horticultura brasileira

Pesquisa / *Research*

MONTEIRO, AL; SILVA, PSL; TAVELLA, LB; OLIVEIRA, FHT; SILVA, PIB. 2016. *Mimosa caesalpiniifolia* intercropping, weeds removal after hoeing and nitrogen fertilization on maize. *Horticultura Brasileira* 34: 175-182. DOI - http://dx.doi.org/10.1590/S0102-053620160000200005

Mimosa caesalpiniifolia intercropping, weeds removal and nitrogen fertilization on maize

Alex L Monteiro; Paulo SL Silva; Leonardo B Tavella; Fábio HT Oliveira; Paulo IB Silva

Universidade Federal Rural do Semi-árido (UFERSA), Mossoró-RN, Brazil; alex_monteiro02@hotmail.com; paulosergio@ufersa.edu.br; leo_tavella@hotmail.com; fabio@ufersa.edu.br; pauloigorbs@gmail.com

ABSTRACT

Weeding is expensive and laborious, and some weeds may re-establish themselves afterwards. Arboreal leguminous plants can control weeds, and fertilization with nitrogen can increases the competitive ability of the maize. The aim of this work was to evaluate the effects of weed-removal and intercropping with sabiá (*Mimosa caesalpiniifolia*) on control of weed plants and maize productivity. A randomized complete block design in a split-plot arrangement was used with five replications. Cultivar AG 105, fertilized with nitrogen (30 and 120 kg/ha of N applied to the plots) was subjected to the following treatments (subplots): A) no weeding; B) intercropping with sabiá (30 viable seeds/m^2, broadcast between the rows of maize); C) hoeing [20 and 40 days after sowing (DAS)] with no removal of weeds (nROW); D) two hoeings at 20 and 40 DAS with ROW at 20 DAS; E) two hoeings at 20 and 40 DAS with ROW at 40 DAS; F) and two hoeings at 20 and 40 DAS with ROW after each hoeing. Increasing the dose of nitrogen reduced the growth of the sabiá (30%) and weeds (32%) and increased the corn green ear yield (115%) and grain yield (40%) of maize. Sabiá did not reduce the growth of weeds, but it was beneficial to corn because increased the number of green ears. Carrying out two hoeings, with or without the removal of weeds, reduced weed growth (92%) and provided the highest yields of green ears (5.6 t/ha) and grains (6.0 t/ha).

Keywords: *Zea mays*, green corn, grain yield, hoeing.

RESUMO

Consorciação com *Mimosa caesalpiniifolia*, remoção das plantas daninhas e adubação nitrogenada em milho

As capinas são caras e trabalhosas e algumas plantas daninhas podem se "reestabelecer" após as capinas. A consorciação com leguminosas arbóreas pode controlar plantas daninhas e a adubação com nitrogênio aumenta a habilidade competitiva do milho. O objetivo do trabalho foi avaliar os efeitos da remoção das plantas daninhas e da consorciação com sabiá (*Mimosa caesalpiniifolia*) no controle das plantas daninhas e nos rendimentos do milho. Utilizou-se o delineamento de blocos ao acaso com parcelas subdivididas e cinco repetições. A cultivar AG 105, adubada com nitrogênio (30 e 120 kg de N/ha aplicados nas parcelas) foi submetida aos seguintes tratamentos (subparcelas): A) sem capinas; B) consorciação com a sabiá (30 sementes viáveis/m^2 a lanço entre as fileiras do milho; C) duas capinas (20 e 40 dias após a semeadura, DAS), sem remoção das plantas daninhas (nROW); D) duas capinas, com ROW aos 20 DAS; E) duas capinas, com ROW aos 40 DAS; F) duas capinas, com ROW após cada capina. O aumento da dose de nitrogênio reduziu os crescimentos da sabiá (30%) e das plantas daninhas (32%), mas aumentou a habilidade competitiva e os rendimentos de espigas verdes (115%) e de grãos (40%) do milho. A consorciação com a sabiá não reduziu o crescimento das plantas daninhas, mas pode ser benéfica ao milho, pois aumentou o número de espigas verdes. A realização de duas capinas, com ou sem remoção do mato, reduziu o crescimento das plantas daninhas (92%) e propiciou os maiores rendimentos de espigas verdes (5,6 t/ha) e de grãos (6,0 t/ha).

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

(Recebido para publicação em 17 de setembro de 2014; aceito em 27 de agosto de 2015)
(*Received on September 17, 2014; accepted on August 27, 2015*)

Maize (*Zea mays*) is one of the most important crops in the Brazilian state of Rio Grande do Norte and is cultivated for the production of both green ears and grain in the 167 municipalities of the state. The average grain yield of the crop in the state for the last ten years is approximately 520 kg/ha, according to the National Company for Provisions (CONAB, 2014). There is no information on the green-ear yield, but it is likely low, because the same problems associated with cultivars and cultural practices occur in the production of both products.

Among the problems related to farming practices are the disregard for weed control and the use of fertilizers. Large companies use fertilizers and herbicides, but most crops are cultivated in Rio Grande do Norte with no fertilization and with weeding being done by hoe. According to some farmers, some weeds can "re-establish" or "take" after the weeding, resulting in reduced crop yields. Silva *et al*. (2010b) saw indications that this opinion is true for maize. The removal of the vegetative organs of weeds before planting maize also supports the view of farmers (Boydston *et al*., 2008). Weeding is laborious, expensive and time consuming. However, the application of herbicides, although effective in controlling weeds, can cause environmental damage and contribute to the selection of resistant weed biotypes.

So, farming methods should be researched regarding weed control on maize crop (Melo *et al*., 2007).

The soil covering with branches of *Gliricidia* (*Gliricidia sepium*) had no allelopathic effect on the maize, but did reduce the weed population (Kamara *et al*., 2000). These results have encouraged studies of maize intercropping with *Gliricidia* (Silva *et al*., 2009a, 2009b), a perennial leguminous plant native to Mexico (Drumond & Carvalho Filho, 2005). Silva *et al*. (2009a) concluded that plots of maize intercropped with *Gliricidia* presented averages for maize yield intermediate between the averages of non-weeded and weeded plots, indicating that *Gliricidia* was beneficial to the maize and exercised some control over the weeds. However, *Gliricidia* did not afford weed control in maize subjected to applications of nitrogen (Silva *et al*., 2010a). In addition, with the application of 120 kg/ha of N, weed control had no effect on the growth and yield of green ears, indicating that nitrogen improves the competitive capacity of the maize (Silva *et al*., 2010a).

The control of weeds gained by intercropping with *Gliricidia* stimulated studies with other arboreal species used for the same goal. Silva *et al*. (2013) found that *Mimosa caesalpiniifolia*, known locally as sabiá, a leguminous plant native to northeastern Brazil (Maia, 2004), also partially controlled weeds. There is, therefore, interest in evaluating intercropping with sabiá with the application of nitrogen for the control of weeds in maize. The objective of this work was to evaluate the effects of removing weeds (using a rake) from the field after hoeing and of intercropping with sabiá on weed control and the yield of the maize cultivar AG 1051 when subjected to the application of nitrogen.

MATERIAL AND METHODS

The research was performed at the Rafael Fernandes Experimental Farm of the Federal Rural University of the Semi-Arid (UFERSA). The farm is located in the district of Alagoinha, 20 km far from Mossoró (5º11'S, 37º20'W, altitude of 18 m). According to the Gaussen bioclimatic classification, the climate in the Mossoró region is of the 4a type, severe thermo-*xerochimenic*, being tropical, hot and markedly dry, with a long dry season of seven to eight months and a xerothermic index between 150 and 200. The region has a maximum average air temperature between 32.1 and 34.5°C, with June and July being the coldest months. The average annual rainfall is approximately 825 mm (Carmo Filho & Oliveira, 1989).

The soil of the experimental area is classified as a Red-Yellow Argisol according to the Brazilian System of Soil Classification (Embrapa, 2006) and as a Ferric Lixisol according to the Soil Map of the World (FAO, 1988). The soil was prepared twice with a harrow, using a tractor. Chemical analysis of a sample of the soil used in the experiment gave the following results: N= 0.42 g/kg; pH (water)= 7.71; organic material = 6.90 g/kg; P= 5.4 mg/dm^3; K= 61.1 mg/dm^3; Na= 38.8 mg/dm^3; Ca= 1.85 cmol$_c$/dm^3, sum of bases = 2.93 cmol$_c$/dm^3; effective CTC (t)= 2.93 cmol$_c$/dm^3; base saturation (V)= 100%; Al saturation (m)= 0%; exchangeable sodium percentage (ESP)= 6%. P and K were extracted by Mehlich 1 solution (0.05 M HC1 in 0.0125 M H_2SO_4).

Before sowing the maize the following fertilizers were applied: one third of the total nitrogen dosage (10 kg or 40 kg/ha of N, depending on the treatment, as ammonium sulfate); 100 kg/ha of P_2O_5 (single superphosphate); 50 kg/ha of K_2O (potassium chloride). The fertilizers were applied in furrows located below and adjacent to the rows to be used for planting. The remainder of the N was applied in equal portions as top dressing after each of the two hoeings. A spacing of 1.0 m was used between rows, leaving holes in the same row spaced 0.40 m apart. Planting was performed manually with four seeds per hole. At 20 days after sowing, the plants were thinned, leaving the two largest plants in each hole. After thinning, the experiment therefore had a planting density of 50,000 plants/ha. An experimental design of randomized blocks was used, with split-plots and five replications. Cultivar AG 1051 was subjected to two groups of treatments; nitrogen (30 and 120 kg/ha), applied to the plots and six methods of weed control (applied to the subplots): A) no weeding; B) intercropping with sabiá; C) hoeing [20 and 40 days after sowing (DAS)] with no removal of weeds; D) hoeing (20 and 40 DAS), removing weeds at 20 DAS; E) hoeing (20 and 40 DAS), removing weeds at 40 DAS; F) hoeing (20 and 40 DAS), removing weeds after each weeding. For intercropping, the sabiá was sown by broadcasting between the maize rows at the same time as the maize, at a density of 30 viable seeds/m^2. The seeds of sabiá, with a germination rate of almost 100%, were broadcast onto the ground with the goal of even distribution between the rows of maize and then incorporated into the soil using a rake. The response of the above cultivar to the nitrogen should be evaluated using a larger number of dosages. However, two dosages of nitrogen were specifically adopted to check the possibility of interaction between the two treatment groups. Each subplot consisted of four rows of plants, 6.0 m in length. The area taken up by the two central rows was considered as the usable area; from each of these rows, the plants from the hole at either end were ignored when harvesting.

The experiment was irrigated by sprinkler, with the experimental lots arranged parallel to the sprinklers. The amount of water necessary for maize (5.3 mm) was calculated considering the effective depth of the root system to be 40 cm. Irrigation was done every two days and based on the water retained in the soil at a pressure of 0.40 MPa. Irrigation was started after planting and suspended 15 days before the harvest of the mature ears.

The main pest of the crop in the region, the caterpillar *Spodoptera frugiperda*, was controlled by spraying Lorsban 480 BR (0.4-0.6 L/ha) and Decis 25 EC (200 mL/ha) using a backpack sprayer fitted with a flat fan nozzle.

Of the two rows of the usable area of each subplot, one at random was used for evaluation of the green-ear yield and the other for that of the ripe corn. Green corn yield was assessed by the total number and weight of ears and by the number and weight of marketable ears, both husked and non-husked. Marketable, non-husked ears, those having a suitable appearance for marketing and a length equal to or greater than 22 cm, were considered. Marketable husked ears, those of suitable health and graining for marketing and a length equal to or greater than 17 cm, were considered. For ripe maize, the grain yield and its components were evaluated. The mature ears were harvested when the grains showed a water content of approximately 20%, placed in the sun to dry and then threshed manually. The number of ears and grains obtained from them made it possible to estimate the number of ears per hectare and the grain yield. The number of grains per ear was estimated from the grains taken from ten of these ears. The 100-grain weight was obtained from five samples, each of one hundred grains.

After harvesting the ripe corn, characteristics of the weeds and sabiá were evaluated. The weeds from an area of 0.80 m^2 of the central part of each subplot were cut close to the ground, identified and triturated in a forage machine. A sample of 200 g of this triturated material was placed into a forced-air circulation oven set to a temperature of 75ºC until reaching constant weight to estimate the shoot dry matter. From the identification of the species of weeds which occurred in each experimental unit, the rate of occurrence was calculated, defined as the ratio between the number of experimental units where any one species was found and the total number (60) of units in the experiment. The sabiá plants between the two central rows of maize were counted and cut close to the ground to determine their height and shoot dry weight, using procedures similar to those adopted for the weeds.

Data were subjected to variance analysis using the SISVAR version 5.3 software (Ferreira, 2010). The means were compared at 5% probability by the Scott-Knott test whenever the value of the F-test from the variance analysis was significant. Data were tested for homogeneity of variance prior to statistical analysis according to Bartlett (1937).

RESULTS AND DISCUSSION

Twenty-three weed species were identified in the experimental area with *Adenocalymma* sp., *Borreria verticillata* and *Cenchrus echinatus* being the most frequent (the numbers in parentheses indicate the rate of occurrence as a percentage, i.e., the ratio between the number of experimental units in which the species occurred and the total number of units in the experiment): *Adenocalymma sp*. (75)*, Alternanthera tenella* (17), *Amaranthus spinosus* (8), *Borreria verticillata* (68), *Cenchrus echinatus* (55), *Centrosema brasilianum* (2), *Commelina benghalensis* (8), *Cucumis anguria* (17), *Dactyloctenium aegyptium* (15), *Desmanthus virgatus* (13), *Digitaria sanguinalis* (42), *Eragrostis* sp. (7), *Euphorbia hirta* (5), *Euphorbia hyssopifolia* (8), *Evolvulus ovatus* (2), *Ipomoea bahienses* (35), *Merremia aegyptia* (3), *Mimosa candollei* (3), *Mimosa* sp. (2), *Portulaca oleracea* (7), *Senna obtusifolia* (10), *Sida cordifolia* (22) and *Solanum agrarium* (6).

The predominance of a few species, as found in the experiment, is consistent with the proposition by Buhler (1999). According to the author, the weed population in any given area depends on several factors, and although the population comprises several species, few of them are predominant, representing 70 to 90% of the total number of species (Buhler, 1999). These species are probably those most resistant to the control measures usually adopted and the most adapted to the area of cultivation.

There were effects of the nitrogen application (N) and methods of weed

Table 1. Averages for the fresh and dry weights of weeds at 105 days after planting the maize cultivar AG 1051, in response to weed control methods and nitrogen application (médias para as massas fresca e seca de plantas daninhas, aos 105 dias após a semeadura da cultivar de milho AG 1051, em resposta a métodos de controle de plantas daninhas e a doses de nitrogênio). Mossoró, UFERSA, 2012.

Method of weed control[1]	Fresh weight (kg/ha)		Dry weight (kg/ha)		
	N dosage		N dosage		Averages
	30	120	30	120	
A	10008 Aa	6454 Ba	3259	1729	2.494 a
B	9395 Aa	7058 Ba	3054	2276	2.665 a
C	869 Ab	775 Ab	357	171	264 b
D	815 Ab	820 Ab	191	189	190 b
E	510 Ab	296 Ab	130	65	97 b
F	845 Ab	1350 Ab	172	384	278 b
Averages	-	-	1194 A	802 B	-
CV_{Plots} (%)	52,5		41,0		
$CV_{Subplots}$ (%)	42,2		75,9		

[1]Methods of weed control: A= No weeding (sem capina); B= Intercropping with sabiá (consorciação com sabiá); C= Two hoeings, at 20 and 40 days after planting (DAP), with removal of weeds after each hoeing {duas capinas, 20 e 40 dias após o plantio (DAP), com remoção das plantas daninhas após cada capina}; D= Two hoeings, at 20 and 40 DAP, with weeds removed after the first hoeing (duas capinas, com remoção das plantas daninhas, após a primeira capina); E= Two hoeings, at 20 and 40 DAP, with weeds removed after the second hoeing (duas capinas, com remoção das plantas daninhas após a segunda capina); F= Two hoeings, at 20 and 40 DAP with no removal of weeds (duas capinas, sem remoção das plantas daninhas); Averages followed by the same lowercase letter for columns and by the same uppercase letter for lines do not differ at 5% probability by Scott-Knott test (médias seguidas pela mesma letra minúscula, nas colunas, e pela mesma letra maiúscula, nas linhas, não diferem entre si, a 5% de probabilidade, pelo teste de Scott-Knott).

control (C) on fresh and dry weight of shoots of weeds. The interaction N x C occurred only for fresh weight (Table 1). The weed fresh weight in the plots that received 30 kg/ha of N was higher than that obtained in the plots that received the highest dose of fertilizer in treatments where maize was not weeded or control weed was made by intercropping. For other treatments to control weeds there were no differences between nitrogen levels. This difference between the two treatment groups was responsible for the existence of the N x C interaction mentioned. In treatments where maize was not hoed or that weed control was done by intercropping, the fresh weight of weeds was higher than on the other treatments. Similar behavior to that was observed when considering the dry matter of weeds (Table 1).

Probably the differences in treatment effects on fresh and dry weight of weeds (C x N interaction) was observed on the fresh weight but not on dry weight, are associated with differences in precision on the evaluation of traits. The precision (measured by the coefficient of experimental variation, CV) for evaluation of the dry weight tends to be lower than the accuracy for evaluating the fresh weight. The evaluation of dry weight is made with a subsample (which will be carried to the oven) of the material used for the evaluation of fresh weight, which carries less precision. Furthermore, losses usually occur in the material placed in the oven, which further reduces experimental precision.

The highest dose of nitrogen may have increased the competitive ability of corn, resulting in the reduction of fresh matter of shoots (biomass of the aboveground part) of the weeds in the plots where maize was not weeded or control was performed by intercropping (Table 1). For other treatments of weed control, the hoeings with the elimination of most of the weeds, may have "canceled" the effects of fertilizer. Nitrogen can have positive, negative or no influence on the increase in weed biomass, suggesting that several factors, including weed species and the crop associated with them, may be involved in the process (Chikoye *et al*., 2008). Some weed species respond better to the application of nitrogen than do crops (Blackshaw *et al*., 2003).

Intercropping maize with sabiá in the present work was based on the hypothesis of a reduction in weed growth caused by the sabiá, due to competition

Table 2. Averages of the characteristics of sabiá and maize cultivar AG 1051 in response to nitrogen application (médias de características de sabiá e da cultivar de milho AG 1051 em resposta à aplicação de nitrogênio). Mossoró, UFERSA, 2012.

Nitrogen dosage (kg/ha)	Characteristics of the sabiá				
	Fresh weight (mg/plant)	Dry weight (mg/plant)	Number of plants/m²	Stem diameter (mm)	Plant height (cm)
30	2,877 a	1,245 a	16.1 a	3.4 a	25.4 a
120	1,375 a	524 a	15.3 a	2.7 a	17.9 b
CV(%) $_{plot}$	64.9	63.5	41.0	18.6	19.1

Nitrogen dosage (kg/ha)	Characteristics of the maize			
	Number of grains/ear	Number of ears/ha	100-grain weight (g)	Grain yield (kg/ha)
30	373 b	45,177 b	27.8 b	4,380 b
120	457 a	49,062 a	30.2 a	6,332 a
CV(%)$_{plot}$	10.3	4.9	8.3	29.1

[1]Averages followed by the same letter do not differ at 5% probability by Scott-Knott test (médias seguidas pela mesma letra não diferem entre si, a 5% de probabilidade pelo teste de Scott-Knott).

Table 3. Averages for the number of green ears in the maize cultivar AG 1051 submitted to nitrogen application and weed control methods (médias do número de espigas verdes da cultivar de milho AG 1051 submetida à doses de nitrogênio e a métodos de controle de plantas daninhas). Mossoró, UFERSA, 2012.

Method of weed control	Total	Marketable non-husked ears		Marketable husked ears	
	Average of N dosage	N dosage (kg/ha)		N dosage (kg/ha)	
		30	120	30	120
A	49,651 a	1,181 Bd	32,681 Ab	5,941 Bc	28,756 Ab
B	49,101 a	2,885 Bc	35,576 Ab	2,468 Bc	28,132 Ab
C	50,153 a	25,138 Bb	42,115 Aa	20,139 Bb	38,558 Aa
D	50,331 a	33,019 Ba	42,986 Aa	26,269 Ba	35,102 Aa
E	47,323 a	31,439 Ba	42,211 Aa	26,435 Ba	39,869 Aa
F	48,839 a	34,647 Aa	39,308 Aa	28,292 Aa	33,442 Aa
CV(%)$_{plot}$	6.8	19.3		23.7	
CV(%)$_{subplot}$	7.8	13.8		19.1	

[1]Methods of weed control: A= No weeding (sem capina); B= Intercropping with sabiá (consorciação com sabiá); C= Two hoeings, at 20 and 40 days after planting (DAP), with removal of weeds after each hoeing {duas capinas, 20 e 40 dias após o plantio (DAP), com remoção das plantas daninhas após cada capina}; D= Two hoeings, at 20 and 40 DAP, with weeds removed after the first hoeing (duas capinas, com remoção das plantas daninhas, após a primeira capina); E= Two hoeings, at 20 and 40 DAP, with weeds removed after the second hoeing (duas capinas, com remoção das plantas daninhas após a segunda capina); F= Two hoeings, at 20 and 40 DAP with no removal of weeds (duas capinas, sem remoção das plantas daninhas); Averages followed by the same lowercase letter for columns and by the same uppercase letter for lines do not differ at 5% probability by Scott-Knott test (médias seguidas pela mesma letra minúscula, nas colunas, e pela mesma letra maiúscula, nas linhas, não diferem entre si, a 5% de probabilidade, pelo teste de Scott-Knott).

Table 4. Averages for the weights of green ears in the maize cultivar AG 1051 submitted to nitrogen application and weed control methods (médias das massas de espigas verdes da cultivar de milho AG 1051 submetida à aplicação de nitrogênio e a métodos de controle das plantas daninhas). Mossoró, UFERSA, 2012.

Method of weed control	Total ears		Marketable non-husked ears		Marketable husked ears	
	N dosage (kg/ha)		N dosage (kg/ha)		N dosage (kg/ha)	
	30	120	30	120	30	120
A	6,192 Bb	11,633 Ab	2,450 Bc	9,145 Ab	888 Bb	5,239 Ab
B	4,925 Bb	11,464 Ab	994 Bc	9,205 Ab	345 Bb	4,904 Ab
C	9,035 Ba	13,669 Aa	5,983 Bb	12,531 Aa	3,272 Ba	7,597 Aa
D	10,745 Ba	14,317 Aa	8,487 Ba	12,694 Aa	4,563 Ba	6,914 Aa
E	9,967 Ba	14,468 Aa	7,629 Ba	13,194 Aa	4,287 Ba	7,603 Aa
F	10,510 Ba	12,967 Aa	8,418 Ba	11,309 Aa	4,586 Ba	6,308 Aa
$CV(\%)_{plot}$	18.7		34.3		37.8	
$CV(\%)_{subplot}$	11.4		16.4		22.0	

[1]Methods of weed control: A= No weeding (sem capina); B= Intercropping with sabiá (consorciação com sabiá); C= Two hoeings, at 20 and 40 days after planting (DAP), with removal of weeds after each hoeing {duas capinas, 20 e 40 dias após o plantio (DAP), com remoção das plantas daninhas após cada capina}; D= Two hoeings, at 20 and 40 DAP, with weeds removed after the first hoeing (duas capinas, com remoção das plantas daninhas, após a primeira capina); E= Two hoeings, at 20 and 40 DAP, with weeds removed after the second hoeing (duas capinas, com remoção das plantas daninhas após a segunda capina); F= Two hoeings, at 20 and 40 DAP with no removal of weeds (duas capinas, sem remoção das plantas daninhas); Averages followed by the same lowercase letter for columns and by the same uppercase letter for lines do not differ at 5% probability by Scott-Knott test (médias seguidas pela mesma letra minúscula, nas colunas, e pela mesma letra maiúscula, nas linhas, não diferem entre si, a 5% de probabilidade, pelo teste de Scott-Knott).

for water, light, nutrients and space, as well as allelopathy; however, we observed an increase in the growth of the weeds (Table 1). The relationship between plants is not always one of competition; a relationship based on facilitation may occur between plants when one species has a positive effect on another (Vandermeer, 1989). This facilitation can occur in several ways, but one of the most frequent occurs in the interaction between leguminous and non-leguminous plants. The leguminous plant that is associated with N2-fixing bacteria probably increases the availability of nitrogen to the non-leguminous species (Forrester *et al.*, 2006). In this study, it is possible that the sabiá plants, although competing with weeds, may also favor the same plants by supplying nitrogen. Maron & Connors (1996) found that the leguminous plant, *Lupinus arboreus* favored the growth of weeds.

The idea of removing plants after hoeing was adopted assuming that some species of the infesting weed community could regrow or "take" if their "residue" was left in the field. Therefore, plant removal should only be effective when species with the capacity for regrowth occur in the weed community. No information was found in the literature about the capacity for regrowth or "taking" of weed species found in experimental areas.

For each of the characteristics used in evaluating the growth of the sabiá, the average obtained with the application of 120 kg/ha of N was less than that obtained with the smaller dosage of the fertilizer, although the difference was only significant when assessing plant height (Table 2). In contrast, Marques et al. (2006) found that increasing the amount of nitrogen increased the growth of sabiá. There are at least three reasons for the reduction in growth of the sabiá with increasing nitrogen levels, as observed in the present work. First, the increase in the nitrogen dosage increased the competitive ability of the weeds in relation to that of the sabiá, reducing the growth of this leguminous plant. Procópio *et al*. (2004) found that weeds in competition with both the common bean and the soybean were more efficient in using increasing dosages of nitrogen than the leguminous plants. Second, it is well known that crops respond to nitrogen fertilization in terms of growth, up to a certain dosage of the fertilizer, after which growth is reduced. Therefore, in the present work it is possible that the optimal response for the sabiá to the nitrogen is in the range of 0 to 120 kg/ha of N. Cruz *et al*. (2011) found a similar response to nitrogen in *Senna macranthera*, a leguminous arboreal plant, to that found in the present work for sabiá. Third, the negative response of the sabiá to higher dosages of nitrogen can be attributed to the species under study being a leguminous plant with the potential of forming an association with N_2-fixing microorganisms (Paron *et al*., 1997). In this case, the applied nitrogen would not be used by the legume.

The total number of green ears was not influenced by the application of nitrogen or by weed control (Table 3). The start of the formation of female inflorescences in maize occurs very early in the cycle of the plant (Nielsen, 2007), probably before the stress caused by weeds or lack of nitrogen interferes in this formation. The number of marketable green ears, both husked and non-husked, was affected by nitrogen dosage (N), by weed control (C) and by the interaction of N and C. Formation of maize grains is determined starting from

Table 5. Averages for grain yield and its components in the maize cultivar AG 1051 submitted to weed control methods (médias do rendimento de grãos e de seus componentes da cultivar de milho AG 1051 submetida a métodos de controle de plantas daninhas). Mossoró, UFERSA, 2012.

Methods of weed control	Number of grains/ear	Number of ears/ha	100-grain weight (g)	Grain yield (kg/ha)
A	370 b	45,131 a	27.7 b	4,305 b
B	338 b	45,518 a	26.2 b	3,642 b
C	447 a	47,315 a	30.1 a	6,179 a
D	455 a	49,755 a	31.0 a	6,629 a
E	450 a	45,630 a	29.3 a	5,959 a
F	431 a	49,369 a	29.6 a	5,426 a
$CV(\%)_{subplot}$	10.6	10.0	9.5	23.6

[1]Methods of weed control: A= No weeding (sem capina); B= Intercropping with sabiá (consorciação com sabiá); C= Two hoeings, at 20 and 40 days after planting (DAP), with removal of weeds after each hoeing {duas capinas, 20 e 40 dias após o plantio (DAP), com remoção das plantas daninhas após cada capina}; D= Two hoeings, at 20 and 40 DAP, with weeds removed after the first hoeing (duas capinas, com remoção das plantas daninhas, após a primeira capina); E= Two hoeings, at 20 and 40 DAP, with weeds removed after the second hoeing (duas capinas, com remoção das plantas daninhas após a segunda capina); F= Two hoeings, at 20 and 40 DAP with no removal of weeds (duas capinas, sem remoção das plantas daninhas); Averages followed by the same lowercase letter for columns and by the same uppercase letter for lines do not differ at 5% probability by Scott-Knott test (médias seguidas pela mesma letra minúscula, nas colunas, e pela mesma letra maiúscula, nas linhas, não diferem entre si, a 5% de probabilidade, pelo teste de Scott-Knott).

when the plant is approximately 50 to 60 cm in height until 10 to 14 days before flowering (Nielsen, 2007). Therefore, stresses occurring during this period may determine losses in yield.

For the number of marketable non-husked ears at the lower nitrogen dosage, the best yields were seen when hoeing was done twice and the weeds were not removed (Table 3). These treatments, in terms of yield, were followed by those where hoeing was done twice and the weeds removed each time, where the maize was intercropped with sabiá and where there was no weeding (Table 3). With the application of the higher nitrogen dosage, treatments involving two hoeings gave higher yields of marketable non-husked green ears, with no differences between the treatments, than did the other treatments, which also showed no differences (Table 3). Regarding the number of marketable husked ears at the lower nitrogen dosage, the best yields were obtained when hoeing was done twice and the weeds were not removed. For this dosage, the lowest yields were seen when intercropping with sabiá without weeding. The treatment where hoeing was done twice and the weeds removed each time gave yields that were intermediate between the other two treatment groups. With the application of the higher nitrogen dosage, the treatments which included two hoeings gave the highest yields of marketable non-husked green ears, with no differences between treatments, than did the other treatments, which also showed no differences (Table 3).

For total weight and that of marketable green ears, both husked and non-husked, there was an effect from nitrogen dosage (N), weed control (C) and the interaction of N and C. The effects of the two treatment groups were similar in those characteristics, with the exception of the weight of marketable non-husked ears where the lower nitrogen dosage was applied (Table 4). At this dosage, the treatments involving two hoeings with removal of weeds after each hoeing showed no differences between treatments and provided the highest yields. The treatments with intercropping and no weeding also showed no differences between treatments and provided the lowest yields. Carrying out two hoeings with the removal of weeds determined a yield that was intermediate between the other two treatment groups of weed control (Table 4). For the total weight of ears and that of marketable husked ears, with the application of 30 or 120 kg/ha of N, and the weight of non-husked ears with the application of 120 kg/ha of N, the treatments where hoeing was done twice showed no differences between treatments and were superior to the other two treatments. For each of the characteristics shown in Table 4 the increase in nitrogen dosage gave better results.

At least three aspects of the data in Tables 3 and 4 must be considered. Intercropping with sabiá may be beneficial to maize because it produced a larger number of non-husked ears than the treatment with no weeding, where 30 kg/ha of N was applied (Table 3). The removal of weeds after each of the two hoeings is not beneficial to the maize for such characteristics as the number of marketable husked and non-husked ears (Table 3) and the weight of marketable non-husked ears (Table 4) when the lower nitrogen dosage is applied. Decomposition of weed residue when the weeds are left in the field after hoeing can translate into the addition of nutrients to the soil, with benefits for the maize. Lindsey *et al.* (2013) found that weed residue released 25 to 45% of the total nitrogen in a period of two weeks. Therefore, the removal of weed residue after hoeing can be beneficial or detrimental to maize. If there is a predominance of species with the capacity for regrowth, removal can be beneficial. If this type of weed does not occur or the environmental conditions are favorable to the decomposition of weed residue, removing these residues may be of no benefit to the crop.

The third aspect that should be considered in the data of Tables 3 and 4 is that nitrogen increases the competitive ability of the maize. Hoeing twice with removal of the weeds gave, at the lower nitrogen dosage, lower yields of some of the characteristics used in the assessment of the maize than those obtained with the best treatments (Tables 3 and 4). With the application of the higher nitrogen dosage, this treatment was included among the best treatments. Improvements in the competitive ability of maize with increasing levels of nitrogen, effects of the interaction of nitrogen levels and methods of weed control and increased green-ear yield with increasing nitrogen levels have been observed by other authors (Abouziena *et al*., 2007; Silva *et al*., 2010b).

Increasing the nitrogen dosage increased grain yield as a result of an increase in the three main components of production (Table 2). The methods of weed control did not affect the number of ears with ripe grain, but weed control, with or without the removal of weeds after hoeing, resulted in higher grain yields than when there was no weeding or the maize was intercropped with sabiá (Table 5). The higher yields obtained when weeding was due to increases in the number of grains/ear and in the 100-grain weight (Table 5).

Increasing the dosage of applied nitrogen increased the yields of green ears (Table 3 and 4) and grain in the maize (Table 2). The beneficial effects of the nitrogen are probably a result of its action on various plant processes. For example, there is a decrease in the longevity of the leaves in maize deprived of nitrogen in relation to plants that received 180 kg/ha of the element (Wolfe *et al*., 1988). Low levels of nitrogen reduce the accumulation of biomass (McCullough *et al*., 2007). Moreover, the supply of nitrogen affects biomass partitioning (Evans *et al*., 2003) and the architecture and morphology of the maize root (Durieux *et al*., 1994).

The weeds reduced most of the characteristics of the maize that were evaluated in this study (Tables 3 to 5). Weeds reduce crop yields by competing with them for water, nutrients, light and space.

Finally, increasing the dose of nitrogen reduced the growth both of the sabiá and weeds and increased the ability and green ear yield and grain corn yield of maize. Intercropping with sabiá did not reduce the growth of weeds, but can be beneficial to corn because it increased the number of green ears. Treatments where hoeing was done twice, with or without the removal of weeds, reduced weed growth and resulted in the highest yields for green ears and grain. At the lowest nitrogen dosage, the removal of weeds after hoeing was detrimental as it reduced the yield of green ears.

REFERENCES

ABOUZIENA, HF; ELKARMANY, MF; SINGH, M; SHARMA, SD. 2007. Effect of nitrogen rates and weed control treatments on maize yield and associated weeds in sandy soils. *Weed Technology* 21: 1049-1053.

BARTLETT, MS. 1937. Some examples of statistical methods of research in agriculture and applied biology. *Jornal of the Royal Statistical Society* 4: 137-183.

BLACKSHAW, RE; BRANDT, RN; GRANT, CA. 2003. Differential response of weed species to added nitrogen. *Weed Science* 51: 532-539.

BOYDSTON, RA; COLLINS, HP; ALVA, AK. 2008. Control of volunteer potato (*Solanum tuberosum*) in sweet corn with mesotrione in unaffected by atrazine and tillage. *Weed Technology* 22: 654-659.

BUHLER, DD. 1999. Weed population responses to weed control practices. I. Seed bank, weed populations, and crop yields. *Weed Science* 47: 416-422.

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

CHIKOYE, D; LUM, AF; ABAIDOO, R; MENKIR, A; KAMARA, A; EKELEME, F; SANGINGA, N. 2008. Response of corn genotypes to weed interference and nitrogen in Nigéria. *Weed Science* 56: 424-433.

CONAB. 2014. www.conab.gov.br (acessado em 14/08/2014).

CRUZ, CAF; PAIVA, HN; CUNHA, ACMC; NEVES, JCL. 2011. Resposta de mudas de *Senna macranthera* cultivadas em argissolo vermelho-amarelo a macronutrientes. *Ciência Florestal* 21: 63-76.

DRUMOND, MA; CARVALHO FILHO, OM. 2005. *Espécies vegetais exóticas com potencialidades para o semi*árido brasileiro. Brasília: Embrapa Informação Tecnológica. 340p.

DURIEUX, RP; KAMPHRATH, EJ; JACKSON, WA; MOLL, RH. 1994. Root distribution of corn: the effect of N fertilization. *Agronomy Journal* 86: 958-962.

EMBRAPA, Centro Nacional de Pesquisa do Solo. 2006. *Sistema Brasileiro de classificação de solos*. Brasília: Serviço de Produção de Informação. 306p.

EVANS, SP; KNEZEVIC, SZ; LINDQUIST, JL; SHAPIRO, CA. 2003. Influence of nitrogen and duration of weed interference on corn growth and development. *Weed Science* 51: 546-556.

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

FERREIRA, DF. 2010. *SISVAR – programa estatístico. Versão 5.3 (Build 75)*. Lavras: UFLA.

FORRESTER, DI; BAUHUS, J; COWIE, AL; VANCLAY, JK. 2006. Mixed-species plantations of Eucalyptus with nitrogen-fixing trees: a review. *Forest Ecology and Management* v. 233: 211-230.

KAMARA, AY; AKOBUNDU, IO; CHIKOYE, D; JUTZI, SC. 2000. Selective control of weeds in an arable crop by mulches from some multipurpose trees in Southwestern Nigeria. *Agroforestry Systems* 50: 17-26.

LINDSEY, LE; STEINKE, K; WARNCKE, DD; EVERMAN, WJ. 2013. Nitrogen release from weed residue. *Weed Science* 61: 334-340.

MAIA, GN. 2004. *Caatinga; árvores e arbustos e suas utilidades*. São Paulo: D&Z Computação Gráfica e Editora. 413p.

MARON, JL; CONNORS, PG. 1996. A native nitrogen-fixing shrub facilitates weed invasion. *Oecologia* 105: 302-312.

MARQUES, VB; PAIVA, HN; NEVES, JCL; GOMES, JM. 2006. Efeitos de fontes e doses de nitrogênio no crescimento de mudas de sabiá (*Mimosa caesalpiniaefolia* Benth.). *Scientia Forestalis* 34: 77-85.

McCULLOUGH, DE; GIARDIN, PH; MIHAJLOVIC, M; AGUILERA, A; MELO, AV. 2007. Dinâmica populacional de plantas daninhas em cultivo de milho-verde nos sistemas orgânico e tradicional. *Planta Daninha* 25: 521-527.

MELO, AV; GALVÃO, JCC; FERREIRA, LR; MIRANDA, GV; SANTOS, LDT; SANTOS, IC; SOUZA, LV. 2007. Dinâmica populacional de plantas daninhas em cultivo de milho-verde nos sistemas orgânico e tradicional. *Planta Daninha* 25: 521-527.

NIELSEN, RL. 2007. *Ear size determination in corn*. West Lafayette: Purdue University Department of Agronomy. 3p.

PARON, ME; SIQUEIRA, JO; CURI, N. 1997. Fungo micorrízico, fósforo e nitrogênio no crescimento inicial da trema do fedegoso. *Revista Brasileira de Ciência do Solo* 21: 567-574.

PROCÓPIO, SO; SANTOS, JB; PIRES, FR; SILVA, AA; MENDONÇA, ES. 2004. Absorção e utilização do nitrogênio pelas culturas da soja e do feijão e por plantas daninhas. *Planta Daninha* 22: 365-374.

SILVA, PSL; BRAGA, JD; RIBEIRO, MSS; OLIVEIRA, OF; SANTOS, TS. 2010a. Nitrogen doses and weed control via intercropping with gliricidia for corn production. *Planta Daninha* 28: 531-539.

SILVA, PSL; CUNHA, TMS; OLIVEIRA, RC; SILVA, KMB; OLIVEIRA, OF. 2009b. Weed control via intercropping with gliricidia. II. Corn crop. *Planta Daninha* 27:105-112.

SILVA, PSLS; OLIVEIRA, AC; OLIVEIRA, OF; FREITAS, FCL; SANTOS, TS. 2010b. Effects of weeds "reestablishment" after hoeing of corn yields. *Planta Daninha* 29: 281-291.

SILVA, PSL; SILVA, JCV; CARVALHO, LP;

SILVA, KMB; FREITAS, FCL. 2009a Weed control via intercropping with gliricidia. I. Cotton crop. *Planta Daninha* 27: 97-104.

SILVA, PSL; SILVA, PIB; OLIVEIRA, VR; BARROS, GL; MONTEIRO, AL. 2013. Corn cultivar intercropping with arboreal legumes for weed control. *Planta Daninha* 31: 559-567.

SILVA, PSL; SOUZA, AD; PAULA, VFS; OLIVEIRA, FHT; SILVA, KMB. 2010. Influence of corn sowing density and gliricidia intercropping on weed control. *Planta Daninha* 28: 271-279.

VANDERMEER, JH. 1989. *The ecology of intercropping*. New York: Cambridge University Press. 237p.

WOLFE, DW; HENDERSON, DW; HSIAO, TC; ALVINO, A. 1988. Interactive water and nitrogen effects on senescence of maize. I. Leaf area duration, nitrogen distribution, and yield. *Agronomy Journal* 80: 859-864.