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Evaluation of Striga Suppression Effect Herbicides (*Chlorsulfuron 75% WDG*) on Sorghum ((*Sorghum bicolor* (L.) Moench) in Western Tigray, Ethiopia

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Abstract: Striga is the major sorghum production constraints in western Tigray, Ethiopia. Three Striga sick plot locations (Rawyan, Adebay and Beaker Kebeles) were selected during 2019 main cropping season. The objective of the study was to evaluate the Striga suppression effect of Chlorsulfuron 75% WDG (Turkey and china) product herbicides on sorghum. The experiment was laid out in randomized complete block design (RCBD) with three replications and ten (10gram/hectare) Chlorsulfuron 75% WDG were diluted in water and applied three weeks after planting. Striga count at 60 days after planting, at harvesting and grain yield were recorded and analyzed using GenStat 18version. The treatments showed statistically significant difference (p<001) in Striga and grain yield. But, there was no significant variation between the tested herbicides. The highest Striga count (1602.3/plot) was recorded from control followed by china product (365/plot) and turkey (303.3). The highest mean Striga reduction (81.07%) was recorded from Turkey followed by china (77.22%). The highest Striga count was recorded in Adebay (1298.33) followed by Rawyan (631.33) and Beaker (345).17.98 quintal/hectare, 16.11 and 9.55 yield was recorded in Rawyan, beaker and Adebay respectively The highest grain yield 18.33 quintal/hectare was recorded from Turkey product which is 50.19% yield advantage, 16.48 quintal/hectare 44.6% yield advantage in china product while 9.13quintal/hectare from control. From the study result recommended that both the Turkey and china product herbicides will be promoted to further demonstration and popularization at farm level.

Keywords: Striga, Chlorsulfuron 75% WDG, Sorghum (“Arfagedam”), Sick Plot, Supersession Effect

1. Introduction

Sorghum (*Sorghum bicolor* (L.) Moench), a Poaceae, is native to Africa. Sorghum, the staple food crop in Africa, South Asia and Central America particularly in rural areas. Sorghum is the fifth major cereal crop in terms of production, after maize (*Zea mays* L.), wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), and barley (*Hordeum vulgare* L.) [1].

Sorghum is one of the major traditional food crops of Ethiopia that ranks third in area coverage following Taf and maize. It is grown on 1.2 million ha with a total production of 1.6 million comprising about 13% of the total cereal production in the country [2]. The grain is used for human food, whereas the crop residue is used for livestock feed. The plant stem and foliage are used for green chop, silage and hay. In some parts of the country the stem is used for construction material and fuel [3].

Ethiopia is the center of origin and diversity for many crops including sorghum [4]. In the country, there is a huge source of genetic diversity for cultivated as well as wild relatives. Ethiopia serves as the global reservoir for sources of favorable genes of various crops including sorghum. More than 10,000 sorghum accessions which were collected from different sorghum growing administrative regions and agro-ecologies have been conserved in the Institute of Biodiversity and Conservation [5]. The presence of immense genetic diversity of the crop provides an opportunity to find noble traits in sorghum improvement endeavor. [6] Suggested that sorghum was domesticated and originated in the northeast quadrant of Africa, most likely in the Ethiopian-Sudan border regions and the presence of wild and cultivated sorghums in Ethiopia reveals that Ethiopia is the primary center of origin and center of diversity.

Sorghum is one of the most important cereal crops of the tropics grown extensively over wider areas with elevation range from 1400 to 2100 meters above sea level (m.a.s.l). Its ability to adapt to adverse environmental conditions has made sorghum a popular crop worldwide. It is the major source of energy and protein for millions of people living in semi-arid tropical Africa and Asia. It remains to be the primary source of food in Ethiopia where poor harvest due to drought is common [7].

Millions of people throughout the world including Africa, Asia, and other semiarid regions depend on sorghum as a staple crop. In many households, sorghum is the primary source for energy, protein, vitamins, and mineral [8]. [6] and the third most economically important crop in the US [9], sorghum plays a huge role on the world market as a means of livelihood for millions of subsistence farmers and as an important part of food security [10]. Furthermore, sorghum is used as an important feed source, particularly in developed countries such as the US. Worldwide, 31 million tons, or 48% of all sorghum grown, are used for livestock feed [11].

Sorghum production is negatively influenced by a biotic (heat, drought and low fertility) and biotic stresses (diseases, insects and weeds). Of all weeds *Striga Hermonthica* an obligate root parasite has been identified as one of the major biological threats to sorghum production in the savannah zones of sub-Saharan Africa. *Striga* species are obligate parasite draws water and its nutritional needs from the host root system. During its under-ground stages *Striga* is a hemi-parasite, therefore, once *Striga* seeds germinate, a xylem connection with the roots of the host plant must be established within few days in order to survive [12, 13].

Prodigious seed production, the subterranean nature of the early stages of parasitism and the complex nature of the host parasite relationship make *Striga* a difficult weed to control. Chemical control of *Striga* is an alternative, easy, effective and non-costive method that could be used in an integrated *Striga* management approach to reduce damage inflicted by the parasite. Chlorsulfuron 75% WDG reduce damage caused by *Striga* and effectively control the parasitic weed. Chlorsulfuron enters plants through the root zone and foliage.

The herbicide is an acetolactate synthases (ALS) inhibitor that inhibits the synthesis of the 14 amino acid L-leucine, L-isoleucine and L-valine and subsequently protein synthesis [14]. According to [15], Chlorsulfuron 75% WDG 3.2 and 4 gram ha-^{1} resulted in satisfactory to excellent suppression of the Striga emergence early in the season. However, presence of the herbicide from more than one source of production will enhance availability and reduce the cost of control. Western Tigray is one of the sorghum production potential areas however the productivity is very low due to high striga infestation. Therefore the experiment was designed to evaluate striga suppression effect herbicides (Chlorsulfuron 75% WDG).

2. Material and Methods

Description of study area: The field experiment was conducted in k/Humera district, Western Tigray Ethiopia during 2018/2019 main cropping season. The experimental sites are characterized by hot to warm temperature and high evaporation condition (hot to warm semiarid lowland agroecology). The experiment was conducted in three locations (Adebay, Rawyan and Baeker). Adebay site is located at 14°17′22″ North latitude and 036°38′ East longitude in the altitude 625 meter above sea level. Rawyan has found in latitude 14°17′ 19″N, longitude 036°37′ 18″E, altitude 600 meter above sea level. Baeker is located at 14°04′28″ North latitude 036°45′10″ East longitude in the altitude 645 meter above sea level.

Striga sick plot locations (Adebay, Rawyan, and Beaker Kebeles) three farmer's fields were selected in k/Humera district during 2018/2019 main cropping season. Turkey and China product herbicides including control were evaluated in the study using Striga susceptible sorghum ("Arfagedam") local variety. Ten (10 gram) of each Chlorsulfuron 75% WDG were diluted in 200litter of water/hectare and applied three weeks after planting using knapsack sprayer. The recommended spacing of 20 cm between plants and 75 cm between rows and randomized complete block design (RCBD) with three replications was used. Each treatment was assigned into a plot area of 10*10m ($100m^2$) randomly. Least Significant Difference (LSD) values were used to separate differences among treatment means at 5% probability level. Striga count data (at 60days after planting, harvesting) and grain yield were recorded.

ANOVA was performed using General Linear Model (GLM) GenStat 18 version.

Yield loss: Yield loss due to *S. hermonthica* was measured as percentage yield reduction of untreated plots compared with the most integrated plot using the following formula:

$$\mathrm{RL}(\%) = \frac{(Y_1 - Y_2) \times 100}{Y_1}$$

Where, RL = relative loss (reduction of the parameters grain yield)

Y_1 = mean of the respective grain yield parameter on maximum protected plot

Y_2 = mean of the respective grain yield parameter in other treatments and unprotected plot.

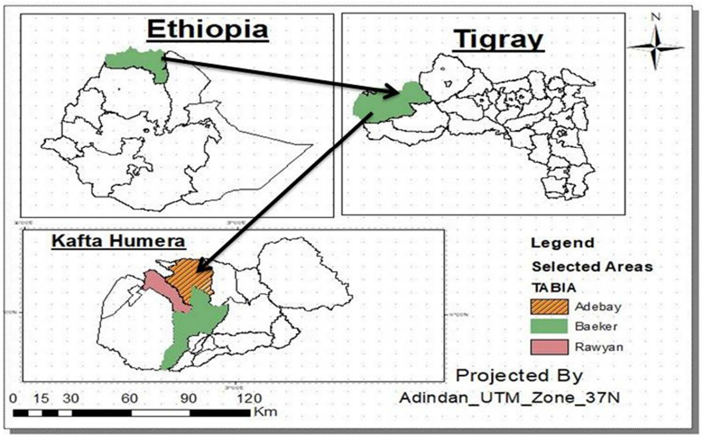

Figure 1. *Location map of the study area, Kafta Humera District western zone of Tigray region, Northern Ethiopia using ARC GIS 10.4.*

3. Result and Discussion

3.1. Striga Cunt

Statically significant difference in striga count (p<001) among treatments was observed but there was no between the herbicides. The highest striga population per plot was recorded in the control (1602.3) followed by china product herbicide (365) and Turkey (303). Stiga infestation was different from one area to another. The highest striga count was recorded in Adebay (1298.33) followed by Rawyan (631.33) and Beaker (345). grain yield 17.98 quintal/hectare, 16.11 and 9.55 yield was recorded in Rawyan, beaker and Adebay respectively indicated in figure 2. The mean percent striga reduction (81.07%) was recorded in Turkey product herbicide (Chlorsulfuron 75% WDG) while 77.22% in the china product presented in table 1. The result is in line with [15] application of Chlorsulfuron reduced Striga emergence more than 90%. In addition, similar results were obtained by [16] who found that Chlorsulfuron at 2.38 and 2.98 gram a.i ha^{-1} effected excellent suppression of the parasite (83.3%). However, presence of the herbicide from more than one source of production can enhance availability and reduce the cost of control [15]. This could be attributed to the mode of action of Chlorsulfuron one of amino acid inhibitors belongs to sulfonylurea’s group, the mode of action in this group is the tendency of poorly developing roots and the secondary roots are shortened. Chlorsulfuron is acetolactate synthase (ALS) inhibitor [17].

3.2. Striga Cunt and Yeld Aross Lcations

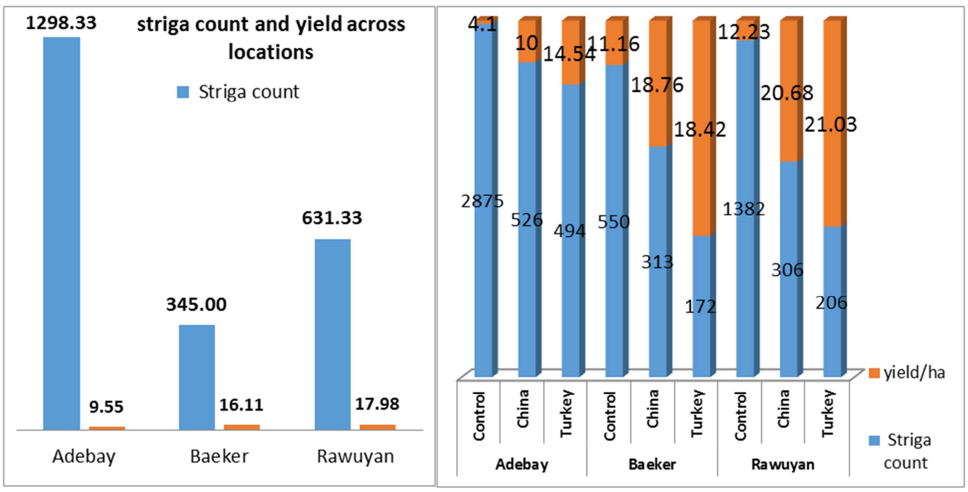

Figure 2. *Striga count and yield across locations.*

Table 1. *Types of herbicides, striga count at different days, total striga per plot and percent of striga population reduction at different sorghum growth stages.*

Treatments	Manufacturer country	Striga count at 60 DAE	% Striga reduction at 60 DAE	Striga count at harvesting	% Striga reduction at harvesting	Total Striga count	% Striga reduction
Control		1408	-	194.3	-	1602.3	-
(Chlorsulfuron 75% WDG	China	250.7	82.19	114.3	41.17	365	77.22

Treatments	Manufacturer country	Striga count at 60 DAE	% Striga reduction at 60 DAE	Striga count at harvesting	% Striga reduction at harvesting	Total Striga count	% Striga reduction
(Chlorsulfuron75% WDG)	Turkey	195.3	86.13	108	44.42	303.3	81.07
Grand mean		618		138.9		757	
LSD (5%)		94.4		13.09		71.7	
CV (%)		6.7		4.2		4.2	

DAE; Day after Emergence; CV: Coefficient variation; LSD: List significant difference

3.3. Sorghum Grain Yield

From study result showed that grain yield had statistically significant (p<0.01) variation among the treatments. But there was no any significant variation between the herbicides. The highest striga count (1602.3/plot) was recorded from control followed by china product (365/plot) and turkey (303.3). The highest mean striga reduction (81.07%) was recorded from Turkey product followed by china (77.22%). The highest grain yield 18.33 quintal/hectare was recorded from Turkey product which is 50.19% yield advantage 16.48 quintal/hectare 44.6% yield advantage over china product while 9quintal/hectare from control indicated in (Table 2). The result is line with [15] tested Chlorsulfuron formulations significantly increased sorghum grain yield in comparison with the untreated (control) by 191%.

Table 2. *Yield and yield advantage of different striga controlling herbicides.*

Treatments	Manufacturer country	yield quintal/hectare	Yield advantage over control (%)
(Chlorsulfuron 75% WDG)	Turkey	18.33	50.19
(Chlorsulfuron 75% WDG	China	16.48	44.60
Control (no herbicide application)	control	9.13	-
Grand mean		14.65	
LSD (5%)		1.63	
CV (%)		4.9	

CV: Coefficient variation; LSD: List significant difference

Yield components: The application of Chlorsulfuron 75% WDG was showed significant (p<0.05) effect on yield component except 1000 grain weight. The maximum plant height and panicle weight were recorded in the application Chlorsulfuron 75% WDG (Turkey). However, the minimum plant height and panicle weight were recorded from the untreated herbicide which is control (Table 3). Chlorsulfuron 75% WDG reduce damage caused by *Striga* and effectively control the parasitic weed. This could be due to the suppressing and reducing establishment striga weed chemical entering through the root zone and foliage. The current result supported by [15] who reported application of Chlorsulfuron 75% WDG excellent suppression of the Striga emergence early in the season and highest grain yield record from treated.

Table 3. *Effect of Chlorsulfuron 75% WDG on yield component of sorghum.*

Treatment	Manufacture country	Plant height	Panicle weight	1000 grain weight
Control (no herbicide application)		52.67b	28.33b	27.50a
(Chlorsulfuron 75% WDG	China	69a	56.33a	29.17a
(Chlorsulfuron 75% WDG)	Turkey	72a	64a	29.00a
Grand mean		64.55	49.55	28.55
LSD (5%)		3.54	15.96	ns
CV (%)		2.42	14.21	3.24

4. Conclusion and Recommendation

Striga is one of the major sorghum production constraints in western Tigray, Ethiopia. Even though western Tigray is one of the potential for sorghum production and most of farmers depend on sorghum. Most of farmers are changing growing sorghum to other different crops because of the striga weed. There were no any chemicals to control striga in the area but those two newly introduced herbicides studied their suppression effect during 2018/2019 cropping season. There was statistically significant difference (p<001) among the treatments compared to control. However, there was no any significant variation between the tested herbicides. The highest striga count (1602.3/plot) was recorded in the control followed by China product (365) and (303) from Turkey product herbicide. Striga infestation was different from one area to another. The highest striga count was recorded in Adebay (1298.33) followed by Rawyan (631.33) and Beaker (345). The highest grain yield 17.98 quintal/ha^{-1}, 16.11 and 9.55 recorded in Rawyan, beaker and Adebay respectively. The highest mean striga reduction (81.07%) was recorded in Turkey herbicide while 77.22% in china product. The highest grain yield was obtained in the Turkey product herbicide 18.33 quintal/hectare which is 50.19% yield advantage over control whereas the lowest yield was measured from untreated control 9.13 q/ha^{-1}. From the study result recommended that both the Turkey and China product herbicides had significant effect on striga control and should be promoted to further demonstration and popularization at farm level in the coming cropping season in collaboration with office of Agriculture in our mandate areas and other related agro ecologies of Striga infestation in Ethiopia.

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