Critical period of weed competition and yield losses of irrigated common bean (*Phaseolus vulgaris* L.) in northern Sudan

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ABSTRACT

Weeds constitute one of the major biotic constraints that limit production of common bean (*Phaseolus vulgaris* L.) in Sudan. A field study was conducted at Hudeiba Research Station Farm, Ed Damer, River Nile State, Sudan, during 1998/99 and 1999/2000 winter seasons, to determine the magnitude of yield losses due to weed competition and identify the critical period of weed competition. Plots were kept weedy for 0, 2, 4, 6 and 8 weeks after sowing, while others were maintained weed-free for the same periods. Unrestricted weed growth reduced grain yield by 33 and 51% in seasons 1998/99 and 1999/2000, respectively. The critical period of weed competition varied between seasons. In the first season, the critical period was found to be between 2 and 6 weeks after sowing, whereas in the second season, it was between 4 and 6 weeks after sowing depending on the level of weed infestation and climatic conditions.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.*)* is an important food legume in Sudan. It ranks second to faba bean in northern Sudan. It is mainly grown under residual moisture after river Nile recession or under pump irrigation. The main production areas are Shendi and Barber. Dry bean is recognized as a poor competitor with weeds (Blackshaw, 1991). The magnitude of yield losses due to weeds in common bean in northern Sudan has not been estimated. However, yield losses of up to 80% in other leguminous crops such as faba bean (*Vicia faba* L.), chickpea (*Cicer arietinum* L.) and lentil (*Lens culinaris* L.) have been reported (Mohamed, 1996; Mohamed *et al.*, 1997). The traditional method of weed control in legumes in northern Sudan is hand weeding, which is carried out voluntarily by farmers to collect fodder for livestock.

The yield losses are mainly due to delayed weeding or insufficient weed control (Hamdoun and El Tigani, 1977). Winter weeds emerge before or simultaneous with common bean. The competitiveness of weeds with a crop depends on species, time of weed emergence and abundance. There is a relationship between the time of weed emergence, the pressure exerted on the crop through competition and the resulting loss in yield (Ciuberkis *et al*., 2007). Yield losses due to weeds infestation in beans varied from one country to another (Wolley, 1989; Blackshaw, 1991; Arnold *et al*., 1993; Malik *et al*., 1993).

Limited research has been done in Sudan on the effects of weeds on common bean. The present study was, therefore, conducted to determine the magnitude of yield losses due to weeds and identify the critical period of weed competition.

MATERIALS AND METHODS

A field experiment was conducted during 1998/99 and 1999/00 winter season at Hudeiba Research Station Farm (lat. 17° 34` N, long. 33° 56´ E) in the River Nile State, Sudan. The soil is clay loam in texture with a pH of 8.0 to 8.6, organic carbon of 0.37% and total nitrogen of 0.03%. The experimental site was disc ploughed, harrowed, leveled and ridged. Common bean, cv.R/O/2/1, was planted on the top of the ridge at 2 seeds per hole at inter- and intra- ridge spacings of 60 cm and 10 cm, respectively. The sowing date was the first week of November and the last week of October for the first and second seasons, respectively. Nitrogen, as urea, was applied at 43 kg N/ha immediately before the third irrigation.

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 allowed to become weedy. In the second set, the weeds were allowed to grow with the crop for similar periods and thereafter, kept weed free till harvest. The experimental design was a randomized complete block with 4 replications. The plot size was 3 x 7 m. In the weedy check, total and individual weed species were counted at 6 weeks after sowing using $1m^2$ randomly placed quadrangle. Yield and yield components of common bean were measured at harvest. Number of pods/ plant was calculated by taking 6 plants randomly from the three central ridges. Number of seeds /pod was calculated by taking 5 pods from each of the 6 plants. The 1000- seed weight was recorded. The plots were harvested and grain and straw yields were determined.

Data were subjected to analysis of variance and means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS

In the first season**,** the total weeds were 49 m^{-2} and broad leaved weeds constituted 72% of the total weed flora. The dominant weed species were common beet (*Beta vulgaris* L), wild mustard (*Sinapis arvensis* L)., *Ipomoea sinensis* (Desr.) Choisy, cheese weed *(Malva parviflora*), purslane (*Portulaca oleracea*), croton *(Chrozophora plicata* (Vahl.) A. Juss. Ex Spreng and sweet signal grass (*Brachiaria eruciformis* (Sm) Grieseb. Weeds had no significant effect on number of seeds per pod or 1000- seed weight (data not shown). The number of pods per plant, however, was significantly reduced by the presence of weeds throughout the growing season (Table 1). The presence of weeds throughout the crop duration resulted in 22% and 33% loss in straw and grain yields, respectively (Table 1). Removal of weeds for 2, 4, 6 or 8 weeks after sowing gave straw yield comparable to the weed-free check (Table 1). However, delaying weed removal for 6 or 8 weeks after sowing reduced straw yield by 24% and 26%, respectively, compared to the weed- free check (Table 1). Removal of weeds for 2, 4, 6 or 8 weeks after sowing increased grain yield by 25%, 25%, 82% and 28%, respectively (Table 1). Delaying weed removal up to 6 weeks after sowing reduced grain yield by 14%. However, delaying weed removal for 8 weeks after sowing resulted in a significant reduction (26%) in grain yield (Table 1).

Table 1: Effect of duration of weed- free and weed infested (weeks after sowing) on yield and yield components of common bean (1998/99).

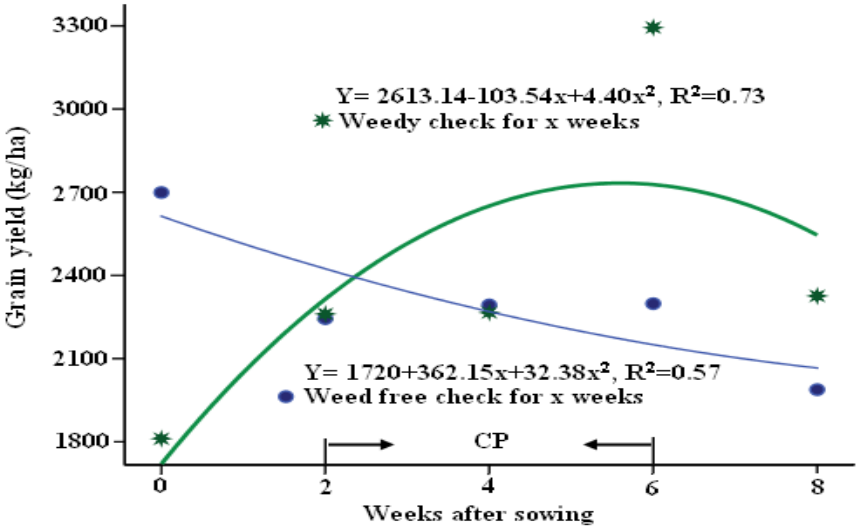
Weeks after sowing	Weedy check for x weeks			Weed free check for x weeks		
	No. of pods /plant	Straw yield (kg/ha)	Grain yield (kg/ha)	No. of pods /plant	Straw yield (kg/ha)	Grain yield (kg/ha)
0	27.9 ab	5325 a	2699 a	19.5 c	4129 bc	1811 c
2	27.3 ab	5179 a	2244 abc	21.5 bc	4425 abc	2261 abc
4	29.5 a	4779 abc	2293 abc	28.9 ab	5014 ab	2266 abc
6	22.0 abc	4024 bc	2298 abc	29.7 a	4624 abc	3294 ab
8	24.2 abc	3935 c	1988 bc	27.8 ab	5305 a	2326 ab
SE±	2.29	315.89	167.90	2.29	315.89	167.9

Means within each column followed by the same letter(s) are not significantly different at the 5% level according to Duncan's Multiple Range Test.

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 common bean. The early period threshold, the period of weed competition 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 (Fig. 1).

In the second season**,** the total weeds were 125 m^{-2}. Of the total weed flora, broad leaved weeds constituted 65%. The dominant broad leaved weeds were *Beta vulgaris* L., *Sinapis arvensis* L, *Ipomoea sinensis, Malva. parviflora, Portulaca olereacea,* and Big Rhynchosia *{(Rhynchosia minima (L.) DC. var memnonia* (Del) Cooke}. The dominant grassy weeds were *Brachiaria eruciformis* and *Sorghum* spp.Weeds had no significant effect on 1000- seed weight of common bean (data not shown). The presence of weeds throughout the season or for 8 weeks after sowing significantly reduced the number

of pods per plant and the number of seeds per pod (Table 2). Unrestricted weed growth reduced grain and straw yield by 51% and 45%, respectively. Removal of weeds for 4, 6 or 8



Where y= grain yield (kg/ha), R^2 coefficient of determination and x = weed free check or weedy check. CP= Critical period.

Fig.1. Influence of weeds on grain yield of common bean (1998/1999 season.

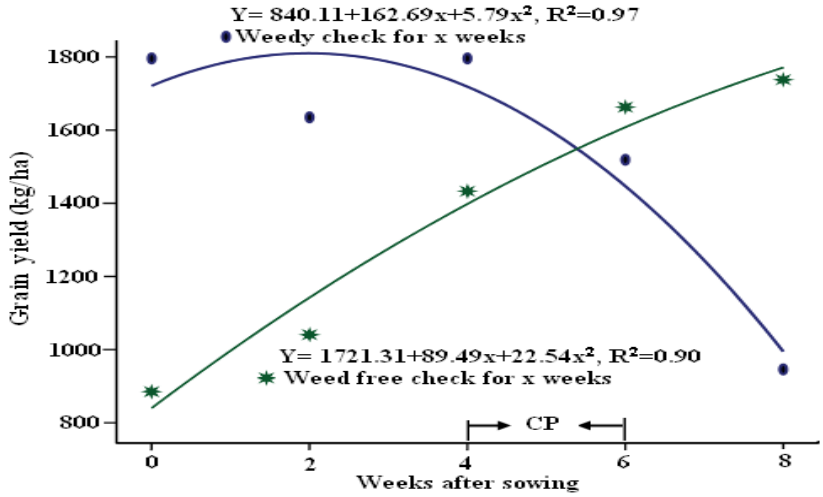
weeks after sowing increased straw yield by 40, 51 and 60%, respectively, and affected comparable yield to the weed- free check (Table 2). Delayed weeding for 8 weeks after sowing reduced straw yield significantly compared to the weed- free check. Removal of weeds for 4, 6 or 8 weeks after sowing increased grain yield significantly (62, 88 and 96%, respectively) and gave comparable yield to the weed- free check (Table 2). Delaying weed removal up to 6 weeks after sowing had no effect on grain yield. However, delaying weed removal for 8 weeks after sowing reduced yield significantly (Table 2).Further delays in weed removal did not result in further reductions in yield.

It is evident that early weeding, before 4 weeks after sowing, or late weeding, after 6 weeks from sowing, did not increase grain yield. The early period threshold, therefore, appeared to be the first 4 weeks after sowing; whereas the late period threshold was found to begin 6 weeks after sowing. So the critical period for weed control appeared to be between 4 and 6 weeks after sowing (Fig. 2).

Table 2. Effect of duration of weed free and weed infested (weeks after sowing) on yield and yield components of common bean (1999/2000).

Weeks after sowing	Weedy check for x weeks				Weed free check for x weeks			
	No. of pods /plant	No. of seeds/ pod	Straw yield (kg/ha)	Grain yield (kg/ha)	No. of pods /plant	No. of seeds / pod	Straw yield (kg/ha)	Grain yield (kg/ha)
0	20.4 ab	5.2 a	2698 a	1796 a	10.0 c	4.3 b	1484 c	885 b
2	18.2 ab	5.2 a	2520 a	1635 a	13.0 abc	5.1 a	1649 bc	1041 a
4	20.8 a	5.0 a	2689 a	1796 a	15.3 abc	4.9 a	2073abc	1433 a
6	13.2 bc	5.1 a	2160 ab	1519 a	18.5 ab	5.3 a	2235 ab	1663 a
8	10.0 c	4.7 ab	1453 c	946 b	18.5 ab	4.9 a	2375 a	1738 a
SE±	2.23	0.189	202.30	122.30	2.23	0.189	202.30	122.30

Means within each column followed by the same letter(s) are not significantly different at the 5% level according to Duncan's Multiple Range Test.



Where the y= grain yield (kg/ha), R^2 =coefficient of determination and x = weed free check or weedy check, C.p. Critical period.

Fig.2. Influence of weeds on grain yield of common bean (1999/2000 season).

DISCUSSION

Unrestricted weed growth reduced grain yield by 33 and 51% in seasons 1998/99 and 1999/2000, respectively. The level of weed infestation was lower in the first season than in the second season. The experimental site, in the first season, was affected by flood, which encouraged germination of some weed species, especially grasses which were then further reduced during land preparation. This is consistent with previous reports that pre-sowing irrigation in wheat and lentil in northern Sudan was more effective in controlling grassy weeds than broad- leaved ones (Mohamed, 1996). The reduction in grain yield, due to weeds interference, was mainly through reduction in the number of pods per plant. This supports the finding of Al- Thababi *et al*. (1994) who showed that reduction in lentil and chickpea yield, caused by weed infestation was mainly from reduction in the number of pods per plant. Wolley *et al*., (1993) had also shown that the number of pods per plant in white bean was more sensitive to weed competition than other yield components.

The critical period is the minimum period during which weeds must be suppressed to prevent yield losses (Weaver, 1984). Hall *et al*. (1992) described the critical period of weed control 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 removal in common bean as indicated by the present study appeared to be between 2 and 6 weeks after sowing in the first season and 4 - 6 weeks after sowing in the second season. In the second season, the early period threshold appeared to be the first 4 weeks after sowing, whereas, the late period threshold, the point of time beyond which additional weeding does not affect yield was 6 weeks after sowing.

Dawson (1964) has shown that the first 5 to 7 weeks after planting field bean is most critical for weed control. Woolley *et al.* (1993) reported that the critical period of weed interference for white bean was between the second trifoliate and the first flower stage. The early onset of the critical period in Sudan may be attributed to the warmer and shorter winter conditions which permit early establishment of weeds compared with
temperate regions. This slight difference in critical period is not unexpected, as crop losses due to weeds depend on environmental conditions, level of weeds infestation and composition of the weed flora (Hall *et al*., 1992; Mohamed *et al*., 1997 and Ciuberkis *et al*., 2007).

From the results of this experiment, it can be concluded that grain yield of common bean was significantly reduced as a result of unrestricted weed growth. However, grain yield of the crop under study was increased up to 96% when weeds were controlled during the first 6 weeks. Therefore, the early and late on- set of the critical period for common bean was found to be 2 to 6 weeks after sowing in northern Sudan.

To obtain weed-free conditions in common bean, use of herbicides and hand weeding 4 weeks after sowing are of great importance to eliminate and protect the crop from adverse effect of early weed competition. The present study provides the basis for an integrated weed management in common beans. For small farms, pre-watering, good land preparation followed by two hand weedings at 4 and 6 weeks after sowing may provide adequate and cost- effective weed management. However, for large farms or where labour is not available, hand weeding may be replaced by selective post-emergence herbicides.

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الفترة الحرجة لمنافسة الحشائش والفقد في الانتاج لمحصول الفاصوليا (*Phaselous vulgaris* L.) في شمال السودان

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الخلاصة

تعتبر الحشائش من المعوقات الرئيسية والمحددة لانتاج محصول الفاصوليا في السودان. أجريت هذه التجربة بمزرعة محطة بحوث الحديبة، الدامر، ولاية نهر النيل، خلال موسمي الشتاء لعامي 1998/1999 و 2000/1999 م بهدف تحديد حجم الفاقد من الانتاج نتيجة التاثير السلبي للحشائش علي محصول الفاصوليا والتعرف علي الفترة الحرجة لمنافسة ومكافحة الحشائش. أزيلت الحشائش من الاحواض لفترات صفر، 2، 4، 6 و8 أسابيع من الزراعة، بينما تركت الحشائش دون ازالة لنفس الفترات السابقة. أما الفترة 33% أتضح من الدراسة ان الفقد في انتاج البذور لمحصول الفاصوليا قد بلغ 51% في الموسمين علي التوالي. الحرجة فكانت مختلفة بين الموسمين حيث كانت بين الاسبوع الثاني و السادس من الزراعة في الموسم الاول و بين الاسبوع الرابع والسادس في الموسم الثاني وذلك حسب الظروف المناخية السائدة ومستوي الاصابة بالحشائش.