GREEN EAR YIELD AND GRAIN YIELD OF MAIZE CULTIVARS IN COMPETITION WITH WEEDS[1]

Rendimentos de Espigas Verdes e de Grãos de Cultivares de Milho em Competição com Plantas Daninhas

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ABSTRACT - The reduction in herbicide use is one of the greatest interests for modern agriculture and several alternatives are being investigated with this objective, including the adoption of cultivars that suppress weeds. The objective of this study was to verify if maize cultivars develop differently, in competition with weeds, to produce green ears and grain. Randomized complete block design was used, with split-plots and five replications. Cultivars DKB 390, DKB 466, DKB 350, AG 7000, AG 7575 and Master, were evaluated in the plots, without weeding and two weedings (at 22 and 41 days after sowing) in sub plots. Twenty-one species were identified in the experimental area, the most frequent being Gramineae (Poaceae), Euphorbiaceae, Leguminosae (Fabaceae) and Convolvulaceae species. There was no difference in the dry biomass above-ground part of the weeds in the plots of the evaluated cultivars. The cultivars behaved similarly in treatments with or without hoeing, except for plant height and ear height evaluations. Without hoeing, plant height increased in cultivar DKB 390, while plant height and ear height decreased in cultivar AG 7575. In the other cultivars, these traits did not change under weed control. The presence of weeds decreased the values of all traits employed to assess green corn yield, with the exception of the total number of green ears and grain yield.

Keywords: *Zea mays*, green corn, leaf, root, tolerance to weeds.

RESUMO - A redução do uso de herbicidas é um dos maiores interesses da agricultura moderna e várias alternativas estão sendo investigadas com esse objetivo, dentre elas a adoção de cultivares que suprimam as plantas daninhas. O objetivo do trabalho foi verificar se cultivares de milho, em competição com plantas daninhas, apresentam comportamento diferente para produzir espigas verdes e grãos. Utilizou-se o delineamento de blocos completos casualizados, com parcelas subdivididas, e cinco repetições. As cultivares DKB 390, DKB 466, DKB 350, AG 7000, AG 7575 e Master, semeadas nas parcelas, foram submetidas aos seguintes tratamentos: sem capina e duas capinas (aos 22 e 41 dias após a semeadura). Vinte e uma espécies foram identificadas na área experimental, sendo Gramíneas (Poáceas), Leguminosas (Fabáceas), Euforbiáceas e Convolvuláceas as famílias mais freqüentes. Não houve diferenças na biomassa seca da parte aérea de plantas daninhas nas parcelas das cultivares avaliadas. O comportamento das cultivares foi coincidente nos tratamentos com e sem capina, exceto quando foram avaliadas as alturas da planta e de inserção da espiga. A cultivar DKB teve a altura da planta aumentada e a cultivar AG 7575 teve as Alturas da planta e de inserção da espiga reduzidas, sem a realização das capinas. Nas demais cultivares, essas características não foram alteradas com o controle de plantas daninhas. A presença das plantas daninhas reduziu todas as características utilizadas para avaliação do rendimento de milho verde, à exceção do número total de espigas verdes, e também o rendimento de grãos. As cultivares avaliadas não diferiram quanto ao rendimento de espigas verdes nem quanto ao rendimento de grãos, exceto no peso de espigas despalhadas comercializáveis, em que as cultivares DKB 390 e DKB 350 foram as mais produtivas.

Palavras-chave: *Zea mays*, milho verde, folha, raiz, tolerância a plantas daninhas.

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INTRODUCTION

Herbicides provide many advantages, including application efficiency and weed control efficiency, good cost effectiveness, and selectivity (Deuber, 2006). Because of these advantages, the use of herbicides has grown practically throughout the world. In Brazil, the use of herbicides has grown from 546.6 million dollars in 1990 to over 1,300 million dollars in 2002 (ANDEF/SINDAG, 2005). 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. Furthermore, the extensive use of herbicides has resulted in the selection of weed biotypes resistant to these products (Christoffoleti & López-Ovejero, 2003). In northeastern Brazil, herbicide use is still very restricted, but it is increasing with the growth of corn production by large agricultural product export companies. The reduction in herbicide use is one of the modern agriculture's main interests (Ngouajio et al., 1999) and several alternatives are being investigated with this objective (Carruthers et al., 1998). These alternatives include crop rotation (Nalewaja, 1999), inter-cropping (Carruthers et al., 1998), and cultivars that suppress weeds (Begna et al., 2001).

Varietal differences in the capacity to control weeds were reported for several crops, including maize (Callaway, 1992; Begna et al., 2001). Tollenaar et al. (1994) evaluated weed interference and soil nitrogen application on four maize hybrids. They found that there was difference among cultivars in relation to average yield loss. The greater yield loss of the older hybrid, in two nitrogen levels, was attributed to less efficiency in nitrogen use and to the differences between the hybrids in leaf area index (LAI) and photosynthetic photon flux density.

Plant height, leaf development rate, LAI and crown leaf distribution are among the most important characteristics in the competition for light (Sinoquet & Caldwell, 1995). Such characteristics can be improved through crop practices, such as change of the spacing or plant density, and/or plant breeding (Lindquist & Mortensen, 1998). These approaches can help maize plants compete better with weeds and help farmers to reduce herbicide inputs required to control the weeds, and consequently, reduce environmental damage (Begna et al., 2001).

The previous considerations about maize varietal differences in response to competition with weeds were made with regard to grain yield. No information was found in the literature about green ear yield. However, it is known that the absence of weeding reduces the number and the total weight of green ears and the number and weight of marketable ears with and without husks (Silva et al., 2004b).

Green maize can be consumed in a variety of forms, either fresh or as an ingredient in cakes, ice-creams and a number of other foods, either industrialized or not. The planted area is expanding, thanks to the crop's profitability (Silva et al., 2006) and diversified use (Pereira Filho, 2003), but its harvest period is shorter than the period available to harvest dry grain. With regard to the crop's profitability, a net income (in US$ as of 11/30/2003) of US$ 1,886.49 ha^{-1} was obtained with green ear commercialization, while the net income obtained with dry grain sales was US$ 150.20 ha^{-1} (Silva et al., 2006). According to the latest farming/livestock census, the total area planted with maize for green ear production in the country was 102,325 ha, with a production of 292,138 tons of ears. The production is concentrated in the states of Minas Gerais, São Paulo, and Goiás (Pereira Filho, 2003), but apparently all Brazilian states are green maize producers. The green maize market is becoming so encouraging that traditional producers of dry grain maize, bean, and coffee, among others crops, are either abandoning those crops and starting to exploit green maize or are diversifying their activities, by including green maize among the crops they grow (Pereira Filho, 2003). Green maize exploitation in the Northeastern region of

Brazil, previously restricted to small farmers, currently also includes large agricultural companies which grow green maize during the rainy period as a replacement for melon plants (*Cucumis melo*), grown in the drought period.

There are currently hundreds of maize cultivars available in the seed market in Brazil, but only 15 are recommended by seed-producing companies as appropriate for green maize. There is still a large number of growers that cultivate green maize for fresh consumption using the same cultivars employed to produce dry grain (Pereira Filho et al., 2003). The objective of this study was to evaluate the maize capacity against weeds, as a function of cultivar differential response to green ears and grain yield.

MATERIAL AND METHODS

The experiment was carried out at the "Rafael Fernandes" Experimental Farm at the Universidade Federal Rural do Semi-Árido (UFERSA), 20 km from the county seat, Mossoró-RN, Brazil (5º' latitude, 37º 20' WGr longitude and an altitude of 18 m), with sprinkler irrigation. According to Gaussen's bioclimatic classification, the climate in the Mossoró region is of the 4th type, i.e., distinctly xerothermic, which means hot tropical and accentuated drought, with a long 7 to 8 month season and a xerothermic index between 150 and 200. The region has an average minimum air temperature ranging between 21.3 and 23.7 ºC and an average maximum between 32.1 and 34.5 ºC, with June and July as the coolest months, and average annual precipitation of around 825 mm (Carmo Filho & Oliveira, 1989). During the experimental period (August through December 2004), the maximum air temperature in the region ranged from 32.4 to 38.0 ºC, while the minimum temperature ranged from 19.9 to 25.8 ºC. In the same period, the relative humidity varied between 46.5 and 72.0% with a total precipitation of 1.5mm (data provided by Departamento de Ciências Ambientais/ UFERSA).

The experimental soil, classified according to the Brazilian Soil Classification System as *Argissolo Vermelho-Amarelo Eutrófico* (Embrapa, 1999) and as Ferric Lixisol according to the Soil Map of the World (Fao, 1988), was prepared with two plowings, using a tractor, and fertilized with 30 kg N (urea) 60 kg of P_2O_5 (simple superphosphate) and 30 kg of K_2O (potassium oxide), per hectare. The fertilizers were placed in furrows located alongside and below the sowing furrows. The analysis of a sample of the experimental soil indicated: pH = 6.8; Ca = 1.80 $cmol_c\ dm^{-3}$; Mg = 0.40 $cmol_c\ dm^{-3}$; K = 0.10 $cmol_c\ dm^{-3}$; Na = 0.01 $cmol_c\ dm^{-3}$; Al = 0.00 $cmol_c\ dm^{-3}$; P = 25 mg dm^{-3}; Org. Mat. = 1.90 g kg^{-1}.

Seeding was performed by hand on 08/19/2004 using four seeds per pit. Spacing of 1.0 m was used and the holes in the same row were spaced of 0.4 m. The thinning was carried out on the 17th day, leaving the two taller plants in each hole. After thinning, the planting density was of 50 thousand plants ha^{-1}. Deltamethrin (250 mL ha^{-1}) was sprayed on the crop 12 days after sowing to control the "fall armyworm" (*Spodoptera frugiperda*), the crop's main pest in the region. The spraying was carried out with a backpack sprayer. On days 22 and 41 sidedressing fertilizations were done using 30 kg ha^{-1} (urea).

Randomized complete block design was used, with split-plots and five replicates. Each subplot consisted of four rows with 6.0 m in length each. The useful area was considered to be the area occupied by the two 5.2 m long central rows. Maize cultivars DKB 390, DKB 466, DKB 350, AG 7000, AG 7575 and MASTER, were sowed in the plots. The reason why these cultivars were adopted is because their seeds were being sold in the region at the time the study was carried out. Each plot was split in weedy and weeding treatment (22 and 41 days after planting). The weedings were performed with a hoe.

One of the two rows of the usable area of each subplot was used to evaluate green ear yield, while the other was used to evaluate grain yield. Four green corn harvests were made, in two or three day intervals, the first being at 68 days after planting. The ears were harvested when the grain had a moisture content between 70 and 80%.

The number and total weight of green ears with husks and by the number and weight of marketable ears with and without husks were used to evaluate the green corn yield. Marketable ears with husks were considered as those measuring 22 cm or more in length, without stains or evident signs of attack from disease or pests. Marketable ears without husks were considered as those measuring 17 cm or more in length, with grains appropriate for commercialization. These dimensions, which were also adopted by other authors (Gomes et al., 2007), were employed based on the dimensions of green maize ears sold in the region. After the harvesting of the green ears, plant height, ear height, length, width, the area of four leaves and root biomass were evaluated. Plant height and ear height were evaluated in ten randomly chosen plants. Plant height was taken from soil level to the highest leaf blade insertion. Ear height was measured from soil level to the ear insertion node. Leaf characteristics were evaluated in four leaves (two above and two below the leaf associated with the ear), in two randomly chosen plants. Leaf area was evaluated in four leaves only because of the excessive labor and time that would be required if all leaves were to be measured. The leaf area was measured using the 3100 LICOR (LI-COP, Inc. Lincoln, Nebraska, USA) model automatic leaf area integrator. The corn root system was removed with a straight shovel. A soil volume of approximately 0.040 m^3 was removed together with the roots, i.e., the soil surface layer was removed at a height of 0.25 m, in a 0.40 m x 0.40 m area, established around the two plants of a pit. A sample of approximately 500 g of root system was placed in an air circulation oven adjusted to 75 °C, until the root biomass reached constant weight, in order to estimate its dry mass value.

The harvest of mature ears was done at approximately 97 days after sowing. The number of ears/ha (based on ears harvested in one of the two rows of the usable area of each subplot), the number of grains/ear (based on 15ears), the weight of 100 grains (based on five samples of 100 grains) and the grain yield (of useful plants, corrected to 15.5% moisture content) were evaluated after harvest. A sample of 20 grains was gathered from the shelled corn to evaluate grain height, width and thickness using a digital caliper.

The composition and weight of the dry biomass of the above-ground part of the weeds were evaluated at 100 days after sowing. The weeds were collected, cutting them even with the soil, in two areas randomly chosen in the useful area of each plot delimited by a 0.5 x 0.5 m wooden frame.

The treatment design adopted for statistical analyses consisted of split-plots with C (cultivars) and W (weed control) fixed, according to the model (Zimmerman, 2004): $Y_{ijk} = \mu + B_j + C_i + (BC)_{ij} + W_k + CW_{ik} + E_{ijk}$, where: Y_{ijk} = observation for the experimental unit that received cultivar $\underline{i}$ in block $\underline{j}$, in weed control $\underline{k}$; μ: fixed effect of the overall mean for the experiment, with $E[\mu] = \mu$ and $Var[\mu] = 0$; B_j: random effect of block $\underline{j}$, with j = 1, 2, ..., J with $b_j \cap NID(0, \sigma^2_B)$; C_i = fixed effect of cultivar $\underline{i}$; with i = 1, 2, ..., I and $c_i \cap NID(0, \sigma^2_C)$; $(BC)_{ij}$ = random effect of the interaction between block $\underline{j}$ and cultivar $\underline{i}$; W_k = fixed effect of weed control $\underline{k}$, with k = 1,..., K; $(CW)_{ik}$ = fixed effect of the interaction between cultivar $\underline{i}$ and weed control $\underline{k}$, with $cw_{ik} \cap NID(0, \sigma^2_{CW})$; E_{ijk} = random effect of the average experimental errors associated with observation Y_{ijk}, with $e_{ijk} \cap NID(0, \sigma^2)$. The treatment means were compared by Tukey test up to a 5 % probability value.

RESULTS AND DISCUSSION

Twenty-one species were identified in the experimental area (Table 1). The Poaceae, Euphorbiaceae, Leguminosae and Convolvulaceae families were the most frequent. Other authors (Gomes et al., 2007) found only ten species in a similar area and a similar experiment. However, the area used by those authors had been previously cultivated for a longer time than the area used in the present work. Apparently, the cultivation intensity in a given area is related to the number of weed species that occurs in that area. The dry biomass of the above-ground part of the weeds as well as the density and diversity of these plants is less in conventional crops (soil preparation and high doses of chemical products), intermediate in minimum planting systems and higher in organic systems (Menalled et al., 2001). The weed population in a given area varies in accordance with many factors and although this population is comprised of many species, a few dominant species account for 70 to 90% of all species (Buhler, 1999).

Cultivar x weed control interaction did not exist in the evaluated characteristics, except in the plant height and ear height. In the characteristics where cultivar x weed control interaction did not exist, only the averages of the main effects of the two treatment groups will be shown.

Table 1 - Species of weeds observed in weedy plots of six maize cultivars

Botanical name	Family
Acanthospermum hispidum DC	Asteraceae
Alternathera tenella Colla	Amaranthaceae
Spermacoce verticillata G. Mey.	Rubiaceae
Chamaesyce hirta L.	Euphorbiaceae
Chamaesyce hyssopifolia L.	Euphorbiaceae
Cajanus cajan (L.) Millsp.	Fabaceae
Cenchrus echinatus L.	Poaceae
Commelina sp.	Commelinaceae
Cucumis anguria L.	Cucurbitaceae
Dactyloctenium aegyptium (L.) P. Beauv	Poaceae
Desmanthus virgatus (L.) Willd.	Mimosaceae
Digitaria sanguinalis Scop	Poaceae
Ipomoea asarifolia Roem. et Schult	Convolvulaceae
Ipomoea sp.	Convolvulaceae
Macroptilium lathyroide (L.) Urb	Fabaceae
Merremia aegyptia (L.) Urb	Convolvulaceae
Phyllanthus amarus Schum. et Thonn.	Euphorbiaceae
Portulaca oleracea L.	Portulacaceae
Solanum agrarium Sendtn.	Solanaceae
Spigelia sp.	Loganiaceae
Waltheria indica L.	Sterculiaceae

There were no differences in the dry biomass of the above-ground part of the weeds in the plots of evaluated cultivars (Table 2). Ford & Pleasant (1995) did not verify differences to number, coverage area or weed biomass among the planted plots with different corn hybrids either. Cultivar DKB 390 presented wider leaves, but cultivar AG 7000 presented longer leaves, larger area and a bigger root system (Table 2). The dry biomass of the aerial part of the weeds, as well as the width, leaf area and root system of the corn were reduced with the weedings, but leaf length was not altered by weed control (Table 2). Aflakpui et al. (2002) observed reductions in corn leaf area and Thomas & Allison (1975) in the root system caused by competition between crop and weeds.

There was cultivar x weed control interaction in plant height and ear insertion (Table 3). Only cultivars DKB 390 and AG 7575 presented lower plant height with the presence of weeds. Only AG 7575 was affected in ear height by weed control. This interaction suggests that some cultivars are more tolerant to weed interference, at least in terms of growth, when the plant height is evaluated. Similar to this study, Begna et al. (2001) verified reductions in plant height and ear height due to weed presence.

Table 2 - Means for leaf length, width and area, and root dry biomass of maize cultivars and above-ground dry biomasses of weeds grown in the plots of the maize cultivars with and without weeding[1]

Treatment	Maize				Weeds dry biomass (g m^{-2})
Cultivar	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^{2} leaf$^{-1/}$)	Root dry biomass (g per plant)	
DKB 390	78.9 bc	9.8 a	545 ab	48.7 ab	389.6 a
DKB 466	78.8 bc	8.2 c	471 c	49.3 ab	390.3 a
DKB 350	79.6 bc	8.4 bc	488 bc	45.5 ab	448.2 a
AG 7575	80.9 b	8.1 c	449 c	38.9 b	384.0 a
AG 7000	90.6 a	9.1 b	593 a	52.8 a	393.5 a
MASTER	74.7 c	8.2 c	432 c	46.0 ab	394.7 a
CVa[2], %	7	9	15	25	55
Two weedings					
With	247.1 b	81.6 a	8.9 a	513.5 a	51.7 a
Without	553.0 a	79.7 a	8.4 b	479.0 b	42.1 b
CVb[2], %	5	7	9	15	27

[1] In each treatment group (cultivars and two weedings), means followed by the same letter do not differ from one another at 5% probability by Tukey's test. [2] CVa and CVb = coefficient of experimental variation corresponding to plots and subplots, respectively.

Table 3 - Means for plant height and ear height of maize cultivars with and without weeding[1/]

Cultivar	Plant height (cm)		Ear height (cm)	
	Two weedings		Two weedings	
	With	Without	With	Without
DKB 390	147 aB	155 bA	81 aA	79 aA
DKB 466	169 aA	171 aAB	89 aA	90 aA
DKB 350	157 aAB	165 aAB	94 aA	91 aA
AG 7575	171 aA	157 bB	92 aA	85 bA
AG 7000	170 aA	174 aA	94 aA	91 aA
MASTER	159 aAB	156 aB	86 aA	82 aA
CVa[2/], %	10		19	
CVb, %	7		8	

[1/] Means followed by the same upper case letter, in the columns, and by the same lower case letter, in the row, are not different among themselves, at 5% probability, by Tukey's test. [2/] CVa and CVb = coefficient of experimental variation corresponding to plots and subplots, respectively.

For green corn, there was no difference among cultivars, except to marketable ears weight without husks. DKB 390 and DKB 350 cultivars were the most productive, but only differed from the Master cultivar, which presented the smallest yield (Table 4). In other words, only cultivar Master produced ears that could not be grouped as the most acceptable for the market. Weedy plots presented reduction for all green corn yield evaluating characteristics except for the total number of green ears (Table 4). Silva et al. (2004a) also verified a reduction in green ear yield as a consequence of corn-weed competition.

Higher numbers of kernels per ear, 100-kernel weight, and kernel thickness were obtained with cultivars DKB 350, DKB 466, and AG 7575, respectively (Table 5). No differences were observed among cultivars for grain yield, kernel height, and kernel width (Table 5). Despite of differences among cultivars in relation to number of grains per ear and to the weight of 100 grains, there was not difference to grain yield of different genotypes (Table 5), probably due to the well-known compensation that occurs among yield components. Actually, the cultivars did not differ in the number of ears ha^{-1}, evaluated in this study by the total number of green ears either (Table 5). The absence of weedings reduced grain yield and their components (except the number of ears ha^{-1}) and grain height, but it did not influence grain width and thickness (Table 5).

No effect was observed for cultivars in five out of the six characteristics employed to evaluate green ear yield (Table 4) or grain yield (Table 5), while the absence of hoeing reduced green ear yield (with the exception of total number of green ears) and grain yield. Although the cultivar and hoeing effects on green ear yield and grain yield were similar, this is not always the case (Gomes et al., 2007). The cultivar effect on weight of marketable

Table 4 - Green ear yield of maize cultivars with and without weeding[1/]

Treatment	Total ears with husks ha^{-1}		Marketable ears with husks ha^{-1}		Marketable ears without husks ha^{-1}	
Cultivar	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)
DKB 390	46943 a	12777 a	43527 a	12284 a	37300 a	7703 a
DKB 466	48834 a	13371 a	45372 a	13009 a	36017 a	7327 ab
DKB 350	48104 a	12297 a	45219 a	11519 a	38982 a	7601 a
AG 7575	49655 a	11983 a	47091 a	11601 a	40361 a	7375 ab
AG 7000	48729 a	11944 a	43767 a	11145 a	35298 a	7309 ab
MASTER	51150 a	11274 a	45119 a	10939a	36353 a	5799 b
CVa[2/], %	12	23	18	27	26	26
Two weedings						
With	49055 a	13736 a	46947 a	13462 a	40248 a	8300 a
Without	48751 a	10812 b	43084 b	10037 b	35316 b	6070 b
CVb[2/], %	11	23	17	23	22	25

[1/] In each treatment group (cultivars and two weedings), means followed by the same letter do not differ from one another at 5% probability by Tukey's test. [2/] CVa and CVb = coefficient of experimental variation corresponding to plots and subplots, respectively.

Table 5 - Means for number of grains per per ear, weight of 100 grains, grain yield, grains height, width and thickness of maize cultivars with and without weeding[1/]

Treatment Cultivar	Number of grains per ear	Weight of 100 grains (g)	Grain yield (kg ha^{-1})	Grain height (mm)	Grain width (mm)	Grain thickness (mm)
DKB 390	429 ab	33.7 ab	6578 a	10.5 a	8.4 a	5.0 ab
DKB 466	379 b	35.5 a	6125 a	10.3 a	8.2 a	4.6 b
DKB 350	446 a	32.7 ab	6525 a	10.4 a	8.4 a	4.7 ab
AG 7575	384 ab	34.0 ab	6028 a	10.3 a	8.7 a	5.2 a
AG 7000	413 ab	32.0 b	6336 a	9.9 a	8.4 a	4.9 ab
MASTER	402 ab	32.2 b	5697 a	10.2 a	8.2 a	4.7 ab
Cva[2/], %	16	11	27	13	10	11
Two weedings						
With	440 a	35.0 a	7206 a	10.6 a	8.5 a	4.9 a
Without	378 b	31.7 b	5224 b	9.9 b	8.2 a	4.8 a
CVb[2/], %	13	8	20	10	11	11

[1/] In each treatment group (cultivars and two weedings), means followed by the same letter do not differ from one another at 5% probability by Tukey's test. [2/] CVa and CVb = coefficient of experimental variation corresponding to plots and subplots, respectively.

husked ears indicates that, depending on the trait employed to evaluate yield, the best cultivars (and/or crop management practices) can be different. This fact highlights the importance of using simultaneous evaluations for green ear yield, maize grain yield, cultivars, and crop management practices.

The coefficient of experimental variation value for plots (CVa) is considered high in the plant height, ear height, 100-kernel weight, and grain yield evaluations, according to the classification proposed for maize (Scapim et al., 1995). The coefficient of experimental variation value for subplots (CVb) is considered medium for the same characteristics, under the same classification. The values of both above-mentioned coefficients in the evaluation of the other characteristics studied had a magnitude comparable to the values obtained by other authors (Gomes et al., 2007), in a similar study conducted in the same region.

Weeds interference reduced most of the evaluated characteristics in this study (Tables 3). The weeds reduce crop yield by competing for water, nutrients and light (Carruthers et al., 1998). The removal of nutrients by weeds has an impact on nutrient availability for the crop, affecting its accumulation of dry matter (Sreenivas & Satyanarayana, 1996). The weeds reduced the root system in all cultivars (Table 3).The corn root system is less developed with weed presence (Thomas & Allison, 1975). A smaller corn root system due to weed presence would be less efficient in nutrient absorption.

The corn crop develops stress symptoms due to lack of water earlier when it is infested by weeds than when it is weed free (Young et al., 1984; Tollenaar et al., 1997). Nevertheless, there are no differences in water content in the profile of the soil for corn with or without weeds (Young et al., 1984; Tollenaar et al., 1997). The development of water stress symptoms with the presence of weeds may not be caused by water availability, but by the reduced ability to absorb water through the root system. Therefore, despite the fact that the experiment on which this study was based used irrigation, the reduction in the corn root system caused by the weeds (Table 3) could reduce water absorption capacity. Water deficiency induces the closing of stomata thus paralyzing photosynthesis and drastically reducing production in corn competing with weeds (Silva et al., 2004a). This problem is aggravated if there are C_4 weeds in the area, such as the *Cenchrus echinatus* L. (Table 1) that, like corn, have high efficiency in water use (Silva et al., 2004a). Another possibility would be the invader root exudates that could inhibit corn root growth (Rajcan & Swanton, 2001).

Two components are involved in the competition for light: the quantity and the quality of light (Rajcan & Swanton, 2001). An important characteristic of corn is that most of the light is intercepted by the younger, more efficient leaves above the ear and less than 10% of the photon flux density (PFD) reaches the leaves below 1 m. On the other hand, most weeds are below 1 m in height at blooming and after blooming. Thus, the direct competition for PFD between corn and weeds is relatively small. The leaf area index (LAI) defines the ability of a plant to intercept PFD and it is an important determining factor for the accumulation of dry matter (Rajcan & Swanton, 2001). A high degree of competition with weeds reduced corn LAI at blooming by 15% (Tollenaar et al., 1994). Thus, grain yield loss resulting from competition for light is best explained through the reduction in LAI than in lower photosynthetic rates of shaded leaves (Rajcan & Swanton, 2001). Actually, in the experiment on which this study is based a reduction was observed in the corn leaf area (Table 3), which agrees with other authors (Aflakpui et al., 2002), due to competition with weeds. Other authors (Ford & Pleasant, 1995) also verified a reduction in the number of corn leaves due to weeds.

It is interesting to mention that the reduction in leaf area (Table 3) should reduce shadows on weeds making them more aggressive towards corn, and therefore generating a vicious cycle for the crop: the weeds reduce the corn leaf area, and this reduction favors the growth of weeds, and so on.

The lower leaves are not only exposed to a reduced amount of PFD, but they also receive a quality of light that differs from the total sunlight received by the upper leaves. The light within the crown is rich in far red radiation (FR, 730 at 740 nm). This is caused by the selective absorption of red light (R, 660-670 nm) by photosynthetic pigments and the reflection of FR light by green leaves. This makes the far-red/red (FR/R) ratio higher in the lower part of the crown than on the upper part of the crown. The FR/R ratio plays an important role in the induction of many morphological changes in plant architecture (Salisbury & Ross, 1991). Consequently, plants that grow in FR rich light tend to have an architecture different from plants that grow in complete sunlight. Although, as mentioned previously, weeds generally do not shade corn, there are indications that corn grown in the presence of weeds receives a higher FR/R ratio than the weed free crop (Rajcan & Swanton, 2001).

It can thus be concluded that the cultivars do not behave differently in competition with the weeds. The presence of the weeds reduced all evaluating characteristics of green corn yield, with the exception of the total number of green ears, as well as grain yield. The evaluated cultivars did not differ in green ear yield except in the weight of the marketable husked ears, where the DKB 390 and DKB 350 cultivars were the most productive. The cultivars did not differ with regard to grain yield.

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.

BEGNA, S. H. et al. Morphology and yield. response to weed pressure by corn hybrids differing in canopy architecture. **Europ. J. Agron.**, v. 14, n. 1, p. 293-302, 2001.

BUHLER, D. D. Weed population responses to weed control practices. I. Seed bank, weed populations, and crop yields. **Leed Sci.**, v. 47, n. 4, p. 416-422, 1999.

CALLAWAY, M.B. A compendium of crop varietal tolerance to weeds. **Am. J. Altern. Agric.**, v. 7, n. 4, p. 169-180, 1992.

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.

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.

FORD, G. T.; PLEASANT, J. Competitive abilities of six corn (*Zea mays* L.) hybrids with four weed control practices. **Weed Technol.**, v. 8, n. 3, p. 124-128, 1995.

GOMES, J. K. O. et al. Effects of weed control through cowpea intercropping on mayze morphology and yield. **Planta Daninha**, v. 25, n. 3, p. 433-441, 2007.

LINDQUIST, J. L.; MORTENSEN, D. A. Tolerance and velvetleaf (*Abutilon theophrasti*) suppressive ability of two old and modern corn (*Zea mays*) hybrids. **Weed Sci.**, v. 46, n. 5, p. 569-574, 1998.

MENALLED, F. D.; GROSS, K. L.; HAMMOND, M. Weed aboveground and seedbank community responses to agricultural management systems. **Ecol. Applic.**, v. 11, n. 6, p. 1586-1601, 2001.

NALEWAJA, J. D. Cultural practices for weed resistance management. **Weed Technol.**, v. 13, n. 1, p. 643-646, 1999.

NGOUAJIO, M.; LEMIEUX, C.; LEROUX, G. D. Prediction of corn (*Zea mays*) yield loss from early observations of the relative leaf area and the relative leaf cover of weeds. **Weed Sci.**, v. 47, n. 3, p. 297-304, 1999.

PEREIRA FILHO, I. A. (Ed.). **O cultivo do milho-verde**. Brasília: Embrapa Informação Tecnológica, 2003. 204 p.

PEREIRA FILHO, I. A.; CRUZ, J. C.; GAMA, E. E. G. Cultivares para o consumo verde. In: PEREIRA FILHO, I.A. (Ed.). **O cultivo do milho-verde.** Brasília: Embrapa Informação Tecnológica, 2003. p. 17-30.

RAJCAN, I.; SWANTON, C. J. Understanding maize-weed competition: resource competition, light quality and the whole plant. **Field Crops Res.**, v. 71, n. 2, p. 139-150, 2001.

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

SCAPIM, C. A.; CARVALHO, C. G. P.; CRUZ, C. D. Uma proposta de classificação dos coeficientes de variação para a cultura do milho. **Pesq. Agropec. Bras.**, v. 30, n. 5, p. 683-686, 1995.

SREENIVAS, G.; SATYANARAYANA, V. Nutrient removal by weeds and maize (*Zea mays*). **Indian J. Agron.**, v. 41, n. 1, p. 160-162, 1996.

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 de milho.** Viçosa, MG: Universidade Federal de Viçosa, 2004a. p. 269-310.

SILVA, P. S. L.; SILVA, E. S.; MESQUITA, S. S. X. Weed control and green ear yield in maize. **Planta Daninha**, v. 22, n. 1, p. 137-144, 2004b.

SILVA, P. S. L. et al. Green ear yield and grain yield of maize after harvest of the first ear as baby corn. **Hortic. Bras.**, v. 24, n. 2, p. 151-155, 2006.

SINOQUET, H.; CALDWELL, R. M. Estimation of light capture and partitioning in intercropping systems. In: SINOQUET, H.; CRUZ, P. (Eds.). **Ecophysiology of tropical intercropping**. Paris, Institute Nationale de la Reserche Agronomique (INRA), 1995. p. 79-80.

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, n. 5, p. 596-601, 1994.

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

YOUNG, F. L.; WYSE, D. L.; JONES, R. J. Quackgrass (*Agropyron repens*) interference on corn (*Zea mays*). **Weed Sci.**, v. 32, n. 2, p. 226-234, 1984.

ZIMMERMAN, F. J. P. **Estatística aplicada à pesquisa agrícola**. Santo Antônio de Goiás: Embrapa Arroz e Feijão, 2004. 402 p.