Push-Pull Technology:

Advancing Success Towards SDG2 through Exploiting Chemical Ecology and Plant Signaling

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www.icipe.org

icipe

INTERNATIONAL CENTRE OF INSECT PHYSIOLOGY AND ECOLOGY (*icipe*), Nairobi, Kenya

icipe's mission and vision

Our mission is to help alleviate poverty, ensure food security and improve the overall health status of peoples of the tropics, by developing and extending management tools and strategies for harmful and useful arthropods, while preserving the natural resource base through research and capacity building.

Our vision is to pioneer global science to improve the well being and resilience of people and the environment to the challenges of a changing world, through innovative and applied research, alongside deep exploratory study, impact assessment, evaluation and sustainable capacity building.

Professor Thomas Odhiambo, Founder Director, *icipe*

icipe
African Insect Science for Food and Health

'We should fully elucidate the **science** of mixed cropping and **go beyond** mere description and explanation of the regulatory factors, to a system of **more formalized** and **constructed crop mixtures**, with **predictive value** and potential to **upgrade** subsistence farming to a more commercial enterprise'

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Problems faced by 30 million cereal-livestock farmers in sub-Saharan Africa

- Low crop production
- Stemborer and Fall armyworm damage
- Parasitic striga weed damage
- Poor soil fertility
- High aflatoxin in grains
- Low fodder & poor milk production
- Climate change

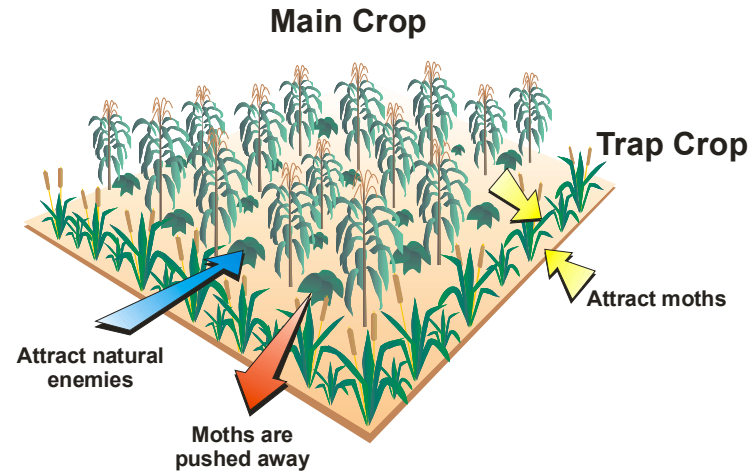
MAJOR THREATS TO MAIZE PRODUCTION IN AFRICA

CEREAL STEMBORERS
1.5 b USD

PARASITIC STRIGA WEEDS
2.5 b USD

FALL ARMYWORM
6.25b USD

Push-Pull Farming System



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The 'Push-Pull' is a novel approach in farming system, developed by understanding the complex mechanisms that govern the chemical ecology of plant-insect interactions and plant signalling. The system uses carefully-selected repellent intercrops and attractive trap plants. Insect pests are repelled from the food crop and are attracted to trap crop. The repellent intercrop attracts natural enemies of pests and also effectively controls parasitic striga weed. The intercrop improves soil fertility, both companion plants provide livestock fodder.

Climate Smart Push-Pull

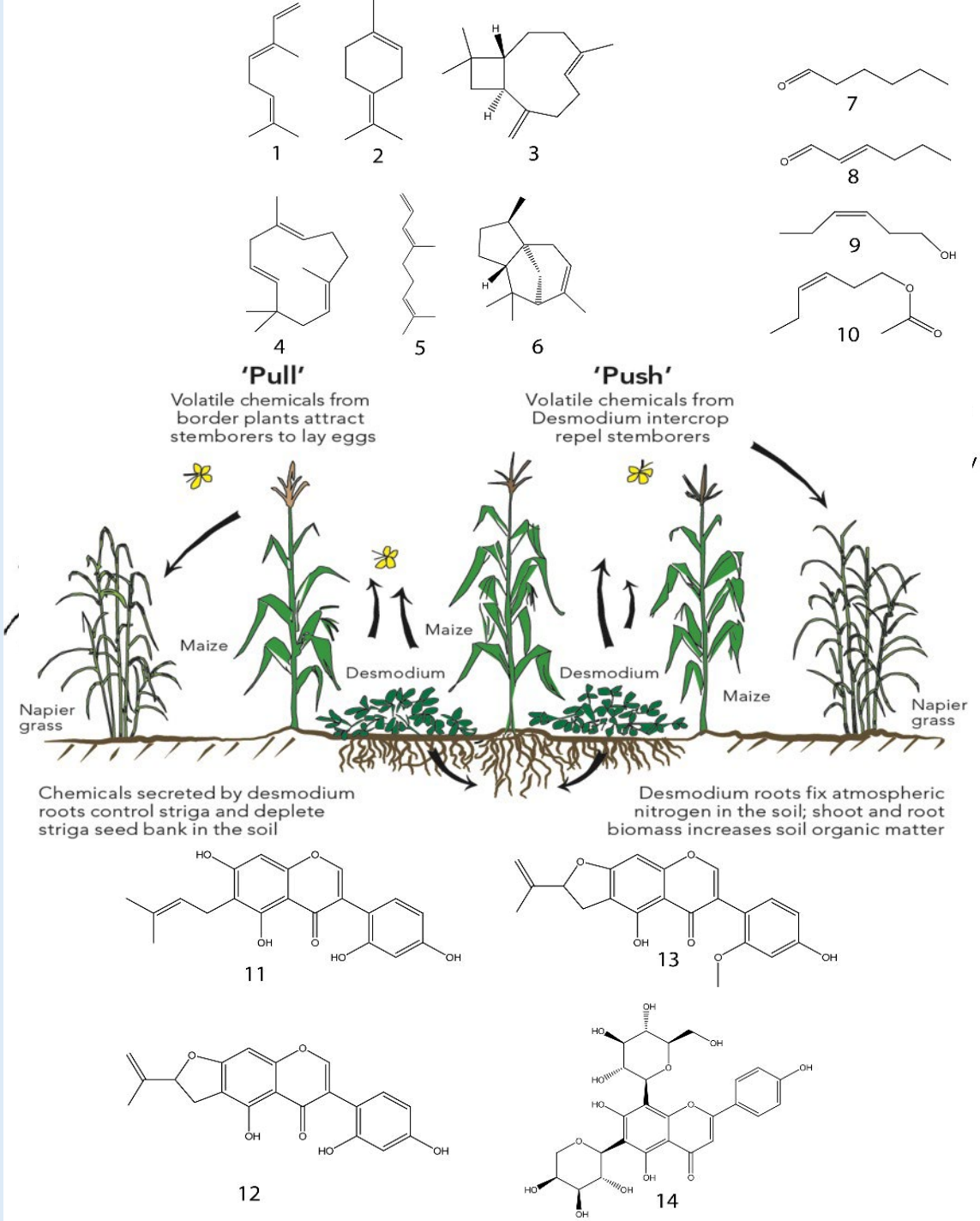
Push-Pull@30: *icipe's* Flagship Program

'Push-Pull' is a climate-resilient biological intensification technology aimed at ending hunger and poverty in Africa and beyond by doubling productivity and incomes through integrated management of parasitic striga weeds, insect pests, aflatoxin contamination and soil fertility while providing quality fodder in crop-livestock farming systems. The technology is contributing to regenerative, circular, and inclusive agri-food systems as it deploys natural processes and locally adapted bio-resources well suited to intensification needs of resource-poor smallholder farmers.

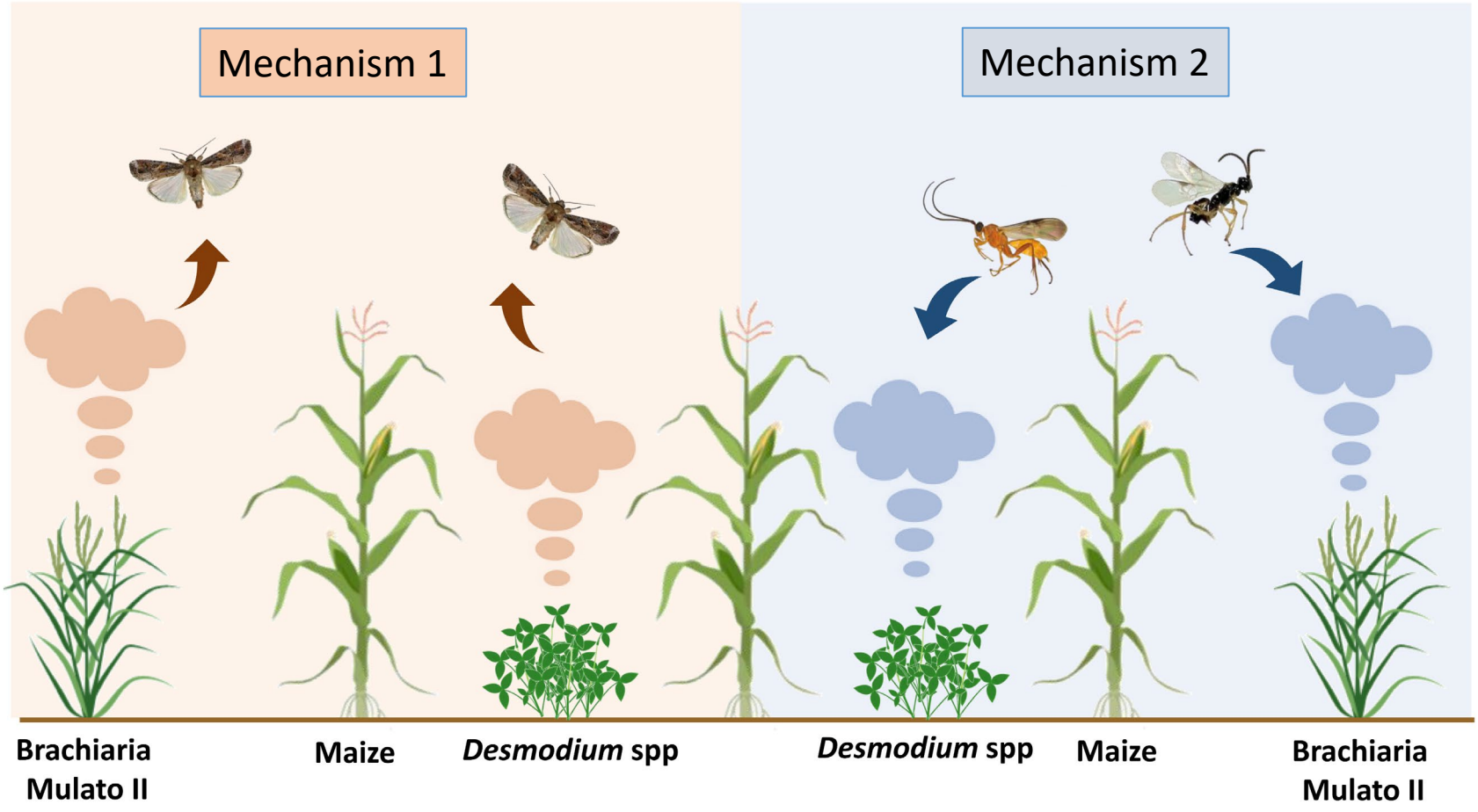
1= (*E*)-ß-ocimene;
2= α-terpinolene;
3= β-caryophyllene;
4= humulene;
5= (*E*)-4,8-dimethyl-1,3,7-nonatriene;
6= α-cedrene;

7= hexanal;
8= (E)-2-hexenal;
9= (Z)-3-hexen-1-ol;
10= (Z)-3-hexen-1-yl acetate ;

11= 5,7,2′,4′-tetrahydroxy-6-(3-methylbut-2-enyl)isoflavanone (uncinanone A);
12= 4″,5″-dihydro-5,2′,4′-trihydroxy-5″-isopropenylfurano-(2″,3″;7,6)-isoflavanone (uncinanone B);
13= 4″,5″-dihydro-2′-methoxy-5,4′-dihydroxy-5″-isopropenylfurano-(2″,3″;7,6)-isoflavanone (uncinanone C);
14= di-*C*-glycosylflavone 6-*C*-α-L-arabinopyranosyl-8-*C*-β-Dglucopyranosylapigenin



HOW PUSH-PULL FARMING SYSTEM CONTROLS FAW?



Sobhy et al. 2022. Frontiers in Ecology and Evolution· DOI: 10.3389/fevo.2022.883020

A PUSH-PULL FARMER BEFORE AND AFTER ADOPTING THE TECHNOLOGY

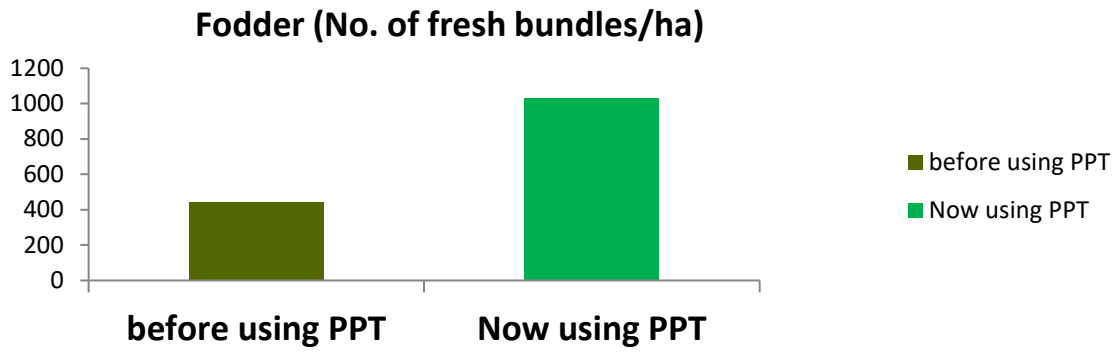
BEFORE

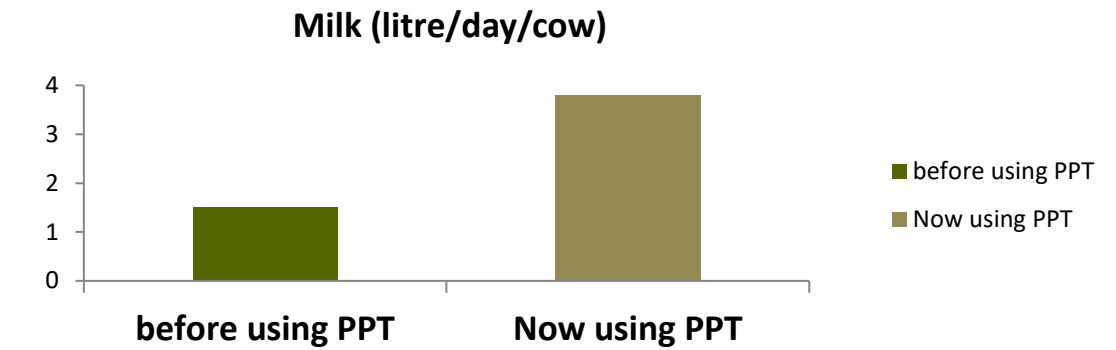
AFTER

EU Ambassador Lodewijk Briet visiting group of disabled Push-Pull farmers in western Kenya, July 2013

Push-pull Improves Fodder and Milk Production

>50,000 farmers have directly benefited from dairy animals





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.

Deployment of dissemination Pathways

Optimizing dissemination pathways for different socio-cultural contexts and farmers' literacy levels

Print Media

Farmer field days (FD)

Farmer Teachers (FT)

Mass media

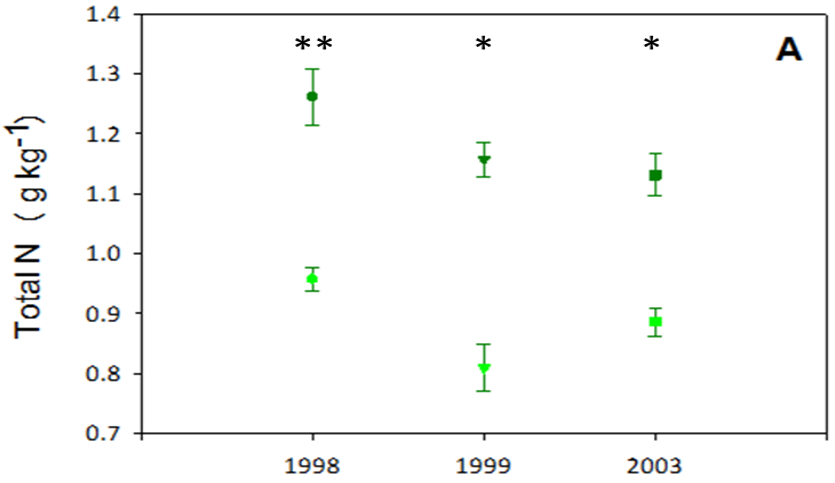
Participatory video

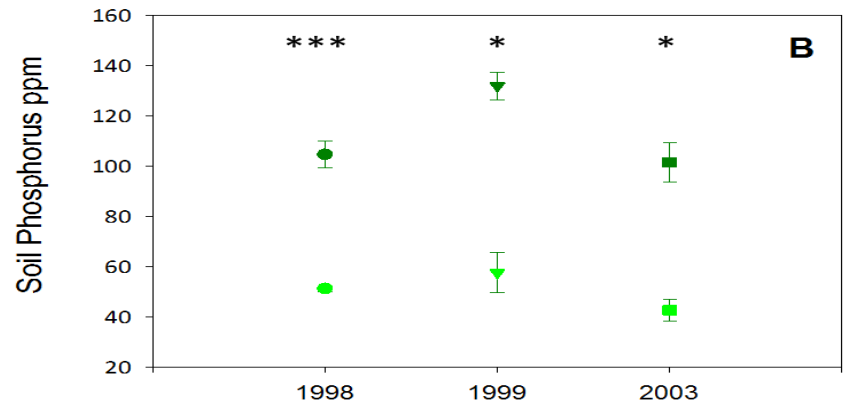
Farmer Field School (FFS)

Murage et al. 2012. Quarterly Journal of International Agriculture 51: 51–71

Push-pull improves soil health

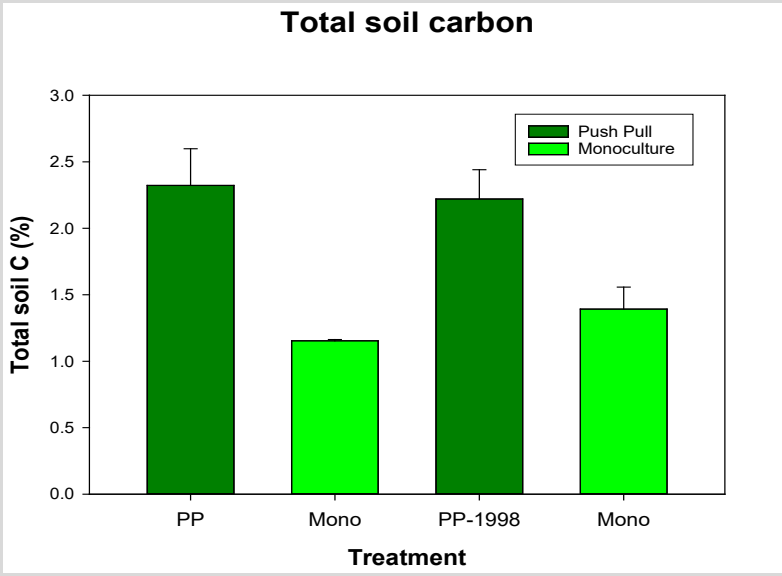
Drinkwater et al. 2021 Agriculture, Ecosystems and Environment 320 (2021) 107566.





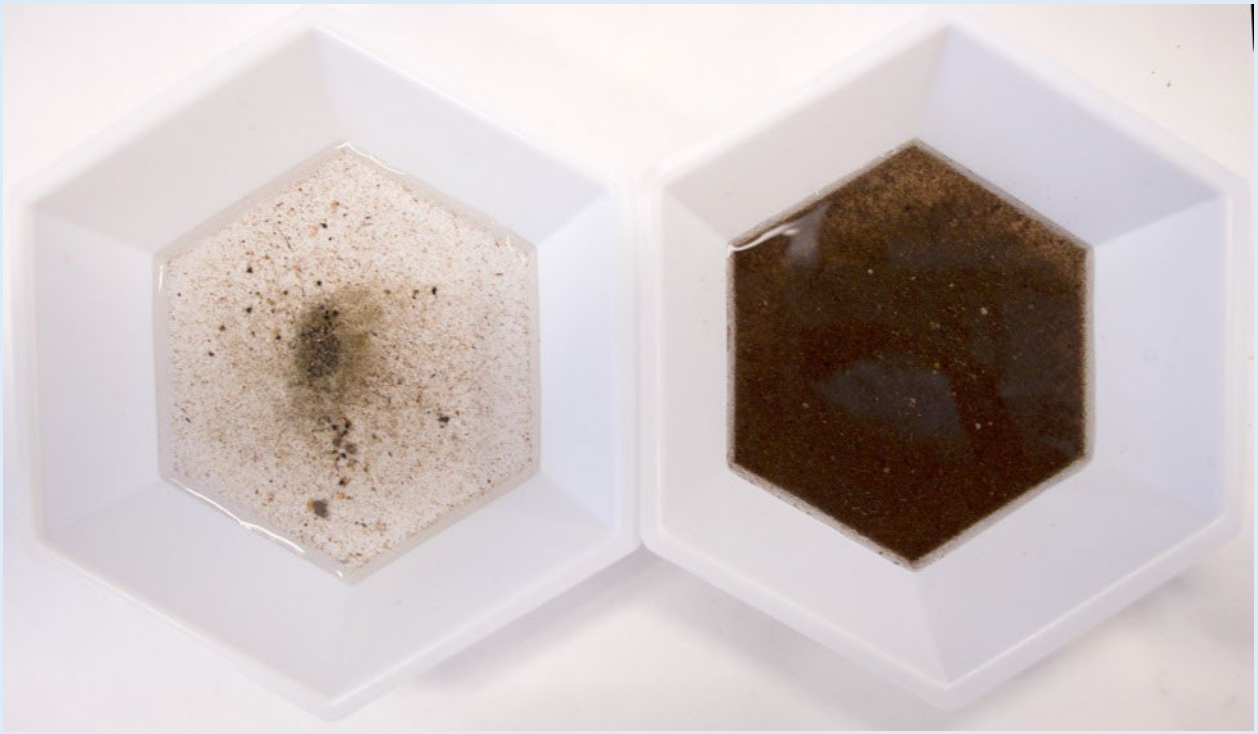
Experiment

Total soil N and plant available P were significantly greater in soils under push-pull intercropping (dark green) than in maize monoculture (light green)



Desmodium improves N, P and C in the soil. It 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. Push-Pull farmers use less inorganic fertilizer, reducing greenhouse gas emissions.

Organic matter in Push-Pull and control fields



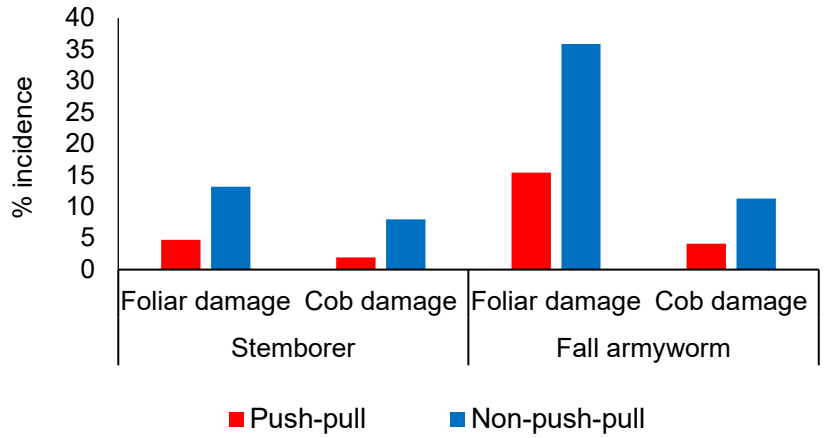
Control Field **Push-Pull Field**

POM plays an important role in giving the soil “crumb structure”, so it impacts water infiltration/water holding capacity and is also an important nutrient reservoir that we believe can supply N (and probably P) to crops

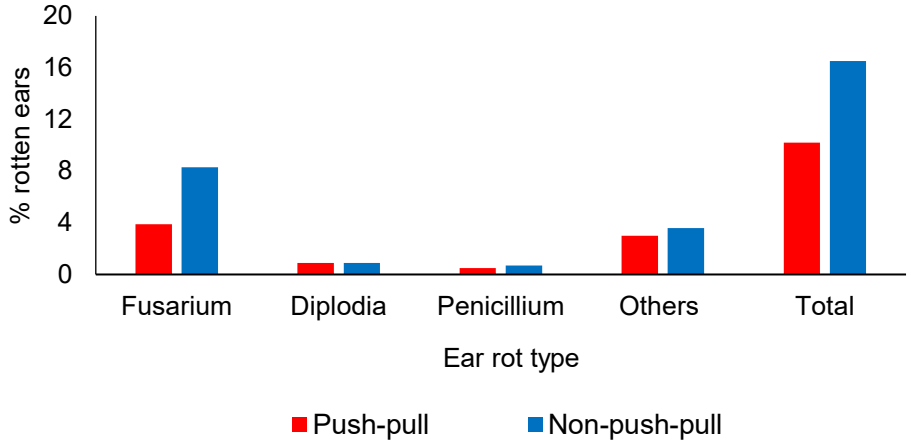
Drinkwater et al. 2021 Agriculture, Ecosystems and Environment 320 (2021) 107566.

Push-pull reduces pest damage and aflatoxin in maize

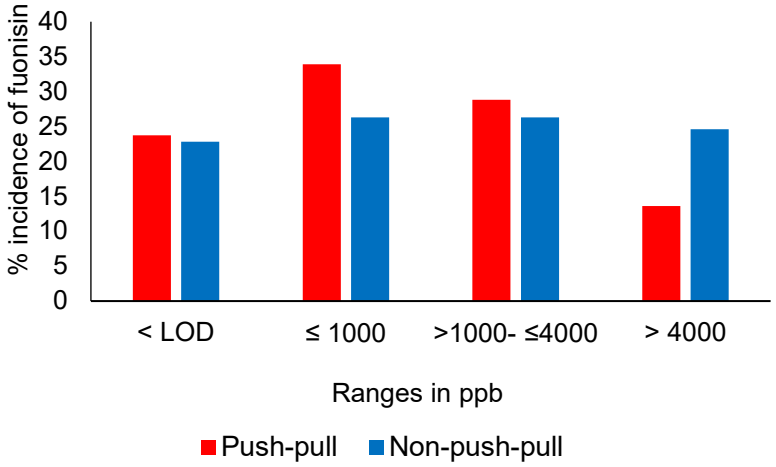
Significant reduction in foliar and cob damage by stemborer and fall armyworm larvae



Reduced incidence of maize ear rots under push-pull system



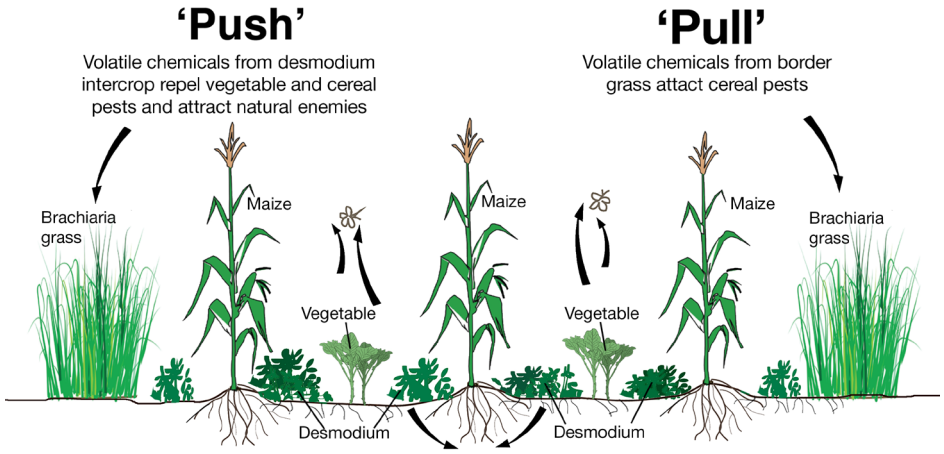
Push-pull effectively reduces contamination of maize by fumonisin

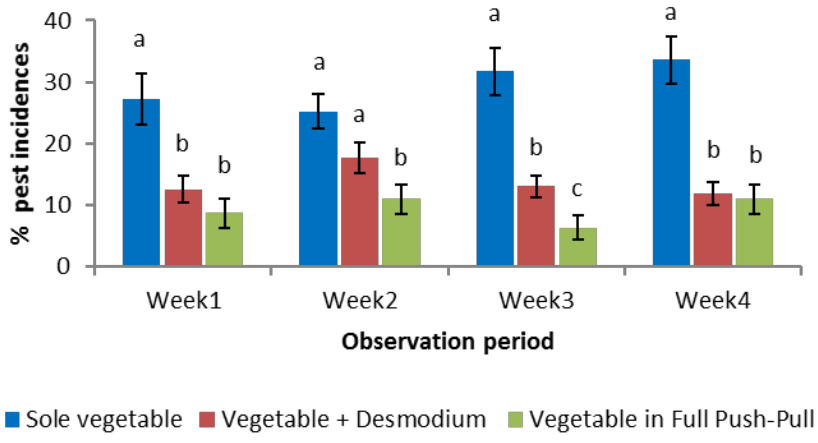


Njeru et al. 2020. Plant Pathology, 69(9), 1644-1654.

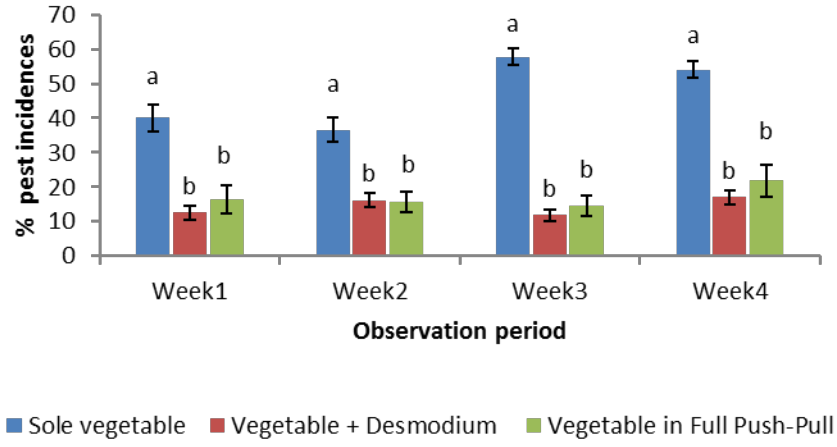
Vegetable integrated within Push-Pull System (VIPPT)

Push-Pull Intensification with Vegetables





Diamondback moth infestations on Kales



Aphid infestations on Kales

Youth and women are attracted to VIPPT

Scaling up Push-Pull through partnerships and mass reach

More than 350,000 farmers in 20 countries (56% females) doubled cereal crop yields, produced 5 times more fodder and 175% more milk, directly benefiting more than 2,000,000 people

Technology delivery mechanisms: group trainings by *icipe* and partner extension staff, farmer visits, farmer teachers, field days, video, drama, cartoon books exchange visits and agricultural shows.

> 26 Million people reached with push-pull information through mass media.

>50,000 new farmers (60% females) are directly trained every year through farmer exchange visits, field days, farmers field schools, farmer teachers, and printed materials

Send a Cow
Change a family's future

fh
food for the hungry

HEIFER INTERNATIONAL

Conservation Farming Unit

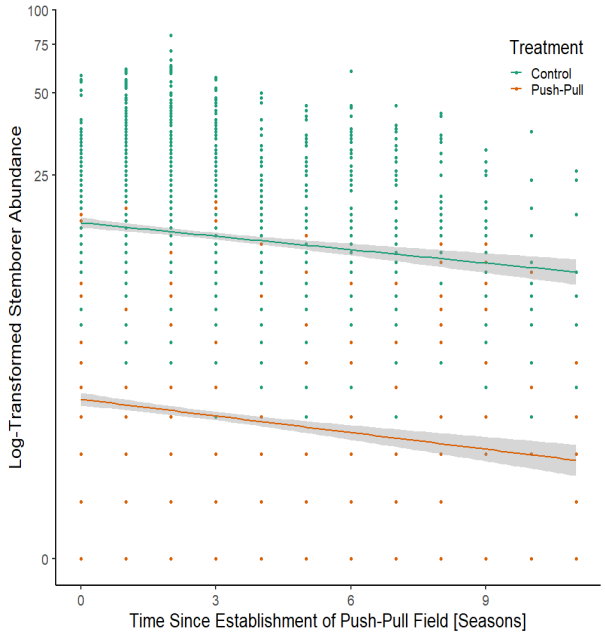
Kasisi Agricultural Training Centre

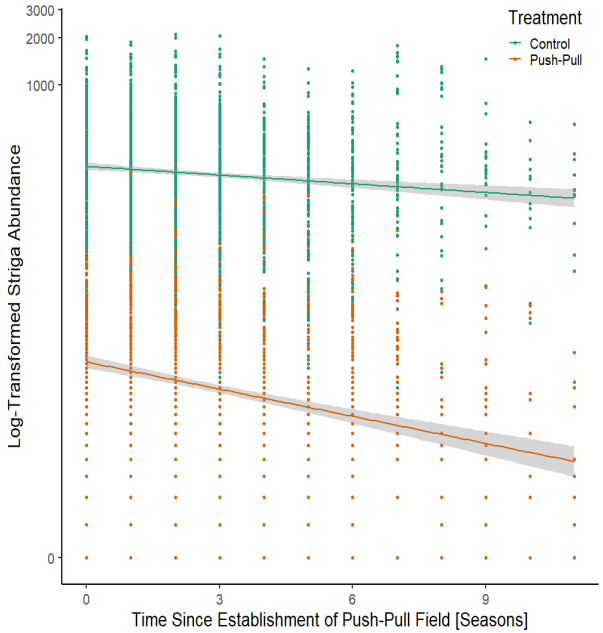
icipe

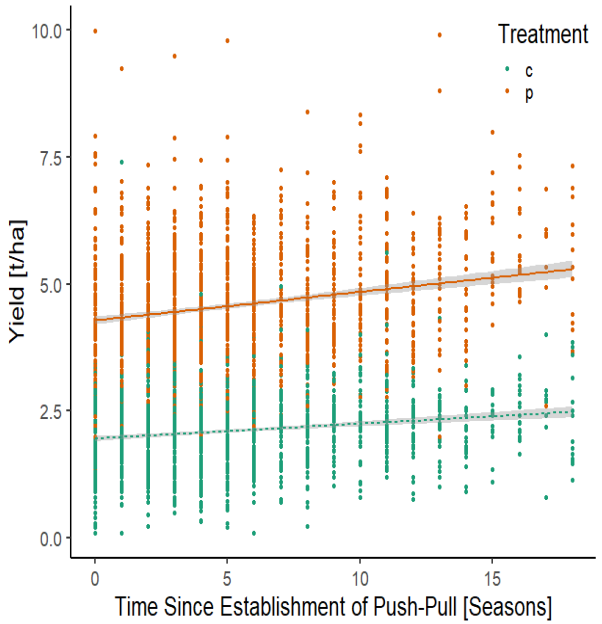
Overall Benefits of Push-pull

- Stemborer and fall armyworm control
- Striga control
- Fodder & milk production
- Climate change adaptation
- Climate change mitigation
- Soil fertility improvement
- Aflatoxin control
- Control of vegetable pests
- Income and employment generation for youth

Are pests adapting to the push-pull system?



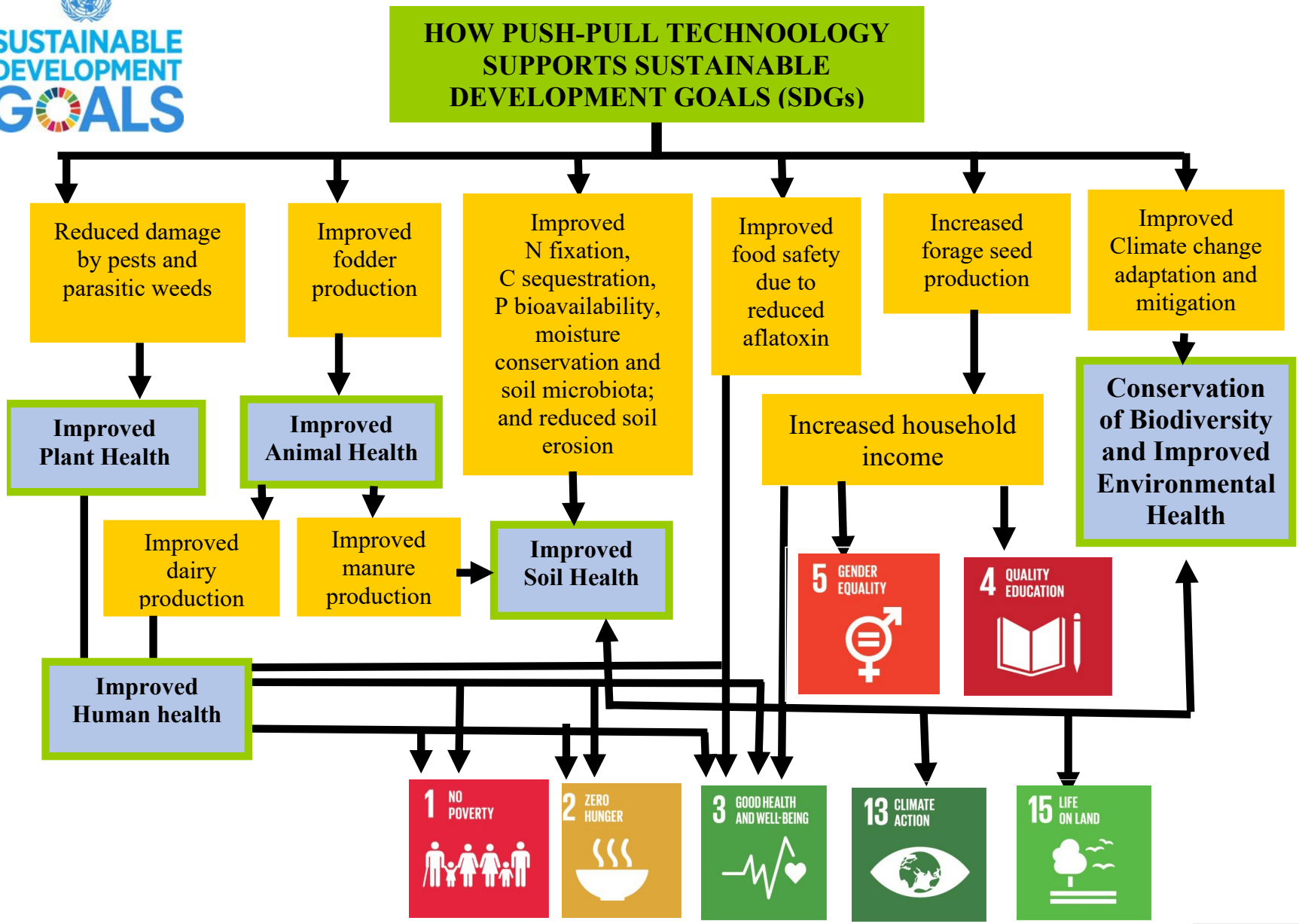




STEMBORERS **STRIGA** **YIELD**

Luttermoser et al. (2023)

HOW PUSH-PULL TECHNOOLOGY SUPPORTS SUSTAINABLE DEVELOPMENT GOALS (SDGs)



2015: Push-Pull Mentioned in UN General Assembly Report

UNITED NATIONS

United Nations A/70/298*

General Assembly

Distr.: General
6 August 2015

Original: English

Seventieth session
Item 20 of the provisional agenda**
Sustainable development

Agricultural technology for development

Report of the Secretary-General

Summary

Agriculture in a broad sense, comprising crops, livestock, fisheries and forest products, presents both a major challenge and a potential solution in terms of sustainable development. Land degradation and soil health, scarcity of and competition for land and water resources, loss and waste of food, the environmental impacts of agrochemicals, biodiversity loss, climate change and natural disasters all affect the ability of producers to ensure food security in a way that is environmentally, economically and socially sustainable. The present report examines trends in technologies that have the potential to overcome those challenges and enable producers to transition to more sustainable agricultural systems.

* Reissued for technical reasons on 9 September 2015.
** A/70/150.

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Push-Pull — a knowledge-intensive solution

The Push-Pull technology, developed by the International Centre of Insect Physiology and Ecology, based in Nairobi, efficiently controls pests and improves soil fertility. Push-Pull provides agroecological solutions to some of the most common challenges facing smallholder farmers in sub-Saharan Africa: stem borers, Striga and low soil fertility affecting cereal production. It is based on research by the International Centre and Rothamsted Research on behaviour-affecting chemicals produced by plants and insects.

The technology consists of intercropping maize with a repellent plant, such asdesmodium, and planting an attracting plant, such as napier grass, as a border crop. Stem borer moths are attracted by the volatile compounds of the napier grass and, after the eggs hatch, the larvae get trapped by a sticky substance produced by the grass. Napier grass is also a valuable carbohydrate-rich livestock fodder. Desmodium, on the other hand, is a perennial cover crop that repels the moth through its volatile compounds, suppresses Striga, fixes nitrogen, conserves soil moisture, enhances arthropod abundance and diversity, and increases organic matter in the soil.

While providing a pest management solution, Push-Pull makes cereal cropping systems resilient to climate change. The latest version of this technology includes drought-tolerant desmodium, brachiaria as a trap crop and sorghum. Furthermore, it promotes the integration of livestock husbandry, increasing household nutrition via milk products, and diversifies income sources, allowing smallholders entry into the cash economy. As it employs local plant varieties, it integrates well with the traditional mixed cropping system of sub-Saharan Africa.

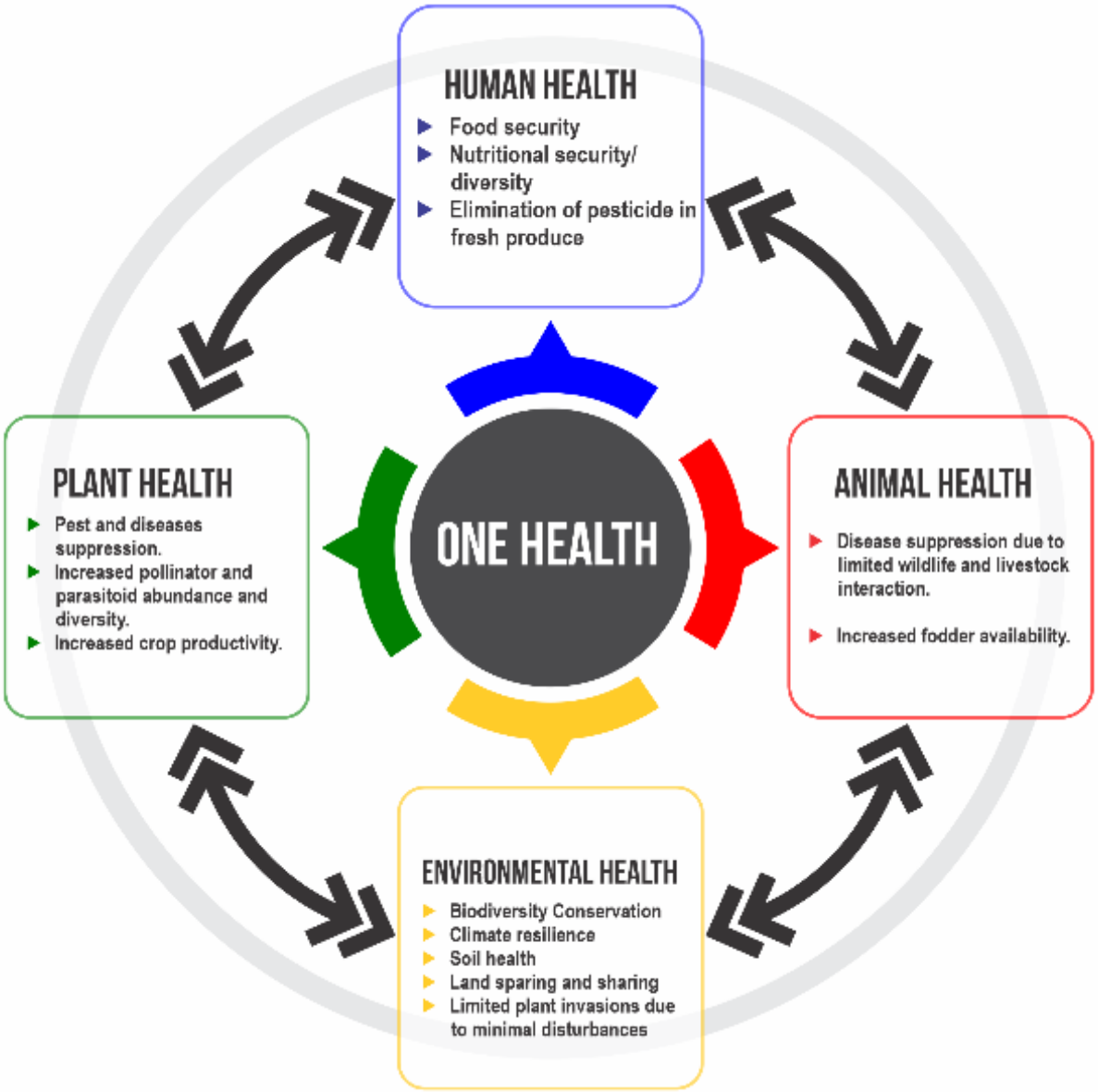
With respect to its impact, Push-Pull has to date been adopted by nearly 100,000 smallholders in East Africa and has successfully and sustainably doubled and even tripled maize yields.

39. Without private funding, it is difficult to achieve widespread adoption of knowledge-intensive agroecological technologies owing to poor public extension and advisory services. Farmer field schools help to scale up technologies and reach marginalized populations by addressing both technical complexities and the local contexts required for knowledge-intensive practices to be understood and adopted. In a West African regional programme, introducing integrated pest management to 30,000 farmers from a field school resulted in a median pesticide use reduction of 75 per cent, yield increases of 23 per cent and net margins of 41 per cent. In addition, building the capacity of farmers to become trainers can enhance the reach of a successful pilot project.[36]

40. Preharvest losses have a significant impact on food security in rural communities. Therefore, new technologies are needed to reduce food loss and waste. The FAO Global Initiative on Food Loss and Waste Reduction helps develop regional programmes and supports their national implementation, including through

[36] FAO, *Investing in Food Security* (2009). Available from http://www.fao.org/fileadmin/templates/ag_portal/docs/i1230e00.pdf.

Attributes of push-pull ensuring optimal one health outcomes



Conclusion and Future Direction

The Climate-Smart Push-Pull, a sunstainable cropping system, was developed for smallholder poor farmers by exploiting insect and plant behaviour, chemical ecology and plant signalling.

Push-Pull is just the kind of technology necessary to support the 'green revolution' that Africa needs because it increases productivity without requiring extra resources for crop protection and soil improvement.

New discoveries relating to control of aflatoxin, fall army worm, soil health improvement, climate change mitigation, and drought resilience represent greater opportunities for further enhancing the effectiveness of the Push-Pull technology, extending its appeal to a wider range of farmer profiles in different agro-ecologies throughout Africa and beyond.

Integration of vegetables to intensify push-pull farming system has made it highly attractive to youth and women. Increasing on-farm agricultural productivity, job creation and income generation will mitigate youth migration to cities and out of Africa.

‘The science should be doing for society what society would hope of science’