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The Critical Period of Weed Control in Maize (*Zea mays* L.) in Sudan

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Abstract: Competition between maize (*Zea mays* L.) and weeds is a serious challenge to crop production. A field study was conducted at the Demonstration Farm, Faculty of Agriculture, University of Khartoum, Sudan, during 2008/09 and 2009/10 winter seasons, to determine the magnitude of yield losses due to weed competition and identify the critical period of weed interference in maize. The experiment consisted of two sets. In the first set the crop was kept weed-free for 0, 2, 4, 6, and 8 weeks after sowing. In the second set weeds were allowed to compete with the crop for 0, 2, 4, 6, and 8 weeks after sowing. Unrestricted weed growth reduced maize cob length, cob weight, grain number/ plant, 100 seeds weight and grain weight/ plant by 62%, 82%, 75%, 49% and 87%, respectively in the 2008/2009 season and by 62%, 89%, 75%, 41% and 85%, respectively in the 2009/2010 season. The presence of weeds throughout the crop growth duration resulted in 82% and 84% loss in grain yield in seasons 2008/09 and 2009/10, respectively. The critical period of weed control in maize was found to be between 2 and 6 weeks after sowing.

Key words: Maize; weed control; critical period; time of weed removal.

INTRODUCTION

Maize (*Zea mays* L.) is one of the important cash crops in the world. In Sudan maize is grown in different parts of the country for local consumption; however, it can occupy a key place in existing cropping

systems in Sudan , because it is a short duration crop and provides more economic returns to growers. Although the yield potential of adapted maize varieties is fairly good , but it has not been exploited fully due to several constraints, among which weed infestation is a major factor reducing the yield of the crop which is more sensitive to weed competition at early stages of development (Muhamed *et al.* 2009). The magnitude of losses in maize grain yield due to weed infestation depends upon the composition of weed flora, weed density and stage of crop growth at which weed crop competition occurs, and severe weed infestation may result in complete crop failure (Khan and Hag 2003). Besides the direct effect of weeds in decreasing maize yield, the resultant loss of its market value is a setback to growers. Weed control, is therefore, essential for achieving high yields. Yield can be increased by up to 50% by adopting different recommended practices including weed management (Patle *et al.* 2006). The time of weed emergence relative to the crop is an important parameter in estimating yield losses due to weed competition (Kropf *et al*. 1994). Weeds that emerge together with the crop or shortly thereafter cause greater yield losses than those emerging later in the growth cycle of the crop (Swanton *et al*. 1999). Importance of timing of weed emergence relative to the crop is described by the critical period for weed control (Weaver *et al*. 1992) the critical period is useful in defining the crop growth stages most vulnerable to weed competition. Thus, selection of optimum weed management practices is important for economical yield. In practice, the critical period is defined as the number of weeks after crop emergence during which the crop must be weed–free in order to prevent yield losses (Knezevic *et al*. 1994). Consequently, studies to find out the critical period of weed control in maize are of a paramount importance in weed management strategies. Mukhtar *et al.* (2007) studied the effect of weeds on growth and yield in maize in the Northern State of Sudan and found that the critical period of weed control ranged between 2 and 8 weeks after planting in winter and 2 and 9 weeks after planting in summer. It is known that the critical periods of weed control are affected by the ecological conditions and farming systems. This study was, therefore, designed to determine the critical period of maize weed control and its impact on maize production under Khartoum environmental conditions.

MATERIALS AND METHODS

A field experiment was conducted at the Demonstration Farm, Faculty of Agriculture, University of Khartoum Sudan, (Latitude 15°40` N and Longitude 32°23` E,) during 2008/09 and 2009/10 winter seasons to study effects of weed competition on maize in heavy clay soil with 48%–54% clay, 25%–29% silt and 17%–25% sand. The pH of the site ranged between 7 and 8. The experiment was laid out in randomized complete block design with four replications. The experimental site was ploughed, harrowed, leveled, ridged and then divided into plots. Each plot was 3×4 m^2 in size and the spacing between ridges was 75 cm. A commercial variety of maize (Giza 2) was sown on the 27th of October in both seasons. The seed rate was 3 – 5 seeds per hole, and the seeds were sown on one side of the ridge with a spacing of 20 cm between holes. The plants were thinned to two per hole to give a plant population of approximately 160.000 per hectare. Two sets of treatments were included. In the first set the crop was kept weed-free for different periods (0, 2, 4, 6 and 8 weeks) by repeated hand weeding and was allowed to become weedy after that. In the second set, the weeds were allowed to grow with the crop for similar periods and thereafter the crop was kept weed-free till harvest. Total and individual weed species, in the weedy check, were counted at 6 weeks after sowing using 1m^2 randomly placed quadrangle. At harvest, maize yield and yield components (cob length, cob weight, grains number/ plant, 100 seeds weight and grain weight/ plant) were measured by taking the average of 10 plants randomly for each treatment and then grain yield ton/ha was calculated. Data were subjected to analysis of variance and means were separated for significance using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISSCUSSION

The total weeds in the experimental site, as represented by the weedy check, were 233/m^2 and 210/ m^2 in 2008/09 and 2009/10 seasons, respectively. Broad-leaved weeds constituted 80% of the total weed flora in both seasons. The predominant weed species were rough or heartleaf

Cccklebur (*Xanthium brasilicum* Vell.), Jimson weed (*Datura stramonium* L.), garden spurge *(Euphorbia hitra* L.), purslane (*Portulaca oleracea* L.), bladder hibiscus *(Hibiscus trionum* L.), erect spiderling *(Boerhavia erecta* L.), white pigweed *(Amaranthus graecizans* L.), pigweed *(Amaranthus vridis* L.), gripeweed *(Phyllanthus niruri* L.), black nightshade (*Solanum nigrum* L.), common caltraps (*Tribulus terrestris* L.), water grass (*Echinochloa colona* (L.) Link.), tropical crabgrass (*Digitaria ciliaris* (Retz) Koel.), lovegrass [*Eragrostis magastachya* (Koel.) Link.] and [*Dinebra retroflexa* (Vahl) Panz.].

Weed infestation till harvest reduced cob length by 62% in both seasons. Keeping the crop weed-free for 6 and 8 weeks after sowing and allowing weeds to compete with the crop for the first 2 weeks gave cob length comparable to the weed-free check in 2008/9 and 2009/10 seasons (Tables 1 and 2).

The maximum cob weights (70 g in the first season and 96 g in the second season) were obtained where the crop was kept weed free till harvest, while the minimum weights (12.1 g in 2008/9 season and 30 g in 2009/10 season) were found in case of weed infestation till harvest . Removal of weeds up to 6 and 8 weeks after sowing gave cob weights comparable to the weed-free check (Tables 1 and 2). Weeds removal for 8 weeks after sowing gave grain number comparable to weed removal throughout the maize growth period in both seasons, whereas delaying weed removal for 8 weeks after sowing gave grain number comparable to the presence of weeds throughout the crop duration.

Table 1. Effects of durations of weedy and weed–free periods (weeks after sowing) on yield and yield components of maize (2008/2009)

	Weedy						Weed-free					
Weeks after sowing	Cob length (cm)	Cob weight (g)	Grain No/plant	100 seeds weight (g)	Grain weigh (g)	Grain yield (ton/ha)	Cob length (cm)	Cob weight (g)	Grain No/plant	100 seeds weight (g)	Grain weigh (g)	Grain Yield (ton/ha)
0	14.6a	70a	270a	19a	56a	4.5a	5.5e	12.1c	67.2e	9.6d	7.2d	o.8c
2	14a	61.9b	241.6b	18.8a	4.7c	3.9a	7.2d	14.2c	96d	11.1c	9.2c	0.7c
4	12.2b	55.8c	192c	16.8b	31.1c	2.5b	10c	42.6b	136c	14.1b	28b	2.2b
6	5.9c	18.9d	95.6d	13c	12.5d	1.0c	13.2ab	60.2a	251b	18a	50ab	4a
8	5.6c	13e	75.6e	10d	8.2e	0.7c	0.7a	62.8a	266a	18.9a	54a	4.3a
S E ±	0.47	2.34	3.1	0.55	0.94	0.15	0.47	2.34	3.1	.055	0.94	0.18

Means within a column followed by the same letters (s) are not significantly different at level according to the Duncan's Multiple Range Test

Table 2. Effects of durations of weedy and weed-free periods (weeks after sowing) on yield and yield components of maize (2009/2010)

Weedy												**Weed-free**
Weeks after sowing	Cob length(cm)	Cob weight(g)	Grain No/plant	100 seeds weight(g)	Grain weight(g)	Grain yield (ton/ha)	Cob length(cm)	Cob weight (g)	Grain No/plant	100 seeds weight(g)	Grain weight(g)	Grain Yield (ton/ha)
0	16.5 a	96 a	380 a	19 a	72.2 a	5.8 a	6.2 d	30 c	96 e	11.2 d	10.8 e	0.9 d
2	16 a	89 a	358 b	18.7 a	67.1 b	5.4 a	9 c	44 c	150 d	12.8 c	19.1 d	1.6 c
4	12 b	50 b	20 c	15 b	30 c	2.4 c	13.1 b	67 b	243 c	15 b	36.5 c	2.9 b
6	7.8 c	35 c	138 d	12.1 c	16.7 d	1.3 d	16 a	88 a	300 b	18 a	54 b	4.3 a
8	6.2 c	30 c	104 e	12 c	12.5 e	1.0 d	16.6 a	92 a	349 a	18.2 a	66.3 a	4.8 a
0.18	1.09	0.35	7.39	2.77	0.82	0.18	1.09	0.35	7.4	2.7	0.82	S E ±

Means within a column followed by the same letters (s) are not significantly different at level according to the Duncan's Multiple Range Test

Weight of 100 seeds was significantly affected by the duration of both weed removal and infestation. The 100 seeds weight decreased significantly when weeds were allowed to grow unrestricted or to grow for 8 weeks after sowing in both seasons. Maximum 100 seed weights were 19, 18.8,18 and 18.9 g for the weed-free check, weedy for 2 weeks, weed-free for 6 and 8 weeks after sowing, respectively the first season; and 19, 18.7, 18 and 18.2 g, respectively in the second season (Tables 1 and 2). The minimum 100 seeds weights (10 -12 g) in both seasons were recorded when weeds were allowed to grow throughout the maize growth period.

Weed removal throughout the maize growth period produced the highest grain weight/plant (56 g) in the first season and in second season (72.2 g), while lowest grain weights (7.2 g in first season and 10.8 g in second season) were recorded in case of weed infestation throughout the maize growth period. Removal of weeds for 8 weeks after sowing gave grain weight comparable to the weed-free check (Tables 1 and 2).

Unrestricted weed growth reduced maize grain yield by 82% and 84% in 2008/09 and 2009/10 seasons, respectively. Removal of weeds for 2 , 4, 6 and 8 weeks after sowing increased maize grain yield by 43%, 72%, 80% and 81%, respectively in the first season (Table 1) and by 44%, 69%, 79% and 82% in the second season (Table 2). Delaying weed removal for 2, 4, 6, and 8 weeks after sowing decreased maize grain yield by 6%, 44%, 77% and 86% respectively in the first season (Table 1) and by 7%, 59%, 77% and 82% in the second season (Table 2).

The reduction in grain yield due to weed interference was mainly through reduction in the maize cob length, cob weight, grain number/plant, 100 seeds weight, and grain weight/plant. It is evident that early weeding till two weeks after sowing or late weeding after 6 weeks from sowing did not mitigate the adverse effects of weeds on maize. The early period threshold, the period of weed control that the crop can tolerate, appeared to be the first 2 weeks after sowing, whereas the late period threshold, the

period beyond which additional weeding does not affect the yield, was found to begin 6 weeks after sowing in both seasons (Figs. 1 and 2). Hall *et al*. (1992) described the critical period of weed competition as the time interval between the maximum length of time weeds emerging with the crop can remain before they reduce crop yield and the length of time a crop must be kept weed–free after planting, so that weeds emerging later do not reduce yield. Thus, the critical period for weed control in maize as indicated by the present study appeared to be between 2 and 6 weeks after sowing (Figs. 1 and 2). This result is in line with Ghoshen *et al*. (1996) who reported that the critical period for weed competition in maize is 3.0-6.5 weeks after emergence. Similar finding was also reported by mukhtar *et al*. (2007) who pointed out that the critical periods for weed control in maize were 2 to 8 weeks after planting in winter and 2 to 9 weeks in summer . Discrepancies in the critical period are not unexpected since it is known that this period is influenced by many factors such as weed species, plant density, soil fertility, crop cultivar and the environment. Depending on the results obtained from this experiment it can be concluded that, maize grain yield was significantly reduced as a results of unrestricted weed growth. However, maize grain yield increased by up to 80%, in both seasons when weeds were controlled during the first 6 weeks. Therefore, the critical period was found to be 2 to 6 weeks after sowing in Khartoum, Sudan. Keeping the crop weed–free within this period protects the crop from the adverse effects of early competition, and it is an optimum time for weed control in maize in order to improve the efficacy and minimize application cost.

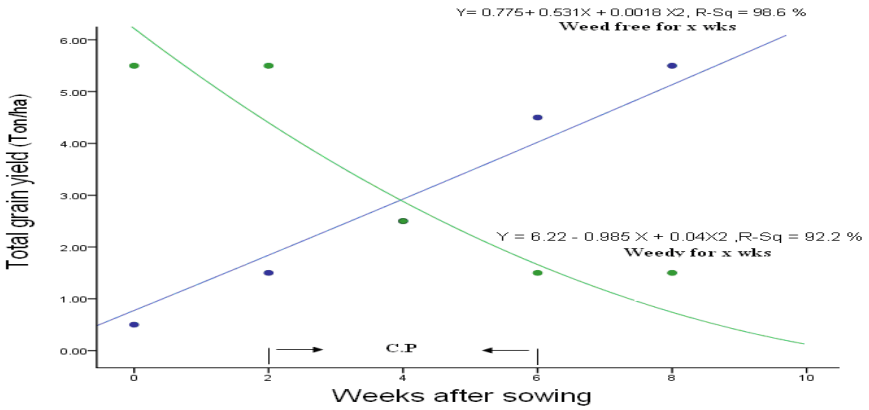

Fig. 1. Effect of duration of weed-free period and weed infestation (weeks after sowing) on yield of maize (2008-2009).
C.P. = Critical period for weed control.

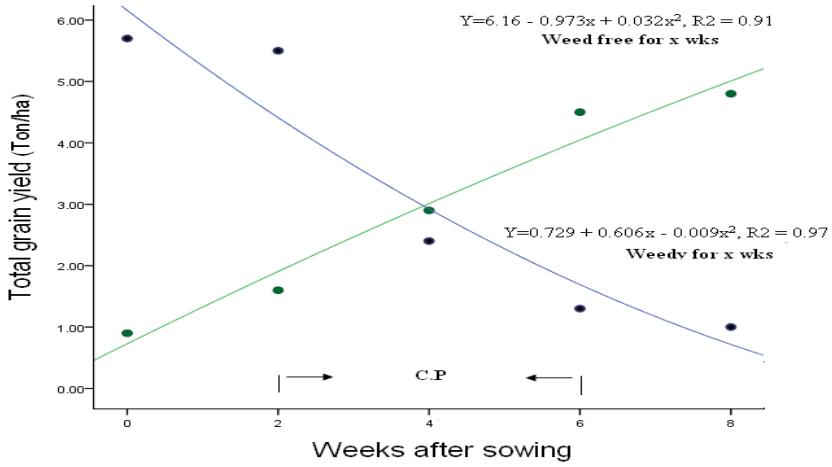

Fig . 2. Effect of duration of weed free period and weed infestation (weeks after sowing) on yield of maize (2009-2010).
C.P. = Critical period for weed control.

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الفترة الحرجة لمنافسة الحشائش لمحصول الذرة الشامية (*Zea mays L.*) في السودان

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المستخلص: تعتبر المنافسة بين الحشائش والذرة الشامية عائقاً حقيقياً لإنتاجية المحصول في السودان. أجريت هذه التجربة بالمزرعة التجريبية لكلية الزراعة جامعة الخرطوم خلال موسمي الشتاء لعامي 2009/2008 و 2010/2009م بهدف تحديد حجم الفاقد من الإنتاج نتيجة التأثير السلبي للحشائش على محصول الذرة الشامية و التعرف علي الفترة الحرجة لمنافسة ومكافحة الحشائش .شملت التجربة مجموعتين من المعاملات: ترك المحصول في المجموعة الأولي خالياً من الحشائش للفترات 0 ، 2 ، 4 ، 6 ، 8 أسابيع من الزراعة ، بينما ترك المحصول في لمجموعة الثانية موبوءا بالحشائش للفترات 0 ، 2 ، 6 ، 8 أسابيع . اتضح من التجربة أن النمو غير المحدود للحشائش أدي إلي نقص في طول كوز الذرة الشامية ، ووزن الكوز، وعدد الحبوب للنبات ، ووزن ال100 حبة و وزن الحبوب للنبات الواحد بنسبة 62% ، 82% ، 75% ، 49% ، و 87% ، على التوالي في موسم 2009/2008 ، وبنسبة 62% ، 89% ، 75% ، 41% ، و 85% على التوالي في موسم 2010/2009 ؛ وأن وجود الحشائش طيلة فترة نمو محصول الذرة الشامية أدي لفقد في إنتاج البذور بلغ 82% في موسم 2009/2008 و 84% في موسم 2010/2009 . أما الفترة الحرجة لمنافسة الحشائش لمحصول الذرة الشامية فقد تراوحت ما بين الأسبوع الثاني والأسبوع السادس من الزراعة