WEED CONTROL IN CORN AND WEED SAMPLE SIZE FOR GROWTH EVALUATIONS[1]

Plantas daninhas: Controle no Milho e Tamanho Amostral para Avaliação do Crescimento

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ABSTRACT - The objectives of this study were to evaluate baby corn yield, green corn yield, and grain yield in corn cultivar BM 3061, with weed control achieved via a combination of hoeing and intercropping with gliricidia, and determine how sample size influences weed growth evaluation accuracy. A randomized block design with ten replicates was used. The cultivar was submitted to the following treatments: A = hoeings at 20 and 40 days after corn sowing (DACS), B = hoeing at 20 DACS + gliricidia sowing after hoeing, C = gliricidia sowing together with corn sowing + hoeing at 40 DACS, D = gliricidia sowing together with corn sowing, and E = no hoeing. Gliricidia was sown at a density of 30 viable seeds m^{-2}. After harvesting the mature ears, the area of each plot was divided into eight sampling units measuring 1.2 m^2 each to evaluate weed growth (above-ground dry biomass). Treatment A provided the highest baby corn, green corn, and grain yields. Treatment B did not differ from treatment A with respect to the yield values for the three products, and was equivalent to treatment C for green corn yield, but was superior to C with regard to baby corn weight and grain yield. Treatments D and E provided similar yields and were inferior to the other treatments. Therefore, treatment B is a promising one. The relation between coefficient of experimental variation (CV) and sample size (S) to evaluate growth of the above-ground part of the weeds was given by the equation $CV = 37.57\ S^{-0.15}$, i.e., CV decreased as S increased. The optimal sample size indicated by this equation was 4.3 m^2.

Keywords: *Zea mays*, *Gliricidia sepium*, integrated control, hoeing, intercropping, corn yield.

RESUMO - O presente trabalho teve como objetivos avaliar os rendimentos de minimilho, de milho-verde e de grãos da cultivar BM 3061, com o controle de plantas daninhas feito pela combinação de capinas + consorciação com gliricídia, e verificar como o tamanho da amostra influencia a precisão da avaliação do crescimento das plantas daninhas. Utilizou-se o delineamento de blocos casualizados com dez repetições. O cultivar foi submetido aos tratamentos: A = capinas aos 20 e 40 dias após a semeadura do milho (DASM); B = capina aos 20 DASM + semeadura de gliricídia após a capina; C = semeadura de gliricídia por ocasião da semeadura do milho + capina aos 40 DASM; D = semeadura da gliricídia por ocasião da semeadura do milho; e E = sem capinas. A gliricídia foi semeada na densidade de 30 sementes viáveis por m^2*. Após a colheita das espigas maduras, a área da parcela foi dividida em oito unidades amostrais de 1,2* m^2*, para avaliação do crescimento (biomassa seca da parte aérea) das plantas daninhas. O tratamento A proporcionou os maiores rendimentos de minimilho, milho-verde e grãos. O tratamento B não diferiu do tratamento A quanto ao rendimento dos três produtos e foi equivalente ao tratamento C no tocante ao rendimento de milho-verde, porém foi superior ao C no que se refere a massas de minimilho e rendimento de grãos. Os tratamentos D e E proporcionaram rendimentos semelhantes e foram inferiores aos demais tratamentos. Esses resultados mostram que o tratamento B é promissor. A relação entre o coeficiente de variação experimental (CV) e o tamanho amostral (T), para avaliar a biomassa seca da parte aérea das plantas daninhas, foi dada pela equação* $CV = 37{,}57\ T^{-0{,}15}$*, isto é, o CV diminuiu com o aumento de T. O tamanho amostral ótimo indicado por essa equação foi de 4,3* m^2*.*

Palavras-chave: *Zea mays*, *Gliricidia sepium*, controle integrado, capina, consorciação, rendimento do milho.

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INTRODUCTION

Corn (*Zea mays*) is grown in all municipalities in the State of Rio Grande do Norte, Brazil, for the production of green corn and dry grain. Most crops are cultivated by small growers, but there are large agricultural companies that produce corn as well. Baby corn can be another interesting product for corn producers in Rio Grande do Norte. Baby corn consists of the husked ear, harvested two or three days after silk emergence. Baby corn is a profitable crop, and growing it allows for a diversification of production, aggregation of value, and increased income (Pandey et al., 2002). Therefore, it would be interesting to evaluate baby corn production under the conditions of the Brazilian Northeast.

Small growers in the State of Rio Grande do Norte utilize hoeings to control weeds in corn, but the large companies in that state use herbicides for the same purpose. Hoeing is a labor-intensive, time-consuming activity. Herbicides provide many advantages, including application efficiency and weed control efficiency, cost effectiveness, and selectivity (Deuber, 2006). Nevertheless, the use of herbicides may contribute toward soil and water pollution (Spliid & Koeppen, 1998) and may reduce flora and fauna diversity (Marshall et al., 2003). In addition, the use of herbicides may result in human consumption of residues via contaminated water and foods. Finally, the extensive use of herbicides has resulted in the selection of weed biotypes resistant to these products (Menalled & Smith, 2007). Because of the problems involved with both hoeing and herbicides, other weed control cultural methods have been studied in corn, including management of cover plants (Foo et al., 2011), sowing with reduced soil turning (Silva et al., 2005), increased corn planting density (Silva et al., 2010a), and intercrops (Silva et al., 2009).

The results obtained in soil mulching studies with gliricidia branches [*Gliricidia sepium*], a fabaceous tree, encouraged some researchers to intercrop corn with gliricidia in order to achieve weed control (Silva et al., 2009). In one such study, gliricidia was grown between corn rows and partially controlled weeds (Silva et al., 2009). Several other studies, in which broadcasting sowing of gliricidia was performed between corn rows (Linhares et al., 2009, Silva et al., 2010a,b), confirmed that gliricidia partially controls weeds in corn, with benefits on green ear yield and corn grain.

The hypothesis of the present study is that intercropping corn and gliricidia, in combination with one or more hoeing operations, could create more benefits than intercropping alone. Sowing gliricidia is faster and less labor-intensive than hoeing. Therefore, broadcasting sowing of gliricidia would be combined with a single hoeing to control weeds, in a kind of weed integrated management program. The concept of integrated pest management (IPM) was first introduced in the 1960s. The primary goals of IPM programs are to reduce pesticide use and its subsequent environmental impact and to rely more on alternative pest control strategies. Integrated weed management (IWM) comes under the umbrella of IPM with similar objectives (Sanyal et al., 2008). IWM involves the combination of two or more weed control practices, and has been identified as a viable alternative to the current methods of weed control in smallholder farms. IWM can lead to sustainable food production, minimize drudgery, and reduce the cost of removing weeds from crops (Chikoyea et al., 2004). In corn, several authors have demonstrated the efficiency of IWM (Chikoyea et al., 2004; Norsworthy & Frederick, 2005).

In weed control assays, there is often an interest in the evaluation of treatment effects on weed growth. In such experiments, a frame, generally measuring 0.5 m x 0.5 m, is “randomly” tossed into the usable area of the plot. Then the above-ground part of the weeds present in the area confined by the frame is collected and a sample is placed in a lab oven to determine dry mass. This procedure may have a couple of implications on the accuracy of weed growth evaluations. Sampling method and sample size (weeds harvested in a 0.25 m^2 area) may not be the best parameters to evaluate weed growth. Some observations have indicated that sampling method and sample size may influence the evaluation accuracy of characteristics associated with weeds (Conn et al., 1982).

The objectives of this study were to evaluate baby corn yield, green corn yield, and grain yield in corn cultivar BM 3061, with weed control achieved via a combination of hoeing and intercropping with gliricidia, and determine how sample size influences weed growth evaluation accuracy.

MATERIAL AND METHODS

The studies were conducted at Fazenda Experimental "Rafael Fernandes" (Experimental Farm), Universidade Federal Rural do Semi-Árido – UFERSA, between April and July 2008. The farm is located in the district of Alagoinha, 20 km away from the municipality of Mossoró-RN (latitude 5^{o}11' S, longitude 37^{o}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 ranges between 32.1 and 34.5 ^{o}C; the mean minimum temperature ranges between 21.3 and 23.7 ^{o}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 experiment area is classified as a Red-Yellow Argisol, according to the Brazilian Soil Classification System (Embrapa, 2006), and as a Ferric Lixisol, according to the Soil Map of the World (FAO, 1988). The analysis of a soil sample, collected at a 0-20 cm depth, showed the following results: pH (H_2O) = 5.8; organic matter = 21 g dm^{-3}; P (Mehlic-1) = 13 mg dm^{-3}; K^+ = 2.8 mmol$_c$ dm^{-3}; Ca^{2+} = 22 mmol$_c$ dm^{-3}; Mg^{2+} = 6 mmol$_c$ dm ^{3}; H^+ + Al^{3+} = 12 mmol$_c$ dm^{-3}; CEC = 49 mmol$_c$ dm^{-3}; B = 0.31 mg dm^3; Cu (Mehlic-1) = 0.4 mg dm^{-3}; Fe (Mehlic-1) = 29 mg dm^{-3}; Mn (Mehlic 1) = 12.9 mg dm^{-3}; Zn (Mehlic-1) = 1.0 mg dm^{-3}.

The soil was tilled with a tractor by means of two harrowings and was fertilized prior to sowing with 1/3 of total N applied (120 kg ha^{-1}), 60 kg P_2O_5, and 40 kg K_2O per ha. 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. Sowing was accomplished manually using four seeds per pit. A thinning operation was performed 20 days after sowing, leaving the two more developed plants in each pit; the experiment was thus left with a programmed sowing density of 50 thousand plants ha^{-1}. Baby corn production is obtained at higher densities, but for comparison purposes the lower density mentioned above was used in this investigation.

"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 conducted under dry land conditions but received sprinkler irrigation as needed, with experimental plots arranged in a parallel fashion 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 after, with three irrigations per week, and were suspended five days before harvesting the mature ears.

A completely randomized block experimental design with ten replicates was used. Each plot consisted of five 6.0 m-long rows. The usable area was considered as the space occupied by the three central rows, disregarding the plants from one of the pits at each end. Corn cultivar BM 3061 was submitted to the following treatments: no hoeing; two hoeings [at 20 and 40 days after corn sowing (DACS)]; hoeing at 20 DACS + gliricidia (30 viable seeds m^{-2}) after hoeing; gliricidia sowing (30 viable seeds m^{-2}) at corn sowing + hoeing at 40 DACS; and gliricidia sowing (30 viable seeds m^{-2}) at corn. In intercropped plots, gliricidia seeds were sown via broadcasting and were incorporated into the soil with a rake. Weeding was performed with a hoe, and the same employee was assigned to do the service in each block.

One of the three rows in the usable area of each plot was selected at random to evaluate baby corn yield, another was used to evaluate green corn yield, and the third was used to evaluate mature (dry) corn yield. Evaluation of baby corn yield was based on the number and weight of unhusked and husked ears. Husked ear measurements for length and diameter were obtained with a ruler and a caliper rule, respectively. 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. The green ears were harvested when grain water content ranged between 70% and 80% in the period from 70 to 75 days after sowing. Marketable unhusked ears were considered as those that had an aspect suitable for commercialization, and length equal to or above 22 cm. Marketable husked ears were considered as those that looked healthy and whosegrain set was suitable for commercialization and with a length equal to or above 17 cm. These criteria were adopted based on the ears that are commonly marketed in the region where this experiment was conducted. The mature ears were harvested when the grain achieved a water content of about 20%, and were then placed to dry and subsequently threshed out manually.

After harvesting the mature corn at 100 days after sowing, data were obtained for corn plant height and corn ear height, and for traits of the legume species and the weeds. Plant height and ear height were measured in all plants of the row that was selected to evaluate grain yield. The distance from ground level to the point of insertion of the tallest leaf blade was considered as corn 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 legume plants found in the usable area of each plot, which were sown either at corn or 20 days later, were counted, measured, and weighed. Legume plant height was considered as the distance from ground level to the top of each plant. Weight of the above-ground part of gliricidia plants were determined in a similar way as weed dry matter determination (described below).

The central area of each plot in five blocks, measuring 2.0 m x 4.8 m, between the three central rows of corn plants, was divided into eight equal areas with 1.0 m x 1.2 m each. The weeds found in each area were cut even with the ground, weighed, and identified. In order to evaluate weed growth, a 200 g sample of those plants was placed in a forced air circulation oven adjusted at 70 °C until constant weight was achieved. The ideal sample size to evaluate weed growth was identified by running an analysis of variance for each of the eight sample sizes under study (1.2 m^2, 2.4 m^2, ..., 9.6 m^2). Those sample sizes were obtained with a random number table, considering 1, 2, ...8 sampling units. An analysis of variance was carried out for each sample size and a coefficient of experimental variation (CV) percentage was obtained. Base on the CV (dependent variable, y) and sample size (x, independent variable) data, a $y = A/x^B$ type equation was fitted (Lessman & Atkins, 1963). From the A and B parameter estimates, an ideal sample size estimate was obtained for each trait evaluated, using the modified maximum curvature technique according to the formula provided by Meier & Lessman (1971).

Legume data were not analyzed statistically. The corn and weed data were submitted to the variance homogeneity test prior to the statistical analyses (Bartlett, 1937). The analyses of variance were carried out using the SAEG software developed by Universidade Federal de Viçosa (Ribeiro Junior, 2001). The means were compared at 5% probability by Tukey's test (Pimentel-Gomes, 2009). Regression analyses were made with the software developed by Jandel (1992).

RESULTS AND DISCUSSION

Twenty-eight weed species occurred in the experimental plots in an evaluation conducted at 100 days after sowing the corn (Table 1). Table 2 shows the means for dry weight of the above-ground part of the weeds, evaluated via different sample sizes. Three aspects ought to be highlighted in Table 2. Gliricidia at corn and lack of hoeing provided the highest weed growths in all sample sizes used in the weed dry matter evaluation (Table 4). The other treatments were not different among themselves, except when four sampling units were used (4.8 m^2), in which two hoeings reduced weed growth more significantly than hoeing at 20 days + gliricidia

Table 1 - Weed species that occurred in the experimental plots, in an evaluation conducted 100 days after corn sowing (after harvesting mature ears)

Weed species	Weed species
Acanthospermum hispidum DC.	*Malachra fasciata* Jacq.
Alternanthera tenella Colla	*Melochia pyramidata* L.
Amaranthus viridis L.	*Merremia aegyptia* (L.) Urb.
Blainvillea acmella (L.) Philipson	*Merremia cissoides* (Lam.) Hallier
Cenchrus echinatus L.	*Mimosa candollei* R. Grether
Centrosema pascuorum Mart. ex Benth.	*Panicum maximum* Jacq. (*Urochloa maxima* (Jacq.) R. D. Webster)
Commelina benghalensis L.	*Portulaca mucronata* Lint.
Corchorus hirtus L.	*Physalis angulata* L.
Cucumis anguria L.	*Phyllanthus amarus* Schumach. & Thonn.
Dactyloctenium aegyptium (L.) Willd.	*Senna occidentalis* (L.) Link.
Desmanthus virgatus (L.) Willd.	*Senna uniflora (Mill.)* H.S. Irwin & Barneby
Eleusine indica (L.) Gaertn.	*Solanum agrarium* Sendtn.
Euphorbia hissopifolia L.	*Spigelia anthelmia* L.
Ipomoea asarifolia (Desr.) Roem. & Schult.	*Tcianthema portulacastrum* L.

Table 2 - Weed above-ground dry mass in a corn crop (*Zea mays* 'BM 3061'), evaluated by sample size at 100 days after crop sowing, as a response to weed control methods[1/]

Weed control methods	Sample sizes (m^2)							
	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6
	Dry matter (g m^{-2})							
Two hoeings [at 20 and 40 days after corn sowing (DACS)]	117.2 c	96.7 b	102.9 b	90.9 c	105.0 b	99.4 b	96.1 b	101.4 b
Hoeing at 20 DACS + gliricidia sowing after hoeing	289.3 bc	245.5 b	231.1 b	256.5 b	252.9 b	244.0 b	247.0 b	245.9 b
Gliricidia sowing at corn + hoeing at 40 DACS	90.2 c	189.1 b	155.8 b	223.0 bc	196.5 b	162.1 b	175.2 b	181.2 b
Gliricidia sowing at corn	431.0 ab	422.9 a	432.3 a	429.4 a	444.2 a	437.3 a	427.5 a	434.0 a
No hoeing	548.2 a	456.6 a	476.5 a	472.8 a	449.9 a	487.4 a	489.5 a	480.1 a
Experimental coefficient of variation, %	39.54	30.68	29.28	28.77	28.71	28.01	28.00	27.66

[1/] Means followed by the same letter are not significantly different at 5% probability by Tukey's test.

sowing. Although the critical period of corn-weed competition varies with corn cultivar and with cultural practices and infesting community, among other factors, it may occur from 21 to 42 days after corn emergence (Shinggu et al., 2009). Two hoeings provided weed growth reduction by eliminating most of them. In the two treatments that involved the combination of one hoeing + intercropping with gliricidia, weed growth reduction occurred from the elimination of part of the weeds during hoeing + competition exerted by gliricidia with weeds for water, light, nutrients, and space. In addition, gliricidia may have had an allelopathic action on the weeds, since at least 15 substances have been identified in the above-ground part of gliricidia that could have allelopathic action (Ramamoorthy & Paliwal, 1993). In the treatments where gliricidia was sown at corn and again 20 days later, 4.1 and 4.1 gliricidia plants were found per m², respectively. The corresponding mean heights for those plants were 56.9 cm and 39.9 cm, while dry weight values of the above-ground parts were 20.0 g per plant and 26.7 g per plant, respectively.

It is worth mentioning that, in corn-gliricidia intercrops, some weed species may have benefited from the nitrogen fixed by gliricidia roots. It can be argued that such benefit may have extended to corn; although possible, this would be less likely to occur. In intercrops, gliricidia plants are much closer to weeds than to corn. The absorption of nitrogen by the recipient plant, excreted by the root system of the donor plant, seems to be the mechanism of nitrogen transfer between plants (Hamel et al., 1991). The most important factor influencing this transfer is the extent of contact between the root systems of plants (Hamel et al., 1991).

A second aspect that should be highlighted in Table 2 is that experimental precision, measured by the coefficient of experimental variation (CV), increased as sample size increased. With one sampling unit (1.2 m^2), CV was almost 40%, but with two sampling units (2.4 m^2), CV decreased by almost 10 percentage points (30.68%). This occurs because an increase in sample size (n) reduces sample mean variance (s^2_x), as long as sample variance (s^2) remains constant, since $s^2_x = s^2/n$ (Li, 1969). The relation between coefficient of experimental variation (CV) and sample size (S) to evaluate growth of the above-ground part of the weeds was given by the equation $CV = 37.57\ S^{-0.15}$, i.e., with a determination coefficient of 0.82. The optimal sample size indicated by this equation by the modified maximum curvature technique was 4.12 m^2. Larger sample sizes will continue to increase experimental accuracy. However, accuracy increases will be so small that they are just not worth the effort, if the labor and time required for sampling are taken into consideration.

The third aspect that should be mentioned is that for some sample sizes (one and three sampling units), Tukey's test indicated different results from those observed for the other sample sizes. This may have happened just by chance, since only one sampling was conducted. A single sample was taken for each sample size, although C^n_8 samples would be possible in the case of replacement sampling, where *n* is the number of sampling units.

The highest baby corn yields per ha were obtained with two hoeings (Table 3). The combination of one hoeing at 20 days after corn sowing (DACS) + gliricidia sowing after hoeing provided a number of ears that was equal to the number observed with two hoeings, but ear weight values, both unhusked and husked, were lower than those obtained with two hoeings. In other words, the ear weight values obtained with the treatment represented by hoeing at 20 DACS + gliricidia sowing after hoeing did not differ from those obtained with two hoeings, but also did not differ from ear weight obtained with gliricidia sowgin at corn sowing + hoeing at 40 DACS (Table 3). In spite of that, this treatment showed the same number of ears provided by two hoeings. Gliricidia sowing at corn sowing (no hoeing) and the no hoeing treatments provided the poorest baby corn yields. Larger baby corn ears in length and diameter were obtained with the combination of one hoeing at 20 DACS + gliricidia sowing after hoeing.

The highest green corn yields were obtained with two hoeings (Table 4). The total numbers of green ears in the two treatments resulting from the combination of one hoeing (at 20 or 40 days after corn sowing) + intercropping with gliricidia were lower than those observed with two hoeings; however, those two treatments were equivalent to the best treatment with respect to the characteristics used for green corn yield assessment, i.e., total ear weight and number and weight of marketable ears, both unhusked and husked (Table 4). Gliricidia sowing at corn (no hoeing) and the no hoeing treatments provided the poorest green corn yields (Table 4).

Table 3 - Mean values for number, weight, and size of baby corn ears - *Zea mays* 'BM 3061' - as a response to weed control methods[1/]

Weed control methods	Ears per ha			Husked ear size	
	Number	Unhusked ear weight (kg)	Husked ear weight (kg)	Length (cm)	Diameter (mm)
Two hoeings [at 20 and 40 days after corn sowing (DACS)]	88,077 a	7,657 a	1,498 a	11.0 ab	14.7 ab
Hoeing at 20 DACS + gliricidia sowing after hoeing	77,985 a	6,618 ab	1,280 ab	11.1 a	15.2 a
Gliricidia sowing at corn + hoeing at 40 DACS	78,082 a	5,646 b	1,205 bc	10.7 ab	14.6 ab
Gliricidia sowing at corn	58,338 b	4,036 c	908 d	10.6 ab	14.1 b
No hoeing	56,458 b	3,847 c	986 cd	10.6 ab	14.4 ab
Experimental coefficient of variation, %	18.6	20.0	19.4	3.6	4.9

[1/] Means followed by the same letter are not significantly different at 5% probability by Tukey's test.

Table 4 - Mean values for green ear yield - *Zea mays* 'BM 3061' - as a response to weed control methods[1/]

Weed control methods	Number of ears per ha			Ear weight (kg ha^{-1})		
	Total	Marketable unhusked	Marketable husked	Total	Marketable unhusked	Marketable husked
Two hoeings [at 20 and 40 days after corn sowing (DACS)]	51,593 a	45,531 a	40,360 a	15,796 a	15,214 a	8,591 a
Hoeing at 20 DACS + gliricidia sowing after hoeing	45,097 ab	43,285 a	40,324 a	14,238 a	13,603 a	8,067 a
Gliricidia sowing at corn + hoeing at 40 DACS	45,342 ab	40,054 a	37,073 a	14,263 a	13,399 a	7,709 a
Gliricidia sowing at corn	41,762 b	31,607 b	23,375 b	9,913 b	8,312 b	4,208 b
No hoeing	41,410 b	30,783 b	25,757 b	10,127 b	8,503 b	4,621 b
Experimental coefficient of variation, %	14.8	15.4	19.2	16.9	19.9	22.6

[1/] Means followed by the same letter are not significantly different at 5% probability by Tukey's test.

The smallest crop growth, measured by plant height and ear height, evaluated at 100 days after sowing, was obtained for corn plants where weed control was performed via "gliricidia sowing at corn + hoeing at 40 days after corn sowing (DACS)" (Table 5).

The highest grain yield was obtained with two hoeings and the lowest was achieved with gliricidia intercropping (no hoeing) and no hoeing (Table 5). The hoeing + gliricidia intercropping combinations provided intermediate yields, with the treatment "hoeing at 20 days after corn sowing (DACS) + gliricidia sowing after hoeing" providing a yield value that did not differ statistically from the treatment that consisted of two hoeings (Table 5). The highest grain yield obtained with two hoeings resulted from higher number of ears per ha, higher number of kernels per ear, and higher 100-kernel weight (Table 5). The no hoeing and intercropping with gliricidia (no hoeing) treatments reduced those three grain yield components. The intermediate grain yields obtained with hoeing + intercropping with gliricidia combinations resulted from higher numbers of ears per ha and (or) higher numbers of kernels per ear.

The hoeing + gliricidia intercropping treatments were equivalent for green corn yield (Table 4), but the hoeing at 20 days after corn sowing (DACS) + gliricidia intercropping (treatment B) combination was superior to the treatment that consisted of gliricidia sowing at corn sowing + hoeing at 40 DACS (treatment C) for baby corn weight (Table 1) and grain yield (Table 3), although differences were not significant. The differences between the two treatments might have depended on two trends. Treatment B kept corn free from competition during part of the critical period of competition in corn (CPCC), while gliricidia may have contributed to reducing corn competition with weeds after the 20 DACS period. Although CPCC varies with corn cultivar and with cultural practices and infesting community, among other factors, it may occur from 21 to 42 days after corn emergence (Shinggu et al., 2009). In treatment C, gliricidia may have contributed to reducing corn competition with weeds during the 40 DACS period. After that period, with the elimination of weeds by hoeing, the older corn had better conditions to compete with weeds.

Although gliricidia sowing via broadcasting is easier, faster, and less labor-intensive than hoeing, it should be kept in mind that obtaining gliricidia seeds involve seed harvesting and processing. Anyway, the hoeing + gliricidia combinations proved promising, which makes the combination between intercropping with gliricidia (or other species) and other methods of weed control an interesting option.

The effects of weed control methods on baby corn yield (Table 3), green corn yield (Table 4), and grain yield (Table 5) were different. Differences can be explained by at least two reasons. First, baby corn, green corn, and grain are products evaluated in different manners. Ears without value as green corn may be used as baby corn, and ears without value as green corn may be used as dry grain. In addition, the three products remain in the field for different periods, meaning that the plants that will produce them undergo different periods of competition (probably with different intensities) with weeds.

Table 5 - Mean values for plant height and ear height, grain yield and its components - *Zea mays* 'BM 3061' - as a response to weed control methods[1/]

Weed control methods	Plant height (cm)	Ear height (cm)	Grain yield (kg ha^{-1})	Mature ears (No. ha^{-1})	Kernels (No. ear^{-1})	100-kernel weight (g)
Two hoeings [at 20 and 40 days after corn sowing (DACS)]	181.4 a	90.1 a	8,326 a	48,718 a	446 a	35.8 a
Hoeing at 20 DACS + gliricidia sowing after hoeing	180.4 ab	89.8 a	7,147 ab	44,722 ab	428 a	32.9 b
Gliricidia sowing at corn + hoeing at 40 DACS	160.0 c	76.3 b	6,646 b	47,334 a	398 a	33.4 ab
Gliricidia sowing at corn	167.8 abc	83.2 ab	4,082 c	40,397 bc	332 b	27.7 c
No hoeing	164.9 bc	81.5 ab	3,571 c	36,962 c	326 b	27.5 c
Experimental coefficient of variation, %	7.1	9.9	17.6	11.8	11.7	11.3

[1/] Means followed by the same letter are not significantly different at 5% probability by Tukey's test.

In general, there was a "parallelism" between the effects of weed control methods on corn yields and the effect of those methods on weed growth. That is, in general, the methods that best controlled weed growth (Table 2) were also the methods that provided the highest yields, and vice versa (Tables 3 to 5). Often, this is not observed. Linhares et al. (2009), for example, verified differences between weed control methods on corn yield, but did not see effects of those methods on weed control. Such occasional lack of "parallelism" between the effects on both characteristics (crop yield and weed growth) may be associated with the small sample sizes used in weed growth evaluation. This implies small experimental precision; consequently, no differences can be detected between weed control methods on growth of those plants. Linhares et al. (2009) evaluated weed growth in a 0.8 m^2 area and obtained a CV around 45%.

It can be concluded that "two hoeings [at 20 and 40 days after corn sowing (DACS)] (treatment A)" provided the best baby corn, green corn, and grain yields. The treatment represented by "hoeing at 20 DACS + gliricidia after hoeing (treatment B)" did not differ from treatment A with regard to yield for the three products and was equivalent to the "gliricidia at corn + hoeing at 40 DACS" treatment for green corn yield, but it was superior to it for baby corn weight and grain yield. The "gliricidia at corn " and "no hoeing" treatments provided similar yields and were inferior to the other treatments. The relation between the coefficient of experimental variation (CV) and sample size (S) was given by the equation $CV = 37.57\ S^{-0,15}$. The optimal sample size indicated by this equation by the modified maximum curvature technique was 4.3 m^2.

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