Evaluation of Cereal-Legume Cropping on *Striga* Control and Maize Yield

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Abstract: *Striga hermonthica* (Del.) Benth is ranked as the number one constraint to maize productivity in Eastern Uganda. The use of trap crops is one of the control measures suggested for farmers with limited resources in *Striga* infested areas. In this study the main focus was on the effectiveness of intercropping in reducing *Striga* infestation and hence overall land productivity. The major objective was to identify suitable legumes in the control of *Striga*. In order to achieve this, on-farm experiments were conducted in Tororo and Busia districts of Eastern Uganda where the effect of the legumes on the *Striga* prevalence was evaluated. Maize (*Zea mays*) was intercropped with common beans (*Phaseolus vulgaris*), soybean (*Glycine max*) and silver leaf desmodium (*Desmodium uncinatum*) with sole maize (*Z. mays*) as the control. Soybean, beans and desmodium decreased the infestation of *Striga* by 26%, 40% and 72%, respectively. There was a significant ($p < 0.05$) difference in the number of emerged *Striga* and maize yield attained by desmodium and the rest of the legumes. Desmodium was found to be the most effective of the legumes in the control of *Striga*.

Key words: *Striga hermonthica* (Del.) Benth, *Zea mays*, legumes, intercropping, Uganda.

1. Introduction

Food production in sub-Saharan Africa has remained constant for years yet the population is increasing [1]. The depletion of soil fertility mainly through soil mining combined with pests, weeds and diseases has greatly contributed to the low per capita food production in these areas. This has consequently led to poverty and food insecurity [2, 3]. The parasitic weed *Striga*, is one of the major constraints to agriculture in the world [4]. *Striga* infested areas can lead to yield losses ranging from 40% to 100%. The weed affects two thirds of all cropping land in Africa with an estimation of 300 million people being affected [5].

There are about 40 species of *Striga*, with 11 being economically important in agriculture. *S. hermonthica*, *S. asiatica* and *S. gesnerioides* are the most widespread. *S. hermonthica* and *S. asiatica* affect cereals, while *S. gesnerioides* affects legumes which include cowpea [6]. In Uganda the purple

flowered *S. hermonthica* (Del.) Benth is ranked as the number one constraint to maize, a major staple in eastern region [7]. Maize is the most affected as it is not native to Africa. *Striga* attaches itself to the host plant depriving it of nutrients, water and food made by the plant, this consequently leads to yield losses. A number of methods have been devised to control *Striga*. These include the use of agricultural inputs like fertilizers, herbicides, mechanical weeding, use of resistant cultivars and the use of trap crops [8]. However, the use of inputs is expensive for most of the farmers, while the resistant cultivars for maize are not easily accessible on the Ugandan market. The use of trap crop has been recommended for poor resource farmers [9]. These trap crops are potentially very important as a *Striga* control measure because they can stimulate the germination of *Striga* which will later die due to the absence of a host and improve soil fertility [10]. Some of the trap crops include sunflower, cotton and legumes.

The objective of this study was to determine the most suitable legume for *Striga* control. This was

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done by evaluating the effect of the selected legume trap crops on *Striga* prevalence and maize grain yield in Eastern Uganda. Commonly grown legumes like beans (*Phaseolus vulgaris*), and soybean (*Glycine max*) were compared against silver leaf desmodium (*Desmodium uncinatum*).

2. Materials and Methods

2.1 Study Site

The experiment was carried out in Eastern Uganda in Tororo and Busia districts. Tororo district lies between 1,097 m above sea level and 1,219 m above sea level, 00°41'34" N and 34°10'52" E. Its average annual rainfall is approximately 1,450 mm while its average minimum and maximum temperatures are 16.2 °C and 28.7 °C, respectively. The soils are predominantly sandy. It has a population of about 58,456 people of whom 54% are females [11]. Busia district is located at the south east corner of Uganda, lying at 1,198 m above sea level, between 33°05' E 00°10' N and 34°01' E 00°35' N. Busia's average annual rainfall is 1,200 mm, with an average maximum and minimum temperatures at 32 °C and 15 °C, respectively. It has a population of 42,596 people with 52% of the population being female [12, 13].

2.2 Plot Layout and Data Collection

Soybean, common beans and desmodium were intercropped with maize on *Striga* infested plots. Soybean and common beans are food crops while desmodium is a fodder crop. Some of the farmers especially in Tororo were practicing mixed farming. Desmodium was intercropped with maize at a ratio of 1:1 (one row of maize with one row of the other intercrop).

The plot size was 25 m². Plots were 5 m by 5 m. Maize was planted at a spacing of 75 cm by 60 cm after application of 60 kg N, 15 kg P and 30 kg K per hectare and a spacing of 1.5 m between the plots. The legumes were drilled in between maize rows. After three weeks soybean was then thinned at an intra-row

spacing of 5 cm while beans were thinned to 15 cm. Varieties included Longe 5 for maize, silver leaf for desmodium, Mak Soy 1N for soybean and K132 for beans.

The treatments were laid out in a completely randomized design with five replicates. Treatments included the following intercrops maize with soybean, maize with cowpeas, maize with common beans, maize with desmodium and sole maize as the control.

Plots were weeded every three weeks to avoid the increase in the soil seed bank (especially when the crops were flowering). During the 8th and 12th week after planting maize 10 plants were sampled in each treatment to assess the *Striga* incidence. The number of *Striga* plants within a radius of 15 cm from each of the 10 sampled plants in each treatment was counted. This was done by counting the number of maize crops infested by *Striga*. The *Striga* seed bank was determined according to Eplee and Norris [14] at Kenya Agricultural Research Institute, Kibos, Kenya. Yield and yield components of maize (the Stover weight), common beans, soybean were collected. All the maize plants in each experimental plot were harvested and grain yields converted were assessed per hectare. The data collected were analyzed using Genstat statistical package version 13. Using a 5% probability level, the least significant difference (LSD) was used to determine differences among treatment means.

3. Results

3.1 *Striga* Incidence

The maize intercrops with soybeans, beans and desmodium significantly reduced the number of emerging *Striga* plants. There was a significant ($p < 0.05$) difference among the intercrops and the sole maize as shown in Fig. 1. Although the maize-bean and maize-soybean intercrops reduced the *Striga* infestation by 26% and 40%, respectively, there were no significant differences between them. The desmodium

maize crop combination had the least number of emerging *Striga* plant with a decrease in infestation by 72%.

3.2 The *Striga* Seed Bank

The crop combination of the maize with the legumes significantly ($p < 0.05$) reduced the number of *Striga* seeds in the soil as compared to the sole maize as seen in Fig. 2. Soybean, beans and desmodium intercrops with maize decreased the number of *Striga* seeds by 15%, 13% and 49%. The maize desmodium intercrop significantly had the greatest effect

compared to the soybean and bean intercrops with maize.

3.3 The Maize Yield

The yield of maize was significantly higher in the intercrops as compared to the mono cropped maize. Results shown in Fig. 3 indicate that soybean, beans and desmodium enhanced maize yields by 17%, 28% and 66%, respectively, after the two seasons. The desmodium intercrop glaringly enhanced the yield of maize as compared to the rest of the legumes.

Fig. 1 Effect of the crop combination on the emerged *Striga* plants.

Fig. 2 The effect of the crop combination on the *Striga* seed bank.

Fig. 3 The effect of crop combination on the yield of maize.

Table 1 Effect of previous crop on organic matter (OM), total soil nitrogen (N) and available phosphorus (P) in the soil.

Treatment	OM %	Total N %	Available P (ppm)
Maize	3.4	0.24	4.69
Maize + beans	4.7	0.26	34.97
Maize + desmodium	5.4	0.27	98.66
Maize + soybean	5.0	0.22	23.53

4. Discussion

4.1 The *Striga* Incidence and Seed Bank

The observed reduction in the number of emerged *Striga* in the intercrops as shown in Fig. 1 could be attributed to their trap crop ability. This is similar to findings by Khan [15]. These legumes are able to stimulate the germination of the *Striga* seeds but without the host crop, the germinated *Striga* dies a condition known as suicidal germination [16]. This suicidal germination eventually also contributes to the decrease of the seed bank. Maize being a host crop to *Striga* stimulates the germination and supports the growth of *Striga* and hence the high number of *Striga* plant emerging in the sole maize plot. The less numbers of emerging *Striga* plants in the intercrops as compared the sole maize can be ascribed to smothering effect of the legumes leading to low temperatures and higher humidity in the soil [17]. This soil condition suppresses *Striga* germination forcing

the weed into wet dormancy [18]. The efficiency of the intercropped maize in reducing emerging *Striga* plants could also be attributed to the increased the organic matter (OM) hence increased soil fertility in the soil as seen in Table 1. The reduction of *Striga* infestation by the legumes can be ascribed to the nitrogen that is biologically fixed by the nitrogen fixing bacteria in the legumes [19]. Increase of nitrogen in the soil reduces the production of strigolactone [20], a precursor for *Striga* germination leading to low *Striga* infestation. Additionally, the ammonium form of nitrogen produced during decomposition of plant residues [20], has been found to suppress *Striga*. Intercropping maize with the legumes also enhanced biodiversity in the soil [21]. This may include microorganisms some of which may be natural enemies of *Striga* [22] like some species of fungi hence leading to the decrease of *Striga* [23]. This could eventually contribute to the decrease of the *Striga* seeds in the soil.

4.2 The Maize Yield

With the suppression of the *Striga* growth there was increase in the yield of maize as shown in Fig. 3. The highest yield was in the maize desmodium intercropping. This is similar to findings of Khan *et al.* [17] who noted that desmodium was superior to other legumes in suppressing *Striga*. In addition to its high nitrogen content in the soil and smothering effect, the perennial nature of desmodium also played an important role in the control of *Striga* [17]. Desmodium can stay in field even after the maize is harvested. In this way it is able to prolong its effects (smothering and nitrogen fixation) in the soil.

5. Conclusions

Intercropping legumes with maize is advantageous in controlling *Striga*. This could be attributed to the smothering effect, increased OM and nitrogen in the soil. This consequently led to increase of maize grain yield. Among the legumes, desmodium was the most efficient legume in controlling *Striga* and had the highest yield of maize in the intercrop. It is therefore recommended that the small holder farmers incorporate this legume in order to improve maize yields in the *Striga* infested areas.

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References

- [1] Sanchez, P. A. 2002. "Soil Fertility and Hunger in Africa." *Science* 107 (1): 41-54.
- [2] Pender, J., Jagger, P., Nkonya, E., and Sserunkuma, D. 2002. "Development Pathways and Land Management in Uganda: Causes and Implications." Presented at 2002 AAEA Annual Meeting, Long Beach, California.
- [3] Bekunda, M. A., Nkonya, E., Mugendi, D., and Msaky, J. J. 2004. "Soil Fertility Status, Management and Research in East Africa." *East African Journal of Rural Development* 20 (1): 94-112.
- [4] Atera, E. A., Itoh, K., and Onyango, J. C. 2011. "Evaluation of Ecologies and Severity of *Striga* Weed on Rice in Sub-Saharan Africa." *Agriculture and Biology Journal of North America* 2: 752-60.
- [5] Yonli, D., Traoré H., Séré P., Sankara, P., and Hess, D. E. 2012. "Integrated Management of *Striga hermonthica* (Del.) Benth in Sorghum Using Fusarium Inoculum, Host Plant Resistance and Intercropping." *Journal of Applied Biosciences* 53: 3734-41.
- [6] Ejata, G. 2007. "The *Striga* Scourge in Africa: A Growing Pandemic." In *Integrating New Technologies for Striga Control: Towards Ending the Witch-Hunt*. London: World Scientific Publishing Co. Pte. Ltd., 3-4.
- [7] African Agricultural Technology Foundation (AATF). 2009. *Baseline Study of Smallholder Farmer in Striga-Infested Maize Growing Areas of Central Malawi*. Nairobi, Kenya: African Agricultural Technology Foundation, ISBN 9966-775-07-2, 1-3.
- [8] Kundra, A., Chemining'wa, G. N., and Onwonga, R. N. 2012. "Relationships between Agronomic Practices, Soil Chemical Characteristics and *Striga* Reproduction in Dryland Areas of Tanzania." *Journal of Agricultural Science and Technology A* 2: 1134-41.
- [9] Kureh, I., Kamara, A. Y., and Tarfa, B. D. 2006. "Influence of Cereal-Legume Rotation on *Striga* Control and Maize Grain Yield in Farmers' Fields in the Northern Guinea Savanna of Nigeria." *Journal of Agriculture and Rural Development in the Tropics and Subtropics* 107 (1): 41-54.
- [10] Odhiambo, J. A., Vanlauwe, B., Tabu, I. M., Kanampiu, F., and Khan, Z. 2011. "Effect of Intercropping Maize and Soybeans on *Striga hermonthica* Parasitism and Yield of Maize." *Archives of Phytopathology and Plant Protection* 44 (2): 158-67.
- [11] Miiro, R., Kabuye, F., Jama, B. A., Musenero, E., Zake, J. Y. K., Nkwiine, C., Kakinda, M. J., Onyango, O., and Delve, R. J. 2004. "Early Farmer Evaluation of Integrated Nutrient Management Technologies in Eastern Uganda." In *Managing Nutrient Cycles to Sustain Soil Fertility in Sub Saharan Africa*, edited by Bationo, A. Nairobi, Kenya: Academy Science Publishers, 549-50.
- [12] Kabuye, F. M., Waata, F., and Kigulu, D. 2003. "Voices of Poor Livestock Keepers in Lake Victoria Basin." In *Proceedings of Voices of Poor Livestock Keepers*, Bondo District, Kenya, ICRAF, VPLK Document 17.
- [13] Uganda Bureau of Statistics, 2002. *2002 Uganda Population and Housing Census; Tororo District Report*. Uganda Bureau of Statistics, Volume 24, 9-11.
- [14] Eplee, R. E., and Norris, R. S. 1990. "Soil Sampling Collection Equipment and Equipment to Separate Seeds from Soil." In *Witchweed Research and Control in the United States*, edited by Sand, P. F., Eplee, R. E., and Westerbrooks, R. G. Champaign, IL: Weed Science

- Society of America, 136-40.
- [15] Khan, Z. R., Hassanali, A., Overholt, W., Khamis, T. M., Hooper, A. M., Pickett, J. A., Wadhams, L. J., and Woodcock, C. M. 2002. "Control of Witchweed *Striga hermonthica* by Intercropping with *Desmodium* spp. and the Mechanism Defined as Allelopathic." *Journal of Chemical Ecology* 28: 1871-85.
- [16] Traore, H., Yonli, D., Diallo, D., and Sereme, P., 2011. "Suicidal Germination of *Striga hermonthica* (Del.) Benth. by Cotton, Cowpea and Groundnut Genotypes in Burkina Faso." *International Journal of Agricultural Research* 6: 49-57.
- [17] Khan, Z. R., Midega, C. A. O., Hassanali, A., Pickett, J. A., and Wadhams, L. J. 2007. "Assessment of Different Legumes for the Control of *Striga hermonthica* in Maize and Sorghum." *Crop Sci.* 47: 728-34.
- [18] Odhiambo, G. D., and Aringa, E. S. 2001. "Effect of Intercropping Maize with Beans on *Striga* Incidence and Grain Yield." In *Proceedings of the Seventh Eastern and Southern Regional Maize Conference*, 183-6.
- [19] Kureh, I., Chikoye, D., Emechebe, A. M., Hussaini, M. A., Kormawa, P., Schulz, S., Ellis-Jones, J., Franke, L., and Odunze, A. C. 2003. "Reduction of *Striga hermonthica* Parasitism on Maize Using Host Plant Resistance, Fertilization and Rotation with Legume Trap-Crops." *African Crop Science Conference Proceedings* 6: 167-71.
- [20] Kabambe, V., Katunga, L., Kapewa, T., and Ngwira, A. R. 2008. "Screening Legumes for Integrated Management of Witchweeds (*Alectra vogelii* and *Striga asiatica*) in Malawi." *World Journal of Agricultural Science* 2 (4): 367-71.
- [21] Khan, Z. R., and Pickett, J. A. 2004. "The 'Push-Pull' Strategy for Stemborer Management: A Case Study in Exploiting Biodiversity and Chemical Ecology." In *Ecological Engineering for Pest Management: Advances in Habitat Manipulation for Arthropods*, edited by Gurr, G. M., Wratten, S. D., and Altieri, M. A. Wallingford, Oxon: CABI Publishing, 155-64.
- [22] Esilaba, A. O. 2006. *Options for Striga Management in Kenya*. Kenya Agricultural Research Institute (KARI) Technical Note No. 19, March 2006.
- [23] Ijoyah, M. O. 2014. "Maize-Soybean Intercropping System: Effects on *Striga* Control, Grain Yields and Economic Productivity at Tarka, Benue State, Nigeria." *International Letters of Natural Sciences* 14: 69-75.