EFFECT OF SEEDBED TYPES, UREA FERTILIZER RATES AND INTERCROPPING OF SORGHUM WITH LEGUMES ON *STRIGA* INCIDENCE AND SORGHUM YIELD

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ABSTRACT

These studies were conducted at Damazin Research Station, Damazin, (Latitude 11^0 47'34N, longitude 34^0 21'55 E) and approximately 343.01 meters above sea level (MSL) for two consecutive seasons of 2006/07 and 2007/08. Three types of seed beds were used namely, flat (control 1); normal ridged and tied ridged in a *Striga* infested field trial. The objectives were to test for the incidence of witch weed (*Striga* spp.) and performance of sorghum under the different treatments. The treatments were: two rates of urea fertilizers applied at 103.5 and 207.0 kg/ha; four leguminous plants namely, Bambara nuts, (*Vigna subterranea* L. Verdc.; Groundnuts, (*Arachis hypogoea* L.); Clitoria, (*Clitoria ternatea);* and *Desmodium* spp.) were intercropped with sorghum, *Sorghum bicolor* L. Moench (cv. Wad Ahmed) and a sole sorghum without any treatment (control 2) were compared for their effect on *Striga* population at 8 and 12 weeks after sorghum emergence (WASE); *Striga* dry weight at harvest; sorghum height and sorghum grain and straw yield. Results showed that normal ridged seedbeds reduced *Striga* population and its dry weight effectively. Amongst the legumes intercropped with sorghum, *Clitoria* spp. reduced sorghum height considerably, and the application urea fertilizers regardless of the rates used, increased sorghum grain yield as well as *Striga* population.

Key words: Bambara nuts, *Vigna subterranea*, ridges, flat, normal, tied, groundnuts, Clitoria spp., Desmodium spp., sorghum, cv. Wad Ahmed.

1. INTRODUCTION

Sorghum is important for its grain as food, animal feed, seeds and brewing local bear. Its stalks are used for shelter, animal feed and at times as source of sugar. Sorghum is a crop of the tropics, performing well at temperatures of 28º ± 3º C and rainfall of 500-800 mm (Raemaekers, 2001). Drought and heat tolerance gives it greater importance in the semi-arid regions. Sorghum is the second most important cereal in Africa and it is the highest consumed grain in the Sudan (ICRISAT, 1992; Khidir, 1983). The crop (sorghum) is grown worldwide. According to FAO (2005), the five top world leading producers in million metric tons were U.S.A. (9.8), India (8.0), Nigeria (8.0), Mexico (6.3) and Sudan (4.2). Sorghum production is constrained by many pests, one of which is *Striga* (witchweed) *Striga* has been distinguished as a national pest in the Sudan (Musselman and Riley, 1984). In Africa, *Striga hermonthica* (Del.) Benth is becoming a problem in the production of major cereals such as pearl millet, maize and sorghum. Parker and Riches (1993) reported that crop damage by *Striga* was most severe where drought and low soil fertility already limits crop productivity. Mumera (1983) found that low nitrogen results in more *Striga* but high levels suppressed it. Parker (1991) pointed out that no consistent rate of fertilizer has been found to control *Striga* and he also suggested that reduction of *Striga* by intercropping was due to both low temperature and shading. Dawoud et al (2007) found that *Striga* was reduced by 56% when urea fertilizer was applied at 190 kg/ha. Many single *Striga* control measures developed earlier, offered varying levels of *Striga* control depending on environment. None could provide complete control. Therefore, an integrated *Striga* management approach may offer the best possibility at farm level but may only be adopted if such a technology is compatible with the existing cropping systems and technology. The study described below was incepted to validate the findings and suggestions mentioned above.

2. MATERIALS AND METHODS

2.1 Design of the experiment and treatments

A split plot designed field trial with four replicates was conducted in a *Striga* infested land for two consecutive seasons- 2006/07 and 2007/08. The main plots consisted of three types of seedbeds- flat (control 1), normal ridged (uninterrupted ridges) and tied ridged (ridges connected at the ends of each subplot by two cross ridges). The subplots each (2.4 x 6) m comprised seven treatments. The treatments were: (i) sorghum sole without urea fertilizer application (control 2), (ii) urea fertilizer applied at the rate of 103.5 and 207.0 kg/ha (nitrogen at 47.6 and 95.2 kg/ha) placed at sowing by the sides of sorghum rows in holes between sorghum planted holes and covered with some soil and (iii) Four legumes [Bambara nut (*Vigna subterranea* L. Verdc), groundnuts (*Arachis hypogeae* L.), (*Clitoria ternatea* L.) and (*Desmodium dichotomum* Klein DC.) were sown separately as intercrop by both sides of sorghum seedlings a week later after sowing sorghum. Sorghum (cv. Wad Ahmed) seeds were treated with Thiram 25% at 3g/kg seeds against fungi. The treated seeds were sown on 25 and 22 July in 2006 and 2007 respectively in rows on flat and on top of ridges 0.8 m apart at intra – row spacing of 0.2 m at the rate of about five seeds per hole. After sorghum seeds emerged, legume seeds were sown on both sides of sorghum seedlings at three seeds per hole. Then sorghum and legume seedlings were thinned to two plants per hole. During all weeding operations, weeds other than *Striga* were removed while *Striga* plants were maintained throughout.

2.2 Data collection and statistical analysis

Assessments of the trial were restricted to sorghum middle rows in each subplot. Data taken included population of *Striga* plants at 8 and 12 weeks after sorghum emergence (WASE),

weight of *Striga* dry plants at sorghum harvest, height of sorghum at 12 weeks after sorghum emergence, yield of sorghum grain and straw after sorghum harvest. Unprocessed data on population of *Striga*, its dry weight were appropriately transformed before analysis to reduce coefficient of variation. All the data taken were computer analyzed using SAS program. After analysis, means with significant differences between treatments were separated by Tukey's Studenitized Range (HSD) Test.

3. RESULTS AND DISCUSSION

There was no interaction between the main plots and subplots. Unless otherwise indicated by results of homogeneity tests. For all results in tables (1a, 1b, 2, 3, 4, and 5), ridged seedbeds are compared with the flat seedbed (control 1) and urea applied treatments and intercropping sorghum with legumes are compared with sole sorghum without fertilizer application (control 2) unless stated.

3.1 Effects of different types of seedbeds, rates of urea fertilizer and intercropping sorghum with legumes on incidence of *Striga.*

Population of *Striga* from the type of seedbed with normal ridges was significantly lower (P= 0.01) by 36% and 70 % in seasons 2006/07 and 2007/08 respectively, at 8 WASE (Table 1a) and 12 WASE, reduction in the population of *Striga* in the normal ridged seedbed declined to about 16% and 67 % in the two consecutive seasons of 2006/07 and 2007/08 (Table 1b).

Table 1a. Shows Population of *Striga* 8 WASE as affected by different types of seedbeds, rates of urea fertilizer and intercropping sorghum with legumes.

Treatments:	Population of *Striga* (plants/m²) in the two seasons	
	Season 2006-2007	Season 2007-2008

(a) Seedbeds		
Flat seedbed (control 1)	3.9 (1.99) a	(1.14) a
Normal ridged seedbed	2.5 (1.57) b	0.3 (0.87) b
Tied ridged seedbed	3.0 (1.71) ab	0.2 (0.85) b
Sig. level	**	**
SE ±	0.133	0.81
(b) Urea and legumes		
Sole sorghum without urea (control 2)	3.7 (1.98) ab	0.4 (0.95)
Urea at 103.5 kg/ha	6.5 (2.49) a	0.6 (1.00)
Urea at 207.0 kg/ha	4.6 (2.12) ab	0.9 (1.10)
Bambara nuts	1.1 (1.23) c	0.5 (0.95)
Groundnuts	1.3 (1.32) c	0.3 (0.88)
Clitoria sp.	2.7 (1.62) bc	0.3 (0.85)
Desmodium sp.	1.7 (1.54) bc	0.5 (0.94)
Sig. level	**	ns
SE ±	0.203	0.092
CV %	28.4	29.5

Means in a column with the same letters are not significantly different at 1% level of Turkey's Studentized Range (HSD) test; Numbers in parenthesis were transformed using $\sqrt{(x + 0.5)}$; WASE= weeks after sorghum emergence; ns= not significant; ** = highly significant, ($P \leq 0.01$).

Although population of *Striga* from the tied ridges did not differ significantly at 8 WASE in season 2006-2007, significant differences (p = 0.01) in *Striga* population occurred in the season 2007-2008 (Table 1a). Four weeks later at 12 WASE, in the same season (2007-2008), the parasite population from the normal and tied ridged seedbeds displayed similar results (Table 1b). However, throughout the two seasons of 2006/07 and 2007/08 the application of urea fertilizer regardless of rates used did not show differences in the population of *Striga* either at 8 and 12 WASE (Tables 1a and 1b). Meanwhile, in season 2006/07, at 8 WASE the intercropping of sorghum with Bambara nuts or groundnuts reduced the population of *Striga* significantly (P= 0.01) by about 70% and 65 %, respectively, (Table 1a). Similarly, at 12 WASE in season 2006/07, intercropping sorghum with Bambara nuts reduced Striga population significantly

(P=0.01) by about 50% (Table 1b). In the following season (2007/08), intercropping sorghum (cv. Wad Ahmed) with legumes did not affect the population of *Striga* either at 8 or 12 WASE as in the proceeding season.

Table 1b. Shows Population of *Striga* at 12 WASE as affected by types of seedbed, rates of urea fertilizer and intercropping sorghum with legumes.

Treatments:	Population of *Striga* (plants/m²) in the two seasons	
	Season 2006-2007	Season 2007-2008
(a) Seedbeds		
Flat seedbed (control 1)	5.7 (2.34)	1.2(1.21) a
Normal ridged seedbed	4.8 (2.05)	0.4 (0.92) b
Tied ridged seedbed	5.7 (2.21)	0.6 (1.01) b
Sig. level	ns	**
SE ±	0.183	0.082
(b) Urea and legumes		
Sole sorghum without urea (control 2)	5.2 (2.33) bc	0.8(1.10) ab
Urea at 103.5 kg/ha	13.2 (3.55) a	1.0 (1.18) ab
Urea at 207.0 kg/ha	10.0 (3.06) ab	1.2 (1.32) a
Bambara nuts	1.5 (1.39) d	0.7 (1.01) b
Groundnuts	2.0 (1.53) cd	0.2 (0.83) b
Clitoria sp.	2.6 (1.81) cd	0.3 (0.87) b
Desmodium sp.	2.6 (1.73) cd	0.6 (1.01) ab
Sig. level	**	**
SE (±)	0.28	0.13
CV (%)	31.2	29.5

Means in a column with the same letters are not significantly different at 1% level of Turkey's Studentized Range (HSD) test; Numbers within brackets are transformed using $\sqrt{(x + 0.5)}$ where x is the number without brackets; WASE= weeks after sorghum emergence; ns= not significant and **= highly significant at ($P \leq 0.01$).

3.2 Effects of different types of seedbeds, rates of urea and intercropping sorghum with legumes on dry weight of *Striga*

Ridging seedbeds generally reduced *Striga* dry weight (Table 2). Normal ridged seedbed reduced *Striga* dry weight at sorghum harvest significantly (p = .01) by about 38 and 70 % in seasons 2006/07 and 2007/08 respectively. On the other hand, tied ridged seedbed reduced *Striga* dry weight by 37 and 57 % in seasons 2006/07 and 2007/08 respectively (Table 2). *Striga* dry weight at sorghum harvest for the normal seedbed in seasons 2006/07 and 2007/08 were consistent (Table 2). In Table 2, sorghum (Cv Wad Ahmed) treated with urea fertilizer regardless of rate, produced similar results in *Striga* dry weight throughout the two seasons (2006/07 and 2007/08) (Table 2). In season 2006/07, intercropping sorghum (cv. Wad Ahmed) with Bambara nuts, groundnuts and *Clitoria* sp. significantly (P =0.01) reduced *Striga* dry weight at harvest but failed to repeat similar results in 2007/08 (Table 2).

Table 2. Shows *Striga* dry weight at sorghum harvest as affected by different types of seedbeds, rate of urea fertilizer and intercropping sorghum with legumes.

Treatments:	*Striga* dry weight (g/m^2) in the two cropping seasons	
	Season 2006-2007	Season 2007-2008
(a) Seedbeds		
Flat seedbed (control 1)	6.3 (2.52) a	3.0(1.64) a
Normal ridged seedbed	3.9 (1.95) b	0.9 (1.10) b
Tied ridged seedbed	4.0 (2.01) b	1.3 (1.25) ab
Sig. level	**	**
SE (±)	0.070	0.102
(b) Urea and legumes		
Sole sorghum without urea (control 2)	7.1 (2.64) a	3.5 (1.68)
Urea at 103.5 kg/ha	7.4 (2.71) a	1.6 (1.26)
Urea at 207.0 kg/ha	6.1 (2.43) ab	2.3 (1.52)
Bambara nuts	2.9 (1.78) b	1.4(1.26)
Groundnuts	2.6 (1.71) b	0.7(1.05)
Clitoria sp.	3.3 (1.82) b	0.8 (1.08)
Desmodium sp.	3.8 (2.00) ab	1.7 (1.38)

Sig. level	*	ns
SE ±	0.21	0.91
CV %	28.3	49.6

Means in a column with the same letters are not significantly different at 1 % level of Turkey's Studentized Range (HSD) Test; Numbers in parenthesis are transformed using $\sqrt{(x + 0.5)}$;
ns= not significant; *= significant at ($P \leq 0.05$); **= highly significant at ($P \leq 0.01$).

3.3 Effects of different types of seedbeds, rates of urea and intercropping sorghum with legumes on height of sorghum

From Table 3 there were no significant differences in height of sorghum throughout the two consecutive seasons (2006/07 and 2007/08).Similar results shown above were also shown for the two seasons (2006/07 and 2007/08) combined in seasons 2006/07 and 2007/08, application of urea fertilizer did not show any significant difference in the sorghum height and similar results were repeated for the two seasons (2006/07 and 2007/08) combined, (Table 3). Among the legumes (Bambara nuts, groundnuts, *Clitoria* and *Desmodium* spp) used for intercropping with sorghum (cv. Wad Ahmed) only *Clitoria* sp increased sorghum height significantly (P= 0.01) whereas the rest of the legumes maintained similar sorghum height (Table 3).

Table 3. Shows sorghum height as affected by different types of seedbeds, rate of urea fertilizer and intercropping sorghum with legumes

Treatments:	*Sorghum height (m)* in the two cropping seasons		
	Season 2006-2007	Season 2007-2008	2006/07-2007/08 (combined)
(a) Seedbeds			
Flat seedbed (control 1)	1.28	1.03	1.16
Normal ridged seedbed	1.31	1.02	1.16
Tied ridged seedbed	1.30	1.02	1.16
Sig. level	ns	ns	ns
SE ±	0.015	0.013	0.01
(b) Urea and legumes			
Sole sorghum without urea (control 2)	1.30	0.97c	1.14b

Urea at 103.5 kg/ha	1.33	0.99bc	1.16ab
Urea at 207.0 kg/ha	1.32	1.02bc	1.17ab
Bambara nuts	1.30	1.05ab	1.18ab
Groundnuts	1.28	1.01bc	1.15b
Clitoria sp.	1.26	1.12a	1.19a
Desmodium sp.	1.28	1.01bc	1.14ab
SE ±	0.019	0.019	0.014
Sig. level	ns	**	**
CV %	5.1	6.5	5.7

Means in a column with the same letters are not significantly different at 1 % level of Turkey's Studentized Range (HSD) test; ns=not significant; (**) =highly significant ($P \leq 0.01$)

3.4 Effects of different types of seedbeds, rates of urea fertilizer and intercropping sorghum with legumes on sorghum grain yield.

There was no significant difference between the seedbeds in grain yield of sorghum throughout the two seasons (2006/07 and 2007/08) (Table 4) Application of urea fertilizer, increased grain yield of sorghum. Application of higher rate of urea resulted in a higher increase in grain yield of sorghum compared with the lower rate, although the differences between them were sometimes not significant (Table 4). In season 2006/07, intercropping sorghum with groundnuts and *Clitoria* sp decreased sorghum grain yield significantly (P=0.01). On the other hand, intercropping sorghum (cv. Wad Ahmed) with any of the four legumes (Bambara nuts, Groundnuts, *Clitoria* spp. and *Desmodium* spp.) did not alter grain yield of sorghum significantly in season 2007/08 (Table 4).

Table 4. Shows sorghum grain yield as affected by different types of seedbeds, rate of urea fertilizer and inter-cropping sorghum with legumes

Treatments	Sorghum grain yield (kg/Ha) in the two cropping seasons	
	Season 2006-2007	Season 2007-2008

(a) Seedbeds		
Flat seedbed (control 1)	1275.0	242.5
Normal ridged seedbed	1339.3	190.3
Tied ridged seedbed	1378.6	237.3
SE ±	39.20	32.80
Sig. level	ns	ns
(b) Urea and legumes		
Sole sorghum without urea (control 2)	1416.7b	153.8b
Urea at 103.5 kg/ha	1858.3a	257.7b
Urea at 207.0 kg/ha	2008.3a	428.7a
Bambara nuts	1125.0bc	254.9b
Groundnuts	983.3c	160.0b
Clitoria sp.	800.0c	158.5b
Desmodium sp.	1125.0bc	149.8b
SE ±	80.7	39.5
Sig. level	**	**
CV %	20.9	61.2

Means in a column with the same letters are not significantly different at 1 % level of Tukey's Studenitized Range (HSD) Test; ns= not significant; (**) = highly significant at ($P \leq 0.0$).

3.5 Effects of different types of seedbeds, rates of urea fertilizer and intercropping sorghum with legumes on sorghum straw yield

There were no significant differences in sorghum straw yield between the different seedbeds (Table 5). Application of urea fertilizer increased straw yield. Generally, intercropping sorghum (cv. Wad Ahmed) with legumes reduced sorghum straw yield throughout the two seasons-2006/07 and 2007/07 (Table 5). Sorghum straw yield through intercropping Wad Ahmed with Bambara nuts, groundnuts *Clitoria* and *Desmodium* spp was significantly (P=0.01) lower by 24%, 29%, 38% and 24%, respectively in season 2006/07 (Table 5).

Table 5. Shows sorghum straw yield as affected by different types of seedbeds, rate of urea fertilizer and intercropping sorghum with legumes

Treatments	Sorghum straw yield (t/ha) in the two cropping seasons

	Season 2006-2007	Season 2007-2008
(a) Seedbeds		
Flat seedbed (control 1)	2.8	3.5
Normal ridged seedbed	2.8	3.1
Tied ridged seedbed	3.1	3.6
SE ±	0.21	0.19
Sig. level	ns	ns
(b) Urea and legumes		
Sole sorghum without urea (control 2)	3.4 a	3.3 bcd
Urea at 103.5 kg/ha	3.9 a	4.5 ab
Urea at 207.0 kg/ha	3.8 a	5.4 a
Bambara nuts	2.5 b	3.7 bc
Groundnuts	2.4 b	2.4 cd
Clitoria sp.	2.1 b	2.0 d
Desmodium sp.	2.4 b	2.6 cd
SE (±)	0.17	0.34
Sig. level	**	**
CV (%)	20.7	34.6

Means in a column with the same letters are not significantly different at 1 % level of Tukey's Studentized (HSD) Test; ns= not significant; (**) = highly significant at ($P \leq 0.01$).

4. DISCUSSION

Parker and Riches (1993) reported that *Striga* damage on sorghum was most severe when drought and infertile soil prevailed. Ridged seedbed is a common seedbed preparation practice to collect rain water to support growing crops in areas with marginal rainfall. The practice also helps to mitigate severity of *Striga* on crops including sorghum. Severe effects of *Striga* on crops as a result of drought have been witnessed in the Blue Nile State (Sudan), Ethiopia and elsewhere due to fluctuations in annual rainfall and its distribution. It is anticipated that ridging seedbed will be useful to the crop as well as *Striga* control through improving rain water collection in times of low rainfall when the crop withers and the parasite flourishes. On the other hand, ridges are expected to improve water drainage in the field where rainfall is heavy. The

reduction in population of *Striga* and its dry weight through seedbed ridging could be attributed to effect of increased moisture content. If that was not the case, then it was perhaps due to differences between the high numbers of viable *Striga* seeds buried at subsoil by ridging and was unable to germinate and emerge, also probably due to the low numbers of *Striga* seeds exposed to germination and emerge from deep soil. However, reduction in *Striga* due to ridging did not result in higher grain yield (Table 4). This could be attributed to the very low differences in the population of *Striga* in sorghum (cv. Wad Ahmed) between the flat and the ridged seedbeds to induce a significant increase in sorghum grain yield.

In this study, the application of moderate to high rates of urea (103.5 to 207 kg/ha) did not suppress *Striga* population and its dry weight (Tables 1a, 1b and 2). This could be due to the insensitivity of *Striga* to low amounts of urea in which even the high rate had been reduced in potency through rains (Andrews, 1945a) leaving insufficient fertilizer to suppress the parasite but enough to increase sorghum grain yield. Although application of urea fertilizer regardless of rate used had no impact on sorghum height and straw yield, it increased sorghum grain yield (Table 4). High rates of urea fertilizer below and above 190 kg urea have been applied to suppress *Striga* in sorghum and improve yield (Bilal, *et al*. 2008, Dawoud, *et al*. 2007). These differences in results above could be attributed to the inconsistent effects of nitrogen rate on control of *Striga* (Parker, 1991) or loss of urea to rains (Andrews, 1945). Such loss of urea fertilizer in rain fed areas may perhaps necessitate application of higher doses of nitrogen to control *Striga* in *Striga* infested fields.

Some plants (trap plants or crops) including legumes induce suicidal germination of *Striga* seeds through release of *Striga* germination stimulant. Intercropping resistant sorghum (cv Wad Ahmed) (Kenyi, 2009) with Bambara nuts, groundnuts, *Clitoria* and *Desmodium* spp that

resulted in variable results on population of *Striga* and its dry weight were probably attributed to relative suicidal germination and shading of the parasite by the legumes and resistance to the parasite by sorghum(Wad Ahmed). Suicidal germination and shading of *Striga* through intercropping sorghum with Bambara nuts and groundnuts confirm the findings by Gworgwor (2002) and Carson (1989). Shading causes the parasite to exhibit weak growth that leads to loss in weight. These reductions in *Striga* population and its dry weight did not increase sorghum yield dramatically perhaps due to the extra competition caused on sorghum by the intercropped legumes.

5. CONCLUSIONS

This study has established that, ridged seedbeds especially the normal ridged, reduced *Striga* population as well as dry weight of the plants. The application of urea fertilizer at the rate of 103.5 kg/ha up to 207.0 kg/ha increased sorghum grain yield and *Striga* population. Intercropping sorghum (cv. Wad Ahmed) with *Clitoria* spp. significantly (P= 0.01) reduced sorghum height. Tentatively, the integration of normal ridged seedbed, with a resistant sorghum cultivar and application of urea fertilizer in *Striga* infested areas may result in low *Striga* population, dry weight and high sorghum grain yield.

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