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Effect of Chlorsulfuron +2, 4-D, nitrogen and their combinations on *Striga hermonthica* (Del.) Benth incidence and Sorghum performance

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Abstract
A series of experiments were conducted during two seasons to study the efficacy and selectivity of the herbicide Chlorsulfuron in tank mixtures with 2,4-D for *Striga* control in sorghum. Application of the nitrogen fertilizer, as urea, was also evaluated as a separate treatments or in combination with the herbicide mixtures. The experiments were conducted at two sites in the Gezira State, Sudan. Application of N, as urea, had slight effects on *Striga* emergence at 60 days after sowing. At 90 DAS, urea at 80 kgfed^{-1} reduced *Striga* emergence by up to 37%. Chlorsulfuron +24-D reduced *Striga* emergence by 41%-59% and 37%-67% in the 1st and 2nd seasons 90 DAS, respectively. Combining urea at 80 kg fed.$^{-1}$ with the tank mixture of Chlorsulfuron + 2,4-D at the rates tested gave 61%-73%, and 56-72% reduction in *Striga* density in the 1st and 2nd seasons 90 DAS, respectively. The benefits of adding nitrogen was clearly reflected by sizable reduction in dry weight obtained. Where the combined application of nitrogen with the herbicide mixture of Chlorsulfuron + 2,4-D at the rates tested gave 41%-65% and 52%-74% reduction in *Striga* dry weight in the 1st and 2nd seasons, respectively. Whereas the sole treatment of herbicide mixture gave 19%-30% and 32%-40% reduction in *Striga* dry weight in the 1st and 2nd seasons, respectively. The corresponding reduction in *Striga* dry weight due to sole nitrogen application was 15%-39% in the two seasons. In conclusion, the application of Urea, herbicides and their combinations reduced *Striga* population and slightly increased sorghum grain and straw yields.

Keywords: *Striga hermonthica*, herbicides, urea fertilization, sorghum

Introduction
Striga species, particularly *Striga hermonthica*, belong to the family Orobanchaceae, cause enormous losses to major crops in sub-Saharan Africa [1, 2]. It attacks mainly sorghum, maize, pearl millet, sugar cane and rice. The production loss of 30-80% of staple food and industrial crops on every continent was estimated as a result of about 20 families of higher plants parasitizing plant kingdom[3]. In Sudan, more than 500,000 hectares under rainfed cultivation heavily infested with *Striga*, leading to 70% – 100% yield loss [4]. Many control measures were reported for *Striga* species. For instance, cultural physical, biological, chemical control and biotechnology-based control measures [2, 3]. Chemical control methods include, fumigants, germination stimulants, antitranspirants, seed hardening, seed treatments and herbicides. Two main groups of herbicides are available: those applied prior to *Striga* emergence, and those applied after emergence. Preemergence herbicides such as Trifluralin and Metalachlor showed success when moved into the soil by rainfall or irrigation 2-3 weeks after sowing at the time of *Striga* seeds germination [5, 6, 7]. The most effective postemergence herbicides which provide efficient control of *Striga* include 2,4-D at a rate of 1 kg ha^{-1} and Gramoxone at 0.25 to 0.5 kg ha^{-1} which can be used either alone or in combination with 2,4-D [6, 8]. The selective control of *S. hermonthica* in Sudan with Chlorsulfuron at 2-4 g a.i ha^{-1} was reported [9]. Chlorsulfuron and its tank mixture with dicamba gave 77%-100% control of *Striga* on both the local variety Gadam El Hamam and the resistant variety SRN-39 [10]. Straw and grain yield of sorghum were negatively correlated with *Striga* population density (r = 0.56- -0.89).

The major constraints to herbicides use particularly in the developing countries are availability, cost, equipment and the technology required for their application [6]. Other alternative preventive measures include hand pulling. However, it is difficult to convince farmers to spend extra efforts to hand pull *Striga* and so prevent production of new seeds even though this is one of the most important ways of preventing further intensification of the problem [11]. On the other hand, urea was selected for this study because the main effects of nitrogen application is believed to mitigate *Striga* via: reduction of stimulant exudation, alteration of host root: shoot balance, reduced osmotic pressure in the parasite relative to the host, a toxic effect of nitrogen on the developing *Striga* and increased shading by the crop [11]. Increased shading as a result of more luxuriant growth of crop shoots results in higher humidity, lower temperature and reduced transpiration, again reducing the flux from host to parasite. Additionally, reduction of stimulation from sorghum roots by moderate levels of N has been clearly confirmed *in vitro* [12, 13, 2]. The

effects of ammonium sulphate and urea were more marked than those of calcium nitrate [12]. The relative importance of these and perhaps other mechanisms awaits further study. Meanwhile, the reduction in stimulant exudation remains to be the best documented. As an example of the successful use of nitrogen to suppress *Striga* in the field including the obtained varying results with added N on sorghum in Sudan **[14]**, depending on both variety and on the initial fertility of the soil. The benefits of herbicides in controlling *Striga* could be enhanced by adding nitrogen. For instance, combining nitrogen with Actril DS or Sorgoprim or both herbicides reduced *Striga* infestation and improved sorghum yield compared to their sole application **[15]**. However, combining nitrogen with Actril DS gave better results than when nitrogen was combined with Sorgoprim. Increasing nitrogen dose up to 120 kg N ha^{-1} consistently reduced *Striga* incidence and improved sorghum growth and yield, and applying nitrogen 40 days after sowing especially at the higher dose gave better results of reducing *Striga* incidence and improving sorghum yields than when applied at sowing or 20 days later. The benefits of N can be judged in several ways. The most important from the viewpoint of an integrated *Striga* control system is the reduction in numbers of emerged and maturing *Striga* and hence, a reduction in seeds produced. The farmers' most immediate reason for investing in N, however, will be the prospect of increased yield. In general, it is rare not to achieve an increased yield where *Striga* is reduced. Conversely, however, *Striga* is not necessarily decreased when yields are increased.Therefore, the objectives of this work were to study the effects of the tank mixture of Chlorsulfuron and 2, 4-D and urea alone or in combinations on *Striga* incidence and growth and yield of sorghum under Gezira, Sudan local field conditions.

Materials and Methods

Field and laboratory experiments were undertaken to investigate the effects of urea and herbicides on *S. hermonthica* and sorghum growth and yield.

Experimental site

Two field experiments were conducted in two consecutive seasons in *Striga* sick plots at the Gezira Research Station (GRS) and Abu Haraz complex, University of Gezira, Wad Madani (Latitude 14° 25'N, Longitude 35° 29' E). The soils is typical of the Central Clay Plains with pH 7.7-8.8 and organic matter content of 0.6% and it is characterized by heavy cracks. The soil is nonsodic, nonsaline with EC 1.8 mm hose cm^{-1}. Calcium content of 0.02, 0.4 and 2.5, respectively. The clay content is 54% and it was classified as chromic haplusterts, fine smectitics and isohyperthemic (Adam, Personal Communications). Typical Profile Sulemi clay 0-3 cm. Dark brown 10YR4/31 mist and brown (10YR 5-3) contrast dry, clay strong very fine and fine granular structure, very sticky very plastic "friable most" hard dry frequent small hard irregular gray $CaC0_3$ nodules, matrix calcareous, few fine roots abrupt, smooth boundaries, pH 8.4

Field experiments

The experimental field was ploughed, harrowed, leveled and then ridged and divided into plots each consists of 4 ridges each 7.0 m long and 0.8 m apart. The experiments were sown with the sorghum variety Wad Ahmed. Six sorghum seeds per hole were sown by hand at 4cm deep and 15cm between holes. *Striga* infestation was augmented by placing 5 mg of soil containing *Striga* seeds in each hole prior to sorghum planting that was prepared by thoroughly mixing of 1 g of *Striga* seeds with 1kg pulverized sieved Gezira soil. Plots were irrigated immediately after sowing. The crop was thinned to 2 plants per hole, 15 days after sowing. The crop was weeded at 4 weeks after sowing. The first and second weeding were done by hand hoes. Whereas, the third was done by hand pulling to avoid damaging emerging *Striga* plants. Urea was applied at sowing and the herbicides were applied 4 weeks after sowing as an aqueous spray by Knapsack sprayer at volume rate of L fed^{-1}. The experiments were laid out in Randomized Complete Block Design with 4 replicates.

Analysis of data

Data from field experiments were analyzed by analysis of variance. Where the test was significant, means were tested for significance by the Duncan Multiple Range Test (DMRT).

Table 1: Effects of Chlorsulfuron + 2, 4-D, urea and their combinations on *Striga* population density (000 fed^{-1}) in the first season

Chlorsulfuron+ 2,4-D Rate kg a.i. fed^{-1}	Urea level fed^{-1}		
	0N	1N	2N
Striga count 60 DAS			
0.0	91.3	82.4	82.1
0.08	58.4	61.4	35.0
0.1	29.8	46.4	46.8
0.12	51.4	78.4	52.2
SE±	11.8 ns		
Striga count 90 DAS			
0.0	102.1	90.2	64.3
0.08	42.2	54.8	27.7
0.1	44.5	54.4	39.5
0.12	60.8	55.3	35.4
SE±	12.4 ns		
Striga dry weight			
0.0	44.5		
0.08	31.0		
0.1	33.2		
0.12	35.9		
SE±	6.2ns		

Table 2: Effects of Chlorsulfuron + 2,4-D, urea and their combinations on *Striga* population density (000 fed^{-1}) in the second seasons

Chlorsulfuron+ 2,4-D Rate kg a.i. fed^{-1}	Urea level fed^{-1}		
	ON	1N	2N
Striga count 60 DAS			
0.0	86.1	71.5	68.6
0.08	54.8	62.5	34.6
0.1	29.7	54.4	50.2
0.12	57.1	77.3	50.8
SE±	12.9		
Striga count 90 DAS			
0.0	105.9	91.1	65.1
0.08	39.7	54.7	30.4
0.1	34.9	55.5	46.3
0.12	67.0	53.7	29.9
SE±	8.2ns		
Striga dry Weight			
0.0	18.8	16.0	12.7
0.08	11.5	9.0	4.8
0.1	11.2	11.6	9.1
0.12	12.8	6.5	5.7
SE±	2.6 ns		

Table 3: Effects of Chlorsulfuron + 2,4- D, urea and their combinations on sorghum growth performance in the first and second seasons

Chlorsulfuron +2,4-D rate kg a.i. fed^{-1}	Urea level fed^{-1}		
	ON	1N	2N
First season			
Sorghum Head(000 fed^{-1})			
0.0	18.0	23.5	27.7
0.08	23.3	49.3	30.1
0.1	31.6	33.3	28.1
0.12	17.7	28.1	32.4
SE±	5.7 ns		
Sorghum straw dwt tons /ha			
0.0	1.3	2.2	2.1
0.08	2.5	3.1	2.8
0.1	2.6	3.0	2.4
0.12	1.5	2.4	3.4
SE±	0.5ns		
Second season: Sorghum heads (000 fed^{-1})			
0.0	19.7	24.3	27.7
0.08	19.7	43.5	32.1
0.1	29.7	16.1	31.0
0.12	19.7	31.9	30.6
SE±	6.3		
Sorghum straw dwt tons /ha			
0.0	1.5	2.3	1.8
0.08	1.5	3.1	3.1
0.1	2.5	2.7	2.7
0.12	1.8	2.7	2.9
SE±	0.6ns		
0.0	19.7	24.3	27.7
0.08	19.7	43.5	32.1
0.1	29.7	16.1	31.0
0.12	19.7	31.9	30.6
SE±	6.3		
Sorghum straw dwt tons /ha			
0.0	1.5	2.3	1.8
0.08	1.5	3.1	3.1
0.1	2.5	2.7	2.7
0.12	1.8	2.7	2.9

Results and Discussion

The influence of the herbicide mixture, nitrogen or both on *Striga* control

The mixture of Chlorsulfuron + 2, 4-D alone at different rates reduced *Striga* emergence by 41%-59% and 37%-67% in the 1st and 2nd seasons, 90 DAS, respectively. These results agreed with reported scores that Chlorsulfuron and its tank mixture with dicamba gave 77%-100% control of *Striga* on both the local variety Gadam El Hamam and the resistant variety SRN-39 [7]. On the other hand, Urea alone at 1N had slight effects on reducing *Striga* density (10%-12%) over the two seasons. However, increasing urea to 2N gave 37%-39% reduction in *Striga* density 90 DAS during the two seasons. These findings are in agreement with reported data that increasing nitrogen dose up to 120 kg N/ha consistently reduced *Striga* incidence and improved sorghum growth and yield, and applying nitrogen 40 days after sowing especially at the higher dose gave better results of reducing *Striga* incidence and improving sorghum yields than when applied at sowing or 20 days later [12]. Combining urea at 2N with the tank mixture of Chlorsulfuron + 2,4-D at the rates tested scored 61%-73%, and 56-72% reduction in *Striga* density in the 1st and 2nd seasons 90 DAS, respectively. The benefits of adding nitrogen was clearly reflected by sizable reduction in dry weight obtained. Where the combined application of nitrogen with the herbicide mixture of Chlorsulfuron + 2,4-D at the rates tested gave 41%-65% and 52%-74% reduction in *Striga* dry weight in the 1st and 2nd seasons respectively. Whereas the sole treatment of herbicide mixture gave 19%-30% and 32%-40% reduction in *Striga* dry weight in the 1st and 2nd seasons, respectively. The corresponding reduction in *Striga* dry weight due to sole nitrogen application was 15%-39% in the two seasons. These could be attributed to the toxic effect of nitrogen on the developing *Striga* [8] which tolerated the herbicide toxicity and increased shading by the crop as a result of more luxuriant growth of crop shoots. These findings concurrent with that combined nitrogen with Actril DS or

Sorgoprim or both herbicides reduced *Striga* infestation and improved sorghum yield compared to their sole application.

The influence of the herbicide mixture, nitrogen or both on sorghum performance

The sole treatment of Chlorsulfuron +2, 4-D at the different rates tested increased sorghum heads in (000 fed^{-1}) and sorghum straw dwt in tons ha^{-1} by 29%-76% and 15%-100%, respectively (Table 3). Whereas, the sole nitrogen treatment at 1N and 2N increased sorghum heads and straw dwt by 23%-31% and 41%-54%, respectively. However, combined application of herbicide mixture and nitrogen inconsistently increased sorghum heads and sorghum dwt irrespective of their rate and season of application. Herbicide application preceded by nitrogen at 1N and 2N increased sorghum heads by 56%-174% and 54%-80%, respectively. The corresponding increase in sorghum straw dwt in response to application of herbicide, nitrogen at 1N and 2N was 80%-138% and 80%-162%, respectively.

In conclusion, using of Chlorsulfuron + 2, 4-D resulted in varying effects on *Striga* depending on the season and/or level of parasitism. Application of urea fertilizers in sorghum fields affected *Striga* parasitism and increased sorghum yield. The integrated application of urea and herbicides reduced *Striga* population and increased the production of the host crop sorghum than sole application of each.

References

1. Runo S, Kuria EK. Habits of a highly successful cereal killer, Striga. PLoS Pathog. 2018; 14(1):e1006731. https://doi.org/10.1371/journal.ppat.1006731
2. Mohemed N, Charnikhova T, Fradin EF, Rienstra J, Babiker AGT, Bouwmeester HJ. Genetic variation in Sorghum bicolor strigolactones and their role in resistance against Striga hermonthica. Journal of Experimental Botany. 2018; 69(9):2415-2430. https://doi.org/10.1093/jxb/ery041
3. Aly R. Conventional and biotechnological approaches for control of parasitic weeds. In Vitro Cellular & Developmental Biology – Plant. 2007; 43(4):304-317. 2007 https://doi.org/10.1007/s11627-007-9054-5
4. Food and Agriculture Organization, FAO. Production Yearbook, 1988, 41.
5. Parker C, Riches CR. Parasitic Weeds of the World and their Control. Wallingford, U.K.; CAB International. 1993.
6. Eplee RE, Norris R. Control of parasitic weeds. In: Parasitic Plants (Press, M.C. and Graveo, J.D.(Eds.) London. U.K. Chapmanand Hall. 1995, 256-277.
7. Parker C. Parasitic weeds: A world challenge. Weed science. 2012; 60(2):269-276. https://doi.org/10.1614/WS-D-11-00068.1
8. Eplee RE, Langston MA. Paraquat efficacy and application in Witchweed (Striga luted) control. Proceedings of the Southern Weed Science Society (USA), (1970); 23:127.
9. Babiker AGT, Reda F. Recent advance in Striga Research in Sudan and Ethiopia. In: Proceedings of 5th International Symposium on Parasitic Weeds. Nairobi, Kenya. (Ransome, J. K., Musselman, L. J., Worsham, A. D. and Parker, C. eds.). 1991, 180-189.
10. Babiker AGT, Ahmed NE, Ejeta G, Butler LG, Mohammed A, El-Mana ESM. Abdel Rahammon BE. Proceedings of 6thInternational parasitic weed symposium, Cordoba, Spain, 1996, 16-18.
11. Parker C. The influence of Striga species on sorghum under varying nitrogen fertilizations. In: Proceedings of the 3rd International Symposium on Parasitic Weeds. (Parker, C, Musselman, L.J., Polhill, R.M. and Wilson, A.K. eds.) Aleppo, Syria. ICARDA, Aleppo, 1994, 90-98.
12. Raju PS, Osman MA, Peacock JM. Effect of N,P and K on Striga asiatica (L.) Kuntze seed germination and infestation of sorghum. Weed Research, 1990; 30:139-144.
13. Cechin I, Press MC. Nitrogen relation of the sorghum-Striga hermonthica host-parasite association: germination, attachment and early growth. New Phytologist. 1993; 14: 681-687.
14. Last FI. Effects of cultural treatments on the incidence of Striga hermonthica (Del.) Benth. and yield of sorghum in the Sudan, Field experiments 1957/58. Annals of Applied Biology. 1960; 40:207-229.
15. Dawoud DA. Effects of herbicides and nitrogen on the incidence of Buda (Strigahermonthica (Del.) Benth.) and the performance of Dura (Sorghum bicolor L. Moench.) Msc. Agric. MSc thesis, University of Khartoum, Khartoum, Sudan, 1986.