http://dx.doi.org/10.18512/1980-6477/rbms.v3n2p204-213

NUMBER AND TIME OF WEEDING EFFECTS ON MAIZE GRAIN YIELD

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Revista Brasileira de Milho e Sorgo, v.3, n.2, p.204-213, 2004

ABSTRACT - Several problems are to blame for the low yields of maize in the State of Rio Grande do Norte, Brazil. Among these problems, the lack of weed control in the proper season is one of the biggest. The experiment was conducted in Mossoró-RN, in a sprinkler-irrigated area. The objective of this work was to evaluate the influence of one weeding (at 15, 30, 45 or 60 days after planting, DAP), two weedings (15 and 30, 15 and 45, 15 and 60, 30 and 45, 30 and 60 or 45 and 60 DAP), three weedings (15, 30 and 45; 15, 30 and 60 or 30, 45 and 60 DAP) or four weedings (15, 30, 45 and 60 DAP) on cultivar Centralmex grain yield. A "no weeding" treatment was also included. A random block design with four replicates was utilized. The lack of weeding reduced plant and ear heights, as well as grain yield and its components. The highest grain yields were obtained with treatments 30 DAP, 15-30 DAP, 30-45 DAP, 30-45-60 DAP, and 15-30-45-60 DAP. Greater net revenue with grain commercialization can be obtained with treatment 15-30 DAP.

Key words: *Zea mays* L., weed.

EFEITOS DO NÚMERO E ÉPOCA DE CAPINAS SOBRE O RENDIMENTO DE GRÃOS DO MILHO

RESUMO - Vários problemas são responsáveis pelos baixos rendimentos do milho no Estado do Rio Grande do Norte e, dentre estes, a falta de controle de plantas invasoras na época adequada é um dos fatores mais importantes. O trabalho foi realizado no distrito de Alagoinha, em Mossoró-RN, sob sistema de irrigação por aspersão. O objetivo da pesquisa foi avaliar os efeitos de uma capina, aos 15, 30, 45 ou 60 dias após o plantio, DAP; duas capinas, aos 15 e 30, 15 e 45, 15 e 60, 30 e 45, 30 e 60 ou 45 e 60 DAP; três capinas, aos 15, 30 e 45; 15, 30 e 60 ou 30, 45 e 60 DAP ou quatro capinas, aos 15, 30, 45 e 60 DAP, sobre o rendimento de grãos do cultivar Centralmex. Um tratamento "sem capina" também foi incluído. Utilizou-se o delineamento de blocos ao acaso com quatro repetições. A ausência de capinas reduz as alturas de planta e de inserção da espiga, o rendimento de grãos e seus componentes. Os maiores rendimentos de grãos foram obtidos com os tratamentos 30 DAP, 15-30 DAP, 30-45 DAP, 30-45-60 DAP e 15-30-45-60 DAP. Maior receita líquida com a comercialização dos grãos é obtida com o tratamento 15-30 DAP.

Palavras-chaves: *Zea mays* L., plantas invasoras, período de competição.

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Maize is grown in all municipal districts in the State of Rio Grande do Norte. In this state, the crop is explored especially under dry land conditions, but in several areas it is also grown under irrigation, in order to produce ears that are either green or have mature kernels, practically throughout the year. The irrigation area is expected to increase in the years to come, due to irrigation incentives provided by the federal and state governments, among other factors.

The mean maize dry grain yield in Rio Grande do Norte is around 500 kg ha^{-1}. Experience and a survey about the problems that occur in maize production systems in Rio Grande do Norte (Silva *et al*., 1994) have demonstrated that many problems are associated with low productivity levels. One of these problems concerns the inadequate control of weeds. Weed control in maize cropping in Rio Grande do Norte has not received adequate attention on the part of farmers. The season in which weeding operations are performed frequently depends on the availability of time and laborers. It is a known fact, however, that there is a critical period when the crop competes with weeds and, as a consequence of this competition, in the case of maize, grain losses may reach 35 to 70%, when weeds are not controlled (Ford and Pleasant, 1994; Teasdale, 1995).

In Rio Grande do Norte, notwithstanding the fact that some growers now use herbicides to control weeds, most farmers continue to control weeds by means of hand hoeing. There has been a trend in many countries for using mechanical weed control methods, in order to reduce the use of herbicides (Liebman and Dick, 1993; Carruthers *et al*., 1998). Some weeds are becoming resistant to herbicides; such products are expensive and may cause environment degradation (Carruthers *et al*., 1998).

Two types of approaches are utilized in most competition studies between weeds and maize (Rajcan and Swanton, 2001): determination of the critical competition period between the crop and the weeds; and, evaluation of the threshold above which weed infestation becomes detrimental to the crop. Hall *et al*. (1992) defined the 3-leaf and 14-leaf stages of plant development as the critical period for weed control in maize. Grain yield in maize can be increased by increasing the number of hoeings, even though differences are not always significant (Bezerra *et al*., 1995). Hoeing is as effective or more effective than herbicides with regard to their effects on maize grain yield (Jat *et al*., 1998; Saikia and Pandey, 1999). Several factors influence the response of maize to weed control, including cultivars (Begna *et al*., 2001), weeds (species and density) (Bendixen, 1986; Young *et al*., 1984), type of control (Jat *et al*., 1998; Saikia and Pandey, 1999) and other cultural practices (Begna *et al*., 2001).

The objective of this work was to evaluate the influence of the number and time of weedings on grain yield and other traits of sprinkle-irrigated Centralmex-3 cultivar.

Material and Method

The experiment was performed at Fazenda Experimental "Rafael Fernandes", of Escola Superior de Agricultura de Mossoró (ESAM), which is located 20 km away from the municipal seat of Mossoró-RN (5º 11' S latitude, 37º 20' W longitude and 18 m altitude), in 1996. 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 dry season, lasting from seven to eight months and with a xerothermic index between 150 and 200.

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According to Köppen, the bioclimate in the region is a BSwh, i.e., hot, with heavier precipitations delayed toward the fall. The mean minimum temperature in the region is between 21.3 and 23.7º C and the mean maximum is between 32.1 and 34.5º C, with June and July as the coolest months, while the mean annual precipitation is around 825 mm (Carmo Filho & Oliveira, 1989). 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 (Chagas, 1997).

The experimental soil, a Red-Yellow Argisol, was tilled by means of two harrowings and fertilized with 30 kg N (ammonium sulfate), 60 kg P_2O_5 (single superphosphate), and 30 kg K_2O (potassium chloride) per hectare. The fertilizers were applied in furrows located alongside and below the sowing furrows. The analysis of a sample taken from the experimental soil indicated: pH = 6.8; Ca = 1.80 $cmol_c^{-1} dm^{-3}$; 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 = 25mg dm^{-3}; Org. Mat. = 1.90 g kg-1.

Planting was carried out on 08-08-1996, and four seeds of cultivar Centralmex were used per pit. The spacing between rows was 1.0 m, and pits on each row were spaced by 0.4 m. Thinning was performed 18 days after planting leaving the two more vigorous plants in each pit. Therefore, after thinning the programmed population stand in the experiment was 50 thousand plants ha^{-1}. Two deltamethrin sprays (250 ml ha^{-1}) were performed at 16 and 29 days after planting, respectively, in order to control the fall armyworm (*Spodoptera frugiperda* Smith), the main pest of maize in the region. Sidedressing applications were performed at 20 and 40 days after planting with 60 kg ha^{-1} of ammonium sulfate. Weedings were made by hand hoeing in numbers and times compatible with the evaluated treatments, and the same worker was assigned to do the job at each block. With regard to irrigation, the required water depth (5.6 mm) was calculated considering the effective depth of the root system as 0.40 m (Espinoza, 1982). The irrigation time was based on the water retained in the soil at a tension of 0.04 MPa (Santos, 1987), transformed into available water according to the particular curve for that soil (Bezerra, 1990), and an availability factor of 40% was obtained. The net irrigation requirement during the crop's cycle, estimated based on evaporation from a class A pan, was 360 mm, and the water application efficiency was 23%. This low efficiency was due to losses by deep percolation (72%). The total irrigation depth and the water distribution uniformity coefficient were 1,565 mm and 83 %, respectively. The irrigation shift was set up as 1 day.

A completely randomized blocks design with four replicates was utilized. Each plot consisted of four 6.0 m long rows. The usable area was considered as the central 5.2 m from the two central rows. The treatments under evaluation were as follows: no weeding; C-15 = weeding at 15 days after planting (DAP); C-30 = weeding at 30 DAP; C-45 = weeding at 45 DAP; C-60 = weeding at 60 DAP; C-15-30 = weedings at 15 and 30 DA; c-15-45 = weedings at 15 and 45 DAP; C-15-60 = weedings at 15 and 60 DAP; C-30-45 = weedings at 30 and 45 DAP; C-30-60 = weedings at 30 and 60 DAP; C-45-60 = weedings at 45 and 60 DAP; C-30-45 = weedings at 15, 30 and 45 DAP; C-15-30-60 = weedings at 15, 30 and 60 DAP; C-30-45-60 = weedings at 30, 45 and 60 DAP; and C-15-30-45-60 = weedings at 15, 30, 45 and 60 DAP.

The weed composition in the experiment was evaluated in plots submitted to weeding, at

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45 days after planting. The weeds were collected from an area measuring 1.0 m (measured across the plot's width, between the two central rows) × 0.4 m (measured along the plot's length, including the two central pits from each row).

Harvest was performed 100 days after planting. Evaluations at harvest time included plant and ear height (from ten plants chosen at random from the plot's usable area). The distance from ground level to the insertion point of the highest foliar blade was considered as plant height. The distance from ground level to the ear insertion node was considered as ear height. After harvesting, evaluations were also made for the number of ears ha^{-1} (based on ears harvested from usable plants), number of kernels/ear (in 15 ears), 100-grain weight (in five 100-grain samples) and grain yield (of usable plants, corrected for a moisture content of 15.5%).

Soil tillage was done with a tractor; the sprays were performed with a back-pack sprayer; weedings were performed with a hoe and the other experiment operations were accomplished by hand.

The data were statistically analyzed by the analysis of variance method, according to Zar (1999).

The economical analysis of the data consisted in calculating the Operating Income (Net Revenue), by subtracting the Total Cost from the Gross Revenue. The Gross Revenue was obtained by multiplying the number of 50 kg bags of maize by the price per bag (R$ 30.00). The Total Cost was obtained by adding the Fixed and Variable costs. We considered as Fixed Cost the labor supplied by a property manager plus the depreciation, maintenance and conservation, insurance and interest on the fixed capital represented by implements (irrigation system and back-pack sprayer). Variable Cost included labor spent on management practices, consumables (fertilizers, etc), machinery and implement rental (harrowing and grooving operations), electric energy for irrigation (1500 kw), technical assistance and PROAGRO (both at 2% of the Variable Cost value), and interest on the working capital (6% APR of the Variable Cost).

Results and Discussion

The weeds occurred were: *Alternaria ficoidea* (L.) R. Br., *Boerhavia coccinea* Mill, *Borreria verticillata* G.F.W. Mayer, *Carnavalia brasiliensis* Mart., *Cassia duckeana* A. Fernandes et P. Bezerra, *Cassia sericea* Sw., *Cassia tora* L., *Cenchrus echinatus* L., *Cucumis anguria* L., *Dactyloctemium aegyptium* (L.) Beauv., *Digitaria sanguinalis* (L.) Scop., *Eragrostis amabilis* (L.) Wight et Arn. Ex Ness, *Euphorbia hirta* L., *Herissantia nemoralis* L., *Ipomoea asarifolia* Roem. Et Sch., *Ipomoea salzmannii* Choisy, *Mentzelia fragilis* Hub., *Merremia aegyptia* (L.) Urban, *Mollugo verticillata* L, *Phyllantus niruri* L., *Portulaca oleracea* L., *Richardsonia grandiflora* Cham. Et Schlecht, *Solanum ambrosiacum* Vell. and *Waltheria indica* L. No quantitative evaluations of weeds were performed; however, the species *Cenchrus equinatus* L. was the most frequent weed.

In all traits evaluated, there was a significant effect of treatments (Table 1). The greatest plant and ear heights were obtained with two (at 15 and 30 days after planting) or three weeding operations (at 15, 30, and 60 days after planting) (Table 1). The smallest value for both traits was observed in the "no weeding" treatment, which did not differ statistically from the values obtained for some of the weeded plots. Other authors (Begna *et al*., 2001; Rout & Satapathy, 1996; Tolenaar *et al*., 1997) also verified that maize growth is reduced by weeds. Begna *et al*.

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TABLE 1. Means for plant height, ear height, no. ears ha^{-1}, no kernels/ear, 100-grain weight, and grain yield of maize cultivar Centralmex-3, when submitted to weed control. Mossoró, RN, Brazil, 1996[1].

Weed control (Days after planting, DAP)	Plant height (cm)	Ear height (cm)	Number of ears ha^{-1}	Nº de kernels/ear	100-grain weight (g)	Grain yield (kg ha^{-1})
No weeding	209 c	128 b	36,408 c	224 d	21.6 b	1,389 c
Weeding at 15 DAP	240 ab	150 ab	45,732 abc	365 abc	30.8 a	4,184 ab
Weeding at 30 DAP	239 ab	148 ab	48,850 ab	403 ab	33.1 a	5,326 a
Weeding at 45 DAP	217 bc	132 ab	49,502 ab	324 bc	30.3 a	4,283 ab
Weeding at 60 DAP	225 abc	142 ab	39,156 bc	287 cd	29.1 ab	3,249 bc
Weeding at 15 and 30 DAP	252 a	156 a	49,527 ab	438 a	33.8 a	5,466 a
Weeding at 15 and 45 DAP	235 abc	145 ab	44,597 abc	363 abc	30.1 a	4,421 ab
Weeding at 15 and 60 DAP	226 abc	151 ab	48,350 ab	335 bc	31.7 a	4,434 ab
Weeding at 30 and 45 DAP	243 ab	149 ab	51,733 a	390 ab	32.8 a	5,256 a
Weeding at 30 and 60 DAP	233 abc	145 ab	49,143 ab	352 abc	32.6 a	4,679 ab
Weeding at 45 and 60 DAP	239 ab	147 ab	49,684 ab	380 ab	33.1 a	4,775 ab
Weeding at 15, 30, and 45 DAP	232 abc	143 ab	47,902 ab	358 abc	32.5 a	4,940 ab
Weeding at 15, 30, and 60 DAP	249 a	155 a	47,458 ab	360 abc	32.9 a	4,927 ab
Weeding at 30, 45, and 60 DAP	241 ab	148 ab	49,432 ab	372 abc	34.5 a	5,272 a
Weeding at 15, 30, 45, and 60 DAP	244 ab	151 ab	47,902 ab	381 ab	33.2 a	5,488 a

[1]In each series of measurements, values followed by a common letter are not different among themselves at 5% probability by Tukey test.

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(2001) verified that this competition reduced plant height in a leafy cultivar with reduced stature by only 4 cm, but caused a reduction of 26 cm in plant height in a long-leaved late cultivar.

Weeding at 30 and 45 days after planting provided the greatest number of ears ha^{-1}, but this number was only different from the "no weeding" and "weeding at 60 days after planting" treatments (Table 1).

With regard to the number of kernels/ear, the best result was attained when the maize was weeded at 15 and 30 days after planting (Table 1). However, this treatment was only different from the "no weeding" treatment or from those treatments where only one (at 45 or at 60 days after planting) or two weeding operations (at 15 and 60 days after planting) were performed. Therefore, weeding at 30 and/or 45 days after planting apparently seem to be important to ensure greater numbers of kernels/ear.

The poorest 100-grain weight was observed in non-weeded plots (Table 1). There were no differences between weeded plots, regardless of the number or moment when the weeding operations were carried out. Plots weeded only at 60 days did not differ from "no weeding" plots. Incidentally, plots weeded at the maximum number of times not always showed the greatest means for the three yield components evaluated. It is likely that frequent or late weedings, performed when the plants have already grown substantially, might determine some type of detrimental effect on maize. Damage to the root system, made with the hoe, or to the leaves, inflicted as the worker walked between plants, could negatively influence some yield components.

The best yields were obtained with one (at 30 days after planting, DAP), two (at 15 and 30 DAP, or at 30 and 45 DAP), three (30, 45, and 60 DAP) or four (15, 30, 45, and 60 DAP) weedings (Table 1). Such treatments did not differ from the others, except from the "no weeding" and "weeding at 60 DAP" treatments, which produced the poorest yields. In the 11 treatments that significantly differed from the control, superiority ranged from 201% ("weeding at 15 DAP" treatment) to 295% (four weedings).

The results obtained in the present work are in agreement with those found by other authors (Begna *et al*., 2001; Tollenaar *et al*., 1997), in that competition with weeds reduces grain yield in maize. The results also confirm that grain yield in maize can be increased by increasing the number of hoeings (Okumura *et al*, 1986; Santos *et al*., 1987; Bezerra *et al*., 1995), even though differences are not always significant (Bezerra *et al*., 1995).

The reduction in maize yield due to the presence of weeds is attributed to the crop's competition with the weeds for water, light and nutrients (Carruthers *et al*., 1998). When infested by invader plants, the maize crop develops stress symptoms earlier due to the lack of water, than when it is weed-free (Young *et al*., 1984; Tollenaar *et al*., 1997). However, there are no differences between water contents in the soil's profile in maize with and without weeds (Young *et al*., 1984; Tollenaar *et al*., 1997). Thomas and Allison (1975) verified that the water content in maize plots infested with weeds was greater than in maize plots without weeds. In the presence of weeds, the development of water stress symptoms may not be caused by water availability, but by a reduced ability of the root system in absorbing water. Another possibility is that weed root exudates would contain toxins that could inhibit root growth in maize (Rajcan and Swanton, 2001).

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With regard to nutrients, it can be observed that nitrogen deficiency symptoms develop earlier in maize infested with weeds than in maize that is kept weed-free. This would imply in N depletion in the soil, when maize is grown in the presence of weeds (Rajcan and Swanton, 2001). Maize yield reductions are smaller under high nitrogen rates than under smaller rates. Tollenaar *et al*. (1997) verified that, under limiting nitrogen conditions, maize yield was reduced due to weeds by 47%. Under high levels of N the reduction was only of 14%. However, another aspect must be involved. Thomas and Allison (1975) verified that the maize root system becomes less developed in the presence of weeds. Thus, a smaller root system would be less efficient in absorbing nutrients. With other nutrients a similar phenomenon must occur.

In the competition for light, two components are involved (Rajcan and Swanton, 2001), the amount and quality of light. The quantitative component determines photosynthetic activity, while light quality influences plant morphology. An important trait in maize is that most of the light intercepted by the younger and more efficient leaves, located above the ear; less than 10 % of the photon flux density (PFD) reach the leaves below 1 m. On the other hand, most weeds at bloom, as well as after bloom time, are below 1 m. Thus, the direct competition between maize and weeds for the incident PFD is relatively small. Even in weed-free maize fields, the leaves below the ear become shaded by the upper leaves, and are also older. Consequently, their photosynthetic rates are smaller than the rates observed in the upper leaves. This means that the maize yield loss due to weed competition for the incident PFD cannot be explained by the reduced photosynthetic rates in the bottom leaves, which are shaded by weeds. The leaf area index (LAI) defines a plant's ability in intercepting the incident PFD and is an important factor that determines dry matter accumulation. It has been verified (Tollenaar *et al*., 1994) that high competition by weeds reduced the LAI in maize at the blooming stage by 15%. Thus, grain yield losses resulting from competition for light are better explained by the reduction in LAI than by smaller photosynthetic rates in shaded leaves (Rajcan and Swanton, 2001).

The bottom leaves are not only exposed to a reduced amount of PFD, but also receive light with a quality that is different from the light received by leaves bathed in full sunlight. The light inside the canopy is rich in ultraviolet radiation (730 to 740 nm). This is caused by the selective absorption of red light (660-670 nm) by the photosynthetic pigments and by the reflection of Far-red (FR) light by green leaves. This makes the Far-red/red ratio (FR/R) greater in the bottom section than in the upper section of the canopy. The FR/R ratio plays an important role in the induction of many morphological changes in plant architecture (stem elongation, apical dominance, reduced branching, thinner leaves, leaf area distribution, etc.) (Salisbury and Ross, 1991). Consequently, plants that develop in FR-rich light tend to have an architecture that is different than plants that grow in full sunlight. Shaded plants tend to allocate a greater leaf area in the upper section of the canopy where more light is available, while plants grown in full sunlight have a more pyramidal leaf area distribution, which limits shading on the bottom leaves by the upper leaves.

The economic analysis performed suggests that two weedings (at 15 and 30 days after planting) must be carried out for a greater net revenue to be obtained (Table 2). It can be

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observed that a lack of weed control could cause almost 50% damage to the resources invested in the production of maize. It can be also observed that, for the same number of hoeings, large differences exist between operating incomes, depending on the moment when those hoeings are performed. Obviously, not always the highest yields are associated with the greatest incomes.

TABLE 2. Grain yield, total cost, and operating income obtained with Centralmex-3 maize cultivar, with or without weeding. Mossoró, RN, Brazil, 1996[1].

Number of weedings (Days after planting = DAP)	Grain yield ($kg\ ha^{-1}$)	Total cost ha^{-1} (R$ 1.00)	Operating income (R$ 1.00)
No weeding	1,389	1,663.83	-830.43
One weeding			
Weeding at 15 DAP	4,184	1,729.36	781.04
Weeding at 30 DAP	5,326	1,729.36	1,466.24
Weeding at 45 DAP	4,283	1,729.36	840.44
Weeding at 60 DAP	3,249	1,729.36	220.04
Two weedings			
Weeding at 15 and 30 DAP	5,466	1,794.79	1,484.81
Weeding at 15 and 45 DAP	4,421	1,794.79	857.81
Weeding at 15 and 60 DAP	4,434	1,794.79	865.61
Weeding at 30 and 45 DAP	5,256	1,794.79	1,358.81
Weeding at 30 and 60 DAP	4,679	1,794.79	1,012.61
Weeding at 45 and 60 DAP	4,775	1,794.79	1,070.21
Three weedings			
Weeding at 15, 30 and 45 DAP	4,940	1,857.42	1,106.58
Weeding at 15, 30 and 60 DAP	4,927	1,857.42	1,098.78
Weeding at 30, 45 and 60 DAP	5,272	1,857.42	1,305.78
Four weedings			
Weeding at 15, 30, 45, and 60 DAP	5,488	1,925.95	1,366.85

[1]The Fixed Costs value was R$ 73.38. The Variable Costs values for no weeding and for one, two, three, or four weedings were R$1,590.45, R$1,655.98, R$1,721.51, R$1,784.04, and R$1,852.57, respectively. The Operating Income was calculated under the assumption that the farmer could sell a 50 kg bag of maize for R$ 30.00. All values refer to costs as of November 2003.

http://dx.doi.org/10.18512/1980-6477/rbms.v3n2p204-213

It can be concluded that the lack of weed control reduces plant and ear heights, as well as grain yield and its components. The highest yields can be obtained with one weeding, at 30 days after planting (DAP), two (at 15 and 30 DAP, or at 30 and 45 DAP), three (30, 45, and 60 DAP), or four weedings (15, 30, 45, and 60 DAP). Greater net revenue with the commercialization of the grain is obtained when weedings are conducted at 15 and 30 days after planting.

Literature Cited

BEGNA, S. H.; HAMILTON, R. I.; DWYER, L. M.; STEWART, D. W.; CLOUTIER, D.; ASSEMAT, L.; FOROUTAN-POUR, K.; SMITH, D. L. Morphology and yield response to weed pressure by corn hybrids differing in canopy architecture. **European Journal of Agronomy**, Montrouge, v. 14, n. 4, p. 293-302, 2001.

BENDIXEN, L. E. Corn (*Zea mays*) yield in relationship to Johnsongrass (*Sorghum hapelense*) population. **Weed Science**, Champaign, v. 34, p. 449-451, 1986.

BEZERRA, N. F. SILVA, P. S. L. e; OLIVEIRA, O. F. de; NOGUEIRA, F. das C. Efeitos do controle de invasores e de níveis de nitrogênio sobre o rendimento de grãos de milho irrigado. **Agrociência**, Chillan, v. 11, p. 17-25, 1995.

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

CARRUTHERS, K., F. E. Q.; CLOUTIER, D.; SMITH, D. L. Intercropping corn with soybean, lupin and forages: weed control by intercrops combined with interrow cultivation. **European Journal of Agronomy**, Montrouge, v. 8, p. 225-238, 1998.

CHAGAS, F. C. da. **Normas climatológicas para Mossoró-RN (1970-1996)**. 1997. 40 f. Monografia (Graduação em Agronomia) - Escola Superior de Agricultura de Mossoró, Mossoró.

FORD, G. T.; PLEASANT, J. Competitive abilities of six corn (*Zea mays* L.) hybrids with four weed control practices. **Weed Technology**, Champaign, v. 8, p. 124-128, 1994.

HALL, M. R.; SWANTON, C. J.; ANDERSON, G. W. The critical period of weed control in grain corn. **Weed Science**, Champaign, v. 40, p. 441-447, 1992.

JAT, R. L.; GAUR, B. L.; KUMAR, S.; KULHARI, R. K. Effect of weed management, fertilizers and *Rhizobium* inoculation on growth, yield attributes of maize (*Zea mays*) and soybean (*Glycine max*) under maize + soybean intercropping system. **Indian Journal of Agronomy**, New Delhi, v. 43, n. 1, p. 23-26, 1998.

OKUMURA, T.; TAKEUCHI, S.; SUGINO, M. Competition between corn plants and weeds for uptake fertilizer. **Memoirs of the Faculty of Agriculture of Kinki University**, Nakamachi, v. 19, p. 1-8, 1986.

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

ROUT, D.; SATAPATHY, M. Chemical weed control in rainfed maize (*Zea mays*). **Indian Journal of Agronomy**, New Delhi, v. 41, n. 1, p. 51-53, 1996.

SAIKIA, T. P.; PANDEY, J. Weed shift in maize (*Zea mays*)-chickpea (*Cicer arietinum*) cropping

http://dx.doi.org/10.18512/1980-6477/rbms.v3n2p204-213

system. **Indian Journal of Agronomy**, New Delhi, v. 44, n. 2, p. 246-249, 1999.

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

SANTOS, J. A. C.; ANDRADE, M. A. de; ANDRADE, L. A. de B.; ABREU, A. R. de. Influência de portes de cultivares, número de capinas e épocas de colheita sobre a incidência de plantas daninhas e produção de grãos de milho. **Pesquisa Agropecuária Brasileira**, Brasília, v. 22, p. 501-503, 1987.

SILVA, P. S. L. e; FREITAS, C. J. de; BEZERRA, N. F. Situação da cultura do milho no estado do Rio Grande do Norte conforme a percepção de extensionistas (Segundo diagnóstico. **Caatinga**, Mossoró, v. 8, p. 7-24, 1994.

TEASDALE, J. R. Influence of narrow/high population corn (*Zea mays* L.) on weed control and light transmittance. **Weed Technology**, Champaign, v. 9, p. 113-118, 1995.

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

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

TOLLENAAR, M.; NISSANKA, S. P.; AGUILERA; WEISE, S. F.; SWANTON, C. J. Effect of weed interference and soil nitrogen on four maize hybrids. **Agronomy Journal**, Madison, v. 86, n. 2, p. 596-601, 1994.

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

ZAR, J .H. **Biostatistical analysis**. 4.ed. Englewood Cliffs: Prentice Hall, 1999. 663 p.