The experimental design consisted of blocks with split-plots and six replicates. Cultivars AG 1051 and BM 2022, planted in the plots, were submitted to the following treatments: no hoeing, two hoeings (at 20 and 40 days after planting), and intercropped with gliricidia. The hoed plots were either submitted to weed removal after the first, second, or both hoeings, or remained without weed removal. In the intercropped treatment, gliricidia was sown by broadcasting at corn planting between the corn rows, at a density of 15 seeds m^{-2}. Twenty-five weed species occurred in the experiment; the most frequent was *Digitaria sanguinalis* (family Poaceae). The weed control methods tested had similar effects on the cultivars, which were not different from one another with respect to the evaluated traits, except for one-hundred-kernel weight, with cultivar AG 1051 being superior. Weed removal did not influence green corn yield or grain yield. However, the number of kernels/ear was higher in plots where weeds were removed in relation to plots without weed removal, suggesting that weed removal might be beneficial to corn. Besides, a higher dry matter weight was obtained for the above-ground part of weeds removed from the field after the first and second hoeings than the weight of weeds removed after the second hoeing only which, in turn, was higher than the weight of weeds removed after the first hoeing only. Green ear yield, grain yield, and dry matter of the above-ground part of the weeds did not show differences in hoed plots and were superior to the non-weeded plots and the intercropped plots, which were not different from each other; therefore, intercropping with gliricidia did not improve corn yield values.

Keywords: *Zea mays*, *Gliricidia sepium*, green ear yield, grain yield.

*RESUMO - Existe a ideia, entre alguns agricultores e pesquisadores, de que após a realização das capinas à enxada poderia ocorrer o "pegamento" ou rebrota de parte das plantas daninhas, prejudicando o milho. O objetivo do trabalho foi avaliar os efeitos da remoção do campo das plantas daninhas (PD), após cada capina, e da consorciação com gliricídia sobre o controle das PD e sobre os rendimentos do milho. Utilizou-se o delineamento experimental de blocos ao acaso com parcelas subdivididas e seis repetições. As cultivares AG 1051 e BM 2022, plantadas nas parcelas, foram submetidas aos seguintes tratamentos: sem capinas, duas capinas (aos 20 e 40 dias após o plantio) e consorciação com a gliricídia. As parcelas capinadas foram submetidas à remoção das PD, após a primeira, a segunda, ou após ambas as capinas ou sem remoção das PD. Na consorciação, a gliricídia foi semeada a lanço por ocasião da semeadura do milho, entre as fileiras da gramínea, na densidade de 15 sementes m^{-2}. Vinte e cinco espécies de PD ocorreram no experimento, sendo **Digitaria sanguinalis**, pertencente à família gramineae, a mais frequente. Os métodos de controle das PD tiveram efeitos semelhantes nas cultivares, que não diferiram entre si nas características avaliadas,*

[1] Recebido para publicação em 1º.9.2010 e na forma revisada em 15.6.2010.

[2] Agronomist, Ph.D., Professor, Universidade Federal Rural do Semi-Árido – UFERSA, Caixa Postal 137, 59625-900 Mossoró-RN. CNPq fellow. <paulosergio@ufersa.edu.br>; [3] Student, UFERSA, <araceleoc@hotmail.com>; [4] Agronomist, M.Sc., Retired Professor, UFERSA, <odaci@uol.com.br>; [5] Agronomist, Ph.D., Professor UFERSA, <franciscoclaudio@ufersa.edu.br>; [6] Student, UFERSA, <tiagronomo_santos19@hotmail.com>.

exceto no peso de cem grãos, com superioridade da cultivar AG 1051. A remoção das PD não influenciou os rendimentos de milho verde e de grãos. Contudo, o número de grãos/ espiga foi maior nas parcelas em que as PD foram removidas, do que nas parcelas sem remoção dessas plantas, sugerindo que a remoção das PD pode ser benéfica ao milho. Além disso, um maior peso da matéria seca foi obtido para a parte aérea das plantas daninhas (PMSPAPD) removidas após as duas capinas, em relação ao PMSPAPD removidas apenas após a segunda capina que, por sua vez foi maior que o PMSPAPD removidas após a primeira capina, apenas. Os rendimentos de espigas verdes e de grãos e a matéria seca da parte aérea das PD não diferiram nas parcelas capinadas e foram superiores aos das parcelas não-capinadas ou consorciadas os quais não diferiram entre si; portanto, a consorciação com a gliricídia não melhorou os rendimentos do milho.

Palavras-chave: *Zea mays*, *Gliricidia sepium*, rendimento de milho verde, rendimento de grãos.

INTRODUCTION

In the Northeast region of Brazil, weed control is performed manually by small growers in practically all crops, using a hoe. In large companies, however, the use of herbicides is employed routinely. Two aspects related to weed control are discussed in this study: weed root setting and weed regrowth after hoeing, as well as an evaluation of alternative methods to the use of herbicides.

The idea exists among many small growers that hoe weeding is not as effective as it could be, since part of the hoed weed species may undergo "root setting" or regrowth. The root setting and regrowth processes would be more intense in periods of frequent rains or in irrigated crops. No reports have been found in the literature about experimental studies dealing with this idea, although some authors mention that hoe weeding may potentially cause root setting in plants that have been pulled out and whose roots remain in contact with the soil (Deuber, 2006). The root setting and regrowth processes would be more frequent in weed species with vegetative propagation. For example, *Sorghum halepense* plants originated from rhizomes would emerge earlier and grow faster than plants of the same species originated from seeds (Mitskas et al., 2003).

Although no direct experimental evidence exists that weed removal from the field to prevent weed root sets influences over corn yield, there are studies that indirectly suggest so. Potato (*Solanum tuberosum*) harvest leaves tubers in the field that originate "volunteer plants", which behave as weeds for other subsequent crops. Manual tuber removal reduced the number of tubers by 42% or more (Williams II & Boydston, 2002). On the other hand, increased tuber density reduced onion and carrot yields (Williams II et al., 2004; Williams II & Boydston, 2006). Spontaneous vegetation remaining in the crop's rows and inter-rows provided greater peach (*Prunus persica*) rootstock growth, probably because of increased soil moisture (Wagner Júnior et al., 2006). The removal of *Imperata cylindrical*, Raeuschel rhizomes from the soil before corn seeding significantly increased corn yield (Akobundu & Ekeleme, 2002). Corn hoeing effectiveness proved to be dependent on weed species and weed density (Chiovato et al., 2007).

Herbicides provide many advantages, including great application efficiency, weed control efficiency, good cost effectiveness, and selectivity (Deuber, 2006). However, in many countries, an increased interest in physical and cultural weed control methods has been observed in the past two decades (Melander et al., 2005). In part, such interest has been created due to soil and water pollution by agrochemicals, which in some countries has been caused mainly by the use of herbicides (Spliid & Koeppen, 1998). In addition to environmental pollution, herbicide use may contribute towards an impoverishment of the fauna and flora (Marshall et al., 2003) and human consumption of herbicide residues via contaminated water and foods. Besides, the extensive use of herbicides has resulted in the selection of weed biotypes resistant to these products (Christoffoleti & López-Ovejero, 2003).

Gliricidia (*Gliricidia sepium*) is a tree legume native from Mexico which may contribute to control weeds (Drumond & Carvalho Filho, 2005), supplementing or replacing the use of herbicides. The use of gliricidia branches as soil mulch did not have an allelopathic effect on corn and bean (*Phaseolus vulgaris*), but decreased the population of some weed species (Obando, 1987). Gliricidia branches used as soil mulch reduced weed density and weed biomass (Kamara et al., 2000). Gliricidia transplanted between corn rows controlled weeds to a certain extent (Silva et al., 2009). However, transplanting involves labor and resources for seedling production and transplanting. Therefore, it is interesting to evaluate if the direct sowing of gliricidia would still control weeds.

The objective of this study was to evaluate the effects of removal of the above-ground part of weeds from the field after each hoeing, and of corn intercropped with gliricidia on weed control and corn yield values.

MATERIAL AND METHODS

The study was conducted at Fazenda Experimental "Rafael Fernandes" (Experimental Farm), Universidade Federal Rural do Semi-Árido – UFERSA. The farm is located in the district of Alagoinha, 20 km away from the municipal city of Mossoró-RN (latitude 5° 11' S, longitude 37° 20' W, and 18 m elevation). According to Gaussen's bioclimatic classification, the climate in the Mossoró region is classified as type 4ath, or distinctly xerothermic, which means tropical hot with a pronounced, long dry season, lasting from seven to eight months and with a xerothermic index between 150 and 200. The mean maximum temperature in the region is between 32.1 and 34.5 °C, with June and July as the coolest months, while the mean annual precipitation is around 825 mm. Insolation increases from March to October, with a mean of 241.7 h; the maximum relative humidity reaches 78% in April while the minimum is 60% in September (Carmo Filho & Oliveira, 1989).

The soil in the experimental area was classified as Eutrophic Red-Yellow Argisol according to the Brazilian Soil Classification System (Embrapa, 1999), and as Ferric Lixisol according to the Soil Map of the World (FAO, 1988). A soil sample was analyzed and indicated the following results: pH = 6.20; P = 18.40 mg dm^{-3}; K^+ = 0.31 $cmol_c$ dm^{-3}; Ca^{2+} = 2.80 $cmol_c$ dm^{-3}; Mg^{2+} =1.30 $cmol_c$ dm^{-3}; Al^{3+} = 0.00 $cmol_c$ dm^{-3}; Na^+ = 0.16 $cmol_c$ dm^{-3}; and organic matter = 0.86 g kg^{-1}. Weed control in this area, where corn was previously grown, has always been achieved by means of two hoeings, performed at 20 and 40 days after sowing. The soil was tilled with a tractor by means of two harrowings and received 1/3 of total N applied (90 kg^{-1}), 60 kg P_2O_5, and 30 kg K_2O per ha as planting fertilization. The remaining N was applied in equal parts after each hoeing. Ammonium sulfate, single superphosphate, and potassium chloride were used as sources of N, P_2O_5, and K_2O, respectively. Plant rows were spaced 1.0 m apart, and pits in the same row were spaced 0.40 m. apart. Seeding was accomplished manually using four seeds per pit. A thinning operation was performed 20 days after planting, leaving the two more vigorous plants in each pit; the experiment was thus left with a programmed sowing density of 50 thousand plants ha^{-1}.

The fall armyworm (*Spodoptera frugiperda*), the crop's main pest in the region, was controlled with sprays of 0.0-diethyl-0.3,5.6-trichloro-2-pyridinyl thiophosphate (0.4 L ha^{-1}), using a backpack sprayer.

The experiment was sprinkler-irrigated, with experimental plots arranged perpendicularly in relation to the row of sprinklers. The water depth required for corn (5.3 mm) was calculated considering an effective depth of the root system of 0.40 m. Irrigation time was based on water retained by the soil at a tension of 0.40 Mpa. Irrigations were performed three times a week, beginning after seeding and suspended five days before harvesting the mature ears.

A randomized block experimental design in split-plots with six replicates was adopted. Each subplot consisted of four rows, each row being 6.0 m in length. The usable area was considered as the space occupied by the two central rows, from which we eliminated the plants from one of the pits at each end. Cultivars AG 1051 and BM 2022, planted in the plots, were submitted to the following treatments, applied to the subplots: no hoeing; two hoeings (at 20 and 40 days after sowing); and corn intercropped with gliricidia. In hoed plots, the weeds were either left on the soil or removed after the first hoeing, after the second hoeing, or after both hoeings. Plant removal was accomplished with a rake. The weeds removed between the two rows of the usable area were placed in an oven adjusted to 70 °C to determine dry matter weight of the above-ground part. In the intercropped treatment, gliricidia was sown by broadcasting at corn planting between the corn rows, at a density of 15 seeds m^{-2}. The gliricidia seeds, with a germination rate of practically 100%, were broadcasted on the soil surface as uniformly as possible between the corn rows, and incorporated with a rake.

One of the two rows in the usable area of each subplot was selected at random to evaluate corn green yield, while the other was used to evaluate mature corn yield. Green corn yield was evaluated by the total number and weight of ears and the number and weight of marketable ears, both unhusked and husked. Marketable unhusked ears were considered as those with appearance suitable for commercialization and length equal to or above 22 cm. Marketable husked ears were considered as those that displayed health and grain sets suitable for commercialization, and length equal to or above 17 cm. Evaluations were made in mature corn for grain yield and its components. The ears produced in the usable area of each subplot were harvested when the grain achieved a water content of about 20%, and were then placed to dry and subsequently threshed out manually. The numbers of ears thus obtained and their grain allowed to estimate number of ears per hectare and grain yield. Number of kernels per ear was estimated based on the kernels counted in ten of those ears. 100-kernel weight was obtained from five samples containing 100 kernels each.

After harvesting the mature corn, evaluations were obtained for plant height and corn ear height, weed dry matter, and weed floristic composition. Plant height and ear height were measured in all plants of the row that was selected for evaluation of grain yield. The distance from ground level to the point of insertion of the tallest leaf blade was considered as plant height; ear height was measured from ground level to the base of the tallest ear (first ear, in the case of prolific plants). The weeds found in a 1.0 x 1.0 m area, established at random in the central part of the subplot, were cut even with the ground, identified, and weighed. The occurrence index, defined by the ratio between number of units where a given species occurred and the total number (60) of experimental units in the experiment, was calculated after the weed species found in each experimental unit were identified.

The data were submitted to analysis of variance using SAEG, a software program developed by Universidade Federal de Viçosa (Ribeiro Junior, 2001). The means were compared at 5% probability by Tukey's test whenever the F test values from the analysis of variance were significant. The data were submitted to the variance homogeneity test prior to the statistical analyses (Bartlett, 1937).

RESULTS AND DISCUSSION

Twenty-five weed species were found in the experiment area (Table 1). The predominant species were *Alternanthera tenella, Ipomoea bahiensis, Commelina benghalensis*, and *Digitaria sanguinalis*, which occurred in approximately 50, 61, 65, and 97% of the experiment's 72 subplots, respectively. That is, among all species found, 16% were predominant. The other species occurred in 15.3% or less of the experimental units. There were variations in the distribution of weed species that occurred in the experiment: between blocks, between plots of the same block, and between subplots of the same plot (Figure 1).

No observations were made for gliricidia, but in another experiment (data not published) conducted in a neighboring area it was observed that, after harvesting the mature corn, gliricidia had 48% survival and a plant height of 34.0 cm.

No effect was observed for the interaction between cultivars x weed control methods. For this reason, only the means for the main effects of both treatment groups are presented here.

Table 1 **-** Index of occurrence (number of experimental units where a given weed species occurred/total number of experimental units) of weed species and their respective families, identified in a corn experiment, at mature ear harvest time. Mossoró-RN, 2008

Order number	Species	Family	Occurrence index (%)
1	*Adenocalymma* sp.	Bignoniaceae	2.8
2	*Amaranthus viridis* L.	Amaranthaceae	9.7
3	*Alternanthera tenella* Colla	Amaranthaceae	50.0
4	*Bauhinia pentandra (Bong.)* Vogel ex Steud	Caesalpinaceae	1.4
5	*Borreria verticillata* (L.) G. Mey	Rubiaceae	12.5
6	*Cenchrus echinatus* L.	Poaceae	9.7
7	*Centrosema brasilianum* (L.) Benth.	Fabaceae	1.4
8	*Centrosema pascuorum* Mart. ex Benth.	Fabaceae	1.4
9	*Commelina benghalensis* L.	Commelinaceae	65.3
10	*Cucumis anguria* L.	Cucurbitaceae	15.6
11	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae	2.8
12	*Desmodium glabrum* (Mill.) DC.	Fabaceae	4.2
13	*Digitaria sanguinalis Scop.*	Poaceae	97.2
14	*Euphorbia hirta* L. (*Chamaesyce hirta* (L.) Millsp.)	Euphorbiaceae	12.5
15	*Euphorbia hyssopifolia* L. (*Chamaesyce hyssopifolia* (L.) Small)	Euphorbiaceae	9.7
16	*Herissantia crispa* (L.) Brizicky	Malvaceae	2.8
17	*Ipomoea bahiensis* Willd. ex Roem & Schult	Convolvulaceae	61.1
18	*Merremia aegyptia* (L.) Urb.	Convolvulaceae	6.9
19	*Portulaca* sp.	Portulacaceae	4.2
20	*Phyllanthus amarus* Schumach. & Thonn.	Euphorbiaceae	2.8
21	*Physalis angulata* L.	Solanaceae	1.4
22	*Schranckia leptocarpa* DC. (*Mimosa quadrivalvis* L. var. *leptocarpa* (DC) Barneby	Mimosaceae	2.8
23	*Senna obtusifolia* (L.) H.S. Irwin & Barneby	Caesalpinaceae	2.8
24	*Solanum agrarium* Sendtn	Solanaceae	1.4
25	*Turnera ulmifolia*	Turneraceae	1.4

A higher dry matter weight was obtained for the above-ground part of weeds removed from the field after the first and second hoeings than the weight of weeds removed after the second hoeing only which, in turn, was higher than the weight of weeds removed after the first hoeing only (Table 2). Weed density begins to increase in the beginning of the corn development cycle; without weed control, weed density peaks at about 28 days after corn seeding (Ramos & Pitelli, 1994). From then on, density begins to decrease (Ramos & Pitelli, 1994), due to the end of the cycle for some individuals and to marked mortality of others, caused by intense competition (Soares et al., 2003).

As the first hoeing was performed, if no root setting or regrowth of hoed plants occurred, it would be expected that dry matter weight of the above-ground part after the second hoeing would be around the same dry matter weight of the above-ground part after the first hoeing. Although the soil tillage provided by hoeing may favor the germination of new seeds and the emergence of new weed species (Heisel et al., 2002), competition with corn as early as at 20 days of age would have a tendency to reduce weed growth. In this study, dry matter weight of the above-ground part of weeds collected after the second hoeing was higher than the weight of species collected after the first hoeing. This suggests that root setting or regrowth of weeds occurred after the hoeing operations were performed. Dry matter of the above-ground part of weeds after the second hoeing would be the sum of the above-ground part of "old" weeds that "reestablished their roots" plus the above-ground part of "new" weeds that appeared after the first hoeing. Reestablished weeds ("old ones") would continue to growth after the hoeing operation, even because they were now free from the competition with weeds that were not able to reestablish. The higher dry matter weight of weeds removed after both hoeings is obviously due to the fact that it is the result of the dry matter sum of weeds removed by each individual hoeing.

The above propositions about weed root setting or regrowth after hoeing are supported by the regrowth observed in *Galium aparine*, *Galeopsis retrahit*, *Polygonum convolvulatus*, and

Block	Treatment											
	Cultivar											
1	BM 2202						AG 1051					
	Weed control methods						Weed control methods					
	with gliricidia	1st w and 2nd w/o	1st and 2nd w/o	No hoeing	1st w/o and 2nd w	1st w and 2nd w	1st w and 2nd w/o	1st w/o and 2nd w	1st and 2nd w/o	No hoeing	with gliricidia	1st w and 2nd w
Species	9,13,18	6,9,13,18	9,13,14,17	9,13,17	6,9,10,13	3,9,13,22	3,6,9,13,17	1,3,9,13	5,9,13,14	9,13,17,21	6,13,14,17	5,13,17,23
2	AG 1051						BM 2202					
	with gliricidia	1st and 2nd w/o	1st w and 2nd w/o	1st w and 2nd w	1st w/o and 2nd w	No hoeing	with gliricidia	1st w and 2nd w/o	No hoeing	1st w and 2nd w	1st w/o and 2nd w	1st and 2nd w/o
Species	9,13,18	9,10,13,17	2,9,13,15	3,9,13,17	2,10,13,14	3,9,13,17	3,9,13,15	9,13,20	9,10,13,17	9,13,14,17	5,13,14	5,13,14,17
3	AG 1051						BM 2202					
	No hoeing	1st w/o and 2nd w	1st w and 2nd w	with gliricidia	1st w and 2nd w/o	1st and 2nd w/o	No hoeing	1st w and 2nd w	1st w and 2nd w/o	with gliricidia	1st w/o and 2nd w	1st and 2nd w/o
Species	3,13,17,18	9,13,17	3,9,11,13	3,10,13,17,23	3,9,10,13	9,10,12,13	3,13,15,17	2,9,13,17	3,9,13,15	9,10,13	3,7,9,13,14	3,7,12,13,17
4	BM 2202						AG 1051					
	1st w and 2nd w/o	No hoeing	with gliricidia	1st w and 2nd w	1st and 2nd w/o	1st w/o and 2nd w	1st w and 2nd w/o	with gliricidia	1st w/o and 2nd w	1st w and 2nd w	No hoeing	1st and 2nd w/o
Species	3,9,13,18	3,9,13,17	3,9,17	2,8,10,13	2,9,13,17	3,9,13,15,17	3,9,13,17,19	9,13,17	3,9,12,13,17	3,9,13,17	5,13,17	6,11,13,14,17
5	BM 2202						AG 1051					
	1st w/o and 2nd w	1st w and 2nd w	No hoeing	1st and 2nd w/o	1st w and 2nd w/o	with gliricidia	with gliricidia	No hoeing	1st and 2nd w/o	1st w and 2nd w	1st w/o and 2nd w	1st w and 2nd w/o
Species	3,9,13,17	3,9,10,13,17	3,9,13,16,	2,3,5,13,17	3,13	3,9,15,17	3,13,17,24	9,12,13,17	1,3,4,13	9,13	6,13,17	13,17,19
	AG 1051						BM 2202					
6	1st and 2nd w/o	1st w and 2nd w	No hoeing	with gliricidia	1st w/o and 2nd w	1st w and 2nd w/o	1st and 2nd w/o	1st w and 2nd w	1st w and 2nd w/o	No hoeing	1st w/o and 2nd w	with gliricidia
Species	2,6,9,13,19	3,13,17	9,13,17,20	3,13,15,16,17	3,5,13	3,5,9,13	3,13,17,25	5,9,13,17	9,13,17	3,9,13,17	5,13,22	3,10,13,16,17

Figure 1 **-** Distribution of weed species in the experimental units, arranged in a random block design with split-plots, of corn cultivars submitted to the following weed control methods: no hoeing; first hoeing without weed removal and second hoeing without weed removal (1st and 2nd w/o); first hoeing without weed removal and second hoeing with weed removal (1st w/o and 2nd w); first hoeing with weed removal and second hoeing without weed removal (1st w and 2nd w/o); first hoeing with weed removal and second hoeing with weed removal (1st w and 2nd w); and corn intercropped with gliricidia (15 seeds m^{-2}) (with gliricidia). The species numbers correspond to the order numbers shown in Table 1.

Table 2 - Means (of six replicates and two cultivars) for dry matter of the above-ground part of weeds, removed after hoeing or after mature ear harvest, that occurred in plots of corn cultivars AG 1051 and BM 2202 submitted to weed control methods, and for plant height and ear height of corn[1/]

Weed control method [2/]	Dry matter of removed weeds (g m^{-2})		Corn height (cm)	
	After hoeing	After corn harvest	Plant	Ear
Weed removal after the 1 st and 2nd hoeings	154.0 a	34.0 b	159 a	80 a
Weed removal after the 2nd hoeing only	86.0 b	23.0 b	161 a	82 a
Weed removal after the 1st hoeing only	11.0 c	38.0 b	159 a	80 a
No weed removal after hoeing	-	73.0 b	155 a	77 a
Corn intercropped with *Gliricidia sepium*	-	218.0 a	151 a	77 a
No hoeing	-	207.0 a	150 a	76 a
Means for cultivars AG 1051 and BM 2202	84.0	99.0	156	79
CV plots, %	66.4	49.9	15.3	21.7
CV subplots, %	66.9	71.9	8.2	11.9

[1/]Means followed by the same letter are not different at 5% probability by Tukey's test. [2/] Weed removal = weed removal from the experimental field with a rake, after hoeing at 20 and 40 days after corn seeding; in the intercrop, gliricidia was sown by broadcasting (15 seeds m^{-2}), between corn rows at corn seeding.

Avena fatua, after they were cut 5 cm or 8 cm above the soil surface (Andreasen et al., 2002). The higher cutting height increased biomass production by 100% to 400% in all species. In one of them, cutting at 8 cm resulted in higher biomass production (30%) than in non-cut plants. The mechanisms by which plants compensate the loss of tissues caused by cutting or pruning include: increased photosynthesis rate in residual tissues; increased allocation of photosynthates for new leaf blades; reallocation of substrates from other plant sites to shoots; removal of old, less photosynthetically active tissues; higher light intensity in tissues located in lower plant parts; greater tillering or development of shoots after the removal of apical or dominant meristems; and greater water use efficiency via reduction of the transpiration surface. Differences in the morphological and physiological responses to cutting result in different compensatory capacities of the species (Andreasen et al., 2002).

Non-hoed plots and intercropped plots did not differ from one another with regard to dry matter weight of the above-ground part of weeds after harvesting the mature ears, but both were inferior to hoed plots, which did not differ from one another, with or without removal of the hoed weeds from the field (Table 2). Although some weeds may become reestablished (rooted), hoeing should permanently eliminate some individuals; consequently, non-hoed plots should have higher weed dry matter weights at the end of the crop cycle. It is worth noting that dry matter weight of the above-ground part of weeds in plots where the weeds were not removed was almost twice as high as dry matter weight of the above-ground part of weeds in hoed plots where they were not removed.

There was no weed control effect on plant height and corn ear height (Table 2). Also, the cultivars had no effect on plant height (Table 2), but cultivar AG 1051 had plants with higher ear height (84 cm) than cultivar BM 2022 (72 cm). Such lack of weed control effect on corn plant height and ear height has also been observed by other authors (Silva et al., 2009).

No differences were found between hoed plots and all were superior to non-hoed or intercropped plots, which in turn were not different from one another compared to the traits employed to evaluate green ear yield (Table 3). A similar observation was made for grain yield, number of mature ears ha^{-1}, and one hundred-kernel weight (Table 4). With regard to number of kernels ear^{-1} between hoed plots, weed removal after both hoeings provided the highest mean; no removal provided the lowest mean; intermediate means were observed in plots where weeds were removed after either the first or second hoeing (Table 4). Weed removal would prevent some plants from reestablishing, reducing their competition with corn. Anyhow, considering all treatments, the poorest results for number of kernels ear^{-1} were observed in non-hoed or intercropped plots. No differences were observed between cultivars for the traits employed to evaluate green ear yield, or for grain yield and its components, except for 100-kernel weight, which was higher in cultivar AG 1051 (25.7 g) than in cultivar BM 2022 (21.8 g).

The results observed for dry matter weight of weeds after each hoeing (Table 2) and for number of kernels ear^{-1} (Table 4) suggest that weed removal must be beneficial to obtain higher corn green ear yield and grain yield, although the differences between yields observed in the present work were not significant (Tables 3 and 4). Weed removals from the field after both hoeings determined higher yields than those obtained without weed removal. In the case of green ear yield, the superiority that was observed in all traits used to evaluate yield ranged from 3.4% (total number of ears ha^{-1}) to 21.7% (marketable husked ear weight) (Table 3). In the case of grain yield, a 14.7% superiority was obtained (Table 4). Weed removal from the field implies in some practical issues. The cost effectiveness of the procedure is one of the

Table 3 - Means (of six replicates and two cultivars) for green ear yield of corn cultivars AG 1051 and BM 2202 submitted to weed control methods[1/]

Weed control method[2/]	Green ear totals ha^{-1}		Marketable unhusked green ears ha^{-1}		Marketable husked green ears ha^{-1}	
	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)
Weed removal after the 1st and 2nd hoeings	48,768 a	14,087 a	46,148 a	13,759 a	35,945 a	7,546 a
Weed removal after the 2nd hoeing only	48,187 a	13,643 a	45,107 a	13,252 a	35,343 a	7,411 a
Weed removal after the 1st hoeing only	45,856 a	13,093 a	42,008 a	12,588 a	34,313 a	6,998 a
No weed removal after hoeing	47,163 a	12,687 a	43,138 a	12,159 a	31,326 a	6,202 a
Corn intercropped with *Gliricidia sepium*	37,203 b	77,95 b	28,774 b	6,570 b	14,345 b	2,732 b
No hoeing	34,747 b	74,12 b	27,265 b	6,487 b	13,839 b	2,516 b
Means for cultivars AG 1051 and BM 2202	43,652	11,453	38,740	10,802	27,518	5,568
CV plots, %	15.9	22.4	20.9	23.0	37.7	37.2
CV subplots, %	13.4	18.9	16.3	21.5	28.3	31.4

[1/]Means followed by the same letter are not different at 5% probability by Tukey's test. [2/] Weed removal = weed removal from the experimental field with a rake, after hoeing at 20 and 40 days after corn seeding; in the intercrop, gliricidia was sown by broadcasting (15 seeds m^{-2}), between corn rows at corn seeding.

Table 4 - Means (of six replicates and two cultivars) for grain yield and its components in corn cultivars AG 1051 and BM 2202 submitted to weed control methods[1/]

Weed control method[2/]	Grain yield (kg ha^{-1})	Number of mature ears ha^{-1}	Number of kernels ear^{-1}	100-kernel weight (g)
Weed removal after the 1st and 2nd hoeings	6,286 a	47,658 a	481.8 a	27.4 a
Weed removal after the 2nd hoeing only	5,933 a	48,482 a	462.1 ab	26.4 a
Weed removal after the 1st hoeing only	5,759 a	48,666 a	455.6 ab	26.3 a
No weed removal after hoeing	5,482 a	47,916 a	418.4 b	27.5 a
Corn intercropped with *Gliricidia sepium*	2,274 b	38,059 b	329.3 c	17.5 b
No hoeing	2,034 b	34,838 b	327.4 c	17.5 b
Means for cultivars AG 1051 and BM 2202	4,628	44,270	412.5	23.8
CV plots, %	21.0	9.5	12.3	14.6
CV subplots, %	18.8	10.4	12.4	12.5

[1/]Means followed by the same letter are not different at 5% probability by Tukey's test. [2/] Weed removal = weed removal from the experimental field with a rake, after hoeing at 20 and 40 days after corn seeding; in the intercrop, gliricidia was sown by broadcasting (15 seeds m^{-2}), between corn rows at corn seeding.

most relevant considerations. Weed removal almost corresponds to a new hoeing. In addition, if not removed, the weeds could benefit physical, chemical, and biological soil properties.

Intercropping with gliricidia was not beneficial to corn, in disagreement with other authors (Silva et al., 2009) who observed that such intercropping provided intermediate yields in relation to those obtained with hoed and non-hoed plots. What must occur is that intercropping as a weed control method is probably influenced by environmental conditions, including the corn cultivars themselves.

Interference by weeds determined lower green ear yield and grain yield (Table 4). Weeds decrease crop yield values by competing with them for water, nutrients, and light (Carruthers et al., 1998). However, other aspects must be involved.

The corn root system becomes less developed in the presence of weeds (Thomas & Allison, 1975). Consequently, a smaller corn root system due to the presence of weeds would be less efficient in absorbing nutrients and water. When infested by weeds, corn develops water stress symptoms earlier than when it is weed-free (Tollenaar et al., 1997). Water deficit induces stomatal closure, stopping photosynthesis and dramatically reducing corn yield when in competition with weeds (Silva et al., 2004).

Light intensity and light quality are factors involved in the competition for light. A trait present in corn is that most of the light is intercepted by the younger and more efficient leaves, located above the ear; less than 10% of the photon flux density (PFD) reaches the leaves below 1.0 m. On the other hand, most weeds, during and after blooming, are below 1.0 m. Consequently, the competition between corn and weeds for incident PFD is relatively small at the more advanced growth stages. Such competition should be higher at the initial corn growth stages. The leaf area index (LAI) defines a plant's ability to intercept incident PFD and is an important factor that determines dry matter accumulation. High competition by weeds reduced corn LAI at the blooming stage by 15% (Tollenaar et al., 1994). As a consequence, yield losses resulting from competition for light are better explained by the reduction in LAI than by smaller photosynthetic rates in shaded leaves (Rajcan & Swanton, 2001). In fact, some authors (Aflakpui et al., 2002) observed leaf area reductions due to competition with weeds.

The lower corn leaves also receive light of a different quality than leaves that receive full sunlight. The light inside the canopy is rich in far-red radiation, FR, (730 to 740 nm). This is caused by the selective absorption of red light, R (660-670 nm) by photosynthetic pigments and by the reflection of FR light by green leaves. This makes the far-red/red ratio (FR/R) greater in the bottom portion than in the upper portion of the canopy. The FR/R ratio plays an important role in the induction of many morphological changes in the plant architecture (Salisbury & Ross, 1991). Shaded plants tend to allocate greater leaf area in the upper portion of the canopy where more light is available, while plants grown in full sunlight have a more pyramidal leaf area distribution, which limits shading on the bottom leaves by the upper leaves. As previously mentioned, although weeds in general do not shade corn, there are indications that corn grown in the presence of weeds receives a higher FR/R ratio than a weed-free crop (Rajcan & Swanton, 2001).

It can be concluded that twenty-five weed species occurred in the experiment; the most frequent was *Digitaria sanguinalis*, which belongs to family Gramineae (Poaceae). The weed control methods had similar effects on both cultivars, which were not different from one another regarding the evaluated traits, except for 100-kernel weight and corn ear height, with cultivar AG 100 being superior. Weed removal from the field after hoeing did not influence green corn yield or grain yield. However, the number of kernels ear^{-1} increased when the weeds were removed after hoeing, suggesting that removal is beneficial to corn. Besides, a higher dry matter weight was obtained for the above-ground part of weeds removed from the field after the first and second hoeings than the weight of weeds removed after the second hoeing only which, in turn, was higher than the weight of weeds removed after the first hoeing only. Green ear yield, grain yield, and dry matter of the above-ground part of the weeds did not show differences in hoed plots and were superior than the non-weeded plots and the intercropped plots, which were not different from each other; therefore, intercropping with gliricidia did not improve corn yield values.

LITERATURE CITED

AFLAKPUI, G. K. S.; GREGORY, P. J.; FROUD-WILLIAMS, R. J. Growth and biomass partitioning of maize during vegetative growth in response to *Striga hermonthica* infection and nitrogen supply. **Exper. Agric.**, v. 38, n. 1, p. 265-276, 2002.

AKOBUNDU, I. O.; EKELEME, F. E. Effect of method of *Imperata cylindrica* management on maize grain yield in the derived savanna of south-western Nigeria. **Weed Res.**, v. 40, p. 335-341, 2002.

ANDREASEN, C. et al. Regrowth of weed species after cutting. **Weed Technol.**, v. 16, p. 873-879, 2002.

BARTLETT, M. S. Some examples of statistical methods of research in agriculture and applied biology. **J. Roy Stat. Soc.**, v. 4, n. 1, p. 137-183, 1937.

CARMO FILHO, F.; OLIVEIRA, O. F. **Mossoró:** um município do semi-árido nordestino. Mossoró: Fundação Guimarães Duque/ESAM, 1989. 62 p. (Coleção Mossoroense, Série B. n. 672).

CARRUTHERS, K. et al. Intercropping corn with soybean, lupin and forages: weed control by intercrops combined with interrow cultivation. **Europ. J. Agron.**, v. 8, n. 2, p. 225-238, 1998.

CHIOVATO, M. G. et al. Diferentes densidades de plantas daninhas e métodos de controle nos componentes de produção do milho orgânico. **Planta Daninha**, v. 25, n. 2, p. 277-283, 2007.

CHRISTOFFOLETI, P. J.; LÓPEZ-OVEJERO, R. Principais aspectos da resistência de plantas daninhas ao herbicida glyphosate. **Planta Daninha**, v. 21, n. 3, p. 507-515, 2003.

DEUBER, R. Métodos de manejo das plantas infestantes. In: DEUBER, R. **Ciência das plantas infestantes:** fundamentos. Jaboticabal: FUNEP, 2006. p. 106-148.

DRUMOND, M. A.; CARVALHO FILHO, O. M. **Espécies vegetais exóticas com potencialidades para o semi-árido brasileiro**. Brasília: Embrapa semi-árido/Embrapa Informação Tecnológica, 2005. 340 p.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA – EMBRAPA. Centro Nacional de Pesquisa do Solo. **Sistema brasileiro de classificação de solos**. Brasília: Serviço de Produção de Informação, 1999. 412 p.

FAO. **Soil map of the world; revised legend**. Rome: UNESCO, 1988. 119 p.

HEISEL, T.; ANDREASEN, C.; CHRISTENSEN, S. Sugarbeet yield response to competition from *Sinapsis arvensis* or *Lolium perenne* growing at three different distances from the beet and removal at various times during early growth. **Weed Res.**, v. 42, p. 406-413, 2002.

KAMARA, A. Y. et al. Selective control of weeds in an arable crop by mulches from some multipurpose trees in Southwestern Nigeria. **Agrofor. Syst.**, v. 50, n. 1, p. 17-26, 2000.

MARSHALL, E. J. P. et al. The role of weeds in supporting biological diversity within crop fields. **Weed Res.**, v. 43, n. 1, p. 77-89, 2003.

MELANDER, B.; RASMUSSEN, I. A.; BÀRBERI, P. Integrating physical and cultural methods of weed control – examples from European research. **Weed Sci.**, v. 53, p. 369-381, 2005.

MITSKAS, M. B. et al. Interference between corn and johnsongrass (*Sorghum halepense*) from seed or rhizomes. **Weed Sci.**, v. 51, p. 540-545, 2003.

OBANDO, L. Potencial alelopatico de *Gliricidia sepium* (Jacq.) Walp. sobre los cultivos de maiz y frijol y las malezas predominantes (abstract). In: WITHINGTON, D.; GLOVER, N.; BREWBAKER, J. L. (Eds.). ***Gliricidia sepium* (Jacq.) Walp**.: management and improvement. Wiamanalo: Nitrogen Fixing Tree Association (NFTA), 1987. p. 59-60. (Special NFTA Publication , 87-01).

RAJCAN, J.; SWANTON, C. J. Understanding maize-weed competition: resource competition, light quality and the whole plant. **Field Crops Res.**, v. 71, p. 139-150, 2001.

RAMOS, L. R. M.; PITELLI, R. A. Efeitos de diferentes períodos de controle da comunidade infestante sobre a produtividade da cultura do milho. **Pesq. Agropec. Bras.**, v. 29, n. 10, p. 1523-1531, 1994.

RIBEIRO JÚNIOR, J. I. **Análises estatísticas no SAEG**. Viçosa, MG: Universidade Federal de Viçosa, 2001. 301 p.

SALISBURY, F. B.; ROSS, C. W. **Plant physiology.** 4.ed. Belmont: Wadsworth, 1991. 459 p.

SILVA, P. S. L. et al. Weed control via intercropping with gliricidia. II. Corn crop. **Planta Daninha**, v. 27, n. 1. p. 105-112, 2009.

SILVA, A. A.; VARGAS, L.; WERLANG, R. C. Manejo de plantas daninhas na cultura do milho. In: GALVÃO, J. C. C.; MIRANDA, G. V. **Tecnologias de produção do milho**. Viçosa, MG: Universidade Federal de Viçosa, 2004. p. 269-310.

SOARES, D. J. et al. Períodos de interferência das plantas daninhas na cultura de cebola (*Allium cepa*) transplantada. **Planta Daninha**, v. 21, n. 3, p. 387-396, 2003.

SPLIID, N. H.; KOEPPEN, B. Occurrence of pesticides in Danish shallow ground water. **Chemosphere**, v. 37, p. 1307-1316, 1998.

THOMAS, P. E. L.; ALLISON, J. C. S. Competition between maize and *Rottboellia exaltata*. **J. Agric. Sci.**, v. 84, n. 1, p. 305-312, 1975.

TOLLENAAR, M. et al. Effects of weed interference and soil nitrogen on four maize hybrids. **Agron. J.**, v. 86, p. 596-601, 1994.

TOLLENAAR, M.; AGUILERA, A.; NISSANKA, S. P. Grain yield is reduced more by weed interference in an old thain in a new maize hybrid. **Agron. J.**, v. 89, n. 1, p. 239-246, 1997.

WAGNER JÚNIOR, A. et al. Influência do manejo da cobertura vegetal sobre a umidade do solo e crescimento do porta-enxerto de pessegueiro 'Okinawa'. **R. Bras. Agroci.**, v. 12, n. 1, p. 99-103, 2006.

WILLIAMS II, M. M.; BOYDSTON, R. A. Effect of shoot removal during tuberization on volunteer potato (*Solanum tuberosum*) tuber production. **Weed Technol.**, v. 16, p. 617-619, 2002.

WILLIAMS II, M. M.; RANSOM, C. V.; THOMPSON, W. M. Effect of volunteer potato density on bulb onion yield and quality. **Weed Sci.**, v. 52, p. 754-758, 2004.

WILLIAMS II, M. M.; BOYDSTON, R. A. Volunteer potato interference in carrot. **Weed Sci**., v. 54, n. 1p. 94-99, 2006.