

Chemical Control of Wild Sorghum [*Sorghum arundinaceum*(Del.) Stapf.] in Faba Bean (*Vicia faba* L.) in the Northern State of Sudan

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Abstract: An experiment was conducted at Merowe Research Station farm, in the Northern State, Sudan, during 2008/2009 and 2009/2010 seasons. The objectives of the experiment were to determine the damage inflicted by a wild sorghum species (*Sorghum arundinaceum* (Del.) Stapf.) on the yield of faba bean (*Vicia faba* L.) and to evaluate the efficacy of the post-emergence herbicide clodinafop-propargyl (Topik) on wild sorghum and its effect on faba bean yield. The wild sorghum reduced faba bean crop stand and straw and seed yields by 53% -76%, 76% -79% and 88% - 91%, respectively, compared with the hand-weeded control. Faba bean was tolerant to the herbicide. The herbicide, at all rates, effected complete (100%) and persistent control of the wild sorghum and resulted in faba bean seed yield comparable to the hand-weeded control. The lowest dose (0.075 kg a.i./ha) of the herbicide used was equal to 75% of the dose recommended for the control of wild sorghum in wheat. It is concluded that clodinafop-propargyl at 0.075 kg a.i./ha could be used in controlling wild sorghum in faba bean. At this rate, the marginal rate of return was about 35 which indicating that every monetary unit (SDG 1) invested in the mentioned treatment would be returned back, plus additional amount of 35 SDG.

Key words: Herbicide; post-emergence; faba bean; wild sorghum; clodinafop-propargyl

INTRODUCTION

Faba bean (*Vicia faba* L.) is the most important food legume in the Sudan. Traditionally, the crop cultivation was, mainly, confined to the Northern and River Nile states (lat. 16°-22° 0'N) and to limited areas in Khartoum

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State and Jebel Marra. Efforts were made to extend production to the Gezira, New Halfa and Rahad schemes, but these efforts were not successful. At present, areas under the crop in these locations are negligible if any (Salih and Farouk 1996).

Until lately, weeds were not a serious constraint to faba bean production in northern Sudan. However, use of uncertified seeds, animal grazing and flooding of the River Nile led to spread of some serious annual weeds, including *Sorghum arundinaceum*, *Sinapis arvensis* L. and *Chenopodium album* L., throughout the Northern State (Bedry 2007). The traditional method of weed control in the Northern State depends on late voluntary hand removal of weeds for fodder. It is worth mentioning that the critical period of weed/faba bean competition is 4-10 weeks after sowing (Bedry 1999; Bedry 2004).

At Selaim basin, the soil-applied herbicides terbutryne and cyanazine together with a supplementary hand weeding at 6-8 weeks after sowing effected adequate weed control and resulted in faba bean seed yield comparable to two hand-weeding (El Bedawi 1987). Oxyfluorfen, oxadiazon and pendimethalin, applied as pre-emergence treatments, resulted in effective control of grasses and broadleaved weeds in faba bean (Adam 1988; Mohamed 1998). Of the several pre-emergence herbicides tested in the River Nile State, imazethapyre alone or in tank mixtures with oxyfluorfen is highly effective against weeds and is tolerated by faba bean (Babiker *et al.* 1990).

At Dongola area, *Cyperus rotundus* L., *Trigonella hamosa* L., *Brassica* sp., *Convolvulus arvensis* L. and *Cynodon dactylon* (L.) Pers, reduced seed and straw yields of faba bean by 54% and 70%, respectively (Mohamed and Mohamed 1992). The herbicides terbutryne, prometryne and imazethapyre in tank-mixtures with oxyfluorfen or pendimethalin, as pre-emergence treatments, are effective against annual weeds in faba bean. However, a supportive hand-weeding is needed where perennial weeds were present (Mohamed and Mohamed 1992). Imazethapyre in tank-mixtures with pendimethalin or oxyfluorfen significantly increased faba bean seed yield over the weedy check and gave yield comparable to the weeded control (Mohamed *et al.* 2004).

Wild sorghum is a serious constraint to wheat production in the Northern State and elsewhere in the Sudan. The herbicide clodinafop-propargyl at 0.1 kg a.i./ha, applied as a post-emergent treatment, effected excellent and lasting control of wild sorghum and resulted in wheat yield comparable to the weed free control (Babiker *et al.* 1993; Osman 1993; Bedry 2005). Recently, wild sorghum has become a problematic weed in faba bean in the Northern State. Pendimethalin at 1.8 kg a.i./ha, applied as a pre-emergence treatment, effected adequate control of the weed in faba bean (El Sadig S. Mohamed, personal communication).

One hand weeding, undertaken at 4-6 weeks after crop emergence, was reported to mitigate the adverse effects of weeds on faba bean (Bedry 2007). However, labour is not available or costly.

The objectives of the present investigation were to determine the effects of wild sorghum on the growth and yield of faba bean and to evaluate the herbicidal efficacy and selectivity of clodinafop-propargyl (Topik), applied as a post-emergence treatment, on wild sorghum and faba bean in the Northern State.

MATERIALS AND METHODS

An experiment was conducted in seasons 2008/2009 and 2009/2010 at the farm of Merowe Research Station. The experimental plot was ploughed, harrowed and leveled. The subplot size was 3 x 7 m. The treatments were arranged in a randomized complete block design with four replicates. Faba bean (cultivar SML) was planted (2 seeds/hole) on flat at an intra-row spacing of 20 cm and inter-row spacing of 50 cm during November. Wild sorghum seeds, 14 g/subplot, were broadcast by hand, and the plants were irrigated every 10 days. Two sprays with Folimat were made in January to control aphids.

The herbicide clodinafop-propargyl was applied at three rates of 0.125, 0.1 and 0.075 kg a.i ha⁻¹, with a knapsack sprayer at a volume rate of 358 L ha⁻¹, 21 days after sowing. Weeded and un-weeded plots were used as controls. In all herbicide treated subplots, weeds other than wild sorghum

were removed by hand. Treatment effects on wild sorghum were assessed by counting the weed in fixed quadrates (25 x 40 cm) randomly chosen in each plot, 4 and 8 weeks after planting (WAP). The crop was harvested in the second and third weeks of March. The harvested area was 2 x 6 m, and the yield and yield components were determined at the time of harvest. Yield data were analyzed by the analysis of variance and means were separated by the Duncan's Multiple Range Test.

Economic evaluation was conducted to arrive at the most economic optimum level of the herbicide used in controlling wild sorghum in faba bean farm through assessing the profitability of these levels. Some of these treatments may have high net benefit but at high cost. For this reason, dominance and marginal analyses were conducted to rank the most cost effective form and level of weed control.

RESULTS AND DISCUSSION

Effect of the herbicide on wild sorghum

The numbers of wild sorghum plants per m² were 412 and 365 in seasons 2008/2009 and 2009/2010, respectively. The herbicide, at all rates, effected moderate (57% - 63%) early season control of wild sorghum. However, excellent (100%) and persistent control was displayed late in the season (Table 1).

Table 1. Effects of clodinafop-propargyl on wild sorghum

Treatment	Herbicide rate (kg a.i./ha)	Control (%)			
		2008/2009		2009/2010	
		4WAP	8WAP	4WAP	8WAP
Clodinafop-propargyl	0.125	61	100	63	100
Clodinafop-propargyl	0.100	62	100	57	100
Clodinafop-propargyl	0.075	60	100	59	100
Hand-weeded control	-	100	100	100	100
Un-weeded control	-	0.0	0.0	0.0	0.0

WAP = Weeks after planting

Effects of the herbicide on faba bean

Visual observations showed that the herbicide had no adverse effects on the growth and yield of faba bean. The presence of wild sorghum did not reduce 100-seed weight (data not shown). In 2008/2009 season, unrestricted wild sorghum growth reduced crop stand by 76%, straw yield by 79%, number of pods per plant by 42% and seed yield by 91%. However, in 2009/2010 season, the reductions were 53%, 76%, 59% and 88%, respectively, compared to weed-free control (Table 2).

The herbicide, at all rates, significantly increased faba bean crop stand by 121% - 324%, straw yield by 301% - 454%, number of pods per plant by 74% - 148% and seed yield by 732% - 1078%, over the weedy control (Table 2).

The notable increase in faba bean seed yield and yield components was consistent with the selectivity of the herbicide and the attained excellent and lasting control of wild sorghum (Table 1). The results indicated the advantage of using post-emergence herbicides over prophylactic pre-emergence herbicide treatments. Post-emergence treatments allow for proper decision making on what product to use and may reduce both cost and the amount of the herbicide (Bedry 2007)

Economic evaluation

The value of faba bean yield that has resulted from different levels of herbicide, hand-weeded treatment and un-weeded treatment were compared with the cost of weeding. Only costs of weeding (herbicide or hand weeding) were considered in the partial budget for being the only variable cost of production that affects the productivity of faba bean. The marginal rate of return, which reflects the relationship between the variable cost of the weeding and the net benefits of produce, is equal to the marginal net benefit divided by the related marginal cost of each treatment. Hand-weeded and high level of herbicide treatments had the highest cost of weeding and lower net return compared to other treatments. For this reason, they are dominated by the low levels of herbicide (0.75 and 1 litre/ha). This means that yield advantage does not compensate for the increase in the cost of weeding or herbicide dose applied. These treatments were excluded from further analysis for not being economically viable (Table 3).

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Return to investment in the herbicide (Topik) was estimated in the form of marginal rate of return of about 35 for the herbicide at the rate of 0.75 litre / ha, which indicate that every monetary unit (SDG 1) invested in the mentioned treatment would be returned back plus additional amount of 35 SDG (Table 4). This indicates that an increase in the herbicide cost will be compensated for by an increase in yield as a result of the herbicide application. The high dose of the herbicide (1 litre/ha) had less marginal rate of return (28.5) and thus less profitable compared with 0.75 litre/ha.

CONCLUSION

Topik (clodinafop-propargyl) at 0.075 kg a.i./ha could be used in controlling wild sorghum in faba bean in the Northern State. At this rate, the marginal rate of return is about 35 which indicate that every monetary unit (SDG 1) invested in the mentioned treatment would be returned back, plus additional amount of 35 SDG.

ACKNOWLEDGE MENT

The permission of the Director General of ARC to publish this paper is highly appreciated. The authors would like to thank Prof. Mohamed Ahmed Ali and Dr. Adel Omer Salah for reading the manuscript.

Control of wild sorghum in Faba bean by Topik

Table 2. Effects of clodinafop-propargyl on faba bean seed yield and yield components

Treatment	Herbicide rate (kg a. i/ha)	Crop stand (000)/ha	Straw yield (kg/ha)	No. of pods/plant	No. of seeds/ pod	Seed yield (kg/ha)
2008/2009 Season						
Clodinafop-propargyl	0.125	523b	5400a	4.7a	3.0	2900a
Clodinafop-propargyl	0.100	593a	5740a	5.0a	2.3	3097a
Clodinafop-propargyl	0.075	590a	5260a	4.0a	3.0	2740a
Hand-weeded control	-	597a	5020a	4.0a	3.0	2813a
Un-weeded control	-	140c	1037b	2.3b	2.3	263b
S.E. \pm	-	17.8	578.9	0.29	0.22	244.5
Sig. level	-	***	***	**	N.S	***
C.V.(%)	-	6.3	22.3	17.0	14.2	18.0

Table 2. Cont.

Treatment	Herbicide rate (kg a. i/ha)	Crop stand (000)/ha	Straw yield (kg/ha)	No. of pods/plant	No. of seeds/ pod	Seed yield (kg/ha)
2009/2010 Season						
Clodinafop-propargyl	0.125	505a	4299a	9.4a	3.3a	2916a
Clodinafop-propargyl	0.100	465a	4246a	9.9a	3.3a	2800a
Clodinafop-propargyl	0.075	470a	4146a	8.3a	3.6a	2746a
Hand-weeded control	-	450a	4319a	9.8a	3.3a	2850a
Un-weeded control	-	210b	1033b	4.0b	1.9b	330b
S.E. \pm	-	24.8	228.4	1.03	0.17	146.4
Sig. level	-	***	***	***	***	***
C.V. (%)	-	11.8	12.7	25.0	11.4	12.6

Means within a column followed by the same letter are not significantly different at $P = 0.05$ and 0.01 , according to Duncan's Multiple Range Test.

*** = Significant at $P = 0.001$, ** = Significant at $P = 0.01$, NS = Not significant

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Table 3. Dominance analysis on the effect of clodinafop- propargyl on faba bean seed yield

Treatment	Seed yield (kg/ha)	Total revenue (SDG/ha)	Herbicide rate (litre/ha)	Cost of herbicide (SDG/ha)	Net revenue (SDG/ha)	Dominance
Un-weeded	296.5	494.0	0	0	494.0	
Clodinafop-propargyl	2743.0	4569.8	0.75	112.5	4457.3	
Clodinafop-propargyl	2948.5	4912.2	1	150.0	4762.2	
Clodinafop-propargyl	2908.0	4844.7	1.25	187.5	4657.2	D
Hand weeded	2831.5	4717.3		200.0	4517.3	D

Faba bean price equals 150 SDG/90kg; (1 US \$ = 3.25 SDG)

Price of herbicide equals 150 SDG/litre

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Table 4. Marginal analysis on the effect of clodinafop-propargyl on faba bean production

Treatment	Seed yield (kg/ha)	Net revenue (SDG/ha)	Cost of herbicide (SDG/ha)	Marginal revenue (SDG/ha)	Marginal cost (SDG/ha)	Marginal rate of return
Un-weeded	296.5	494.0	0	0	-	-
Clodinafop-propargyl (0.75 litre/ha)	2743.0	4457.3	112.5	3963.4	112.5	35.23
Clodinafop-propargyl (1 litre/ha)	2948.5	4762.2	150.0	4268.2	150	28.5

(1 US \$ = 3.25 SDG)

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المكافحة الكيميائية للعدار (*Sorghum arundinaceum* (Del.) Stapf.) في الفول المصري بالولاية الشمالية في السودان

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المستخلص: أجريت تجربة بمزرعة محطة بحوث مروى- مروى (السودان) في موسمي 2009/2008 و 2010/2009 لتحديد الضرر الذي يحدثه العدار في نمو وإنتاجية الفول المصري ولتقييم فعالية استعمال مبيد الحشائش توبك في مكافحته بالولاية الشمالية. أوضحت الدراسة أن وجود العدار في الفول المصري يؤدي إلى انخفاض معنوي في إنتاجيته من الكثافة النباتية والتبن وفي البذور بنسبة 53% - 76% و 76% - 79% و 88% - 91% على التوالي مقارنة بالشاهد. كما أوضحت النتائج أن محصول الفول المصري يتحمل استعمال مبيد التوبك وأن كل جرعات المبيد التي تم اختبارها أدت إلى مكافحة كاملة ومستمرة للعدار حتى نهاية الموسم، كما أدت إلى إنتاجيه من بذور الفول المصري مماثلة للمكافحه اليدوية، وأن الجرعة الخفيفة من التوبك (0,075 كجم ماده فعالة للهكتار) التي تم اختبارها تساوى 75% من جرعتة الموصى بها لمكافحة العدار في القمح. وأوصت الدراسة باستخدام الجرعة الخفيفة من التوبك (0,075 كجم ماده فعالة للهكتار) في مكافحة العدار في الفول المصري لأنها أكثر ربحية من بقية الجرعات.

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