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Chemical Weed Control in Grain Sorghum (*Sorghum bicolor* L.)

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Abstract: A field experiment was conducted at the Demonstration Farm of the Faculty of Agriculture, University of Khartoum, Sudan, during 2012/2013 and 2013/2014 seasons, to determine the magnitude of growth and yield losses in grain sorghum crop due to weed competition, and to evaluate the effects of three herbicides viz, sorgoprim, gesaprim and tank mixture of 2,4-D and gesaprim at three rates of each in addition to a weed-free and a weed- infested treatments *i.e.* eleven treatments. The experiment was laid out in a randomized complete block design with four replications. The results showed that when the weeds were left to compete with the sorghum crop throughout the season, the reduction percentages in the seedlings' dry weight, plant height and plant shoot dry weight in 2012/13 were 55.4, 39,2 and 47.2 respectively; reductions in the same parameters were 74.4, 39.1 and 45.4 respectively in 2013/14. Untreated weeds – infested control, coupled with weed index (WI) of 65%–66%, inflicted considerable reductions in crop grain number/ plant of 60.1% in 2012/13 and 61.4% in 2013/14, grain weight/plant of 66.3% in 2012/13 and 66% in 202013/14 and on yield(ton/ha) by 65% in 2012/13 and by 66% in 2013/14. All herbicide treatments irrespective of rate of application, resulted in a good to excellent weed suppression. Herbicides weed control efficiency (WCE) for 2012/13 and 2013/14 ranged from 56% to 99% for broad-leaved weeds and from 39% to 97% for grassy weeds. The mixture tank of 2, 4-D + gesaprim @ 0.76L/ha + 0.6 Kg/ha treated sorghum reduced the WI to 2.5% in 2012/13 and to 3.2% in 2013/14 and resulted in values of crop grains number/plant, grains weight/ plant and yield significantly comparable to weed-free treatment.

Key words: Weed index; herbicides; sorghum; growth and yield; weed control efficiency

. ## INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Monech] is a very important cultivated crop in Sudan due to its high nutritional value both for food (grains), where about 90% of the Sudanese use sorghum as their staple food crop, and for feed (forage and grains) (Dahlberg *et al.* 2004). The crop is grown annually throughout the country on an area of about 10 million feddans (feddan= 0.42 hectare) with a production of about 3.9 million metric tons (FAO 2008). The current sorghum production is not sufficient to meet the demand for human consumption and animal feed. Generally, in Sudan, both biotic and abiotic factors limit sorghum production. Weeds are considered the greatest biological constraints that threaten crop production. Haussmann *et al.* (2000) reported that sorghum grain yield loss might reach 100% in susceptible cultivars under high weed infestation level and drought condition. Sorghum weed competition in Sudan is a socioeconomic problem that has forced resource-poor farmers to abandon their lands (Atera *et al.* 2012). Weed competition in sorghum fields is a problem, which undermines the struggle to attain food security. In Sudan, manual weeding is the most common method of weed control, but in many instances the available labour is unable to remove weeds from vast areas of land during critical periods. Thus, the use of herbicides is a necessity (Habyarimana *et al.* 2004), and is a highly efficient method for controlling weeds, increasing yield, cost-effective and affordable (Gressel 2009). Therefore, the objectives of this study were to determine the magnitude of sorghum yield losses due to weed competition and to evaluate the effects of three herbicides, viz sorgoprim, gesaprim and 2,4-D, in controlling weeds and determining the effects on sorghum growth and yield.

MATERIALS AND METHODS

Afield experiment was conducted at the Demonstration Farm, Faculty of Agriculture, University of Khartoum, Sudan (Latitude 15°40´N and Longitude 32°23´) during 2012/2013 and 2013/2014 seasons, on 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 experimental site was ploughed, harrowed, leveled and divided into plots; plot size was 4x5m each plot was made of five rows. Sorghum (cv. Fatarieta) was sown on 19th of

August in both seasons at a rate of three to five seeds per hole, seedlings were thinned later to one plant/hole, inter and intra-row spacings were 70cm and 10cm respectively. The herbicides sorgoprim 50% WP @ 0.7, 1.4 and 2.8 Kg/ha and gesaprim 80% WP @ 0.3, 0.6 and 1.2 Kg/ha were applied pre-emergence, immediately after sowing. The herbicide 2,4-D @ o.38, 0.76 and 1.52 L/ha in tank mixture with gesaprim @ 0.3, 0.6 and 1.2 Kg/ha was applied post-emergence, when the crop was six inches tall. Weed-free and weedy treatments were included for comparison. Irrigation was applied at 10–15 days interval depending on temperature and other environmental conditions. The herbicides were applied by knapsack sprayer equipped with a flood jet nozzle. The treatments were laid in randomized complete block design with four replications. The effect of treatments on grasses and broad leaved weeds were measured by counting individual weed species in 1m^2 quadrate at 45 and 90 days after sowing (DAS). Dry weight was taken after leaving the plants at room temperature for a week and then transferred to an oven at 70°C for 48 hours. Predominant weeds in the experimental sites were recorded. Eq1 was used to calculate weed control efficiency (WCE).

Eq1 =

$$(\mathrm{WCE}) = \frac{\mathrm{DWC} - \mathrm{DWTX100}}{\mathrm{DWC}}$$

where DWC= Dry weight of weeds from control plot.

DWT= Dry weight of weeds from treated plot.

To evaluate the effect of the treatments on sorghum crop growth, ten plants were chosen randomly from each plot, 4 weeks after sowing, and their biomass was recorded. At 8 weeks after sowing, the averages of ten randomly selected plants for each treatment were used to measure plant height and shoot dry weight .On the second of December, the three inner rows were harvested to determine the crop yield components. grain number/ plant,1000- seed weight, grain weight/ plant and total grain yield (ton/ha.). Yield reduction due to weed competition, weed index (WI) were measured by using Eq2.

Eq 2 = Weed index (WI) =

$$\frac{\text{Average yield in weed free plot} - \text{Average yield in plot under treatment X100}}{\text{Average yield in weed free plot}}$$

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

RESULTS AND DISCUSSION

The dominant species of weeds in the experimental site, as presented by weedy check treatment, were rough or heartleaf cocklebur (*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. All herbicides at all rates gave good to excellent WCE regardless of time of assessment (45 and 90 DAS), in both seasons (Tables 1 and 2).The range of WCE of sorgoprim for both seasons was 56%-97% for broad-leaved weeds and 47-97% for grassy weeds; for gesaprim was 60%-97% for broad–leaved and 39%-96% for grassy weeds and for the mixture (2,4-D and gesaprim) the range was 70%-99% for broad-leaved and 39%-95% for grassy weeds (Tables 1 and 2). These results are in line with the finding of Babiker *et al.* (2013). It is worth mentioning that the WCE increased in the second assessment (90 DAS) which might be due to herbicides' persistence in the soil (Bovin 2005). Unrestricted weed growth reduced seedlings dry weight, plant height and plant shoot dry weight in 2012/13 by 55.4%, 39.2% and 47.2%, respectively; reductions in 2013/14 were 74.4%, 39.1% and 45.4% respectively for the same parameters (Table 3). Few herbicides treatments had adverse effect on sorghum growth components. That is, the two rates, sorgoprim at 2.8 kg/ha and gesaprim at 1.2 kg/ha were toxic to the sorghum crop. They caused stunting during early stage of growth as indicated by seedlings' dry weights which were comparable to weedy check treatment; later the symptoms disappeared and the crop recovered (Table 3).

Table 1. Effect of herbicide treatments on broad-leaved weed control efficiency(%) 45 and 90 days after sowing (DAS) in 2012/2013 and 2013/2014 seasons

Treatments	Broad leaved weeds control efficiency (%) 2012/2013		Broad leaved weeds control efficiency (%) 2013/2014	
	45 DAS	90 DAS	45 DAS	90 DAS
Sorgoprim				
o.7 kg/ha	56	74	68	78
1.4 kg/ha	85	92	88	92
2.8 kg/ha	94	95	93	97
Gesaprim				
0.3 kg/ha	60	75	69	81
o.6 kg/ha	85	92	86	94
1.2 kg/ha	95	97	95	97
24- D +Gesaprim				
0.38 L/ha + 0.3kg/ha	70	83	76	87
0.76 l/ha + 0.6 kg/ha	92	98	97	99
1.52 l/ha + 1.2 kg/ha	96	99	98	89
Weed free	100	100	100	100
Weedy	0	0	0	0

Table 2. Effect of herbicide treatments on grassy weeds control efficiency/m^2 (%) 45 and 90 DAS in 2012/2013 and 2013/2014 seasons

Treatments	Grassy weeds control efficiency (%) 2012/2013		Grassy weeds control efficiency (%) 2013/2014	
	45 DAS	90 DAS	45 DAS	90 DAS
Sorgoprim				
o.7 kg/ha	47	72	48	60
1.4 kg/ha	76	88	75	83
2.8 kg/ha	93	97	92	96
Gesaprim				
0.3 kg/ha	39	69	52	57
o.6 kg/ha	71	86	81	87
1.2 kg/ha	91	96	95	96
24- D +Gesaprim				
0.38 L/ha + 0.3kg/ha	42	71	44	39
0.76 l/ha + 0.6 kg/ha	76	87	76	73
1.52 l/ha + 1.2 kg/ha	91	95	95	88
Weed free	100	100	100	100
Weedy	0	0	0	0

The tank mixture of 2,4-D and gesaprim at 0.76 L/ha+0.6 kg/ha significantly increased sorghum growth components of seedling dry weight, plant height and plant shoot dry weight (Table 3). These increases may be attributed to their excellent WCE which ranged between 92% and 99%. This result is in line with Babiker *et al.* (2013). When weeds were left to compete with the sorghum throughout the season they reduced crop yield attributes of grains' number/ plant, grains' weight/plant and yield by 60.1%, 66.3% and 65% respectively in 2012/13 and by 61.4%, 66% and 66% respectively for the same parameters in 2013/14 (Table 4). Previous reports showed that undisturbed weed growth in sorghum fields caused considerable reductions in growth components (Platle *et al.* 2006).

All herbicides' treatments, irrespective of rate of application, showed significant increase in crop yield components of grain number/ plant and grain weight/ plant as compared to weedy check treatment (Table 4). The lowest grain number/ plant and grain weight/ plant and yield were recorded under weedy check treatment in 2012/2013 and 2013/2014 seasons (Table 4). It is noteworthy that the mixture tank of 2,4-D+ gesaprim at 0.76 L/ha+0.6 Kg/ha yielded 915 grain number/ plant in 2012/13 and 1032.4 in 2013/14 and grain weight/ plant of 31.8 in 2012/13 and 36.9 in 2013/14 which were significantly comparable to weed free treatment (Table 4). Uninterrupted weed growth reduced sorghum yield by 65% in 2012/13 and by 66% in 2013/14 (Table 4). A notable observation was that the mixture tank of 2,4-D+ gesaprim at 0.76L/ha +0.6 kg/ha reduced the WI to 2.5% in 2012/13 and to 3.2% in 2013/14 coupled with crop yield of 7.9 t/ha in 2012/13 and 9.2 ton/ha in 2013/14 which were significantly comparable to that obtained from weed-free treatment (Table 4). These results are in line with Hallam *et al.* (2001) who stated that the combination of the herbicides 2,4-D and atrazine seemed to be best option to obtained good selectivity to the sorghum crop and high weed control.

Table 3. Effect of herbicide treatments on sorghum seedlings' dry weight, plant height and plant shoot dry weight in 2012/2013 and 2013/2014 seasons

Treatments	Seedlings dry weight (g)		Plant height (cm)		Shoot dry weight(g)	
	2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014
Sorgoprim						
o.7 kg/ha	1.85^{a}	2.05^{d}	132.5^{ef}	140.0^{d}	34.6^{cd}	44.3^{cd}
1.4 kg/ha	1.95^{a}	2.25^{cd}	148.2^{ab}	156.3^{ab}	42.4^{ab}	49.1^{b}
2.8 kg/ha	$1.o3^{b}$	$1.o5^{e}$	130.6^{f}	139.3^{d}	31.3^{d}	41.2^{e}
Gesaprim						
0.3 kg/ha	1.88^{a}	2.55^{cd}	134.0^{def}	143.0^{cd}	31.5^{d}	41.7^{de}
o.6 kg/ha	1.93^{a}	2.85^{bc}	146.0^{bc}	148.2^{c}	40.0^{b}	46.5^{bc}
1.2 kg/ha	0.96^{b}	1.45^{e}	132.0^{ef}	140.6^{a}	29.5^{e}	43.1^{de}
24- D +Gesaprim						
0.38 L/ha + 0.3kg/ha	1.95^{a}	2.60^{bcd}	140.5^{cd}	150.0^{bc}	38.5^{bc}	48.8^{b}
0.76 l/ha + 0.6 kg/ha	2.00^{a}	3.35^{ab}	153.0^{a}	162.6^{a}	46.4^{a}	53.3^{a}
1.52 l/ha + 1.2 kg/ha	1.98^{a}	3.35^{ab}	138.0^{de}	143.0^{cd}	31.5^{d}	41.7^{de}
Weed free	2.13^{a}	3.90^{a}	154.5^{a}	164.1^{a}	49.2^{a}	55.1^{a}
Weedy	095^{b}	1.00^{e}	94.0^{h}	100.0^{e}	26.0^{e}	30.1^{f}
S E±	0.17	0.21	2.12	2.17	1.57	0.87

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

Table 4. Effect of herbicides treatments on sorghum grains number/plant, grains weight/plant, yield (ton/ha) and weed index (%) in 2012/2013 and 2013/2014 seasons

Treatments	Grains' number/plant		Grains' weight/plant (g)		Yield (ton/ha)		Weed index (%)	
	12/13	13/14	12/13	13/14	12/13	13/14	12/13	13/14
Sorgoprim								
o.7 kg/ha	604.8^{e}	764.3^{f}	20.4^{c}	25.8^{cde}	5.1^{c}	6.4^{cde}	37	32.6
1.4 kg/ha	887.9^{a}	960.2^{abc}	31.2^{a}	32.5^{ab}	7.6^{a}	8.1^{ab}	6.2	14.7
2.8 kg/ha	764.3^{bc}	864.5^{cde}	24.9^{b}	27.6^{bcde}	6.1^{b}	6.9^{bcd}	24.7	27.4^{cd}
Gesaprim								
0.3 kg/ha	702.4^{cd}	804.2^{ef}	21.8^{bc}	24.5^{e}	5.5^{bc}	6.2^{e}	32.1	34.7
0.6 kg/ha	882.2^{a}	924.4^{bcd}	29.5^{a}	$30.9a^{bcd}$	7.4^{a}	7.7^{abcd}	8.6	18.9
1.2 kg/ha	659.2^{de}	798.2^{ef}	21.6^{bc}	26.4cde	5.4^{bc}	6.6^{cde}	33	30.5
24- D +Gesaprim								
0.38L/ha+0.3kg/ha	712.4^{cd}	824.5^{def}	21.6^{bc}	25.3^{de}	5.4^{bc}	6.3^{de}	33	33.6
0.76I/ha+0.6kg/ha	915.3^{a}	1032.4^{a}	31.8^{a}	36.9^{a}	7.9^{a}	9.2^{a}	2.5	3.2
1.25I/ha+1.2kg/ha	800.5^{b}	989.5^{ab}	25.4^{b}	31.4^{a}	6.4^{b}	7.8^{abc}	21	17.8
Weed Free	925.2^{a}	1094.6^{a}	33.2^{a}	37.6^{a}	8.1^{a}	9.5^{a}	0	0
Weed	369.3^{f}	422.0^{h}	11.2^{d}	12.8^{f}	2.8d	3.2^{f}	65	66
SE±	19.5	31.04	1.18	1.79	0.29	0.44	-	-

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

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المكافحة الكيميائية للحشائش في الذرة الرفيعة (*Sorghum bicolor* L.)

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المستخلص: أجريت تجربة حقلية بالمزرعة التجريبية لكلية الزراعة، جامعة الخرطوم، في الموسمين 2012/ 2013 و 2014/2013 لتحديد الفقد في نمو وإنتاجية محصول الذرة الرفيعة الناتج عن منافسة الحشائش الضارة وتقييم فعالية ثلاثة مبيدات حشائش: السورجوبريم، الجيسابريم والـ 2.4-D، وتضمنت التجربة معاملة خالية من الحشائش وأخرى موبوءة للمقارنة. تم توزيع المعاملات الأحدى عشر فى تصميم القطاعات العشوائية الكاملة بأربعة مكررات. أظهرت النتائج إن ترك الحشائش تنمو طوال الموسم أدى لنقص في الوزن الجاف للبادرات (جرام)، طول النبات (سم)، والوزن الجاف للنبات (جرام) بلغ فى 2013/2012 55.4% و 39.2% و 47.2% على التوالى. أما فى 2014/2013 فكان النقص 74.4% و 39.1% و 45.4% على التوالى. وأدى ترك الحشائش أيضاً لنقص فى مكونات الإنتاجية من عدد البذورفى النبات الواحد بمعدل 60.1% فى 2013/2012 و 61.4% فى 2014/2013 والإنتاجية بمعدل 65% فى موسم 2013/2012 و 66% فى 2014/2013. أظهرت المبيدات الثلاثة المستخدمة، بغض النظر عن التركيز، فعالية جيدة إلى ممتازة فى مكافحة الحشائش وتراوحت كفاءتها للموسمين بين 39%-97% للحشائش رفيعة الأوراق ومابين 56%-99% للحشائش عريضة الأوراق. أظهرت النتائج أيضاً أن معاملة خليطا المبيدين Gesaprim + 2,4 -D بمعدل 0.76 لتر/ هكتار +0.6 كيلوجرام/ هكتار أنقص معامل ضرر الحشائش إلى 2.5% فى 13/2012 و 3.2% فى 2014/2013 ونتج عن ذلك عدد بذور للنبات الواحد، وزن بذور للنبات الواحد وإنتاجية مماثلاً معنوياً لمعاملة ترك المحصول خالي من الحشائش طوال الموسم.