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Effect of Chlorsulfuron 75% WDG Herbicides on *striga* Control and Sorghum Yield in T/Abergelle District, Central Zone of Tigray, Ethiopia

Hintsa Meresa [a*] and Shambel Syum [a]

[a] *Tigray Agricultural Research Institute, Abergelle Agricultural Research Center, P.O. Box 44, Abi-Adi, Ethiopia.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Chlorsulfuron (75% WDG) is a new systemic herbicide for striga control in small seed grains. Striga is one of the obligate parasitic weeds and reduces sorghum yield by more than 75% by drawing water and nutritional needs from the host root. Due to this intervention, this experiment was executed in Striga-infected areas in three kebeles under rain-fed conditions to evaluate the efficacy of herbicides for controlling Striga infestation on sorghum yield. Results of the experiment indicated that spraying of the chlorsulfuron product in Turkey and China at a rate of 40 g/ha had highly significant effects on striga control and gave a better yield than untreated plots (control). It shows that it's an excellent control system that reduces more than 98% of the striga count at harvest and gives above 50% yield advantage to the product of Turkey over control. This reduction in growth

**Corresponding author: E-mail: hintsa1982@gmail.com;*

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may be closely associated with inhibition of plant cell division. Direct application of those new chemical products has not shown any visible phytotoxicity symptoms on the soil or sorghum growth during the implementation period. Based on the results, we can conclude that spraying of the chlorsulfuron product in Turkey and China dramatically reduced striga infestation and economically feasible to increased sorghum yield. Generally, application of Chlorsulfuron (75% WDG) on the local variety was obtained high yield and profit per investing. Therefore, using this study as a tool, further research should be conducted on the dose and residue effects on soil, grain quality, and other herbs.

Keywords: Chlorsulfuron; partial budget; sorghum; striga; yield; yield advantage.

1. INTRODUCTION

Sorghum is the fifth most important cereal crop in the world [1] Globally, the mean annual production is 63.89 million tons [2] With an average yearly production of more than 25.6 million tons and a greater land area than the other continents, Africa has emerged as the world's top producer of sorghum [2]. As a result, according to [3] sorghum is now the second-most significant crops in Ethiopia. However, [4,5,6].

Witch weeds (*Striga spp*.) are parasitic weeds of great agricultural significance damage in sub–Saharan Africa. Current agricultural practice is insufficient to manage striga infestation, that harms natural resistance mechanisms [7]. The most economically important parasitic weed in the world, it is endemic to the African savannah and the Sahel, where it can devastate the yields of cereal crops [8] *Striga hermonthica* parasitizes all rain-fed graminaceous crops but is particularly problematic on sorghum, pearl millet, and maize, the major staple cereals [9].

Striga hermonthica is believed to have originated around the border of Sudan and Ethiopia (currently referred to as Nuba), where yield losses due to *striga* parasitism have been estimated at 10.7 million tons per year in sub-Saharan Africa [10]. It is a major biotic constraint on sorghum production in most sorghum-growing parts of Ethiopia. Single agronomic or soil fertility management practices are becoming futile attempts to control *striga* in sorghum-growing agro-ecologies in Ethiopia. Successful *striga* control has been difficult to achieve through conventional cultural, chemical, and biological methods success as fallowing, hand pulling, fertilization, and time of planting. Some successes have been obtained with the use of herbicides [8] and more recently in combination with herbicide-resistant or tolerant crops [11]. Due to this intervention, this experiment was executed in Striga-infected areas:(1) To evaluate the efficacy of herbicides for controlling Striga infestation on sorghum yield and (2) To assess the economic visibility of herbicide application.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The field experiment was carried out in Agbe, Giera, and Gereb Giba on the Tanqua-Abergelle station during the 2019/2020 cropping season. Tanqua-Abergelle is located in the central zone of Tigray, Ethiopia. It is situated at 13°14’06" N latitude and 38°58’50" E longitude. The area is agro-ecologically characterized as a hot, warm, sub-moist lowland (SMl-4b) located at an altitude of 1450 m.a.s.l. The district is highly exposed to soil erosion and is *striga*-infested. Most of the district has poor water holding capacity, is less fertile, and is *striga* sick; hence, most crops failed to produce a good yield [11]. The average annual rainfall varies from 350 to 650 mm, and the temperature ranges from 18 to 42 oC. The distribution of rainfall is erratic and variable, which results in strong variation in crop yields [11].

2.2 Experimental Methods and Treatments

The trial was done at two *striga*-infected kebeles of a farmer’s field and one kebele on the station of the Abergelle Agricultural Research Center in Tanqua Abergelle district in the 2019/2020 cropping season. The herbicides of different product: Chlorsulfuron 75% WDG formulations (products of Turkey and China), including control, were used in the study and applied using a knapsack sprayer as an aqueous spray at a rate of 40 gm with 200 L per hectare [12]. The *striga*-susceptible sorghum variety was used in the experimental plot (10 m by 8 m) in each kebelle. Since it is well adapted to the agro-ecology of the study area (the lowlands of northern Ethiopia).

The seed rate was 12 kg /ha and sown manually with a spacing of 75 cm between rows and 20 cm between plants.

2.3 Data Collection

The data, including the number of *striga* pre-application, *striga* count at 30 days after chemical application, harvesting, and yield and yield component of sorghum, were collected and analyzed using Excel 2013 software. The partial budget as reported by [13] was analyzed on grain yield of sorghum crop in order to estimate the costs and benefits associated with different treatment. Economic analysis was made using the prevailing inputs at planting and for outputs at the time crop was harvested. All costs and benefits were calculated on hectare basis in Ethiopian Birr (Birr /ha). Grain yield was adjusted down by 10% to minimize the effect researcher managed small plots as compared to the farmers managed.MMR was calculated using the following formulas: Gross benefit = yield return* price Net profit = gross benefit – total cost that vary, MRR = change in net benefit/ total variable costs.

3. RESULTS AND DISCUSSION

Effects on *striga*: The result of the trail revealed that spraying 40 g/ha of chlorsulfuron 75% WDG product from Turkey and China was highly effective in controlling striga on sorghum. The highest number of *striga* was recorded from the untreated plot, while the lowest number was counted from the plot treated by the testing chemicals (Table 2). Application of the testing chemicals demonstrates more than 98% *striga* reduction both at 30 days after application and at harvesting time compared to the untreated plot (control). The herbicide kills all weeds in the plot during the operation, so this observation indicated that those herbicides may be non-selective. The result is in line with result of [14] who states that, application of chlorsulfuron suppression of striga by (83.3%).

Effects on yield and yield components: The result of the above table indicated that the mean panicle length, biomass yield, and yield of sorghum showed a highly significant difference due to the treatment application of chlorsulfuron (75% WDG), which was manufactured in Turkey, as compared to the product of China and the untreated plot (control). The highest biomass (5833.3 kg/ha) and grain yield (1414.10 kg/ha) were obtained from the testing chemicals of product turkey, followed by product China, which increased sorghum yield by 51.5% and 42.78% of yield advantage over control, respectively. So, the implication of this result was that the testing chemicals were very effective against *striga* control and showed a yield difference from control. This result agrees with [14] tested chlorsulfuron formulation significantly increased sorghum grain yield. It also agrees with [15] who states application of chlorsulfuron herbicide significantly control striga on sorghum and gain high yields compare to control.

The simple liner correlation analysis in the Fig. 1 indicated that the grain yield of sorghum was positively and highly correlated with biomass yield (R-Sq = 92.5%).

$$Y = 0.1908\,x + 355.3,\ R\text{-}Sq = 92.5\%$$

Table 1. Effect of chlorsulfuron 75% WDG herbicides on striga reduction at different stages of sorghum

Treatment	Manufacturing country	Striga count before chemical application (80 m^2)	*Striga* count 30 DA chemical application (80 m^2)	% *Striga* reduction at 30 DAA	*Striga* count at harvest (80 m^2)	% *Striga* reduction at harvesting
Chlorsulfuron 75% WDG	**Turkey**	**892.33**	**10.67**	**98.80**	**9.33**	**98.95405**
Chlorsulfuron 75% WDG	China	874.67	13.67	98.44	11.00	98.74238
Control	-	581.33	957.00	-64.62	1290.00	-121.904

DAA: day after application

N.B.: The negative results at control imply that the number of striga increased from the first time to the harvesting time, which revealed that this much striga emerged in the interval

Table 2. Effect of chlorsulfuron 75% WDG herbicides on the mean yield and yield component of sorghum

Treatments	Manufacturer country	Mean Panicle length (cm)	Mean Biomass yield (kg/ha)	Harvest index	Mean Grain yield kg/ ha	Yield advantage over control (%)
(Chlorsulfuron 75% WDG)	**Turkey**	**25**	**5833.3**	**0.24**	**1414.10**	**51.50**
(Chlorsulfuron 75% WDG	China	25	3800.0	0.32	1198.72	42.78
Control (no herbicide application)	-	22	2066.7	0.33	685.90	-
Mean	**-**	**24**	**3900**	**0.3**	**1099.57**	

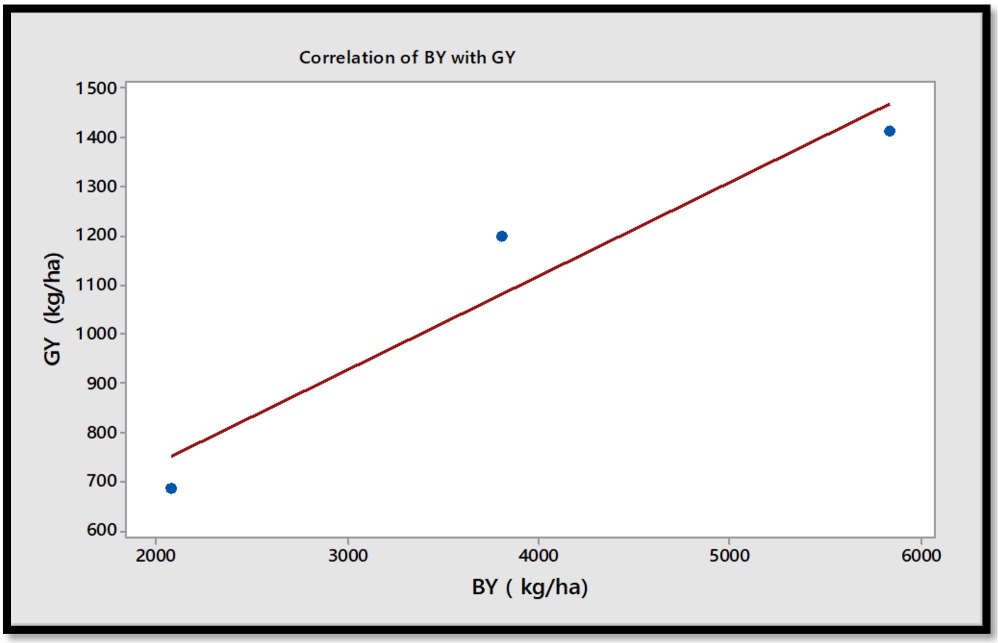

Fig. 1. Correlation of sorghum biomass yield with grain yield

Table 3. Economic analysis herbicides on striga control and sorghum yield

Treatments	Total chemical cost (Birr/ha)	Total revenue	Net revenue (TR-TVC) Bir/ha	Domination Rank	MRR
Control	0	13718	13718	-	
(Chlorsulfuron 75% WDG 40g/ha Product of China)	1000	23974.4	22974.4	ND	22.9
(Chlorsulfuron 75% WDG 40g/ha Product of Turke)	1000	28280	27280	ND	27.3

ND: None dominated

Partial budget analysis: According to the partial budget result of the chemicals, applying Chlorsulfuron 75% WDG 40g/ha product of Turkey and China resulted in the highest net revenue (27280 and 22974.4 ETB/ha), respectively. According to (Table 3), application of Chlorsulfuron 75% WDG 40g/ha product of Turkey and China produced the highest marginal rate of return (27.3 and 22.9) were the largest profit per unit of investment. The impact of chemical herbicide on sorghum productivity was often shown to be larger than 100% based on the marginal rate of return (MRR) on striga control. Hrbicide application with a marginal rate of return above the minimal level (100%) is economically possible, according to [13]. This result is in line with [15] who stated that application of Chlorsulfuron for striga control is economically feasible.

4. CONCLUSION AND RECOMMENDATION

The result of field experiment executed in the striga-infected area revealed a promising result. Application of those chemicals (Chlorsulfuron 75% WDG) in products of Turkey and China were very effective for striga control and economically feasible on sorghum production. The testing chemicals give more than 42% yield advantage over control. So, it may be concluded that the spraying of the Chlorsulfuron product of turkey followed by China product were the best for striga control. However, the finding did not study the effect of the chemical residue on soil and other living things. Therefore, it should be experimented with to determine the effect of the chemical residue on soil nutrients, crop products and other living things to confirm and confidentially recommended it to striga-infested areas using this result as input should be conduct across years and rates.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

DATA AVAILABILITY STATEMENT

All data generated or analyzed during this study are included in this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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