The ‘Push-Pull’ farming system: Climate-smart sustainable agriculture for cereal-livestock production in Africa

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HUNGER, POVERTY AND CLIMATE CHANGE IN AFRICA

- Africa faces increasingly serious problems in its ability to feed its rapidly growing population, resulting in high hunger and poverty incidences.
- Africa’s productivity is the lowest in the world (around 1t/ha compared with 2.4t/ha in South Asia, 3.2t/ha in Latin America and 4.5t/ha in East Asia and Pacific)
- The major production constraints are insects pests, weeds, degraded soils and climate change
The ‘Push-Pull’ system is a novel approach in pest management, developed by understanding the complex mechanisms that govern the ecology of plants and insects, which uses a repellent intercrop and an attractive trap plant. Insect pests are repelled from the food crop and are simultaneously attracted to a trap crop.
Improving cereal-livestock production

- Stemborer control
- Striga control
- Soil fertility improvement
- Fodder & milk production
- Climate change mitigation
1. Cereal Stemborers

Total Maize Area in SSA 25,375,000 ha
Estimated loss due to stemborers 15%
Value of Maize in SSA US$ 10b
Maize lost due to stemborers US$ 1.5b
Napier grass is a perennial fodder grass of African origin and of economic importance for livestock farmers.

Many cultivars of Napier grass were found to be highly preferred for stemborer oviposition as compared to maize. However, Napier grass does not allow development of stemborer larvae to their adulthood and can be used as a trap plant.
Napier grass is preferred to maize plants by stemborer moths for egg-laying because it produces approximately 100-fold higher levels of attractive volatiles during early evening hours, than maize or sorghum, the period at which the moths seek host plants for oviposition.
Control of stemborers effectively reduces ear rot and mycotoxin infections

Push-pull not only significantly reduces stemborer damage but also mycotoxin and ear rot infection of grains. Efforts to elucidate mechanisms of suppression of mycotoxins by push-pull technology are on-going; and will provide an opportunity to manage ear rots and mycotoxins in maize.
2. Parasitic Striga Weed

Total Maize Area in SSA  25,375,000 ha
Total Maize Area with Striga  6,122,000 ha
% SSA Area infested with Striga  24%
Value of Maize in SSA  US$ 10 b
Value of Maize lost due to Striga  US$ 2.4 b
During attempts to control stemborer damage to maize by intercropping with repellent plants, fodder legume silverleaf, *Desmodium uncinatum*, was accidentally found to reduce incidence of infestation by the African witchweed, *Striga hermonthica*. This reduction was confirmed and shown to be significantly greater than that observed with other legumes.
How Desmodim Controls Striga

Retention time
Region of Striga post-germination inhibitors
Region of Striga germination stimulants

Analytical HPLC (C-4 reverse column) profile of the acetone extract of *D. uncinatum* roots

- **genistein** (inactive)
- **uncinonane A** (inactive)
- **uncinonane B** (moderate germination stimulant)
- **uncinonane C** (moderate radical inhibitor)
- **c-glycosylated flavone** (moderate radical inhibitor)
Striga Control through Desmodium

Before

After

Years after planting

Striga seeds/250 g of soil

- Push-pull
- Maize mono

Emerged striga/plot

Kuria  Migori  Bungoma  Kisumu  Siaya  Rongo  Kisii

Maize monocrop  Push-pull
3. Improving Soil Health

Desmodium adds nitrogen to the soil and has a trailing habit, helping conserve soil moisture. It reduces digging and adds to soil organic matter, enhancing the capacity of the soil to sequester carbon. It has a positive effect on plant and insect biodiversity, and has been shown to result in soil that is rich in beneficial microorganisms.
Both trap and repellent plants used in the ‘push-pull’ strategy are of economic importance to farmers as livestock fodder and help increase milk production.
5. Climate Change Mitigation

With research grants from the European Union, we have now adapted the push-pull technology to the increasingly dry and hot conditions associated with climate change in Africa to ensure its long term sustainability. The conventional push-pull system had not been extended to drier areas of sub-Saharan Africa, and thus the new research has provided a relevant and effective agricultural innovation for cereal-livestock smallholders living in those areas.
Drought-tolerant Desmodium spp. of African Origin

African Desmodium species have beneficial chemistry for striga suppression involving germination stimulants and root elongation inhibitors; one such inhibitor is isoschaftoside.

6-C-arabinosyl-8-C-glucosylapigenin (isoschaftoside)
Benefits of the Push-pull Technology

Push–pull reliably increases cereal yields in the long term, and is often used to gain high yields from small areas, while improving soil fertility building the case for sustainable agricultural intensification.
More than 110,500 small-scale farmers (>60% female) have adopted push-pull, out of which over 42,000 adopted its climate-adapted version, cumulatively benefiting approx 750,000 people. The technology is gender friendly and easy to be adopted by women and disabled farmers. Push-pull saves women and disabled from drudgery, and ensures better food security, nutrition and income.
Certain grasses can induce plant defence in maize through signalling. We are studying the production and biology of stress signals—nonatriene and \((E)-\beta\)-ocimene—produced by molasses grass and its induction in maize.
New Science: Early herbivore alert and plant signalling

We identified ‘smart’ maize plants with highly improved inducible defense mechanisms. These plants are capable of attracting parasitoids in response to stemborer oviposition, indicating their superior adaptation with a ‘smart’ defense system that alerts natural enemies as plant bodyguards early enough to prevent plant damage in the future.
Push-pull addresses Sustainable Development Goals

- Stemborers and striga control
- Increased fodder production
- N-fixation, reduced soil erosion, moisture conservation, carbon sequestration
- Increased forage seed production
- Conservation of biodiversity

- Increased crop yields
- Improved livestock health
- Improved soil health
- Increased household income

- Improved dairy production
- Improved FYM Production

- Zero Hunger
- Good Health and Well-Being
- No Poverty
- Climate Action
- Life on Land
- Gender Equality
- Quality Education
Push-Pull mentioned in UN General Assembly Reports

Human Rights Council Sixteenth session
Agenda item 3 Promotion and protection of all human rights, civil, political, economic, social and cultural rights, including the right to development

Report submitted by the Special Rapporteur on the right to food
20 December 2010

Seventieth session Item 20 of the provisional agenda
Sustainable development
Agricultural technology for development
Report of the Secretary-General

6 August 2015
Future

Our discoveries relating to early herbivory alert, plant signalling and drought resilience represent greater opportunities for further enhancing the effectiveness of the Push-Pull technology for mitigating climate change and extending its appeal to a range of farmer profiles in different agro-ecologies throughout Africa, and improving inbuilt long-term sustainability components.

The new research will help extend the technology to 1 million farmers in SSA by 2020.
Major donors and major outputs

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- Ph. D. Students: 20 (9 women)
- M.Sc. Students: 20 (8 women)
- Postdoctoral Fellows: 4 (1 woman)
- WFP Interns: 7 (5 women)
- Peer Reviewed Papers: 96
- Book Chapters: 10
- Books: 5

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