Research Application Summary

Development of integrated *Striga* management package to improve maize production in Western Kenya

Sunda, W.[1], Ochuodho, J.[1], Ngode, L.[1], Okalebo, J.R.[1], Othieno, C.O.[1], Nekesa, A.O.[1] & Kipkoech, A.K.[1]
[1]Moi University, Chepkoilel University College, P. O .Box 1125, Eldoret, Kenya
Corresponding author: wysunda@yahoo.com

Abstract

Maize is the most important cereal in sub-Saharan Africa where it is a staple food for 50% of the population. Improved maize production in Western Kenya has been hampered mainly by *Striga hermonthica*, which has infested 15% of total maize production area. Athough attempts have been made to eliminate the weed, sustainability of the introduced technologies and their adoptability by farmers still remains low. Single control strategies for management of *Striga* have not proven to effective because the *Striga* seed bank in the soil is so large, jeopardising the sustainability of any stand alone technologies. The general objective of the study is to develop strategies for effective *Striga* management in grain-legume systems of Western Kenya. In this study, four maize varieties were used to assess the effect of *Striga* on maize production. The study employed 2 *Striga* tolerant varieties (GAF4 and KSTP 94), a susceptible variety H505 and IR maize, which is resistant to imazapyr herbicide. The experiment was carried out with four treatments. There were: 1) maize seeds coated with a *Fusarium oxysporum* f.sp *strigae* (Foxy FK3), 2) Maize seeds coated with a soluble Phosphorus based fertiliser (Gro-plus), 3) Maize seeds coated with a combination of Phosphorus fertiliser (Gro-plus) and the fungusFoxy FK3, and 4) a control where seeds were not coated. This was done for each of the four maize varieties. The maize was planted in MBILI system with soybean as intercrop. *Striga* density is determined by counting *Striga* numbers per square metre 8, 10 and 12 weeks after maize emergence. The experiment will be used to assess the effectiveness of the different strategies with respect to cost and *Striga* control for promotion through farmer associations in Western Kenya.

Key words: Maize varieties, seed coatings, *Striga*, Western Kenya

Résumé

Le maïs est la céréale la plus importante en Afrique sub-saharienne où il constitue un aliment de base pour 50% de la population. L'amélioration de la production du maïs à l'ouest du Kenya a été entravée principalement par *Strigahermonthica*, qui a infesté 15% de la superficie de production totale du maïs. Bien que les tentatives aient été faites pour éliminer les mauvaises herbes, la durabilité des techniques introduites et leur adoptabilité par les agriculteurs restent encore faibles. Les stratégies simples de contrôle pour la gestion du *Striga* n'ont pas prouvé d'être efficaces parce que la banque de semences de *Striga* dans le sol est si grande, ce qui compromet la durabilité de toutes technologiesautonomes. L'objectif général de cette étude est de développer des stratégies pour la gestion efficace du *Striga* dans les systèmes de légumineuses en grains de l'Ouest du Kenya. Dans cette étude, quatre variétés de maïs ont été utilisées pour évaluer l'effet du *Striga* sur la production du maïs. L'étude a employé 2 variétés tolérantes de *Striga*(GAF4 et KSTP 94), une variété sensible H505 et le maïs IR, qui est résistant à l'herbicide imazapyr. L'expérience a été réalisée avec quatre traitements. Il y avait: 1) les semences de maïs recouvertesde *Fusariumoxy sporum f.*sp *Strigae* (Foxy FK3), 2) les semences de maïs recouvertes d'un engrais soluble à base de phosphore (Gro-plus), 3) Les semences de maïs recouvertes d'une combinaison d'engrais de phosphore (Gro-plus) et lechampignon *fungus*Foxy FK3, et 4) un contrôle là où les semences n'ont pas été recouvertes. Cela a été fait pour chacune de quatre variétés de maïs. Le maïs a été planté dans le système MBILI avec le soja comme culture intercalaire. La densité du *Striga*a été déterminée en comptant le nombre de *Striga* par mètre carré, 8, 10 et 12 semaines après l'émergence du maïs. L'expérience sera utilisée pour évaluer l'efficacité de différentes stratégies en matière des coûts et de contrôle du *Striga* pour la promotion par le biais des associations d'agriculteurs à l'ouest du Kenya.

Mots clés: variétés de maïs, couvertures de semences, *Striga*, Ouest du Kenya

Background

Striga is the major biotic factor responsible for reduction in maize production and causing to up to 50% yield losses (Watson *et al.*, 2007). Under severe infestation, *Striga* causes losses in maize yields of up to 100% and thus, force farmers to abandon maize production fields. Several technologies have been developed to manage *Striga* including the push and pull technology using *Desmodium uncinatum* and *Demodium* *intortum* (Khan *et al*., 2002), use of *Striga* tolerant maize varieties such as KSTP94 and GAF4 (Ngesa *et al.*, 2010). Other approaches include intercropping maize with legumes and use of imazapyr resistant maize (IR maize) varieties. Crop rotation with non-host crops (Parker and Riches, 1993), intercropping legumes with cereals (Khan *et al*., 2007) and use of *Fusarium oxysporium f.sp strigae* (Kroschel *et al*., 1996). All these methods have shown to reduce *Striga* infestation but none has succeeded in eliminating the weed.

Striga acts by wounding the outer root tissues of maize and absorbing photosynthates, moisture and minerals, which eventually leads to severe grain losses due to unavailability of food for normal growth and development of the maize. *Striga* spends most of its life cycle below the ground and only emerge after causing extensive damage to the maize (Ejeta and Gressel, 2007). The *Striga* tolerant maize varieties such as KSTP94 and GAF4, compete well in *Sriga* infested fields and are capable of achieving their yield potential even under infestation. Such varieties unfortunately do not contribute to reduction of *Striga* seed soil bank as they do not have a mechanism for killing the weed.

Coating these seeds with a fungus, *Fusarium oxysporum* f.sp *strigae* leads to killing of *Striga* (Ndambi *et al*., 2011) that attaches to the roots of maize. The practice thus reduces soil *Striga* seed bank. The fungus attacks *Striga* seed during the underground developmental stages (Kroschel *et al*., 1996) reducing the *Striga* seed bank in the soil and prevents production of new seeds. *Fusarium oxysporum* has been found to be cost-effective as it requires no changes in cropping systems used by farmers and in case of the resistant host plants no additional labour is required. The IR maize and *Striga* susceptible varieties like H505 can also be coated with the fungus to enhance their effectiveness in reducing the weed.

Soluble P fertiliser has been used for coating rice seed, a practice that has proved to improve root and shoot growth (Ross *et al*., 2000). The choice of fertiliser used is critical because nutrients play an important role in *Striga* germination. Plants grown under nutrient-deficient conditions, particularly phosphorus and nitrogen have shown to be more active in stimulating germination of *Striga* plant seeds because of the production of strigolactones (Ejeta and Gressel, 2007). Having the P on the seed surface rather than in the nearby soil may cause the germinating seed to reduce its strigolactone production. In acidic soils, the P seed coat is important as much of the phosphorus will not be fixed because the reduced surface area of the phosphorus in contact with the acidic soil, P will not be easily fixed. This mechanism enhances the effectiveness of the P seed coat in inhibiting *Striga* seed germination through suppression of strigolactones production.

Literature Summary

Several strategies have been implemented to manage the impacts of *Striga* in maize cropping systems of western Kenya. Hand pulling of *Striga* has been shown to be effective in reducing the infestation by the weed especially when it is done before seed set (Parker and Riches, 1993). However, the method is only effective in reducing the weed infestation during preceding seasons since most of the damage by *Striga* occurs before the weed emerges from the ground. Crop rotation with non-host crops disrupts production of *Striga* seed, thus reducing weed infestation. With dwindling farm sizes, crop rotation is becoming less feasible. In cases where rotations are attempted, they hardly surpass the three years required for rotation to be effective in controlling *Striga* (Parker and Riches, 1993). According to Khan *et al*. (2007), intercropping different legumes with maize and sorghum helps reduce *Striga* but does not eliminate the weed. This explains why, in spite of most farmers intercropping cereals with legumes as the dominant cropping system in western Kenya, *Striga* infestation is still high in most fields. A variant of intercropping system dubbed "push-pull""where *Desmodium* spp. is intercropped with cereals with an edge of fodder crops is effective in *Striga* management. In this approach, cereal crop population is significantly reduced, thus the practice may not be acceptable to many farmers (Esilaba, 2006). There is therefore need to combine more than one strategy to improve the effectiveness of existing control strategies.

Striga tolerant varieties such as KSTP94 and GAF4 are tolerant to *Striga* but they do not reduce *Striga* seed bank in the soil. IR maize has been used in controlling *Striga* but is toxic to all other crops that do not have resistance to imazapyr herbicide, therefore not very suitable in mixed cropping systems. There is also likelihood of the risk of the evolution of resistance by *Striga* to the herbicide, especially in long season maize as semi-dominant resistant *Striga* could easily evolve late in the season when part of the herbicide has dissipated. The sustainability of many technologies will only be maintained when integrated with other technologies (Ejeta and Gressel, 2007). Handling of IR maize by smallholder farmers is also difficult because of its toxic nature. In the present study, we are investigating the integration of intercrops with legumes and seed coatings using a fungus (Foxy FK3) on the available maize varieties under existing farmers practices.

Study Description

On-farm experiments were carried out in farms belonging to members of three farmer Associations of western Kenya, namely, Angurai Farmers Development Project (AFDEP) in Teso, Bungoma Small Scale Farmers Forum (BUSSFFO) in Bungoma and Mwangaza Farmers Group (MFAGRO) in Vihiga counties while on-station experiment were carried out at the Kenya Agricultural Research Institute (KARI)-Kibos. Teso and Vihiga counties falls in the Upper Midland one (UM1) while Bungoma falls in the Lower Midland (LM1-LM3) agro-ecological zones. The zones receive annual rainfall ranging between 1270 – 2000mm and are good for maize production (Hassan 1988). Predominant soil types in this region are planosol and alluvial. The soils are mainly low in Nitrogen and Phosphorus and are highly prone to *Striga* infestation.

The experiment is set up in MBILI system with two rows of soya beans planted between two rows of maize. *Striga* tolerant maize varieties KSTP94 and GAF4 are used together with IR maize and H505, coated with *Fusarium oxysporum* f.sp *Strigae* (Foxy FK3) at 50g per 2 kg seed, P fertiliser (Gro-plus) at 50g per 2kg seed, a combination of P fertiliser and Foxy FK3 at 50g each for 2 kg seed. The control comprised seed coated only with P fertiliser or Foxy FK3. The experiments were set out in a 4 x 4 factorial with 4 levels of maize varieties and 4 levels of seed coatings, laid out in RCBD. A blanket application of Nitrogen and Phosphorus was done in all the treatments. Data collected include date of planting , crop height, ear height, and stand count at harvest, total number of ears harvested, weight of ears, total field weight, dry weight of grains from usable ears. Data on *Striga* numbers per square metre for each plot in week 8, 10 and 12 after maize emergence were collected. After each count, the *Striga* plants were pulled out/weeded to prevent shedding of seeds. The data collected were subjected to ANOVA using GENSTAT statistical package.

Research Application

This on-going study aims to identify an integrated *Striga* management technique that is sustainable, cheap and economically viable in western Kenya. Because the experiments are done with farmers in farmer groups, farmers are expected to refine and internalise the technologies leading to a quick uptake of the technologies once the performance is ascertained. The technologies will also increase the range of technologies available to the farmers' associations to offer to their members to improve maize production.

Maize yields in fields severely infested with *Striga* in Western Kenya is 425kg/ha, compared to the expected yield of 1.8 tones/ha from non-infested fields (Manyong *et al*., 2007). More than 70% of households in Western Kenya experience food shortage for up to five months in a year, mainly due to *Striga* infestation (Manyong *et al*., 2007). There is potential for improving maize production capacity in this region if adaptation of *Striga* management technologies is enhanced. The integrated *Striga* control approaches are most attractive because they reduce *Striga* infestation on long term and increase crop yield during the cropping seasons when the strategies are applied (Schaub *et al*., 2006).

Acknowledgement

This study is funded by the Regional Universities Forum for Capacity Building in Agriculture for which we are most grateful.

References

Ejeta, G. and Gressel, J. 2007. Integrating new technologies for *Striga* control. World Scientific Publishing Company, London. Esilaba, A.O. 2006. Options for *Striga* Management. Kenya Agriculture Technical Note, No. 19 March 2006.

Khan, Z.R., Hassanali, A., Overholt, W.A., 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 mechanisms defined as allelopathic. *Journal of Chemical Ecology* 28: 1871-1885.

Khan, Z.R., Midega, C.A.O., Hassanali, A., Pickett, J.A. and Wadhams, L.J. 2007. Assessment of Vol. 47.

Kroschel, J., Hundt, A., Abbasher, A.A. and Sauerborn, J. 1996. Pathogenicity of fungi collected in northern Ghana to *Striga hermontica*. *Weed Research* 36: 515-520.

Manyong, V.N, Alene, A.D. Olanrewaju, A. Ayedun, B. Rweyendela, V. Wesonga, A.S. Omanya, G. Mignouna, H.D. and Bokanga, M. 2007. Baseline Study of *Striga* control using IR maize in Western Kenya.

Ndambi, B., Cardisch, G., Helzein, A., Heller, A. 2011. Colonization and control of *Striga* Hermonthica by Fusarium oxysporum f.sp *Striga*e, a mycoherbicidecomponent: An anatomical study. *Biological Control* 58:149-158.

Parker, C. and Riches, C.R. 1993. Parasitic weeds of the World: Biology and Control. CAB International, U.K. 332pp.

Ross, C., Bell, R.W. and White, P.F. 2000. Phosphorus seed coating and soaking for improving seedling growth of Oryza sativa (rice) cv IR66. *Seed Science and Technology* 28 (2):391-401.

Schaub, B., Marley, P. Elzein, A. and Kroschel, J. 2006. Field evaluation of an integrated *Striga hermonthica* management in sub-Saharan Africa: Synergy between *Striga*-mycoherbicides (biocontrol) and sorghum and maize resistant varieties. *Journal of Plant Diseases and Protection, Special Issue / Sonderheft* 20: 691-699.

Watson, A., Gresse, J. Sands, D. Hallett, S., Vurro, M. and Beed, F. 2007. Novel biotechnologies for biocontrol agent enhancement and management, Springer, Netherlands.