Transitioning Cereal Systems to Adapt to Climate Change

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

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

Zeyaur Khan and Charles Midega

# HUNGER, POVERTY AND CLIMATE CHANGE IN AFRICA

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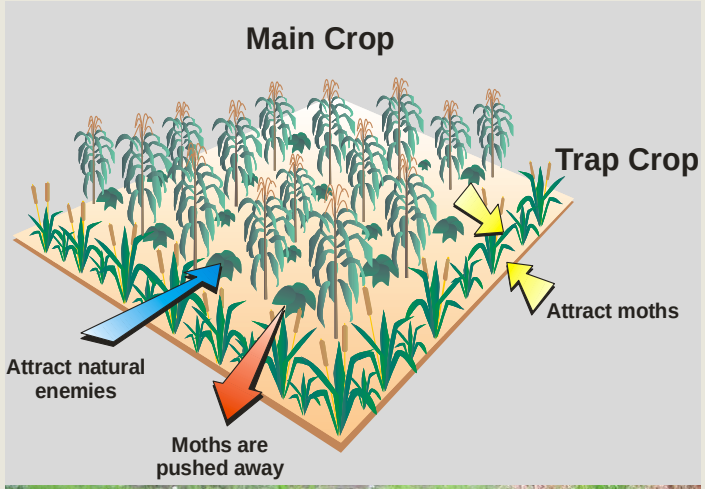
- Africa faces increasingly serious problems in its ability to feed its rapidly growing population, resulting in high hunger and poverty incidences.
- Africa's productivity is the lowest in the world (around 1t/ha compared with 2.4t/ha in South Asia, 3.2t/ha in Latin America and 4.5t/ha in East Asia and Pacific)
- The major production constraints are insects pests, weeds, degraded soils and climate change

# What is Push-Pull System?




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

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- Stemborer control
- Striga control
- Soil fertility improvement
- Fodder & milk production
- Climate change mitigation

# 1. Cereal Stemborers

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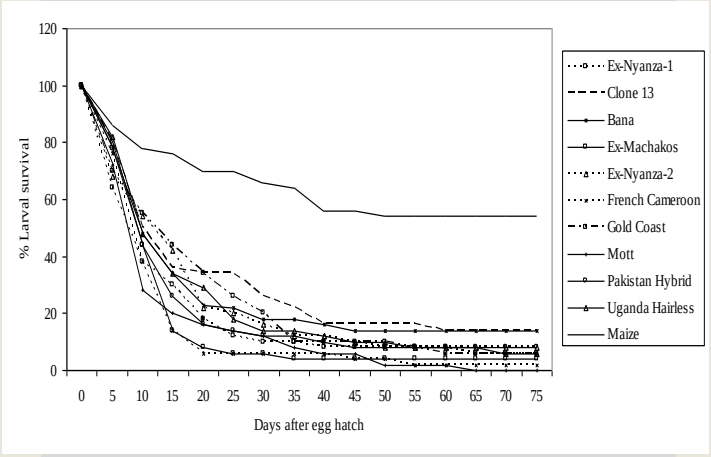
| | |
|---|---|
| Total Maize Area in SSA | 25,375,000 ha |
| Estimated loss due to stemborers | 15% |
| Value of Maize in SSA | US$ 10b |
| Maize lost due to stemborers | US$ 1.5b |

# How Pull Works




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

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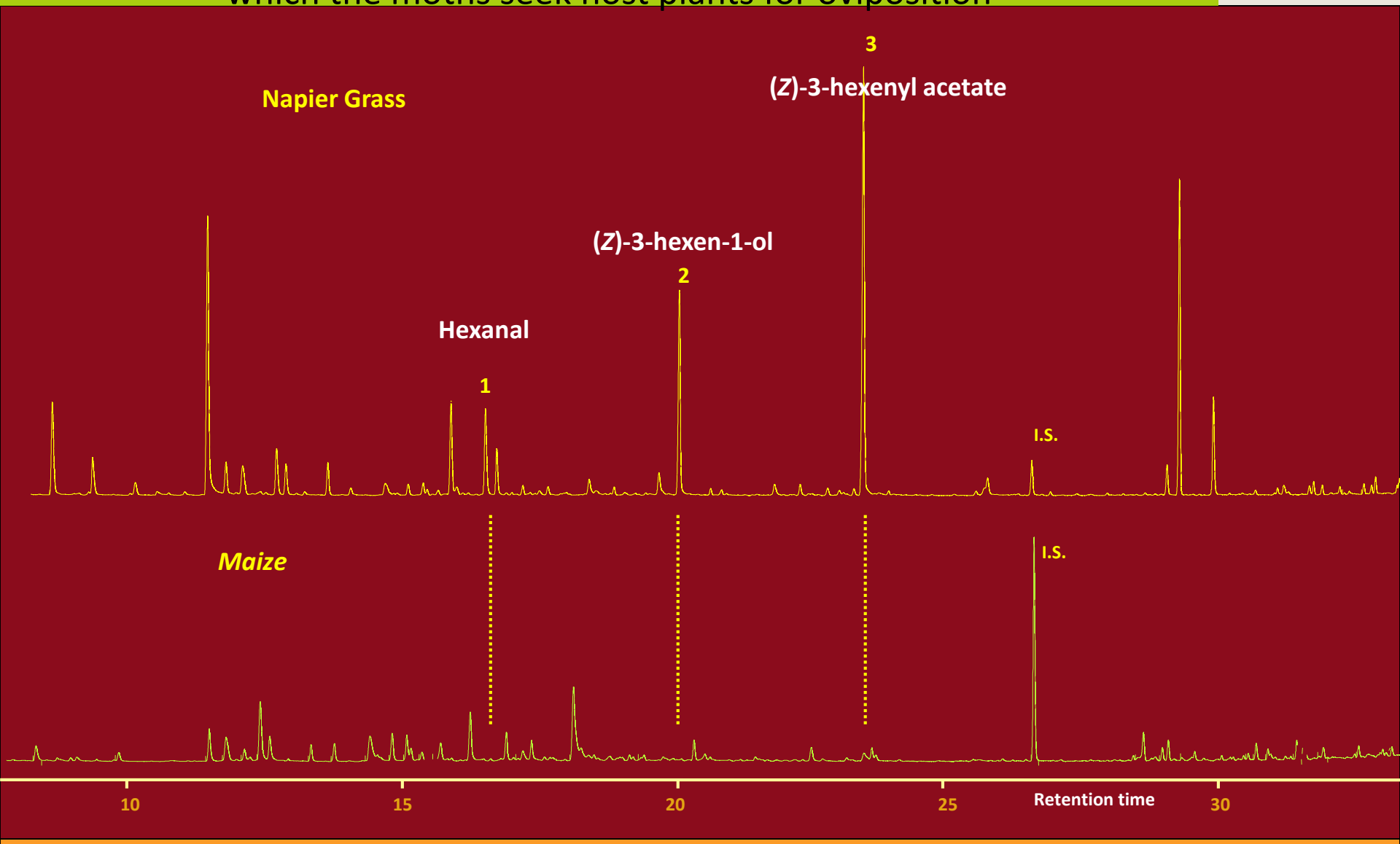
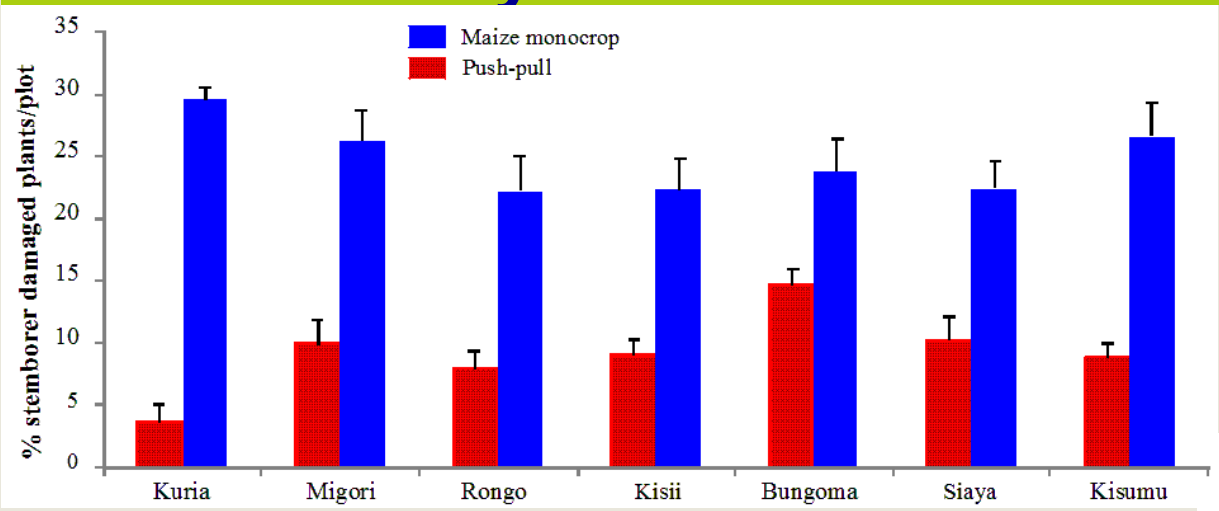
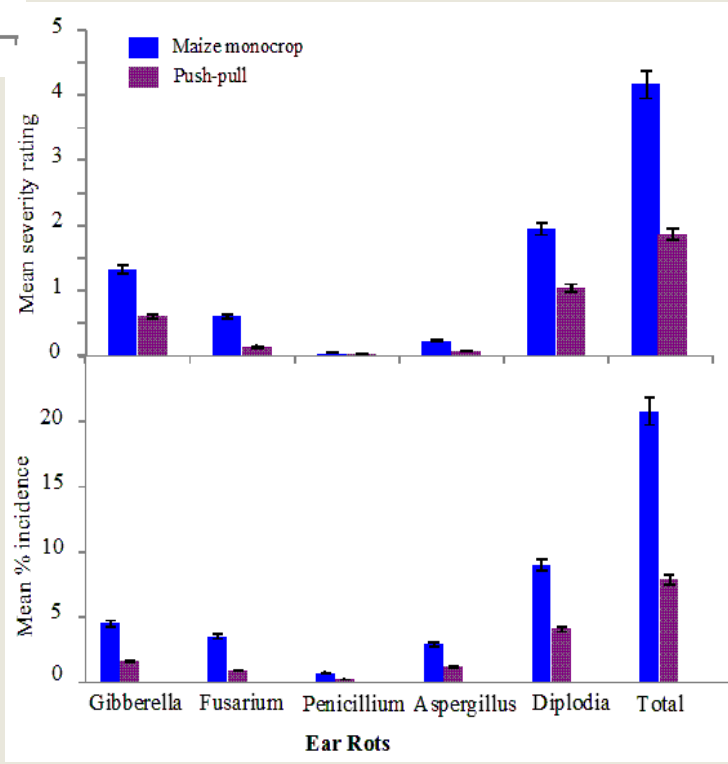



Chamberlain, Khan, Pickett, Toshova and Wadhams, 2006. *Journal of Chemical Ecology* 32:565-577

# 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



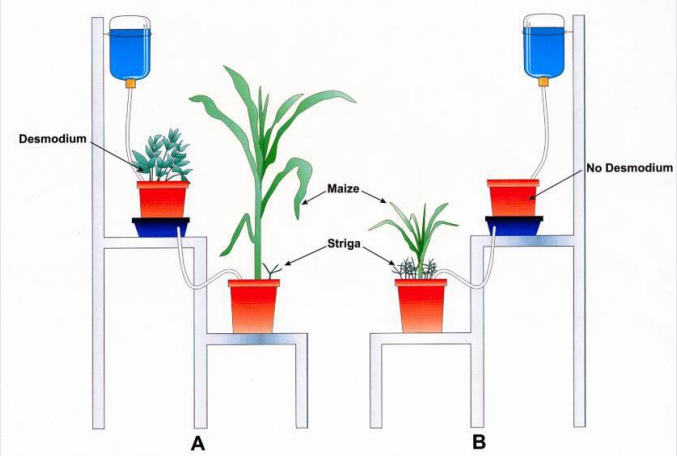
# 2. Parasitic Striga Weed

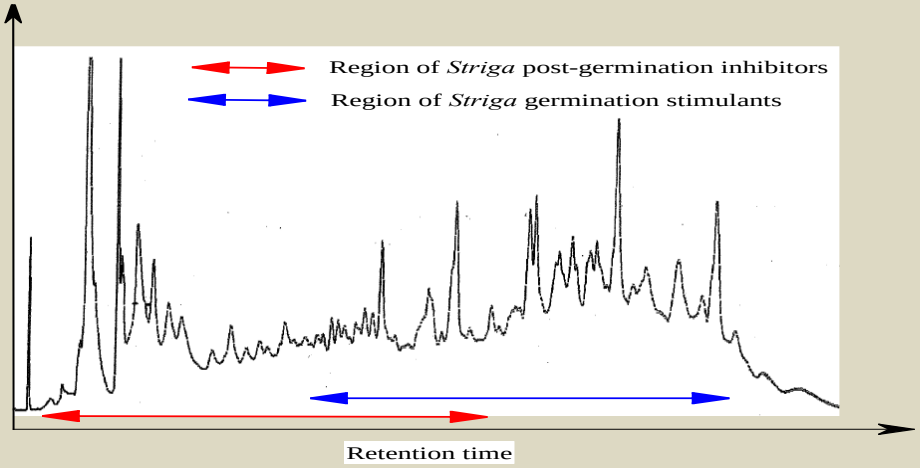
| | |
|---|---|
| Total Maize Area in SSA | 25,375,000 ha |
| Total Maize Area with Striga | 6,122,000 ha |
| % SSA Area infested with Striga | 24% |
| Value of Maize in SSA | US$ 10 b |
| Value of Maize lost due to Striga | US$ 2.4 b |

# Discovery of Striga Inhibition Properties of *Desmodium* spp.

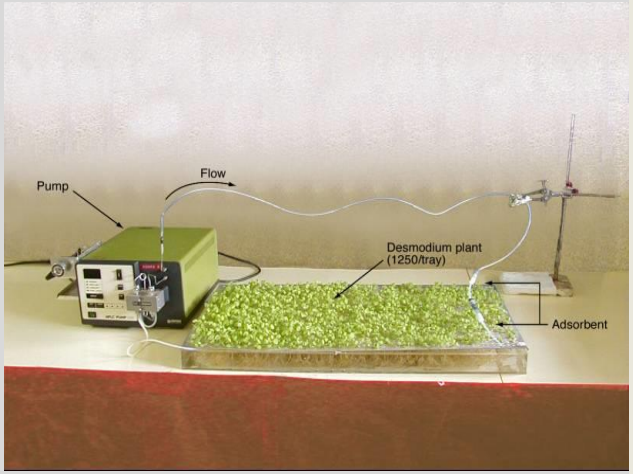

During attempts to control stemborer damage to maize by intercropping with repellent plants, fodder legume silverleaf, *Desmodium uncinatum,* was accidentally found to reduce incidence of infestation by the African witchweed, *Striga hermonthica*. This reduction was confirmed and shown to be significantly greater than that observed with other legumes.

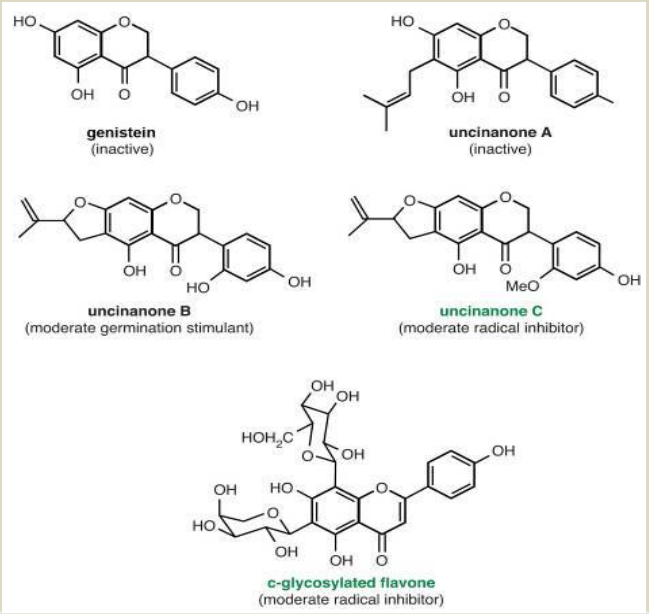
# How Desmodim Controls Striga



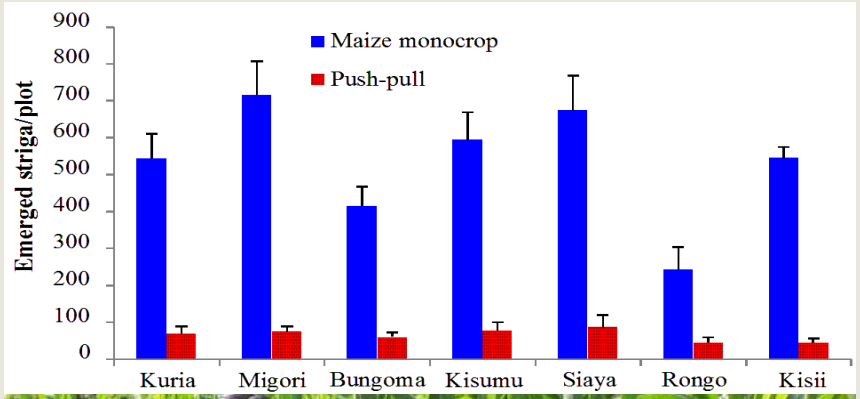




**Analytical HPLC (C-4 reverse column) profile of the acetone extract of *D. uncinatum* roots**

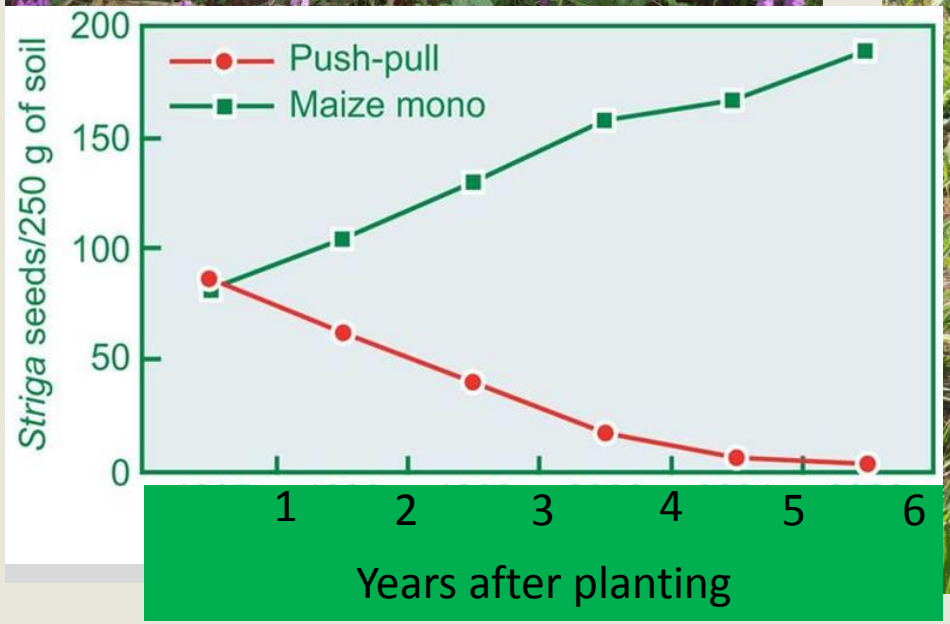


# Striga Control through Desmodium





# 3. Improving Soil Health

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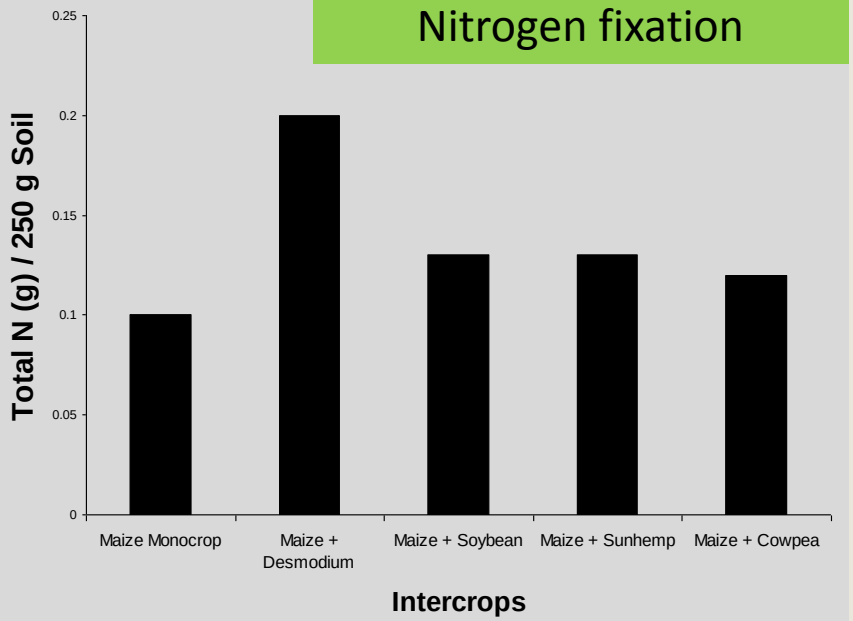
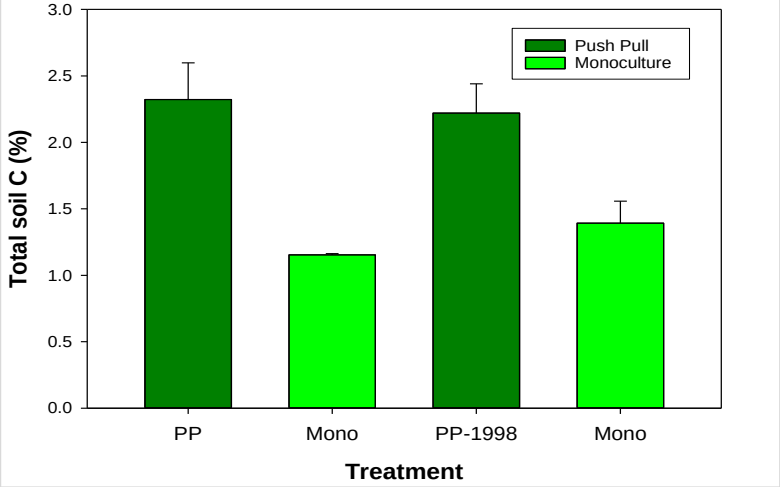
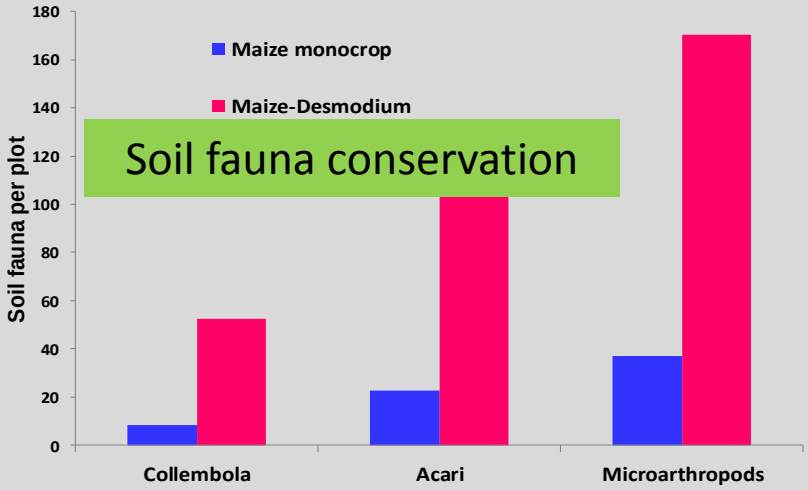
## Nitrogen fixation




## Carbon sequestration

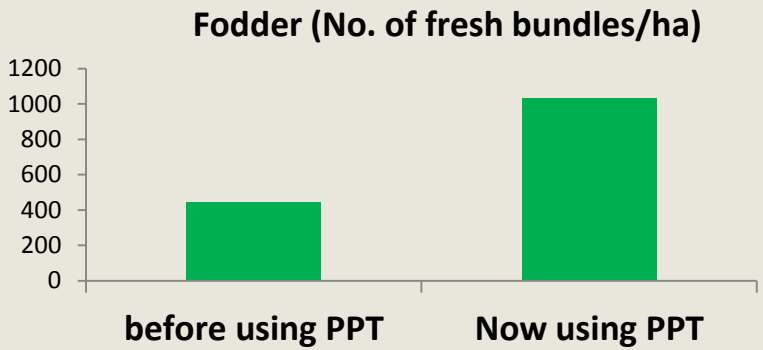


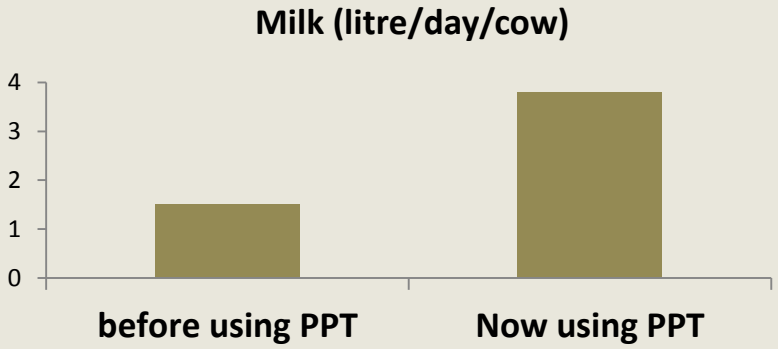

## Soil fauna conservation




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 micro-organisms.

# 4. Fodder Availability and Milk Production



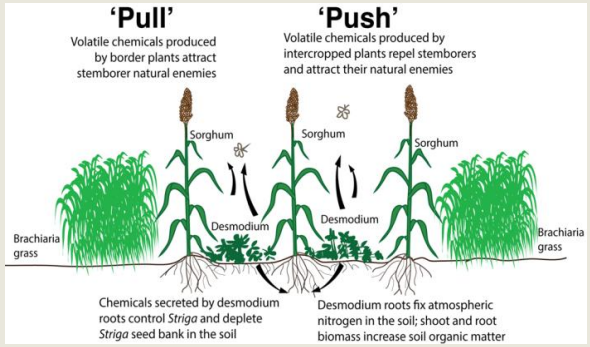




Both trap and repellent plants used in the 'push-pull' strategy are of economic importance to farmers as livestock fodder and help increase milk production.

## Reduced GHC Emission

# 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 Origi

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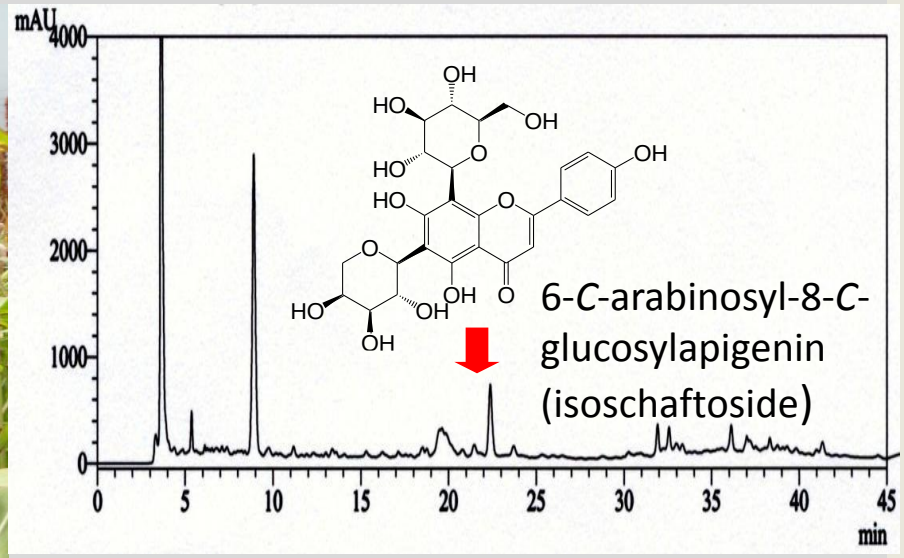
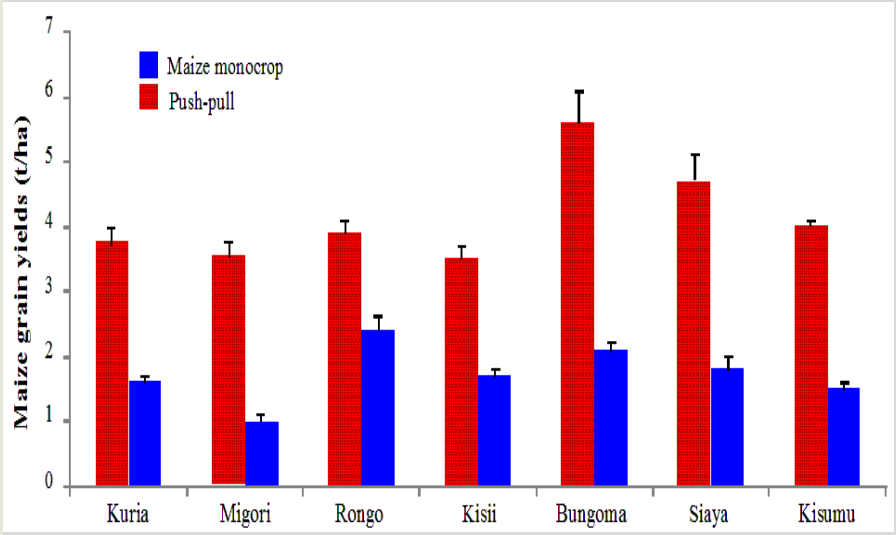
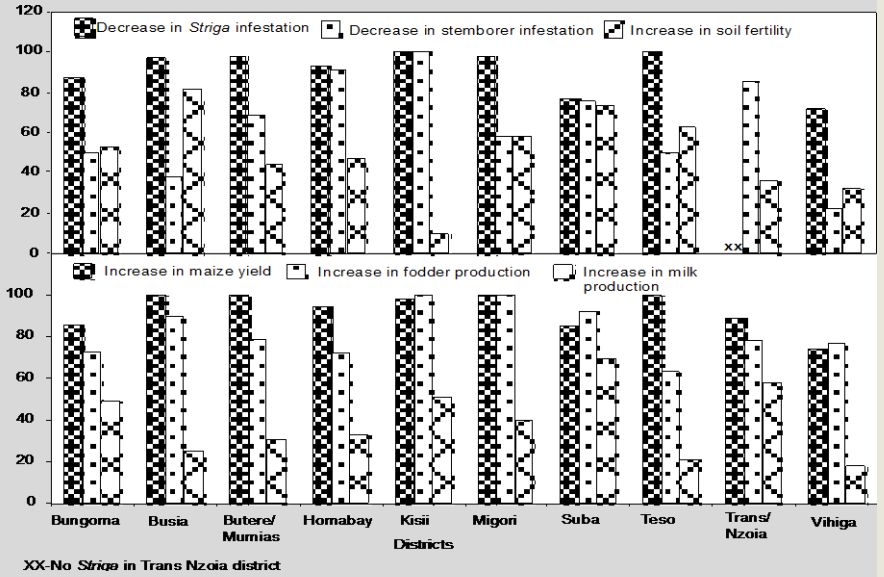


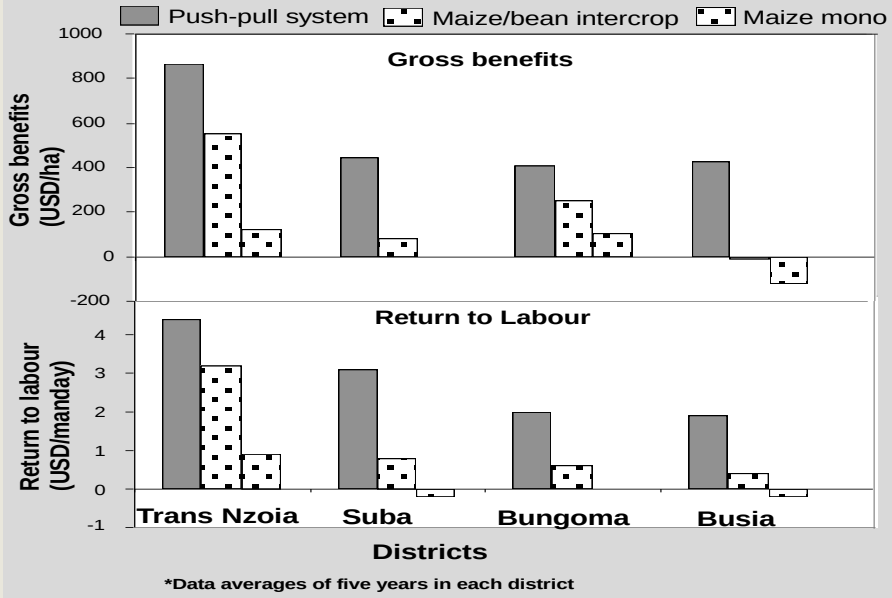

African *Desmodium* species have beneficial chemistry for striga suppression involving germination stimulants and root elongation inhibitors; one such inhibitor is isoschaftoside

# Benefits of the Push-pull Technology



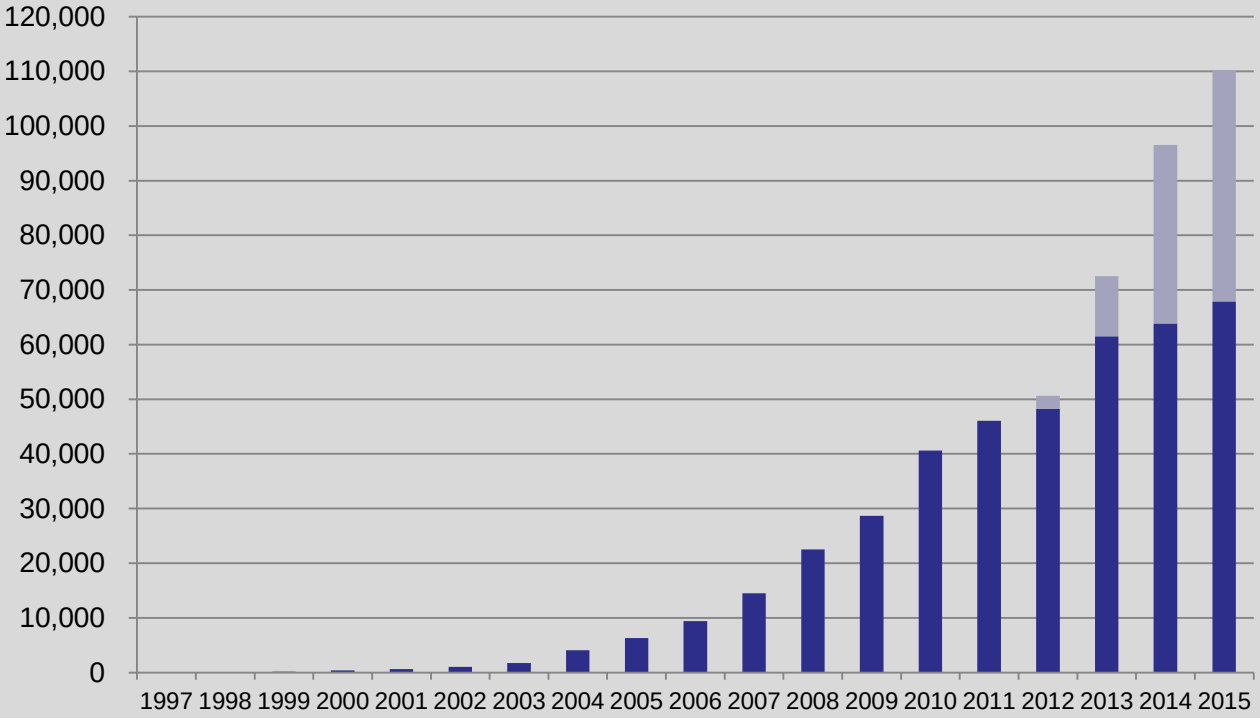

XX-No *Striga* in Trans Nzoia district

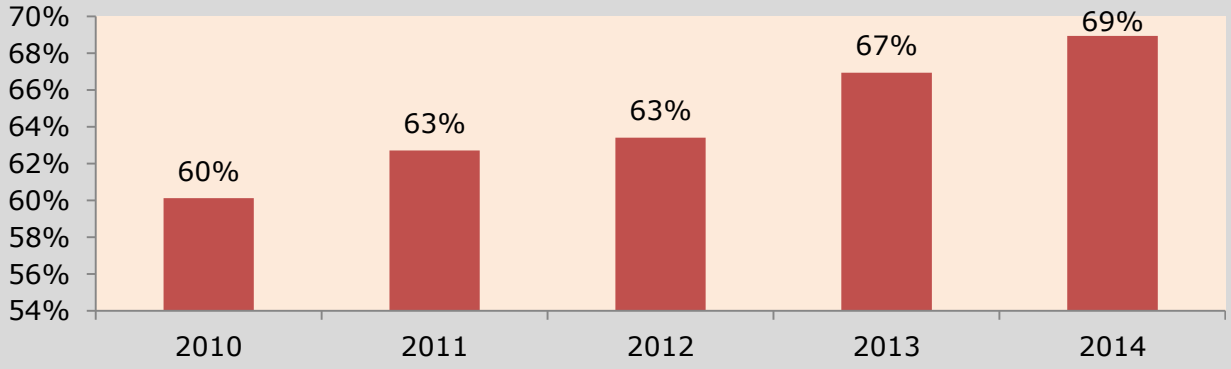


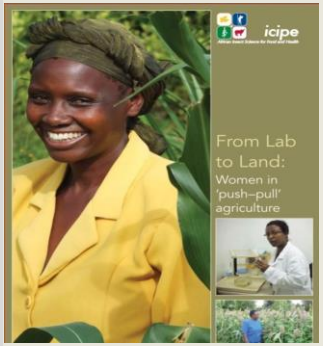

*Data averages of five years in each district

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

# Gender Friendliness and Push-pull Adoption



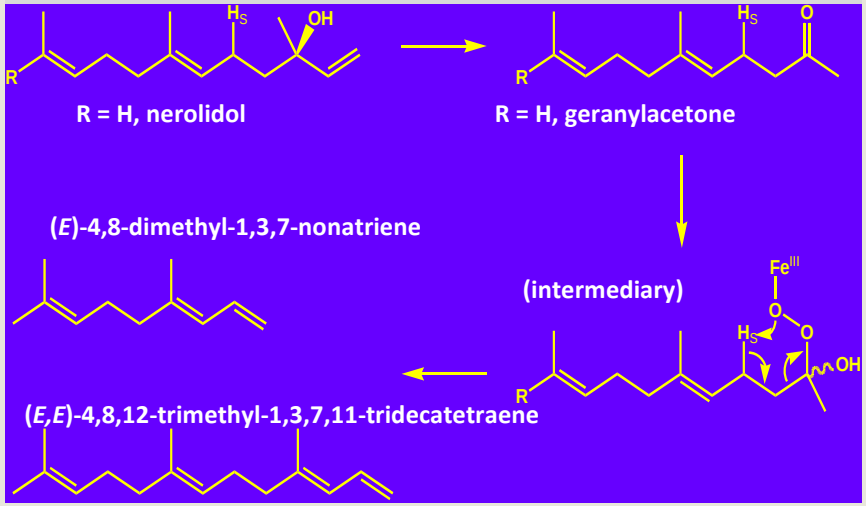




From Lab to Land: Women in push-pull agriculture

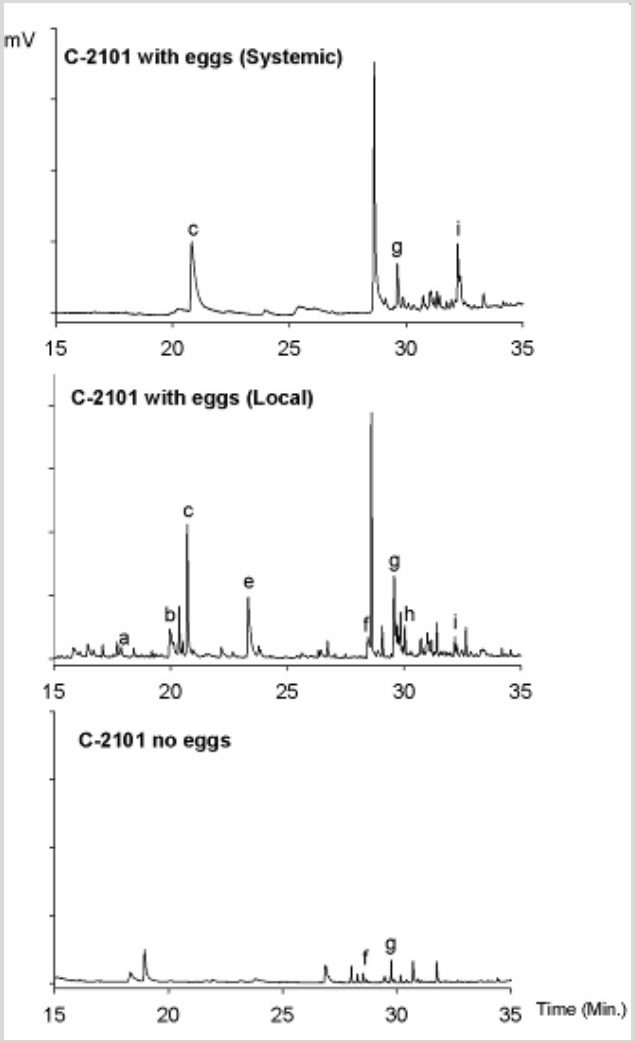
More than 110,500 small-scale farmers (>60% female) have adopted push-pull, out of which over 42,000 adopted its climate-adapted version, cumulatively benefitting approx 750,000 people. The technology is gender friendly and easy to be adopted by women and disabled farmers. Push-pull saves women and disabled from drudgery, and ensures better food security, nutrition and income.

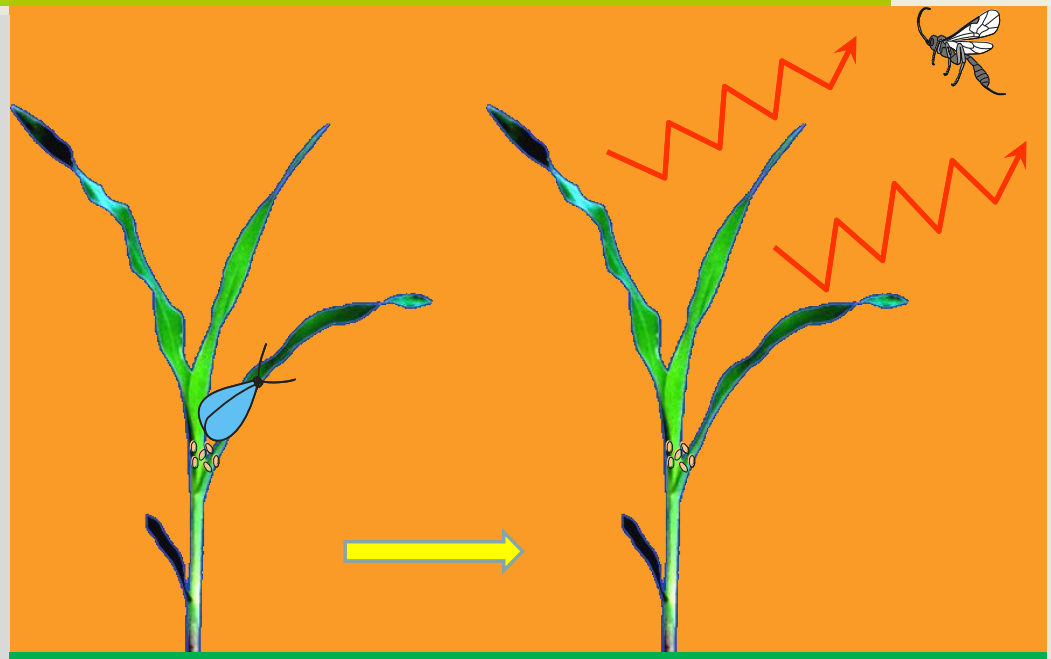
# New Science: Plant stress signaling




Certain grasses can induce plant defence in maize through signalling. We are studying the production and biology of stress signals—nonatriene and (*E*)-β-ocimene --produced by molasses grass and its induction in maize.

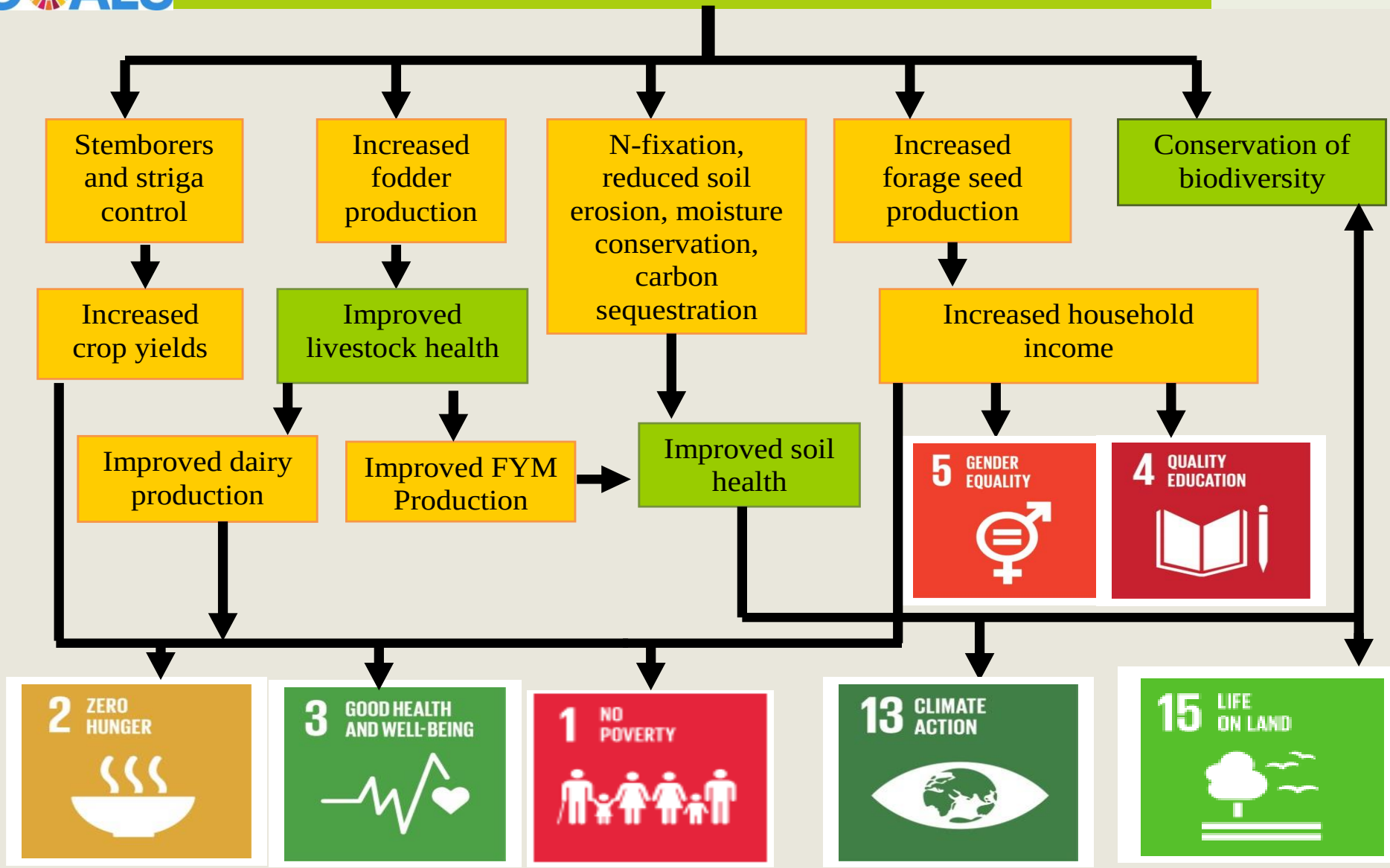
# New Science: Early herbivore alert and plant signalling



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



# Push-Pull mentioned in UN General Assembly Reports

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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

UNITED NATIONS

GENERAL ASSEMBLY

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

6 August 2015

# Future

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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

1994-2006: Gatsby Foundation
1999-2002: Rockefeller Foundation
2001-2003: DFID
2001-2003: SP-IPM
2002-2005: Global Environmental Facility
2003-2005: Farm Africa
2006-2009: Kilimo Trust
2006-Present: Biovision Foundation
2010-2015: Bill and Melinda Gates Foundation ( with IITA)
2010-Present: European Union
2011-Present: McKnight Foundation
2012-Present: SCPRID
2013-Present: Humidtropics

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

www.push-pull.net

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# Thank you!

University of Idaho

Washington State University

USDA NIFA

United States Department of Agriculture
National Institute of Food and Agriculture

Oregon State University OSU

Pacific Northwest Farmers Cooperative

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