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Effect of maize variety and nitrogen fertilizer on striga parasitism and maize yield in western Kenya

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Abstract

Parasitism by *Striga* weed is the major cause of maize yield losses in the Lake Victoria Basin. Severity of attack is greater in soils with poor fertility. This study evaluated the effects of two different maize varieties and inorganic nitrogen sources on striga parasitism and maize yield in Kisumu West, Busia and Teso South districts of western Kenya. A randomized complete block design with a split-split plot arrangement replicated six times was used. The districts formed blocks. The parameters measured in the field included germination count, striga population and maize yield. A combination of a *Striga* tolerant variety- WS 303- nitrogen at the rate of 60kgN/ha, in high fertility plots was superior to other treatments. The lowest striga count at 6, 8 and 10 week after planting (WAP) and the highest maize grain yield were achieved in the WS 303 maize variety in Kisumu West, Busia and Teso South districts. Teso South district realized the least striga emergence in the plots with WS 303 maize variety and thus resulted to high yield. To facilitate proper choice of striga control options and their uptake by most farmers, this calls for the use of integrated *Striga* control technologies that give high yield, increase soil fertility and reduce striga seed bank in farmers' led field experiments.

Key words: maize yield, nitrogen fertilizer, *Striga* parasitism, western Kenya

Introduction

Reduced maize yields in the Lake Victoria basin are attributed to the parasitic weed, *Striga hermonthica* (Odendo *et al.,* 2001). *Striga* is considered an indicator of poor soil fertility (Kanampiu and Friesen, 2004). The frequency and severity of attack by *Striga* weed is greater in soils that are sandy, low in fertility, and with low to moderate water holding capacity (Weber *et al.*, 1995). In Kenya, *Striga* infests about 212 000 ha (Vanlauwe *et al*., 2008), causing an annual crop loss of $US40.8 million (Gethi *et al*., 2005). The weed is common in Nyanza and Western provinces (AATF, 2008).

Farmers in Kenya respond to the problem of *Striga* weed through various traditional control methods. However, research findings show that these methods are insufficient to eradicate *Striga* weed once it is well established in a field (Woomer *et al*., 2004). Also, these measures do not offer complete control and may require several seasons for substantial *Striga* weed reduction (Parker, 1984; Kabambe, 1991; Odhiambo and Ransom, 1996; Kabambe *et al*., 2000).

About 40% of farmers use low rates of fertilizer and often too late for optimum timing of application (Swinkel *et. al*., 1997). Addition of nitrogen to the soil is generally considered to alleviate the effects of *Striga* and lower the amount of *Striga* supported by the host (Mbwaga *et al*., 2001).

A recent technological breakthrough using an herbicide coated, striga resistant maize variety has been developed (Kanampiu *et al.,* 2002). This study was therefore conducted to evaluate the effect of maize varieties and nitrogen fertilizer on *Striga* weed emergence and maize productivity.

Materials and methods

Study site

On-farm experiments were conducted in Kisumu West District (South Kapwonja and West Kanyadwera Sub-location), Busia district (Mayenje and Eshikulu Sub-location) and Teso South District (Adungosi and Akotikok Sub-location) of western Kenya.

The areas are characterized by two rainy seasons with slightly varying climatic conditions with annual rainfall ranging from 800 mm to 2,000 mm, average temperatures range from 14° to 34°C in January and 14° to 30°C in July, altitude range from 1,216 to1, 520 m, above sea level (Obaga *et al*., 2001). The soils varied across the region and comprised chromic *Ferralsols* (Busia and Kisumu West), *Vertisols* (Kisumu West) and humic *Nitsols* (Teso South) (Jaetzold and Schimdt, 2005).

Experimental design and treatments

A randomized complete block design (RCBD) with a split-split plot arrangement replicated six times was used. The main plots were fertility gradients (high and low fertility based on observation, farmers knowledge and initial soil analysis) and the sub- plots comprised maize variety (WS 303 maize variety coated with Imazapyr herbicide and DH 04 an early maturing hybrid maize) while nitrogen fertilizer levels (0 and 60 kgNha^{-1}) were the sub-sub plot.

Soil and plant sampling

Soil sampling was done at 0-20 cm depth, before planting and after harvesting. Zig zag method of soil sampling was used. Soil Samples were collected with a soil auger, air dried then processed for chemical and physical analysis. Bulk density (BD) was determined from the soil cores using the procedure given by Anderson and Ingram (1993). Soil pH `determined at 2.5: 1 soil–water ratios using a glass electrode (Rhoades 1982). Cation exchange capacity (CEC) was measured by standard wet chemical analysis (Anderson and Ingram 1993). Soil organic carbon (SOC) was determined by dichromate oxidation method (Walkley and Black 1934); total soil N by the Kjeldahl method (Anderson and Ingram 1989). Available phosphorus (P) in soil was determined by extracting samples with 0.5 M NaHCO3, and determining P calorimetrically using molybdate (Olsen *et al*., 1954). The samples were analyzed at Crop Nutrition Laboratory Limited. Both fresh and dry weights of the harvested maize in each sub-plot measuring 21.6m^2 were taken. Maize variables were grain yield ha^{-1} adjusted to 12.5% moisture content.

Statistical analysis

The plant and soil data were subjected to analysis of Variance (ANOVA) using Genstat Discovery (13th edition) statistical software for Windows. The least significant difference (LSD) test was used to compare treatment means at P= 0.05.

Results and discussion

Emergency data

The minimum germination registered was 41.3% while the maximum was at the rate of 90.0% in all the plots (Table 1). Most of the plots with maize variety DH 04 showed above 50% germination unlike those with WS 303 where almost half of the plots were less than 50% germination. This is attributable to the fact that WS 303 seeds need more moisture to boost their germination. With absence or less moisture in the ground the germination of the seeds was crippled.

In Kisumu District, the high fertility plots showed high germination with an average mean of above 60% in the three treatments. In Busia district the high fertility plots had almost the same germination with their respective treatments in the low fertility plots. Teso district recorded the highest germination of the entire three districts.

Table 1. Mean of the maize varieties germination in the three districts. n= 6

District	Fertility level	Treatment	Percentage germination
Kisumu West	Low	WS303 +N	56.3
	Low	WS303 –N	56.3
	Low	DH04 +N	76.3
	Low	DH04 –N	83.1
	High	WS303 +N	48.8
	High	WS303 –N	65.6
	High	DH04 +N	74.4
	High	DH04 –N	79.4
Busia	Low	WS303 +N	47.5
	Low	WS303 –N	50.6
	Low	DH04 +N	68.1
	Low	DH04 –N	76.3
	High	WS303 +N	41.3
	High	WS303 –N	48.8
	High	DH04 +N	66.3
	High	DH04 –N	76.3
Teso South	Low	WS303 +N	64.4
	Low	WS303 –N	65.0
	Low	DH04 +N	83.1
	Low	DH04 –N	77.5
	High	WS303 +N	48.1
	High	WS303 –N	55.0
	High	DH04 +N	87.5
	High	DH04 –N	90.0

Effect of maize variety and nitrogen fertilizer on* Striga *infestation

There were differences (P= 0.026) in striga population with maize varieties at 6th, 8th and 10th WAP, respectively. Treated WS 303 maize had the lowest *Striga* population of all counting levels (6 WAP, 8 WAP and 10 WAP) of which there was no *Striga* in all the plots of WS 303 across the district at the 6 WAP. This was based on the fact that suppression of *Striga* by the treated WS 303 maize. The study by Abayo *et al*., (1998) showed that due to active herbicide coating on the seeds, it resulted in late emergence of *Striga* weed in the treated WS 303 maize. Also, the late attachments of *Striga* weed could be attributed to a decrease in herbicide activity with time due to dilution by infiltrating rainfall and herbicide breakdown (Pusino *et al.,* 1997). Early *Striga* attachment affects growth of the host crop resulting in significant crop yield loss (De Groote *et al.,* 2007, Vanlauwe *et al.,* 2008).

Maize variety DH 04 was highly susceptible to *Striga* weed as compared to the WS 303 maize variety. The *Striga* weed grew at the ground near the shoot of the DH 04 maize variety unlike WS 303 where the *Striga* weed grew far from the plant shoot. In plots where nitrogen fertilizer at the rate of 60kgN/ha were applied, a lesser *Striga* population was observed compared to where nitrogen was not applied.

In addition, those plots perceived by the farmer to be low in fertility and proved through soil analysis showed that indeed *Striga* infested more where the soil fertility had been depleted. This implies that use of fertilizer can increase and improve the fertility level of the soil; it can as well exert pressures to weed species and thus change the occurrence frequencies and community components of the weed seed bank.

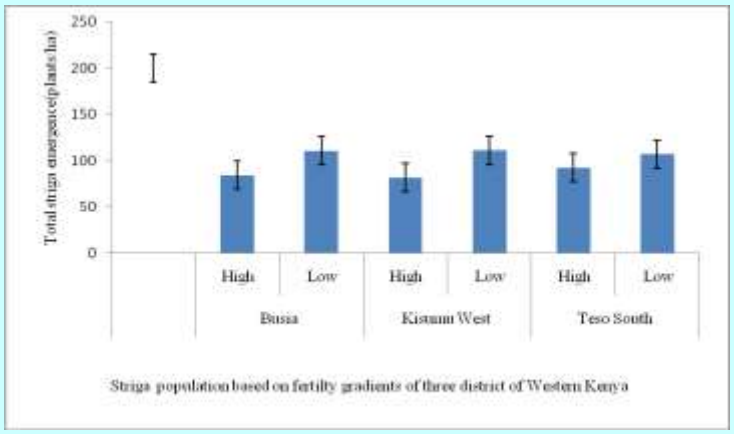


Fig. 1. Log transformed *Striga* population (plants/ha) across fertility gradients and study sites.

Where High =High fertility gradient, Low = Low fertility gradient and SED= 15.0

The results agree with the finding of Farina *et al*. (1985), who conducted long-term fertilizer trials using nitrate and ammonium N sources at 60, 120 and 180 kg/ha, and found that N significantly reduced the incidence of *S. asiatica* on maize in South Africa. Esilaba *et al*. (2000) also reported that *Striga* emergence was minimized with the application of 120kg N/ha. Mumera and Below (1993) and Esilaba *et al*. (2000) reported that *Striga* infestation declined with increasing N availability and the impact depended on the severity of the infestation. Aflakpui *et al*. (1997) reported that to reduce the population of *Striga* in maize, it is essential to apply a minimum of 90kg N/ha fertilizer and it must be applied early.

Effect of maize variety and fertilizer on maize yield

Both variety and fertilizer had a significant effect on the maize yield. Generally, maize variety WS 303 showed a better yield compared to DH 04 .It was however noted that both WS 303 and DH 04 with nitrogen application had a much higher yield, with means of 2.45 and 2.31 tonnes/ha respectively compared to those without nitrogen that recorded a mean of 1.95 and 1.65 tonnes/ ha espectively (Fig. 2).

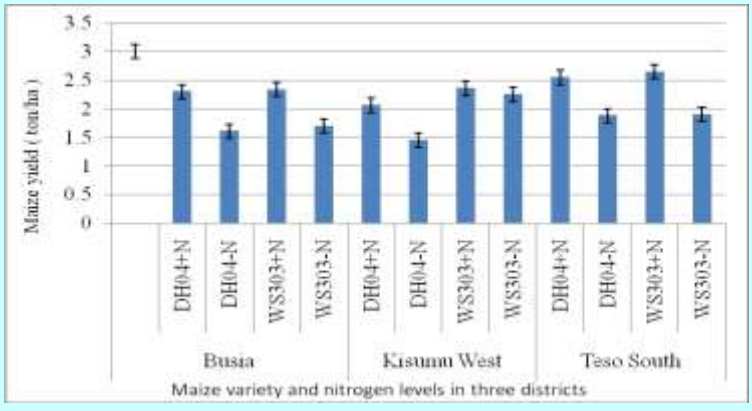


Fig. 2. Significan differences of means of maize yields across districts, error bar with SED= 0.245

The yield of WS 303 with nitrogen application at the rate of 60kgNha^{-1} was high because the herbicide used to coat the seeds acted on the striga seed bank and thus reduced the growth and infestation of striga. The addition of nitrogen supplemented the crop with enough nitrogen that the plant used and thus higher maize yield were achieved. On the other hand, the WS 303 maize variety without nitrogen application was able to reduce the infestation of *Striga* to a considerable level but lacked an external suppliment of nutrients (nitrogen) and thus the yield was lower. The yield of DH O4 with application of nitrogen showed some high yield though less than WS 303+N in Kisumu west and Busia, but almost the same as WS 303-N in Busia district.

The application of nitrogen had an effect on the yield of DH 04 maize variety but the maize seed had less capacity to withstand *Striga* pressure though not to the same maginitude as without fertilizer application. The plots with DH 04 without nitrogen showed a relatively lower yield than all other treatments due to the fact that the *Striga* weed had room to infest the plots and the crops also were not supplemented with nitrogen thus causing some effect to the crops although the crops were relieved from the stress through weeding.

High fertility plots recorded higher maize yields than the low fertility plots (Fig. 3). This is due to the fact that fertility reduces the presence of *Striga* weed and thus *Striga* seed bank was less in high fertile soils.

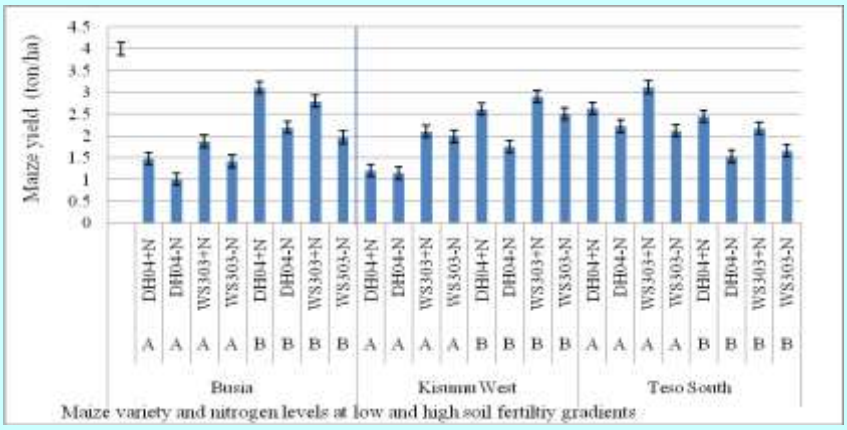


Fig. 3. Means of yields in respect to variety, districts, fertility and nitrogen level

Where A= Low fertility and B= High fertility and SED=0.694

In Busia district the yield of DH 04 in high yield plots was higher than WS 303.The area where DH 04 was planted had low infestation of striga at the later stage compared to WS 303 plots. Generally, the yield of DH 04 maize variety with nitrogen application, in high fertile soils, in Busia was high compared to other treatments. This shows that the variety can produce more yield than WS 303 in areas with less striga or no *Striga*. Low fertility plots with both DH 04 and WS 303 maize variety had lower yield in Busia and Kisumu West but in Teso,the trend was reversed, due to the fact that these plots made use of the applied nitrogen and thus achieved high yields.

These findings are in agreement with those of AATF (2008) who found that StrigAway maize planted with fertilizer yielded three times more than similar seed without fertilizer.

The amount of cereal a farmer grows depends on access to inorganic fertilizer (Douthwaite, 2006). While improving the crop's yield and quality, fertilization profoundly influences the diversity of the whole weed community and its individual components (Woomer, 2004). Economic analysis has shown that the use of *Striga* tolerant maize and legume trap crops grown in rotation with maize can provide better returns than continuous maize (Chikoye *et al*., 2004).

Conclusion and recommendation

The WS 303 maize variety performed well with addition of nitrogen at 60kgNha^{-1}. The DH 04 maize variety overall registered low yields in the range of 1.3 -2.5 tons/ha. Farmers in *Striga* prone areas should be encouraged to grow this maize variety. The seeds should be made available and widely distributed across the region and there is every need that farmers adhere to the recommended quantities of seeds per area for maximum nutrient utilization and optimum production from such areas.

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