CASE STUDY **The push-pull system needs to better consider farmers' constraints and needs**

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The push-pull system -- exploiting semiochemicals to repel insect pests from the crop ('push') and to attract them into trap crops ('pull') which can be used as animal feed -- is considered a promising crop diversification strategy for smallholder farmers in Africa and it can contribute to suppressing maize stemborer Busseola fusca (Fuller) while also improving soil fertility and providing feed for livestock. The system proved especially effective when applied by multiple farmers in the same landscape. However, adoption of the push-pull system remains low in relation to the research and communication efforts for this practice. This case-study explores the constraints and reluctance to replace food crops by individual farmers and finds an overriding influence of landscape context over field level management practices.

Important Details

time (or time period)	2013-2016
country & region	Ethiopia, Hawassa area
context & agro-eco landscape type	Maize-based farming systems
key actors, stakeholders & beneficiaries	smallholder farmers, Ethiopian institute of agricultural research, CIMMYT, Wageningen University (WUR) and ICIPE
model and/or tools used	All analysis were conducted in R using 'ade4' package for the PCA, 'lmer' function for fitting linear mixed-effects models from the lme4-package and 'quantreg' for quantile regressions

Overview

Agricultural landscapes in the Hawassa area went through important transformations over the last 40 years due to the combined effects of national (agricultural policies, commodity prices, and infrastructures), regional, and local level drivers (population density and urbanisation, changes in farmers' livelihood), as well as unexpected climate events. The area of maize monocultures declined and was progressively replaced by perennial crops, such as enset (Ensete Ventricosum, food crop) and khat (Catha edulis, cash crop). In addition, population growth and the expansion of urbanised areas have reduced the availability of land and led to more fragmentation of the croplands.

The push-pull system, a stimulo-deterrent cropping strategy consisting of intercropping cereals with legumes and surrounding by fodder grasses, has been developed by the International Centre of Insect Physiology and Ecology (ICIPE) in Kenya and is considered a promising crop diversification strategy for smallholder farmers in Africa as it can contribute to maize stemborer Busseola fusca (Fuller) suppression while improving soil fertility and providing feed for livestock. However, adoption of the push-pull system remains low in relation to the research and communication efforts for this practice.

To understand the reason being this, we studied the performance of different push-pull systems in terms of stemborer suppression, predator abundance, and maize productivity in different landscape settings in Hawassa area. Within each landscape (simple, intermediate, and complex), experimental plots were established on four representative smallholder farms. At each farm we used a split-plot factorial design with main plots surrounded or not by Napier grass and subplots consisting of sole maize, maize-bean, or maize-Desmodium. Stemborer infestation levels, maize grain and stover yields and natural enemy abundance were assessed for two years.

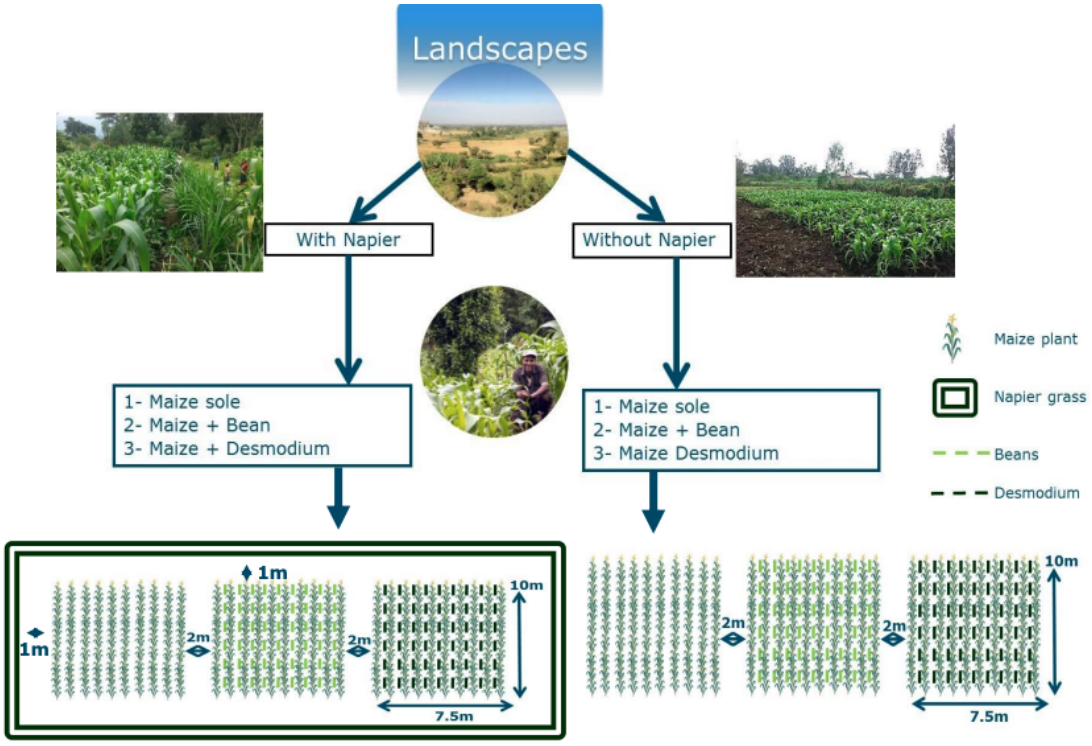

Figure 1. *Experimental design for testing local adaptation of push-pull systems in Hawassa area, Southern Ethiopia.*

We demonstrated that the push-pull system was effective in reducing stemborer infestation only in the intermediate complexity landscape, where subplots with sole maize had higher stemborer infestation levels compared to maize-bean or maize-Desmodium. In the simple landscape, which was dominated by maize, all treatments had high stemborer infestation levels irrespective of within-field crop diversity; the presence of Napier grass was associated with higher predator abundance, while egg predation rates were the highest in the maize-bean intercrop. In the complex landscape, infestation levels were low in all treatments. We found no significant difference between the two push crops tested - Desmodium or bean – suggesting that beans can be used as push crops in push-pull systems with the additional advantage of increasing egg predation rate and being a common maize-bean farmers' practice. However, there were no significant yield differences between the sub-systems nor between the three landscapes. Thus, the benefits of the push-pull system mostly come from the companion crops (bean, Desmodium, and Napier) rather than from stemborer suppression per se.

Key trade-offs or synergies to consider

Adoption of push-pull systems is often limited in land-constrained farming systems, most likely due to the farmers' reluctance to replace food crops, such as common beans, with fodder crops. In addition, the successful use of Napier grass can be hampered when nitrogen is a limiting factor, and Desmodium seeds are not easily available. In addition, uprooting Napier grass which has a very deep and strong root system can be very difficult in cases where a farmer wants to plant something other than maize. A push-pull system using locally available plants with stimulo-deterrent properties - and preferably a food crop - could work well forland-constrained farmers.

Another way to address this constraint is to grow the Napier grass as hedgerows, which helps to increase spacing and reduces the challenges with mechanical work of fields while also maintaining the potential of repulsing stemborers (due to the semiochemicals released by Napier grass). The potential positive impacts of this would be increased if many farmers within the same landscape also apply this practice. Likewise, further impact could be seen if the intentional management of hedgerows includes plants and trees that are themselves multifunctional (e.g. botanicals, feed for livestock, erosion control, carbon storage, beneficials for soil fauna). Above all, given the overriding influence of landscape context over field level management practices demonstrated by this study - and the multifunctional nature of smallholder farming systems - diversified agroecosystems can better address the multiple constraints faced by smallholder farmers.

Lessons Learned & Recommendations

Tackling maize infestation issues requires a landscape approach for sustainable pest management. Landscape composition could either impact the pest abundance directly by affecting its dispersal, mortality, or reproduction, or indirectly by affecting its natural enemies. With a landscape design approach, the ecological control of maize stemborers is addressed, as well as other farming constraints (i.e. soil fertility, fodder availability), the maintenance of moisture to avoid crop failure (by using cover crops, increasing rainfall infiltration) and diversifying farming systems to increase on-farm nutrition and income. Using this more holistic approach in a context-specific way, multiple challenges faced by smallholder farmers can be addressed simultaneously. The promotion of a rigid design of push-pull system is likely to be inadequate for locally specific constraints of farmers. Taking the general scientific principles of the push-pull system and remaining flexible for integrating local knowledge and needs of farmers is necessary. Instead of "focusing" on the adoption of a practice, scientists should remain open to adapting to local circumstances.

Key references

Kebede, Y., Bianchi, F., Baudron, FJJA., and Tittonell, P., 2019. Landscape composition overrides field level management effects on maize stemborer control in Ethiopia. Agriculture, Ecosystems & Environment, 279, pp. 65-73. https://www.sciencedirect.com/science/article/pii/S0167880919300933

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Video abstract: https://www.youtube.com/watch?v=LAPPJYso0F0&t=40s