Push-pull strategy

A case report of successful sustainable agriculture in Sub-Saharan Africa

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Reggio Emilia, May 10th 2016

This journey was possible thanks to World Friends, a medical NGO that working in Nairobi taking care of people who otherwise could not afford any healthcare service

Nairobi

684 km²

Over 4 milion inhabitants

More than 60% people living in squatter areas, called ‘slums’

No electricity and water service

Extremely poor hygenic conditions

The two sides of Nairobi

The slum

World Friends NGO

From 2001 striving to provide Nairobi slum people a free healthcare service possibility

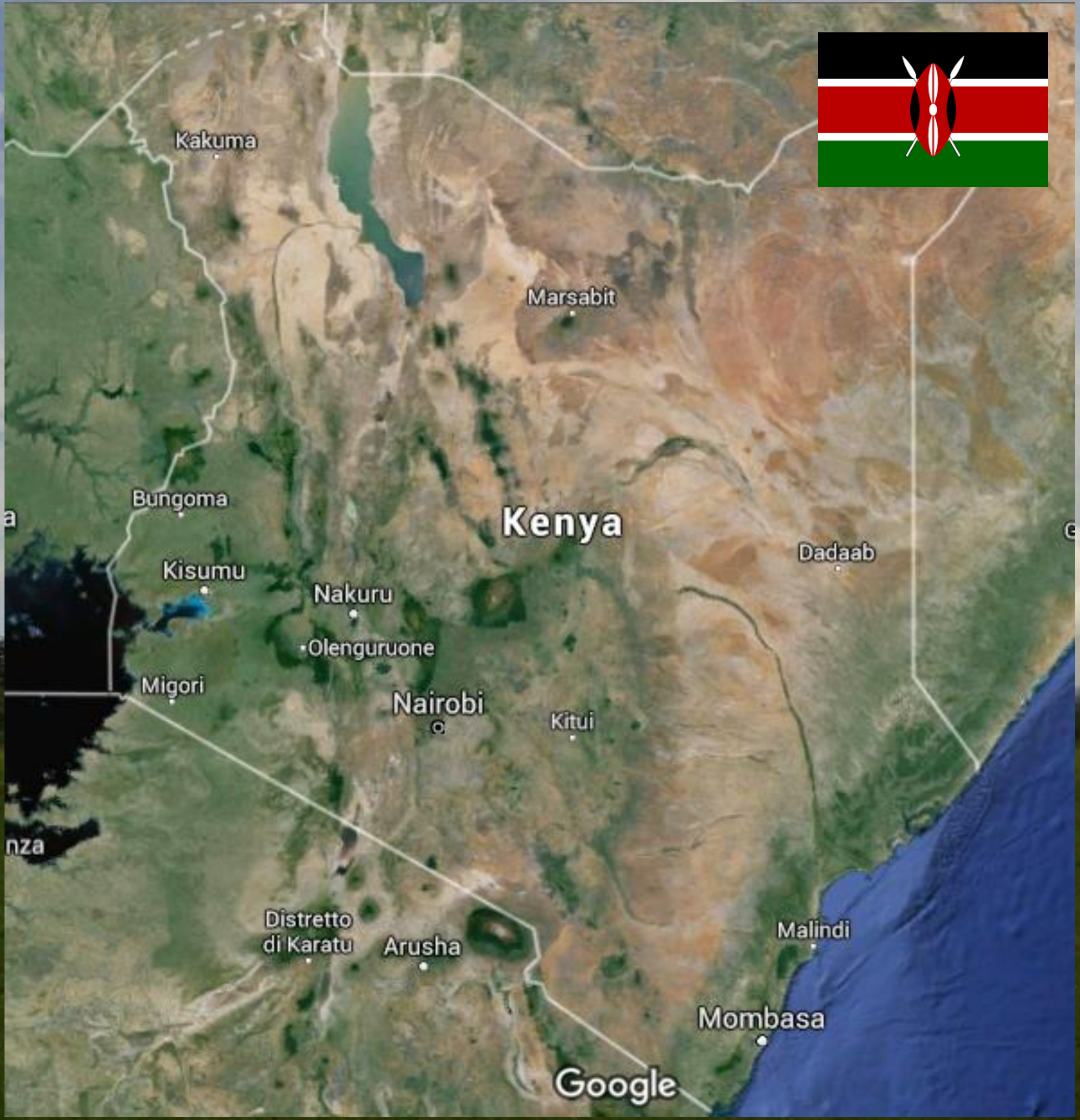
Thanks to private donations in 2008 a new hospital in Nairobi started.

Special care of children with disabilty

www.world-friends.it

Kenya


Omdurman
Khartoum
ERITREA
Asmara
YEMEN
Sanaa
Aden
SUDAN
DJIBOUTI
Djibouti
Gulf of Aden
Addis Ababa
Berbera
ETHIOPIA
SOMALIA
Juba
UGANDA
Kampala
KENYA
Mogadishu
Kigali
RWANDA
Nairobi
Lake Victoria
Bujumbura
BURUNDI
Mombasa
Dodoma
Lake Tanganyika
TANZANIA
Dar es Salaam
Lake Nyasa
Moroni
COMOROS
Glorioso Isla
(FRANCE)
Mayotte
(administered by FRANCE, claimed by COMOROS)
Lilongwe


Kakuma
Marsabit
Bungoma
Kenya
Dadaab
Kisumu
Nakuru
Olenguruone
Migori
Nairobi
Kitui
Distretto di Karatu
Arusha
Malindi
Mombasa
Google

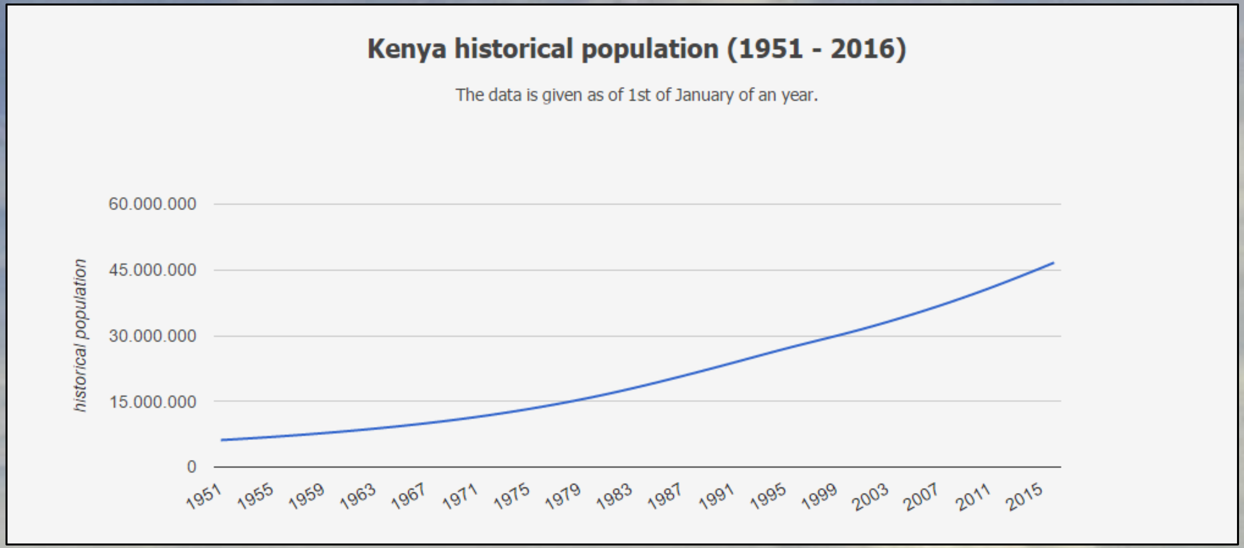
A couple of data introducing Kenya

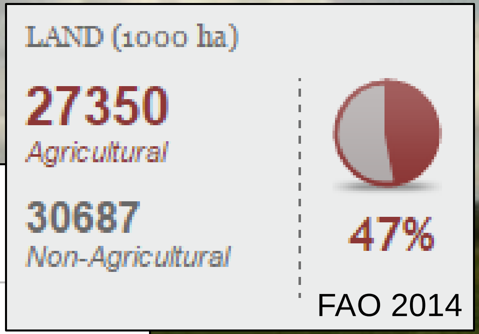
- **Population:**

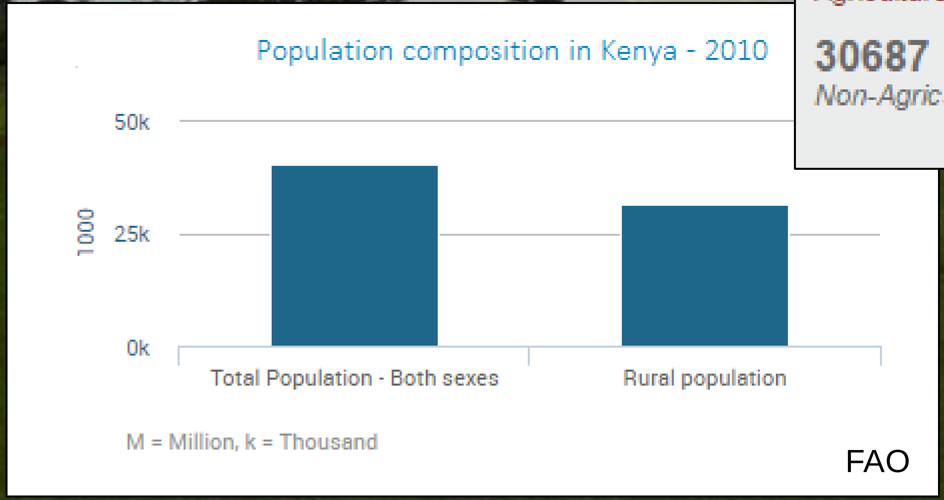
  - Total (World Population Clock, Jan 2016): 47.9 milion
  - Population below $1 per day (WHO, 2005) : 43.3 %
  - Population underfed (WHO, 2014-2016): 21.2 %

- **Agroeconomy (FAO, 2005):**

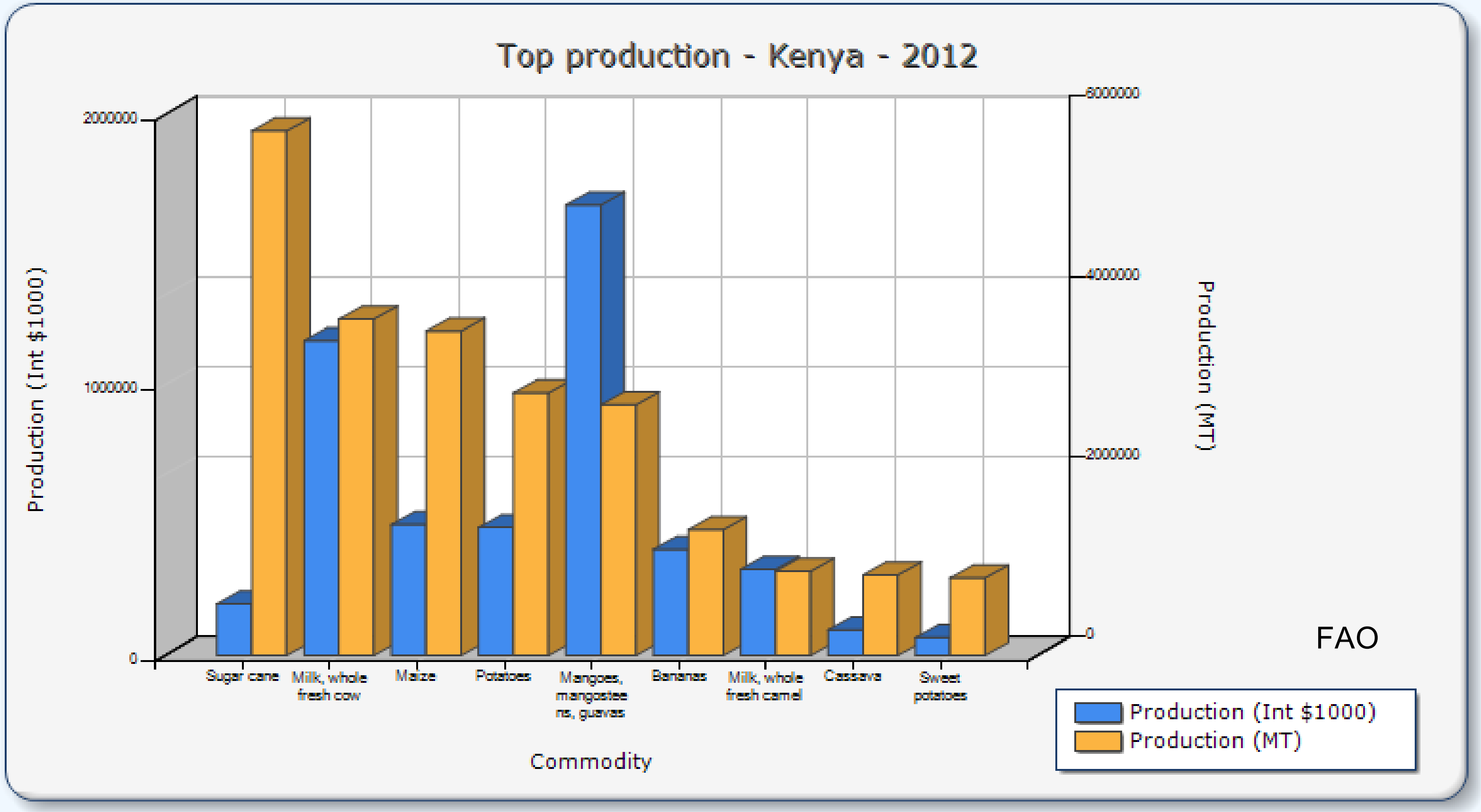
  - Population involved in agriculture: 75 %
  - Income from crop production (GDP): 39.8 %
  - Crop production sold: 26 %
  - Small-holders farm size: 0.04 - 8-3 ha







Agriculture

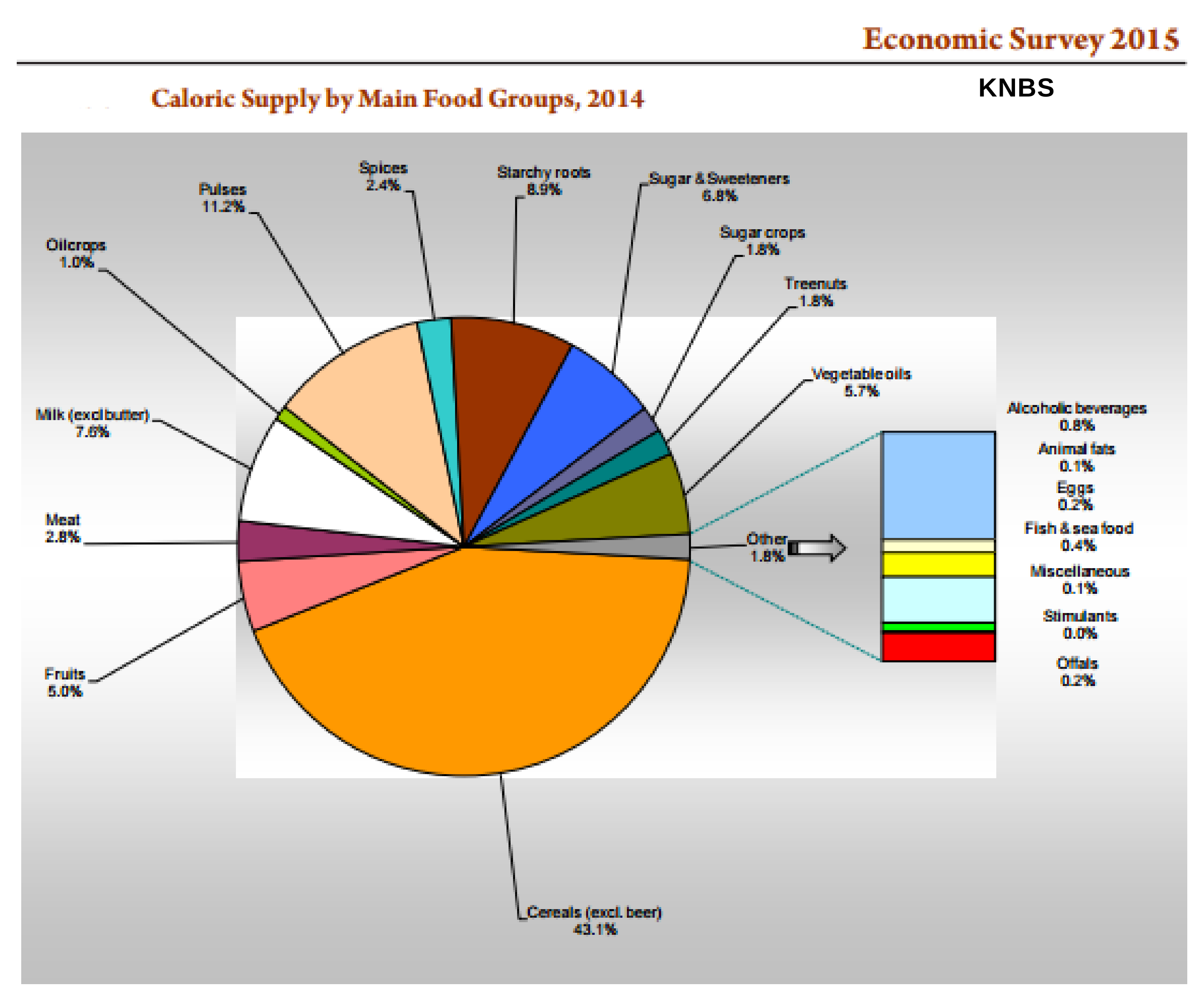


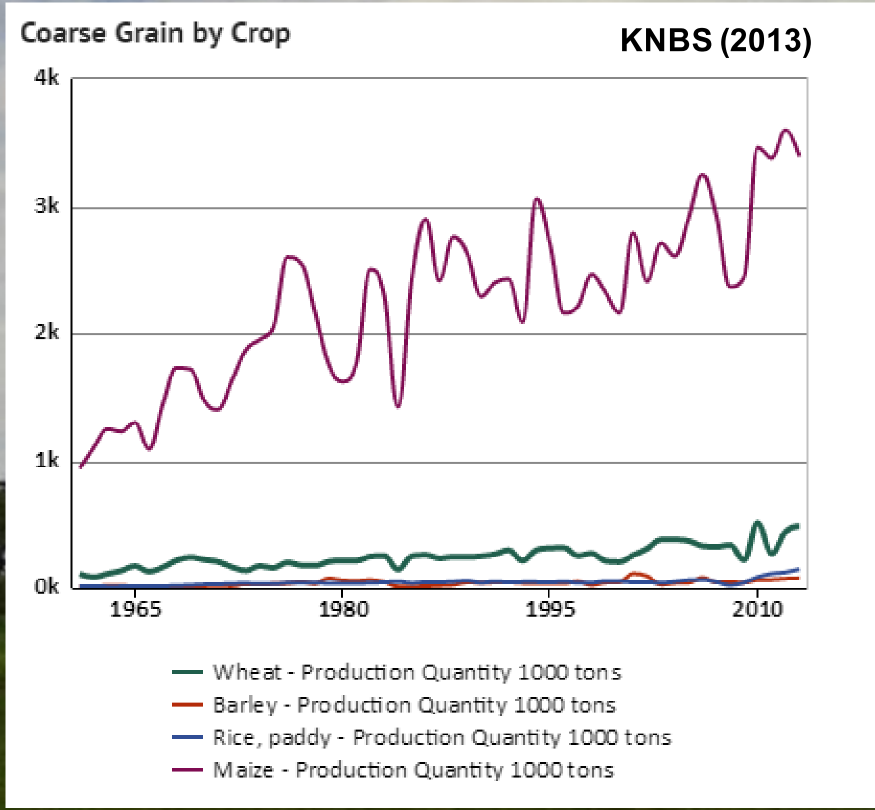
Rank	Commodity	Production (Int $1000)	Production (MT)
1	Sugar cane	191198	5822633
2	Milk, whole fresh cow	1164911	3732960
3	Maize	483817	3600000
4	Potatoes	472655	2915067
5	Mangoes, mangosteens, guavas	1666706	2781706
6	Bananas	392710	1394412
7	Milk, whole fresh camel	318336	933616
8	Cassava	93298	893122
9	Sweet potatoes	64920	859549
10	Cabbages and other brassicas	102355	684000
11	Beans, dry	361192	613902
12	Vegetables, fresh nes	113065	600000
13	Pineapples	132814	465938
14	Wheat	67824	441754
15	Meat indigenous, cattle	1110396	411048
16	Tomatoes	146717	397000
17	Tea	392848	369400
18	Milk, whole fresh goat	89903	267904
19	Peas, green	77450	234021
20	Avocados	129093	186292

Main crops (2013) - Production KNBS

	Area Harvested, Ha	Yield, Hg/Ha	Production, 1000 tonnes
Sugar cane	85,000	694,118	5,900
Maize	2,100,000	16,147	3,391
Potatoes	135,000	185,185	2,500
Sweet potatoes	88,000	130,723	1,150
Cassava	70,000	158,917	1,112
Beans, dry	1,000,000	5,293	529
Wheat	160,000	30,365	486
Rice, paddy	28,000	52,391	147
Sorghum	210,000	6,597	139
Cow peas, dry	220,000	5,576	123

Agriculture

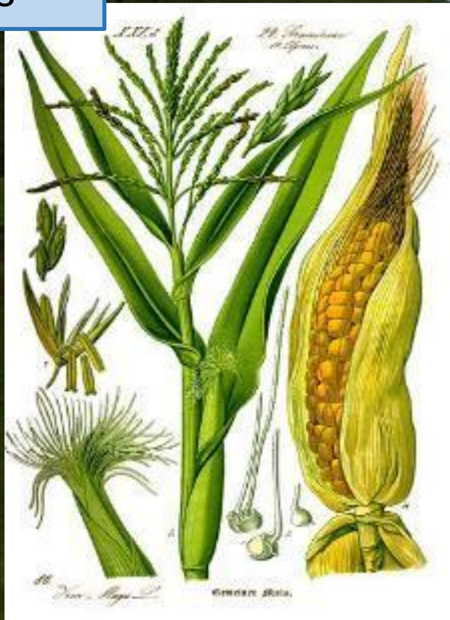




But let's now start with Push-pull...

Push-pull ‘patients’

Zea mais

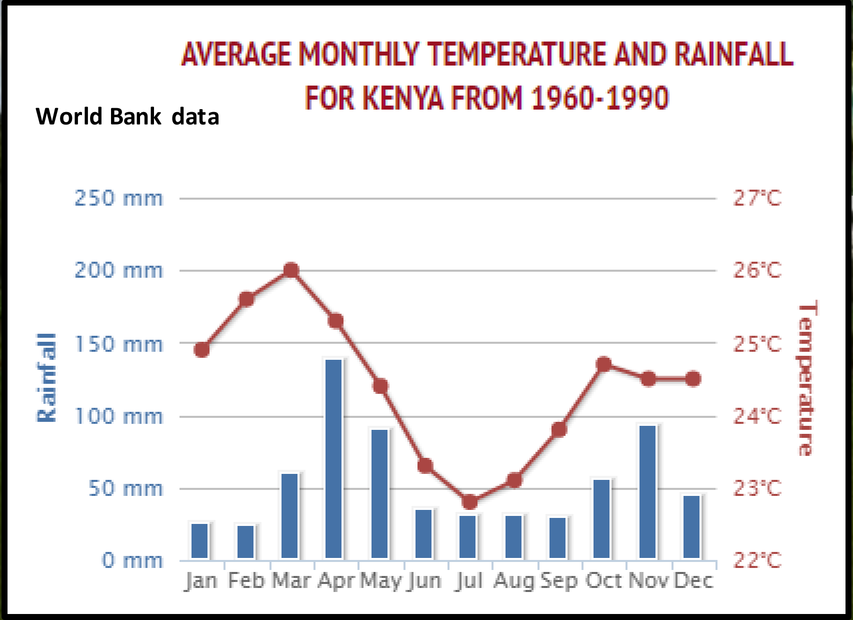


Sowing in East Africa:

- **Twice a year,**
  In correspondence with:

- Long rain season (Mar - Jun)

- Short rain season (Oct- Dec)



- **Often intercropped**
  (edible pulses generally)

Sorghum bicolor

Majour threats

Stemborer damage

Parasitic weed

Climate changes

Stemborers

Busseola fusca

Lepidoptera, Noctuidae family

Native species

Polyphagus:
both species are attracted by and feed on Poaceae, Cyperaceae, Typhaceae

10 – 80 % yield losses
(Khan et al., 2007)

Estimated additional harvesting enough for 27 milion people preventing stemborers damage (ICIPE 2015)

Chilo partellus

Lepidoptera, Crambidae family

Alien species
(from India, first finding in Africa in the 1930s)

Moths life cycle

Busseola fusca

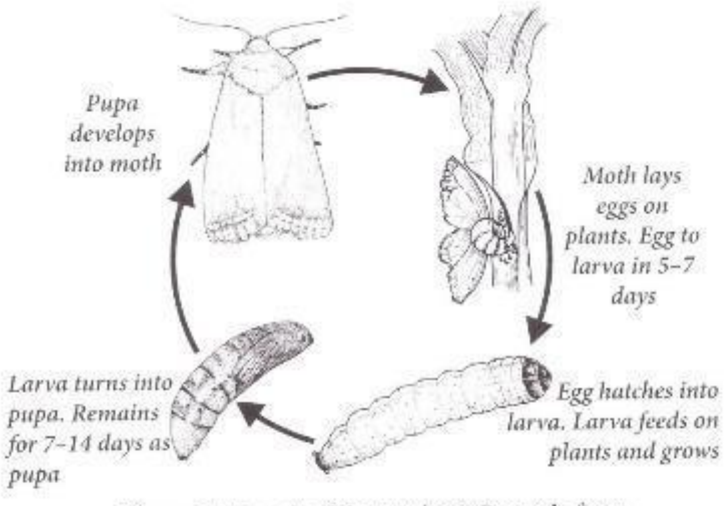


Figure 5. Life cycle of the stemborer Busseola fusca

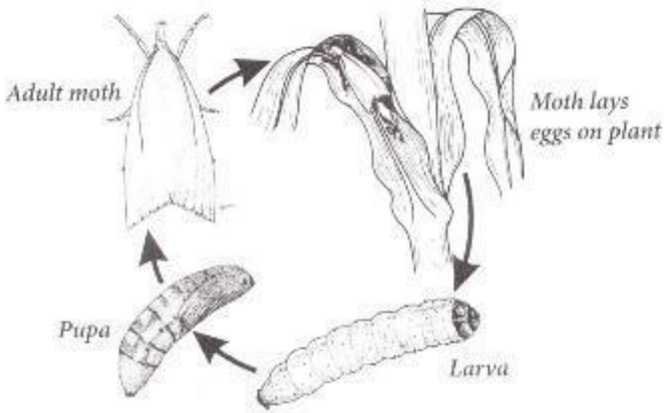


Figure 6. Life cycle of the stemborer Chilo partellus (the spotted stemborer)

Farmer's guide

1.5 months life cycle

10 - 80 eggs laid in a row between the stem and the leaf-sheath

At this latitude generations follow each other almost continuously throughout the year

Chilo partellus

2 months life cycle

About 200 eggs laid in batches on leaf surface

Traditional stemborers management

Detection and prevention:

- Whithering and feeding marks detection
- Cleaning from and destruction of crop leftovers
- Early removal of maize stubbles hosting pupae

Combating:

- Chemical control through pesticides

BUT

- Partial/low effectiveness, non-specificity
- Negative environmental implications
- Mostly too expensive for small-holder farmers

Striga weeds

Striga spp. Lamiales, Orobanchaceae

23 species in Africa, of which *S. asiatica* and, especially, *S. hermonthica* are the most important

Obligate root parasite of cereals.

Huge seed bank in the soil:

High prolific, individual production of thousands tiny dust-like seeds that can remain viable for 15-20 years

Striga hermonthica

It threatens food security of 100 milion Africans, endangering not only maize and sorghum, but also rice, millet and sugar cane crops (ICIPE, 2015)

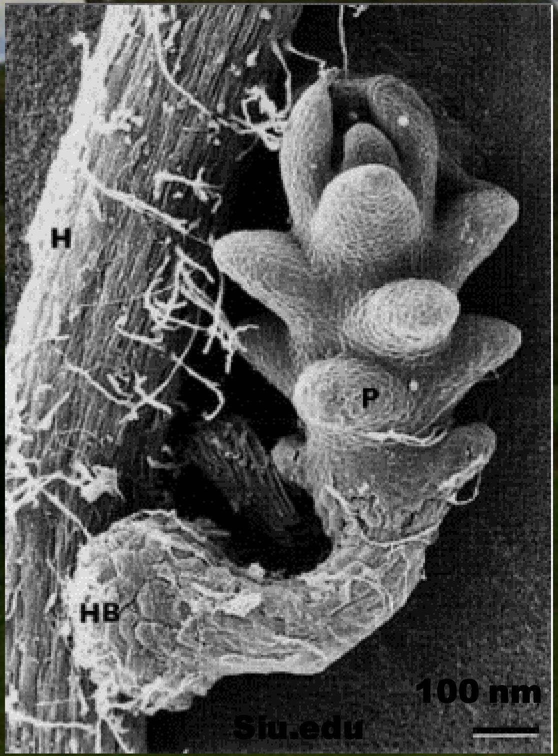
Striga parasitism

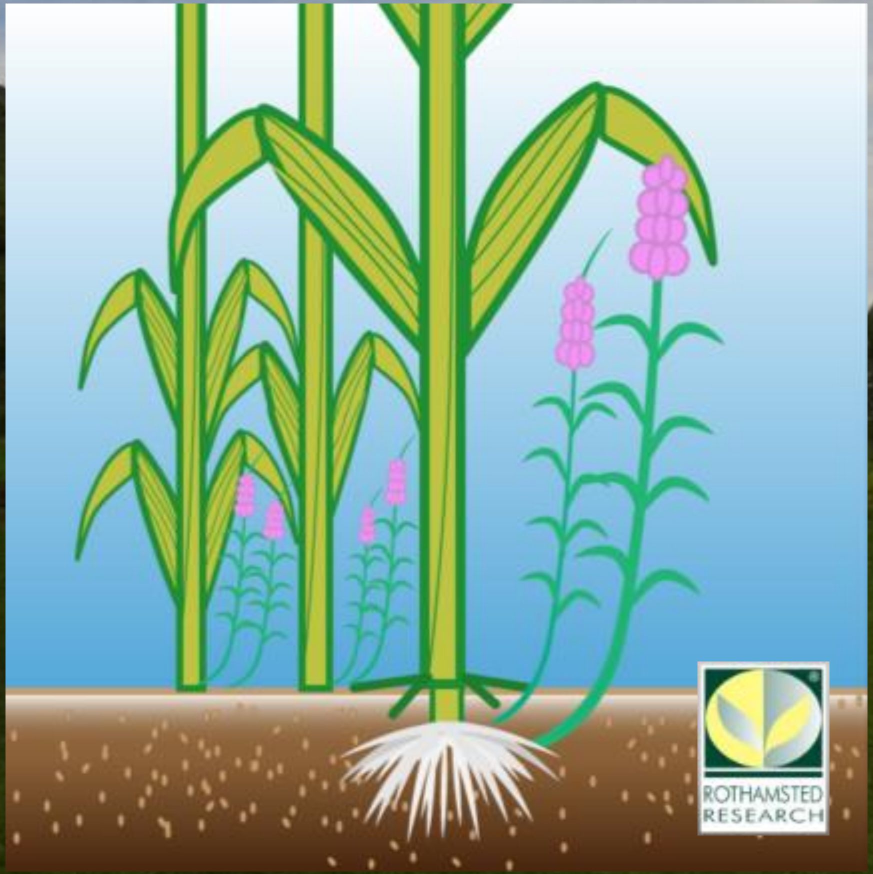
S. hermonthica seedling connected via haustoria to its maize host root

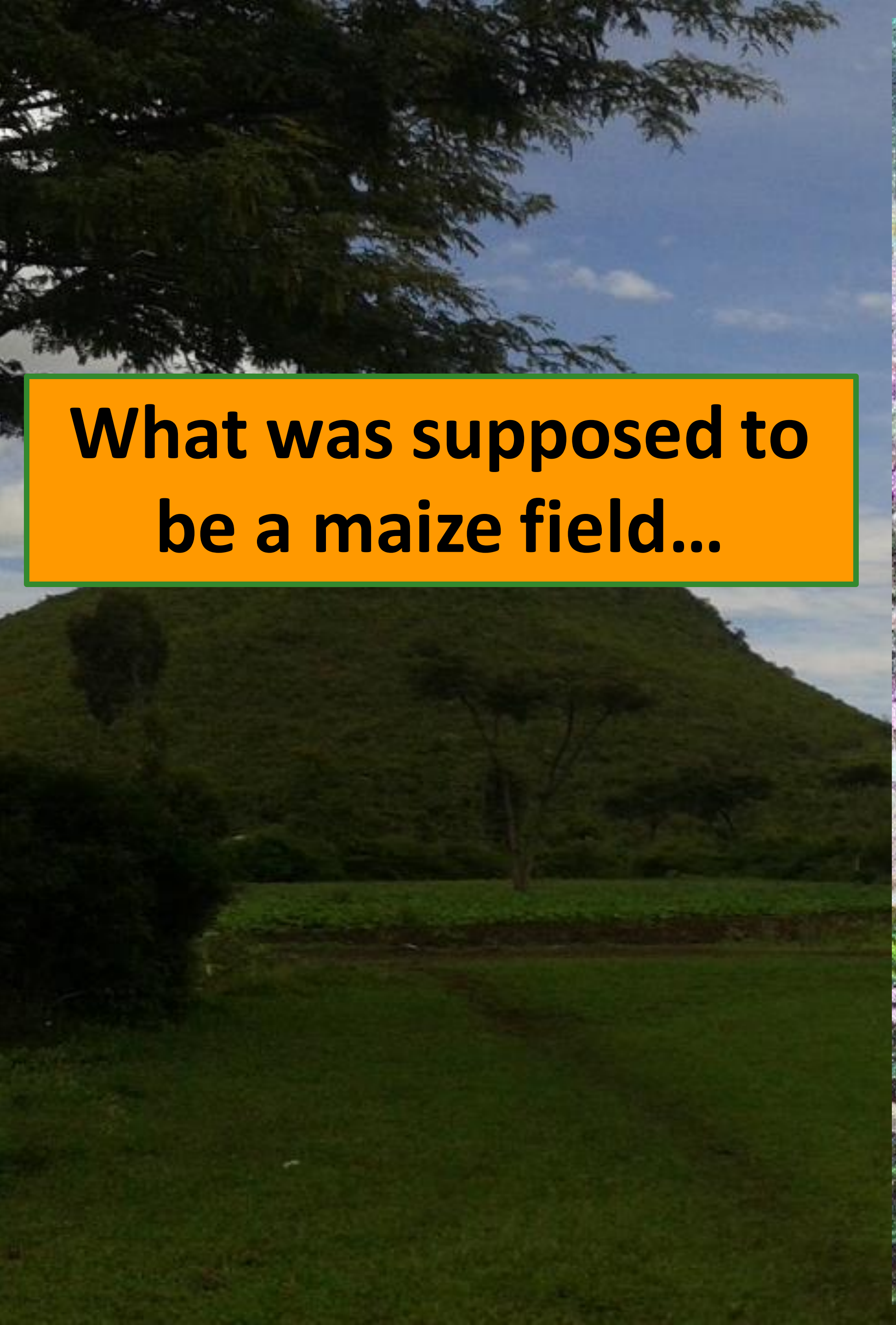
Inhibition of normal host growth

- Competition for nutrients
- Impairment of the photosynthesis
- Phytotoxyc effect

30 – 100 % yield losses
(Khan et al., 2008)







What was supposed to be a maize field...

Traditional approach against Striga

Prevention is hardly a viable path because Striga is widespread and seed bank in the soil is large and persistent

Imapazyr herbicide coupled with imapazyr-resistent mutant maize (IR maize)

BUT, AGAIN

Negative environmental implications

Mostly too expensive for small-holder farmers

Remediation is largely practice through maual labour:

Three quarters of the small-holder farms in Sub-Saharan Africa are hand-weeded

Women do 90 % of the weeding in Kenya, Tanzania and Uganda, which takes up 50 – 70 percent of total labour time

FAO (2015)

Hand-weeding striga is laborious and time-consuming, and is largely the responsibility of women.

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Climate changes

Projections for SSA countries suggest that, with respect to 1960-2002 period, year mean temperatures will be higher for the:

~ 40% of the years by 2025
~ 90% of the years by 2050
~ 100% of the years by 2075

(Khan et al. 2014)

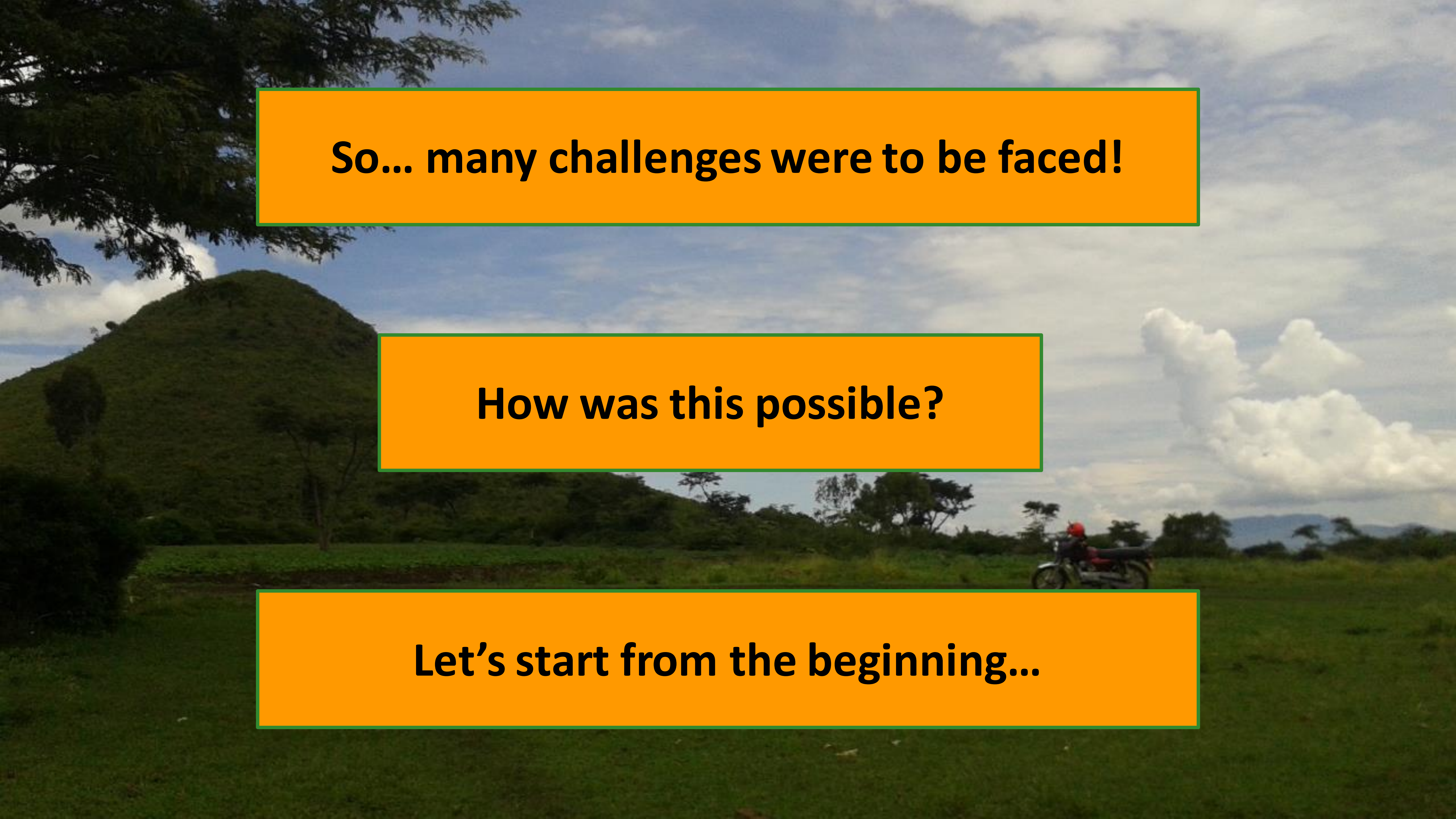
Rainfall are becoming more and more unpredictable and thus sowing season uncertain

Too risky to sow all fields at once at the most appropriate time

Same area, same period

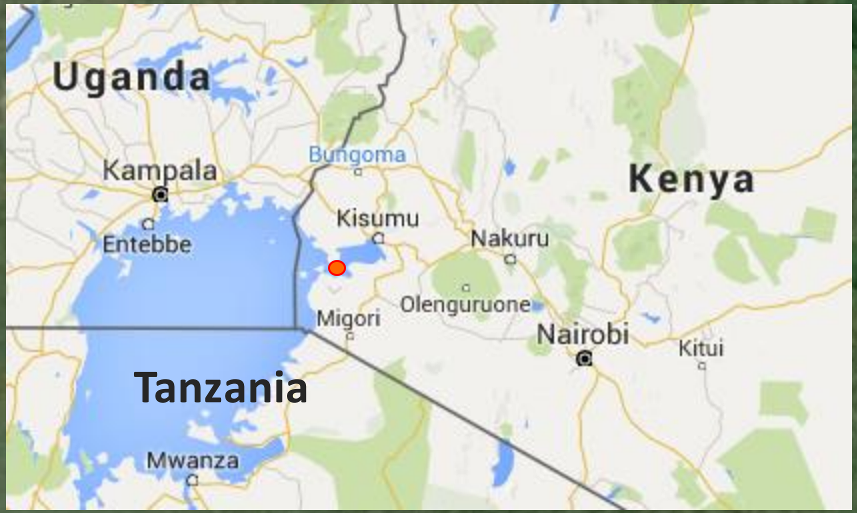
Nearly two months from emergency (VT stage)

Few weeks from emergency (V2-V3 stage)


So… many challenges were to be faced!
How was this possible?
Let’s start from the beginning…

International Centre of Insects Physiology and Ecology

Thomas Odhiambo research campus of ICIPE



International Centre of Insects Physiology and Ecology

ENVIRONMENTAL HEALTH

HUMAN HEALTH

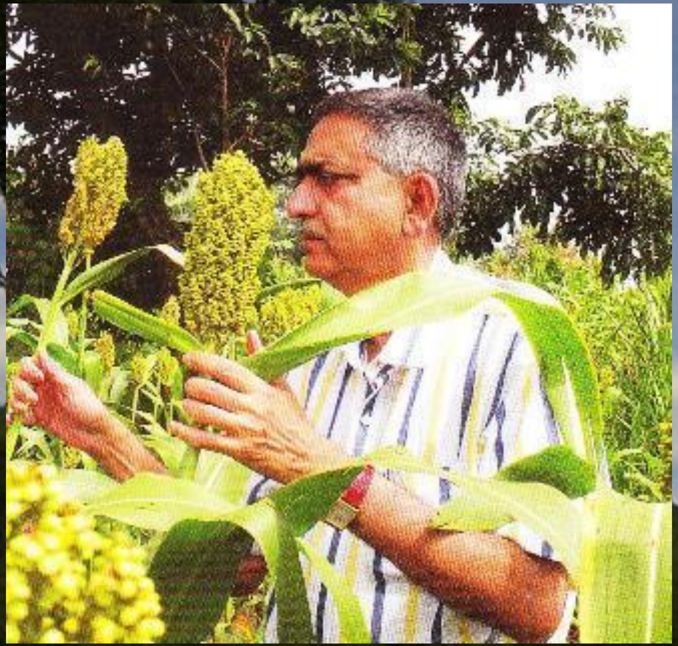
Lake Victoria

PLANT HEALTH

ANIMAL HEALTH

“Our mission is to help to 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.”

Push-pull born



Prof. Zeyaur R. Khan

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African Insect Science for Food and Health

Once upon a time…

…in the far 1993, a team lead by Zeyaur Khan, an agricultural entomologist of ICIPE, in collaboration with a researchers team of Rothamsted Research (UK) headed by professor John Pickett, a chemist specialized in insects pheromones, decided to try to respond to rural and small-holder farmers needs.

Their jointly effort was focused on maize and sorghum pest control. From this perspective they reasoned to find a way to turn away from crops the two most dangerous stemborer moths, *B. fusca* and *C. partellus*.

Prof. John A. Pickett

Rothamsted Research

where knowledge grows

The pull…

Polyphagus stemborers as, *B. fusca* and *C. partellus*, are attracted by a broad range of suitable host plants

More than 400 plants were taken into exam trying to find an attacractive or trap plant for stemborers

Among them 30 species seemed suitable for the purpose.
But the final say to the farmers!

Sorghum x drummondii

Sudan grass, Poaceae

Both attracting female moths for deposition by releasing volatile chemicals

Parasitoid attraction (*Cotesia sesamiae*)

Suitable as livestock fodder

Pennisetum purpureum

Napier grass, Poaceae

Secreting a sticky trapping gum

Largely used livestock fodder

Perennial

80% larva mortality (Khan et al., 2014)

…and the push

Looking for something producing semiochemicals avoided by the moths…

Melinis minutiflora

Molasses grass, Poaceae

(80% reduction in stemborer infestation)

Forage value

Why not in beans?

Traditional forage intercrop

Leguminous benefits

Desmodium uncinatum

Silver-leaf desmodium, Fabaceae

(75% reduction in stemborer damage)

Highly energetic fodder (high protein content)

Nitrogen fixation, fertilisation of degradated soils

Serendipity!

Parasitic striga, as ubiquitous in that area, weed was present in push-pull experimental fields too

After adoption of desmodium as 'push plant', comparing their control/push-pull fields researchers found something they didn't expect…

surprisingly where desmodium was present striga was almost completely absent!

Sorghum experimental fields

Experiment on desmodium effect

Higher [N] effect?

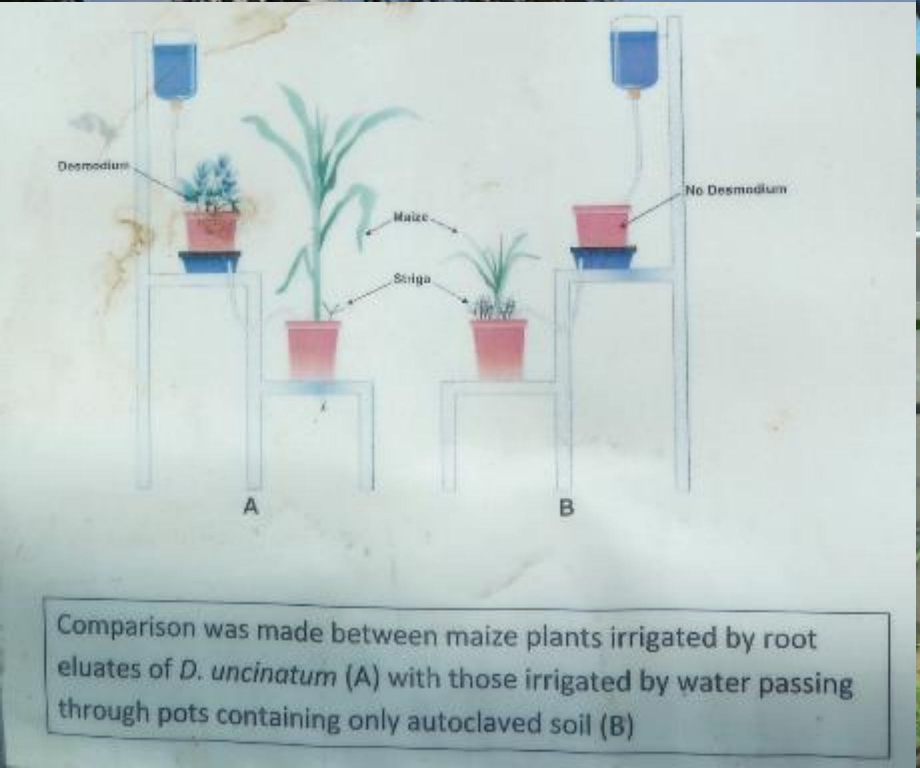
Maize + Striga + Desmodium sowed pots on the background

Maize + Striga sowed pots on the foreground

Striga doesn’t seem really affected by N concetration. While the only visible effect is on maize growth, increased in both cases following [N] rising (from right to left in the image)

Experiment on desmodium effect

Canopy cover suffocating striga by competition for photosynthesis/resources?



Drip experiment

Striga growth inhibited even without Desmodium physically present in the pots. It must be something in root exudates…

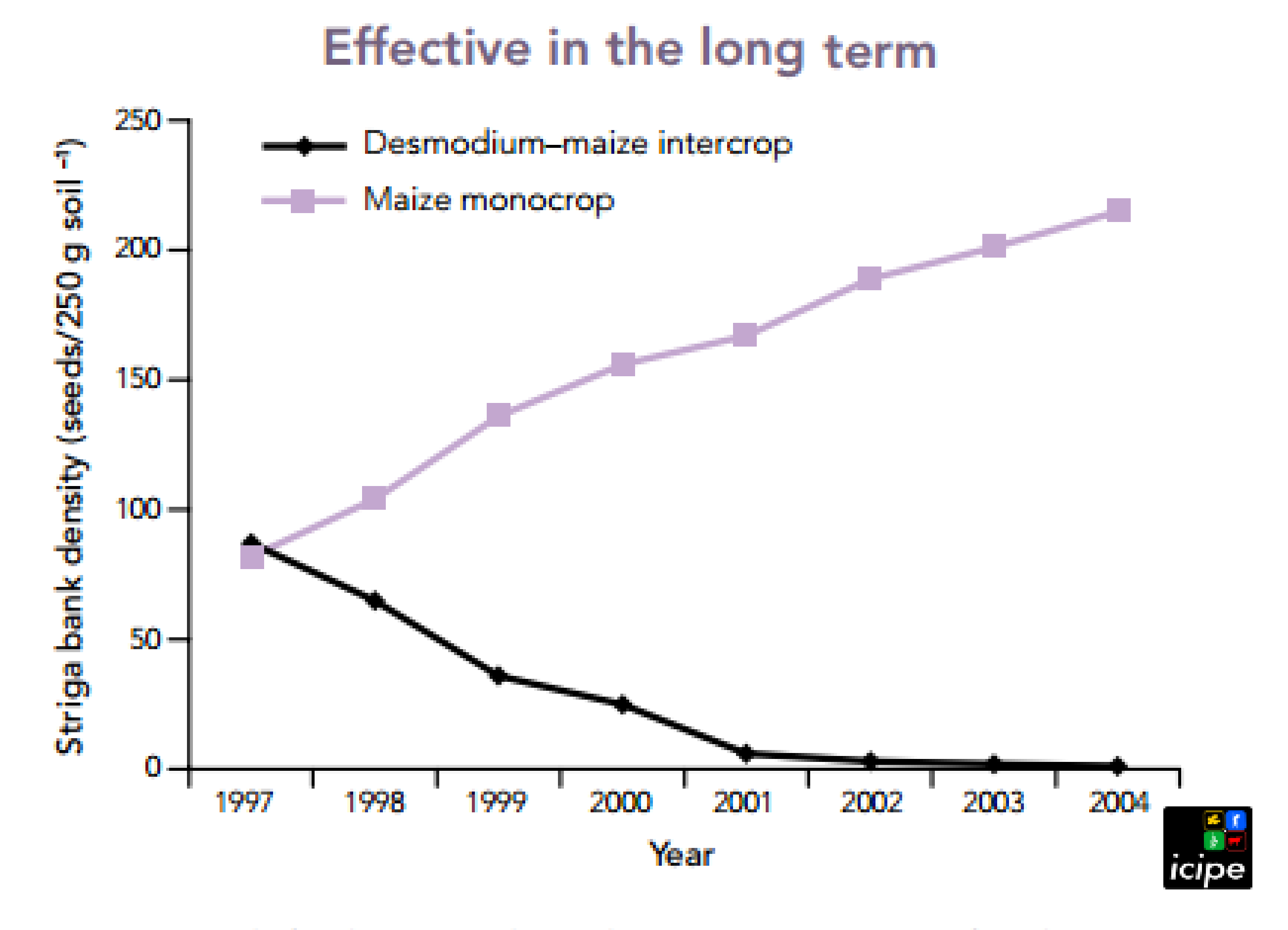
Striga suicide

Phytochemicals exuded in the rhizosphere by desmodium induce the so-called 'suicidal germination' of striga

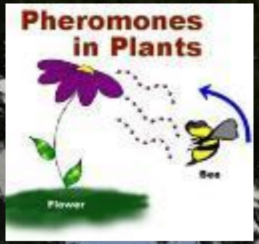
Some of them (isoflavones) are responsible for striga seed induced germination

While others interefer with the susbequent radicle development thus inhibiting striga growth

Due to this allelopathic effect striga seed bank in the soil is drastically reduced



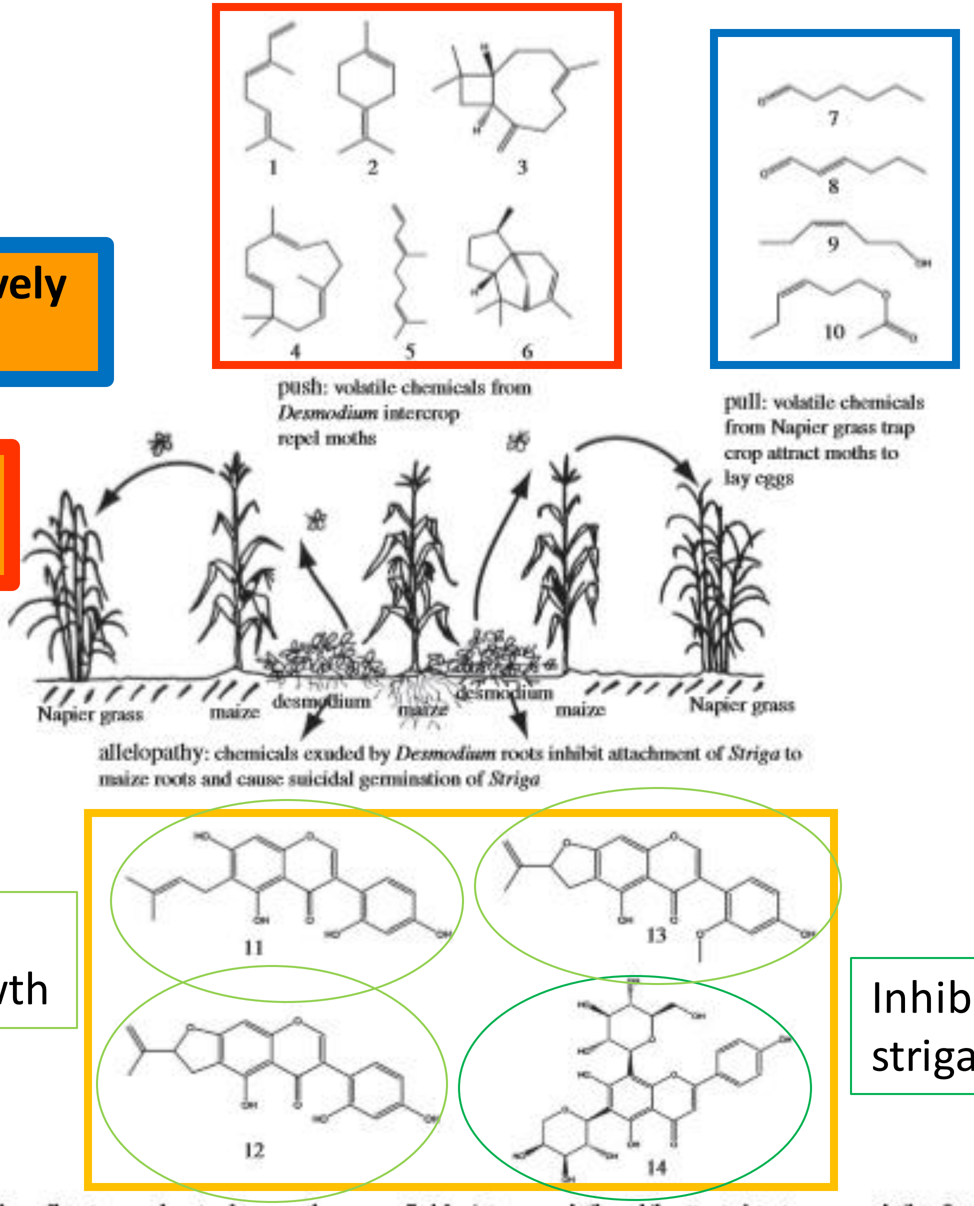
Chemical compounds



Volatile compounds released by trap plant positevely stimulating moth oviposition

Stemborer-repellent compounds emitted from desmodium/molasses, some of which also attractive for parasitoid

Allelopathic root exudates released by desmodium in the soil promoting striga 'suicidal germination'



promoting striga growth

Inhibiting striga growth

Figure 1. How the push–pull system works: stemborer moths are repelled by intercrop volatiles while attracted to trap crop volatiles. Root exudates from the desmodium intercrop cause suicidal germination of striga and inhibits attachment to maize roots. 1, (*E*)-β-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) and 14, di-*C*-glycosylflavone 6-*C*-α-L-arabinopyranosyl-8-*C*-β-D-glucopyranosylapigenin. Adapted with permission from Khan *et al.* [59]

ROTHAMSTED RESEARCH

Push-pull field

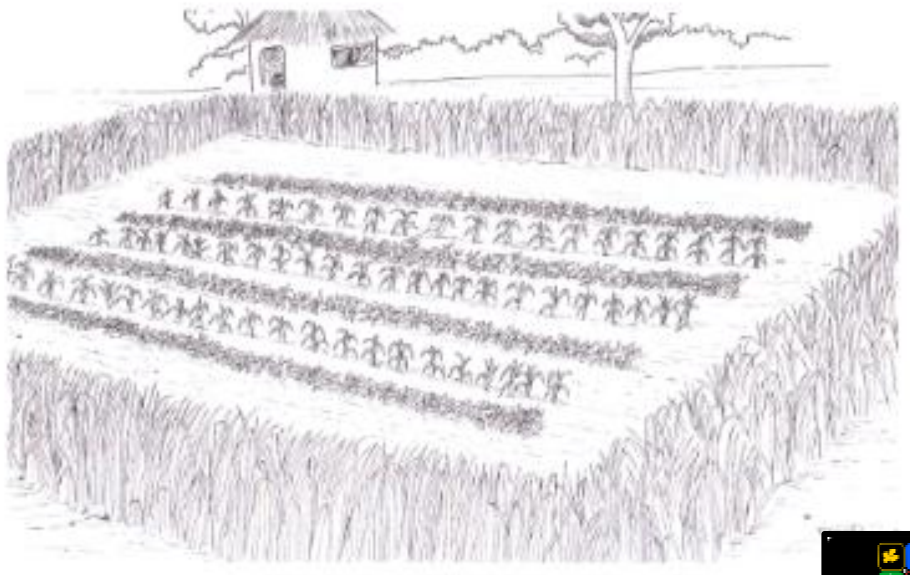


Diagram of a planted push-pull field

Push-pull experimental field at Thomas Odhiambo research campus

The technology to be very effective in experimental plots… it was now time to test it out in the field

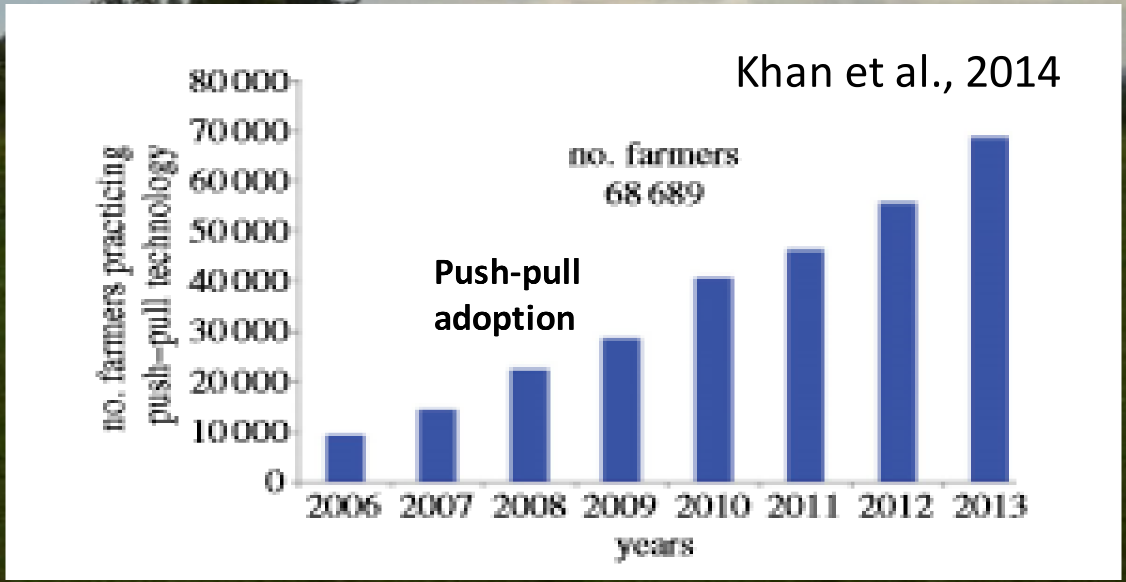
1997 *Baraza*

Push-pull team invited farmers who had field in the proximity of Mbita (Suba district) at ICIPE centre to show the technology for a *baraza* (swahili word for public meeting)

At the beginning it was not easy to convince farmers to leave traditional methods to try the new one. But many had their fields really devasted by the pests, and thus some of them accepted the challenge

Since then many other meetings and field demonstration had been organised, farmer field school were put in place and farmer teachers were trained

But largely push-pull spreading was also promoted by farmers who were positively impressed by its relevant impact



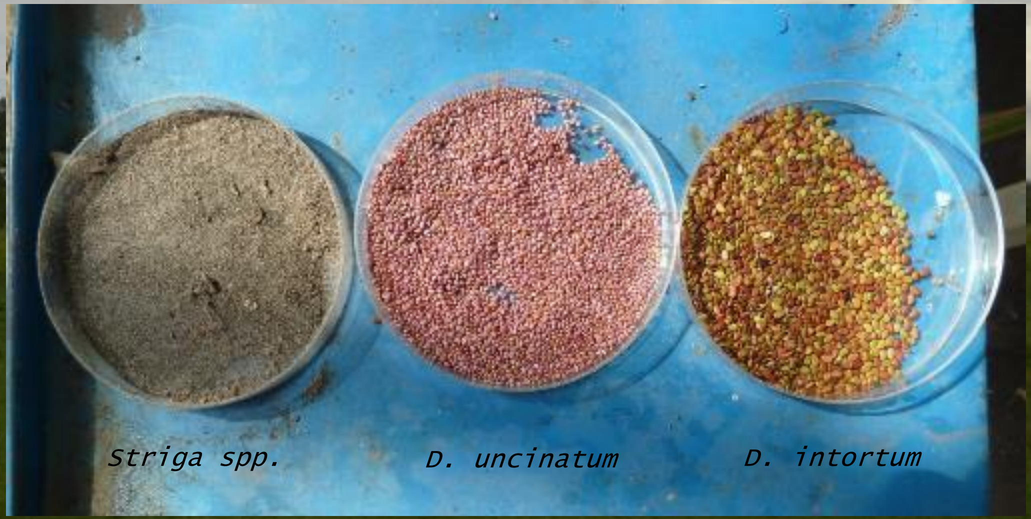
68’000 farmers switched to push-pull (Khan et al., 2014)

With an estimate adoption rate of 30%/year

Push-pull continues to grow…

The technology presented at the first *baraza* was a great success, a big goal was achieved with an extremely significant positive impact on small-holder farmers everyday life!

But push-pull story didn't stop here…
research went further, and still is progressing!



Napier Stunt Disease

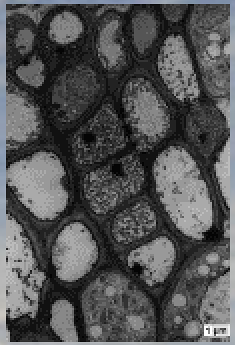
In nineties a novel stunting disease started to affect Napier in East Africa

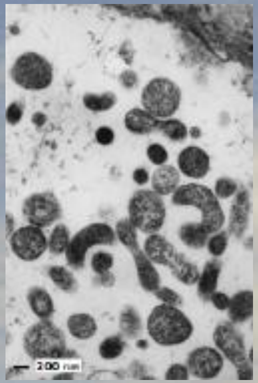
Its impact was heavy on rural farming: by 2008 milk productionin western Kenya was reduced by 65%

Severe stunting and yellowing

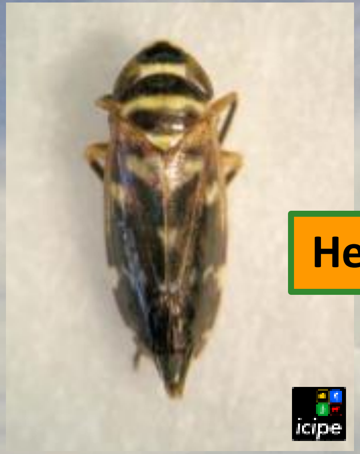
Profuse growth of shrivelled, unhealthy new plant shoots

In 2002 ICIPE's researchers recognised it as a phytoplasm (16Sr XI) disease. Then they focused on its transmission





20 common sap-sucking species were analysed as possible disease vector



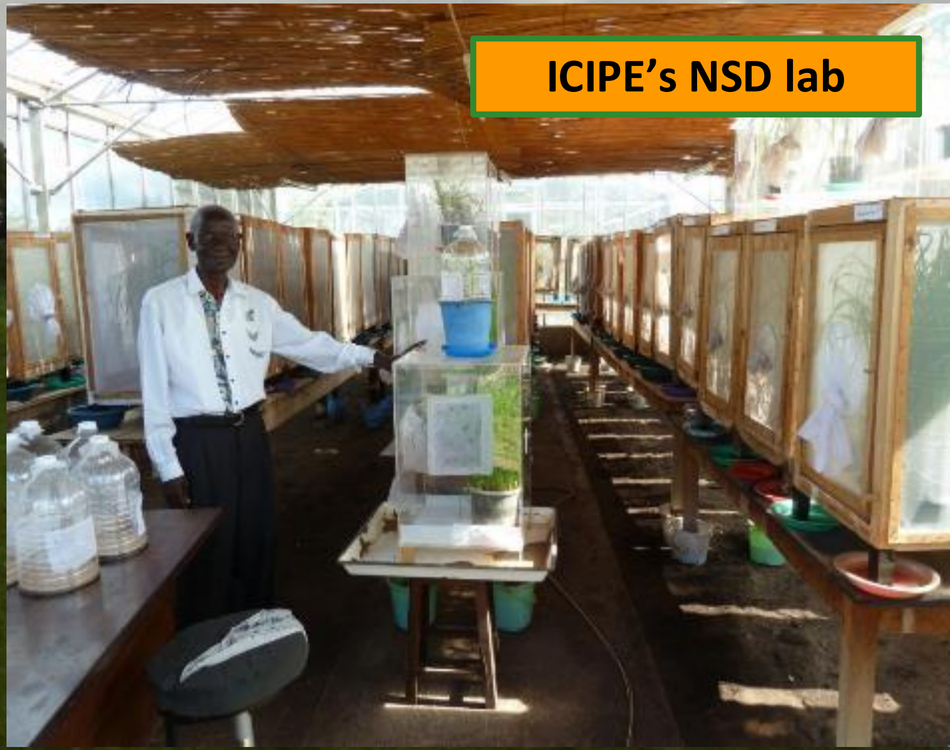
Maiestas banda

Hemiptera, Cicadellidae

With the aid of farmers hundreds of local varieties of Napier grass were run through

Among them two varieties susceptible to vector but enough resistant to the disease were finally found

ICIPE's NSD lab



Moth lab

At ICIPE's campus there's also a whole compund completely dedicated to borers.

Here moths are continously breeded and all life stages are disposable for any experiment or any purpose

Principally larva feeding behaviour, alimentary preferences and aversions are investigated.

Shelves are plenty of 'growth pots' where larva fed on specifically composed diets

The need for seed

With Push-pull increasing adoption the demand for desmodium seeds rose too

Desmodium seeds were imported by KSC (Kenya Seed Company) from Australia. For this reason supply was limited and prices high

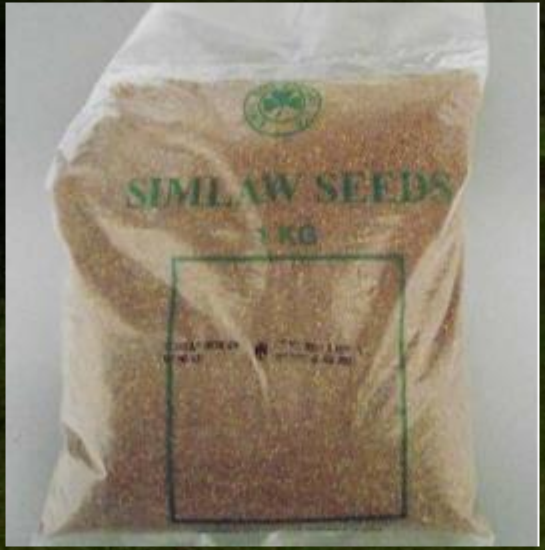
To respond this challenge in 2003 ICIPE in collaboration with KALRO (Kenya Agriculture and Livestock Research Organisation) and launched a farmer-based seed multiplication project

Desmodium vegetative propagation

Farmers were trained how to collect and properly store the seeds saving them for the following season and for selling

From 2004 kenyan seed companies started to contract some of the farmers involved in seed production. By 2011 1500 of them were under contract

So now desmodium seed production is an important additional source of income



Silver-leaf desmodium

Climate smart Push-pull

Meeting farmer reports and needs against climate change

In many areas, rain was scarce or scattered and often Napier grass and silver-leaf desmodium severely suffered drought leading to a decrease in efficiency of push-pull in those conditions

For this reason ICIPE's push-pull team got back to search for new *climate-smart* species to intercrop…

…and finally they found them!

Drought-tolerant trap plant

ICIPE's researchers tested over 500 putative trap plants

Finally they found a cultivar obtained by three generations of hybridization between *Brachiaria ruziziensis* and *B. decumbens* cv Basilisk (Poaceae) at CIAT

Centro Internacional de Agricultura Tropical
Desde 1967 Ciencia para cultivar el cambio

Attractive for borers but at the same time capable to recruit their parasitoid wasps

Cotesia flavipes

Cotesia sesamiae

Braconidae, larva parasitoid

Trichogrammatidae, egg parasitoid

Trichogramma bournieri

Brachiaria cv Mulato II

Able to tolerate long droughts: even three months without water at 30°C (Khan, 2013 - unpub. data)

Preferred to maize and sorghum for oviposition

And also preferred by farmers as animal fodder since it is more unlikely to withers

Drought-tolerant repellent plant

43 successions of 17 Desmodium species investigated

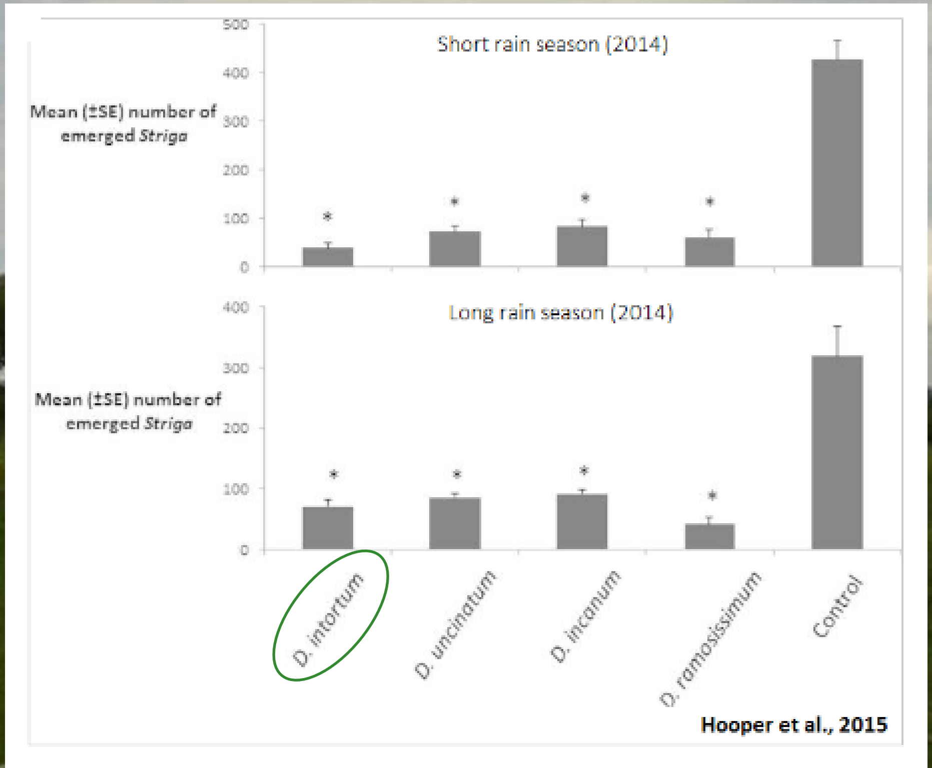
Green-leaf desmodium, Fabaceae

Desmodium intortum

As silver-leaf, highly energetic fodder

Able to withstand drought conditions and less subsceptible to wilt

Similar capability of repelling stemborers and inhibiting striga
(same chemical compounds)



Even better efficiency in nitrogen fixation

Climate smart diffusion

In 2012 Climate smart push-pull was introduced

Since then its growth and spreading has been increasingly risen

Adoption

Number of smallholder farmers who have adopted the Push-Pull technology in eastern Africa by June to December 2015, short rainy season.

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Push-pull effectiveness

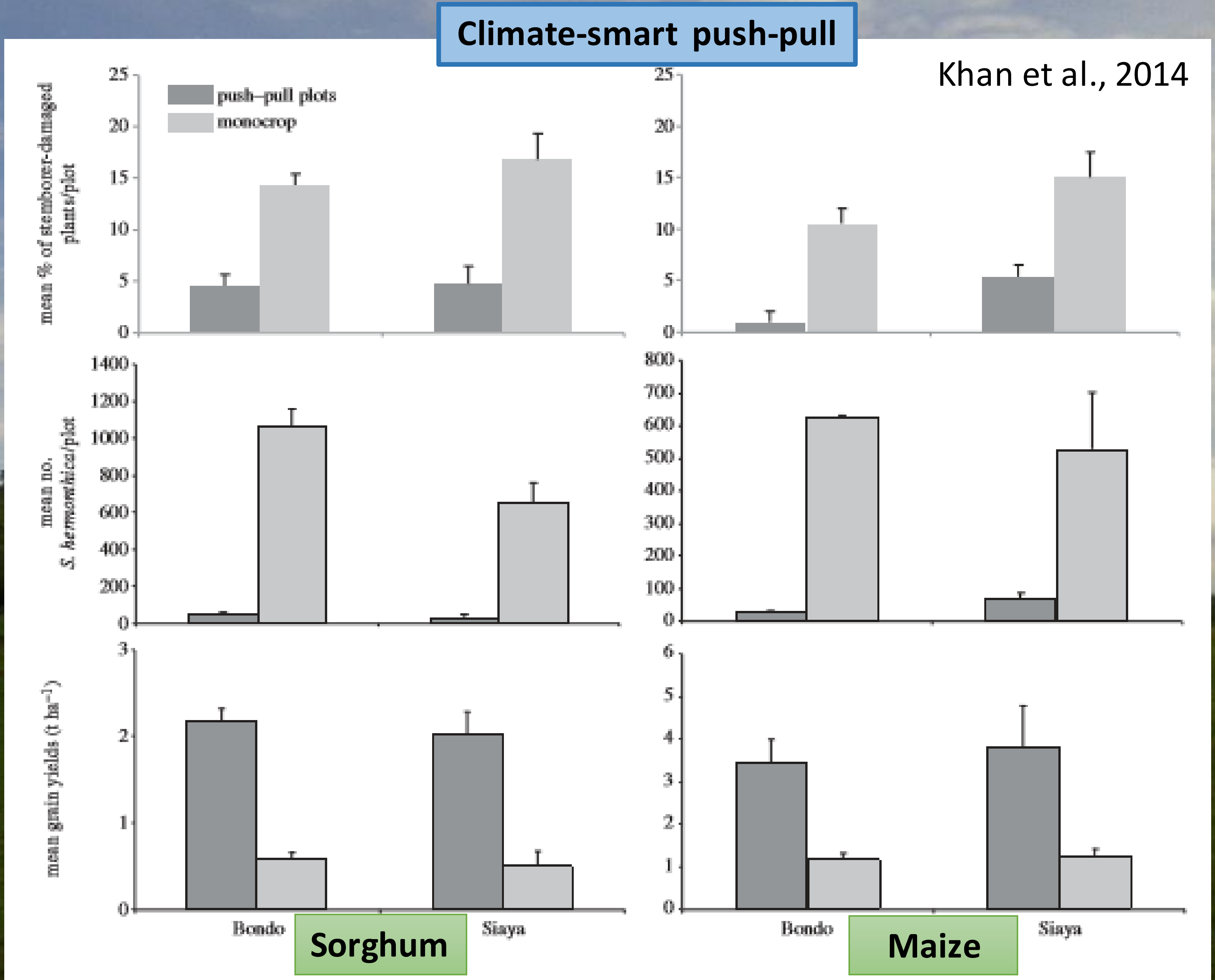
One stone to kill many birds!

Stemborer-damaged plant/crop (mean %)

Striga emerging/plot (mean number)

Grain yields (mean t/ha)

Typical production increase:
Maize from >1 t/ha to at least 3.5 t/ha
Sorghum from >1 t/ha to at least 2.5 t/ha
Even more than with chemical control!



Additional push-pull benefits

Livestock foraging

Soil improvement

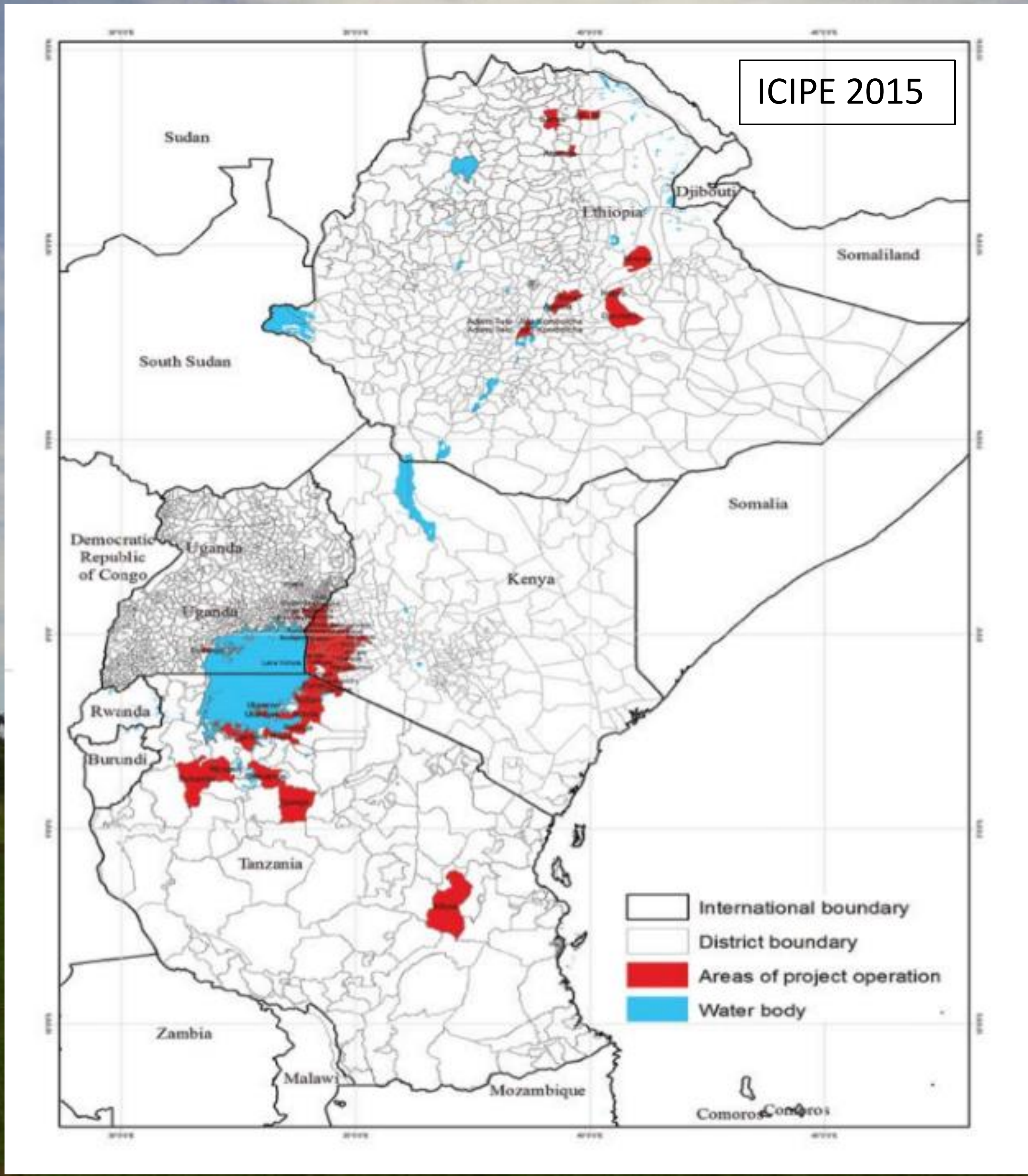
Organic manure

Farmer groups formation

Beyond boundaries

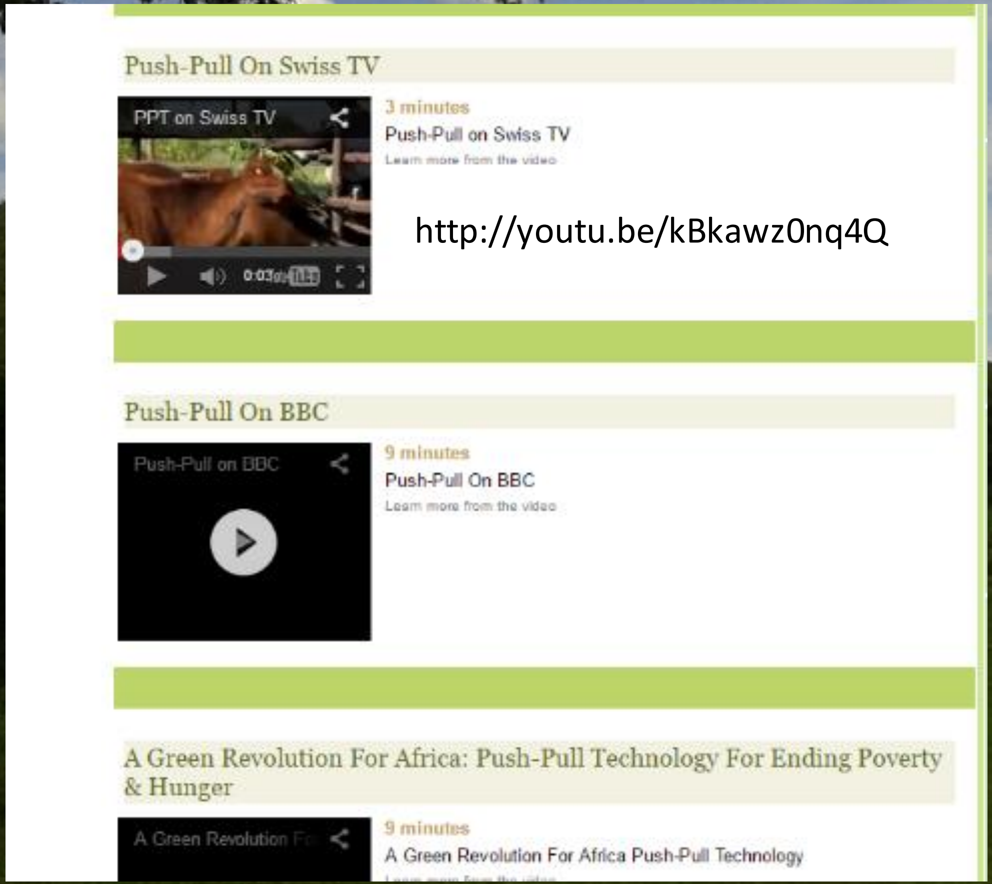
Push-pull technology has reached also Ethiopia, Uganda, Tanzania and recently Somaliland

Partnershisps and exchanges with local agricultural organisation and research centres has started



Communication

http://push-pull.net



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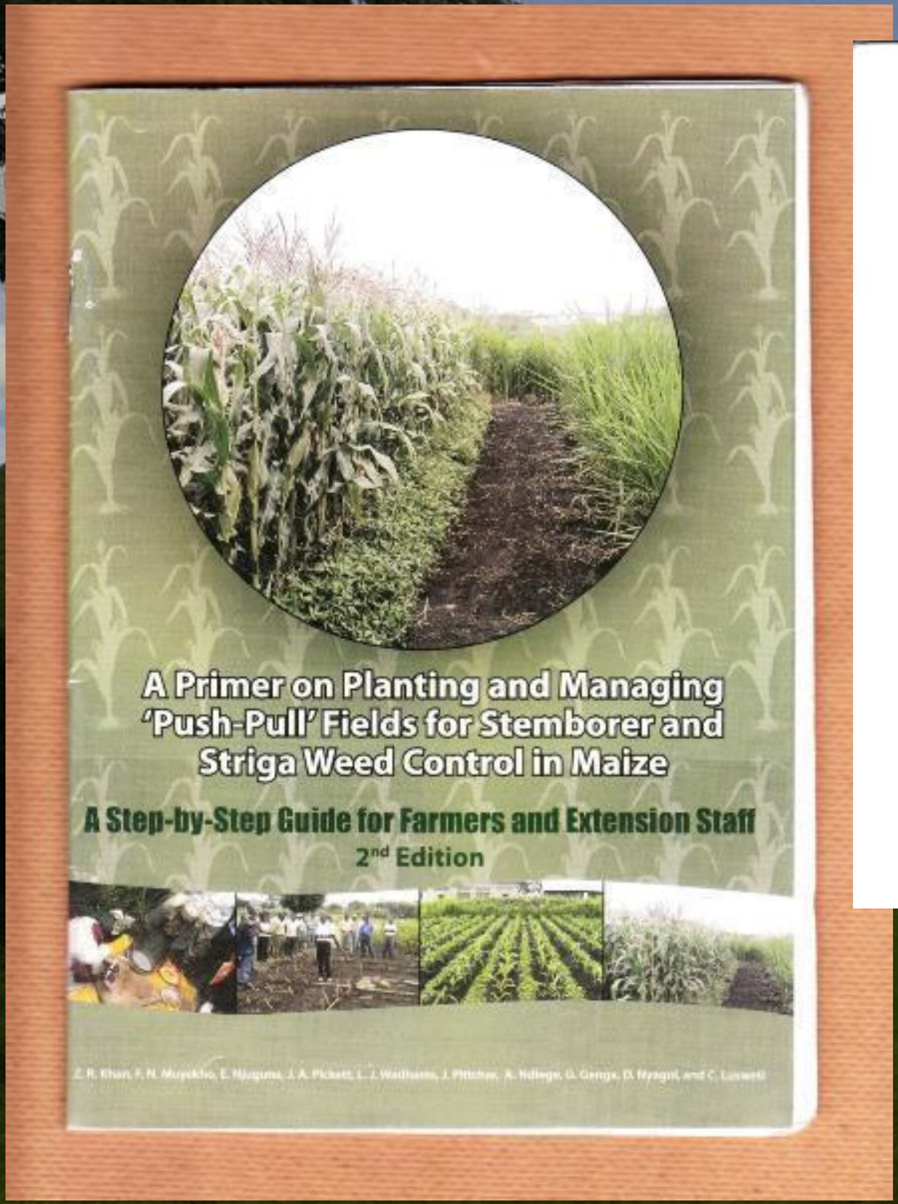
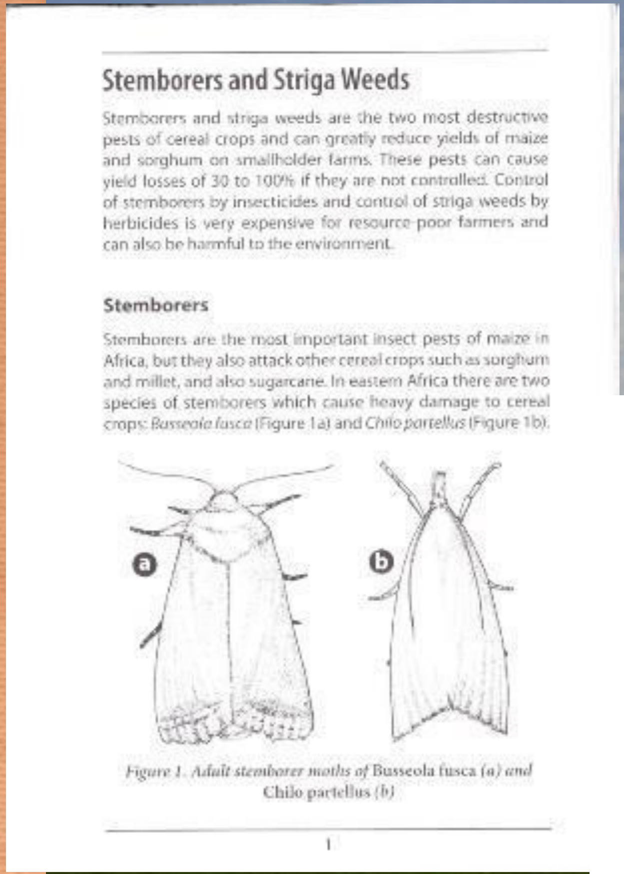
Farmer handbook





Stemborers and Striga Weeds

Stemborers and striga weeds are the two most destructive pests of cereal crops and can greatly reduce yields of maize and sorghum on smallholder farms. These pests can cause yield losses of 30 to 100% if they are not controlled. Control of stemborers by insecticides and control of striga weeds by herbicides is very expensive for resource-poor farmers and can also be harmful to the environment.

Stemborers

Stemborers are the most important insect pests of maize in Africa, but they also attack other cereal crops such as sorghum and millet, and also sugarcane. In eastern Africa there are two species of stemborers which cause heavy damage to cereal crops: *Busseola fusca* (Figure 1a) and *Chilo partellus* (Figure 1b).

Figure 1. Adult stemborer moths of Busseola fusca *(a) and* Chilo partellus *(b)*

1

On pests

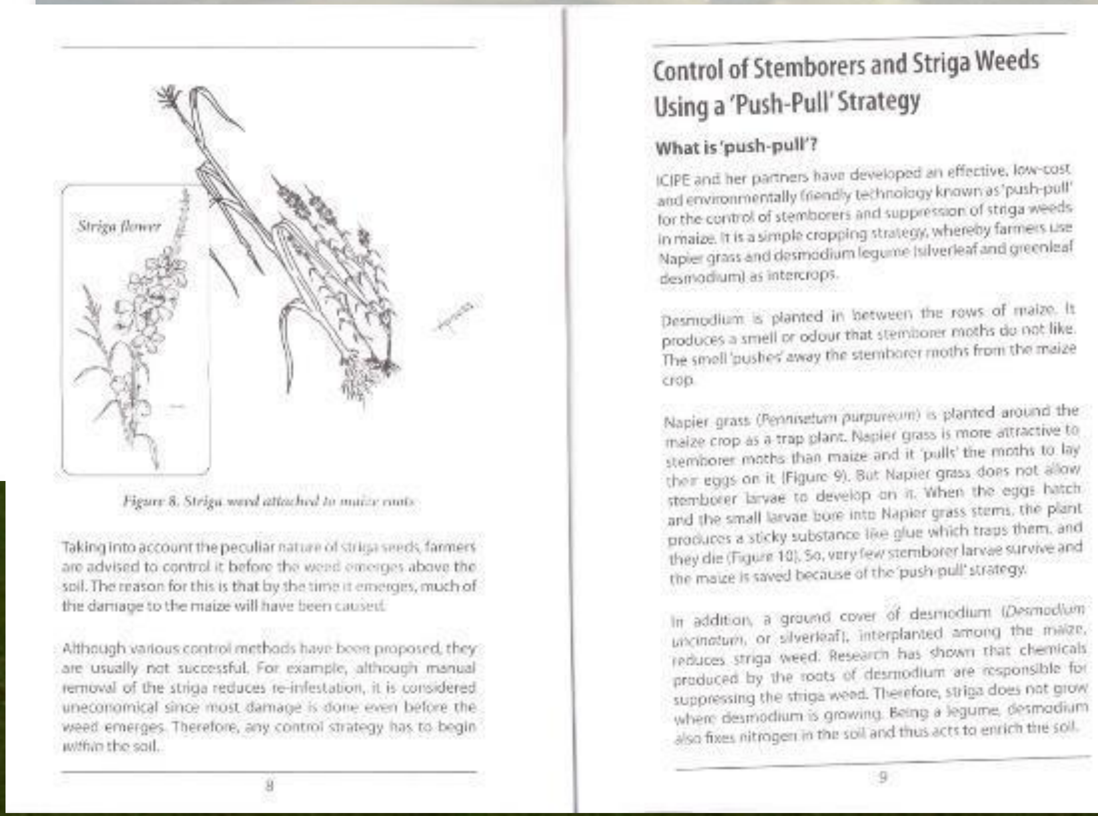


Figure 8. Striga weed attached to maize roots

Taking into account the peculiar nature of striga seeds, farmers are advised to control it before the weed emerges above the soil. The reason for this is that by the time it emerges, much of the damage to the maize will have been caused.

Although various control methods have been proposed, they are usually not successful. For example, although manual removal of the striga reduces re-infestation, it is considered uneconomical since most damage is done even before the weed emerges. Therefore, any control strategy has to begin within the soil.

8

Control of Stemborers and Striga Weeds Using a 'Push-Pull' Strategy

What is 'push-pull'?

ICIPE and her partners have developed an effective, low-cost and environmentally friendly technology known as 'push-pull' for the control of stemborers and suppression of striga weeds in maize. It is a simple cropping strategy, whereby farmers use Napier grass and desmodium legume (silverleaf and greenleaf desmodium) as intercrops.

Desmodium is planted in between the rows of maize. It produces a smell or odour that stemborer moths do not like. The smell 'pushes' away the stemborer moths from the maize crop.

Napier grass (*Pennisetum purpureum*) is planted around the maize crop as a trap plant. Napier grass is more attractive to stemborer moths than maize and it 'pulls' the moths to lay their eggs on it (Figure 9). But Napier grass does not allow stemborer larvae to develop on it. When the eggs hatch and the small larvae bore into Napier grass stems, the plant produces a sticky substance like glue which traps them, and they die (Figure 10). So, very few stemborer larvae survive and the maize is saved because of the 'push-pull' strategy.

In addition, a ground cover of desmodium (*Desmodium uncinatum*, or silverleaf), interplanted among the maize, reduces striga weed. Research has shown that chemicals produced by the roots of desmodium are responsible for suppressing the striga weed. Therefore, striga does not grow where desmodium is growing. Being a legume, desmodium also fixes nitrogen in the soil and thus acts to enrich the soil.

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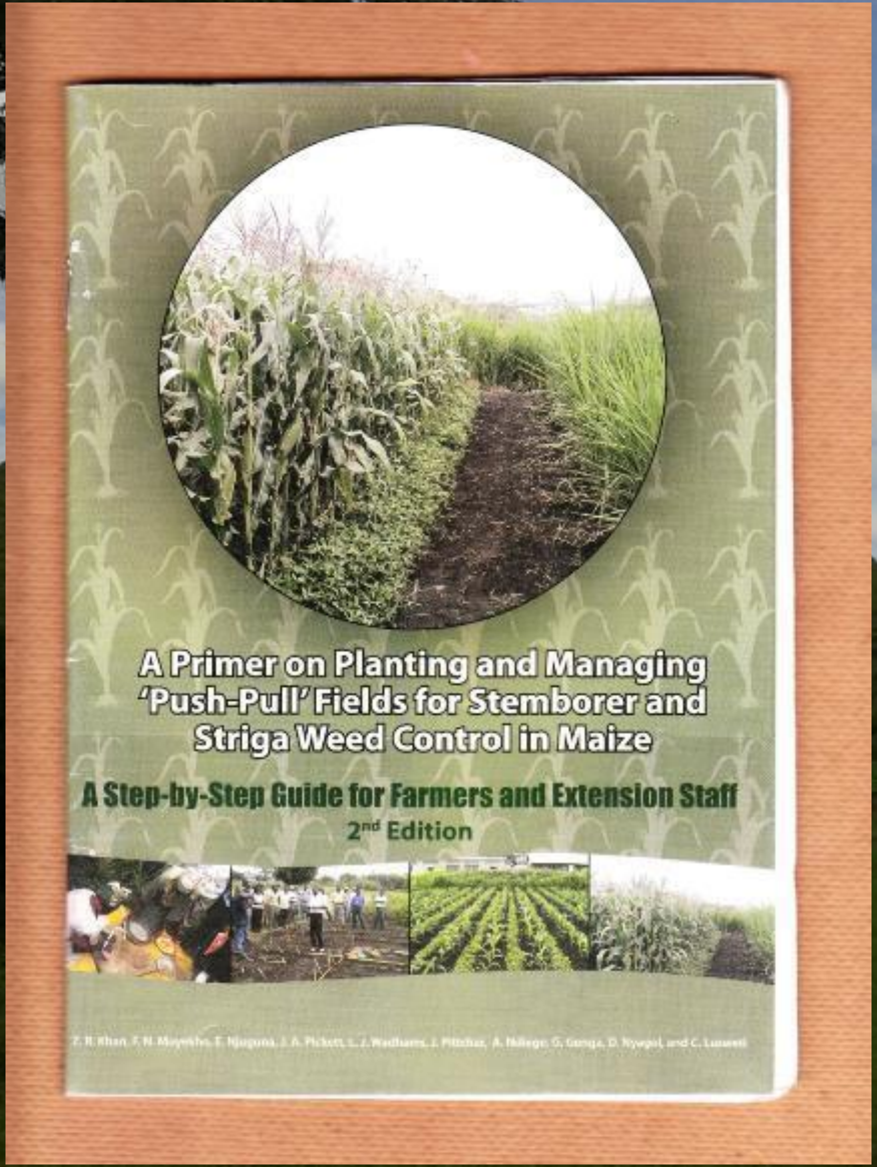
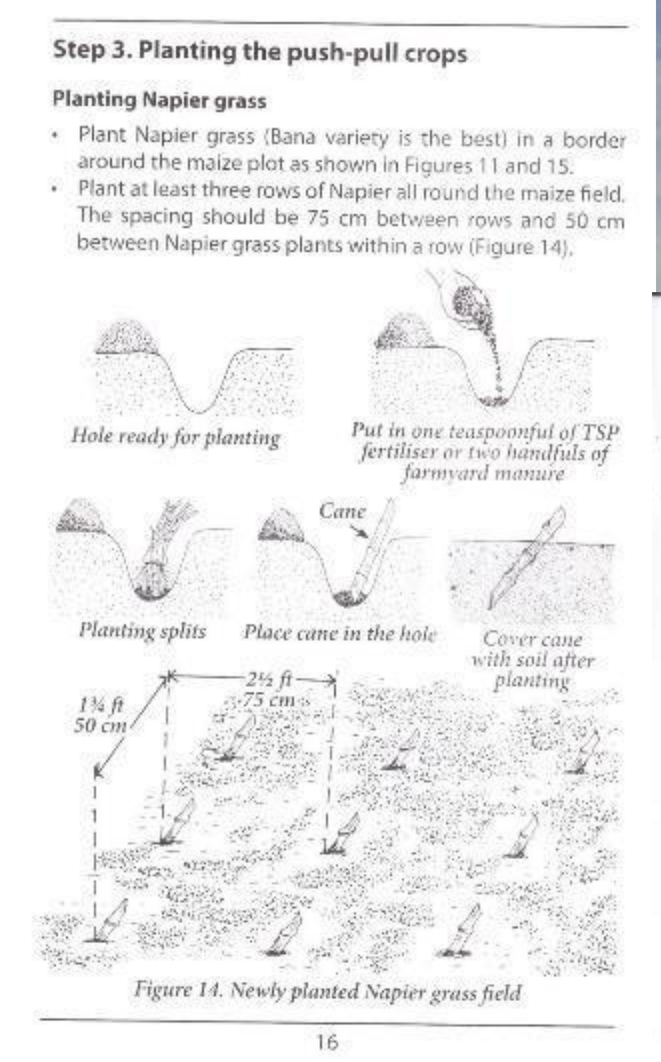
Farmer handbook





Step 3. Planting the push-pull crops

Planting Napier grass

- Plant Napier grass (Bana variety is the best) in a border around the maize plot as shown in Figures 11 and 15.
- Plant at least three rows of Napier all round the maize field. The spacing should be 75 cm between rows and 50 cm between Napier grass plants within a row (Figure 14).

Figure 14. Newly planted Napier grass field

16

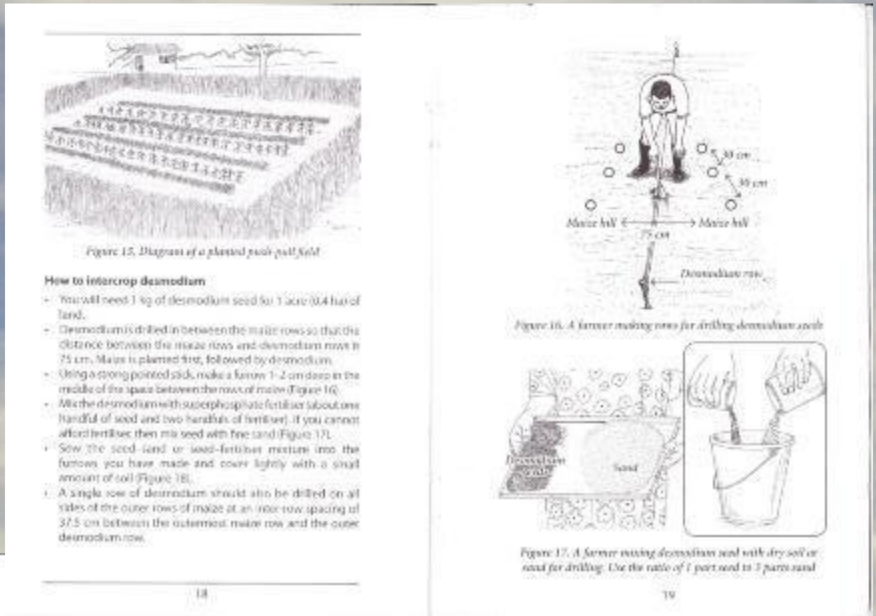


Figure 15. Diagram of a planted push-pull field

How to intercrop desmodium

- You will need 1 kg of desmodium seed for 1 acre (0.4 ha) of land.
- Desmodium is drilled in between the maize rows so that the distance between the maize rows and desmodium rows is 75 cm. Maize is planted first, followed by desmodium.
- Using a strong pointed stick, make a furrow 1-2 cm deep in the middle of the space between the rows of maize (Figure 16).
- Mix the desmodium with superphosphate fertiliser (about one handful of seed and two handfuls of fertiliser). If you cannot afford fertiliser then mix seed with fine sand (Figure 17).
- Sow the seed-sand or seed-fertiliser mixture into the furrows you have made and cover lightly with a small amount of soil (Figure 18).
- A single row of desmodium should also be drilled on all sides of the outer rows of maize at an inter-row spacing of 37.5 cm between the outermost maize row and the outer desmodium row.

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Figure 16. A farmer making rows for drilling desmodium seeds

Figure 17. A farmer mixing desmodium seed with dry soil or sand for drilling. Use the ratio of 1 part seed to 3 parts sand

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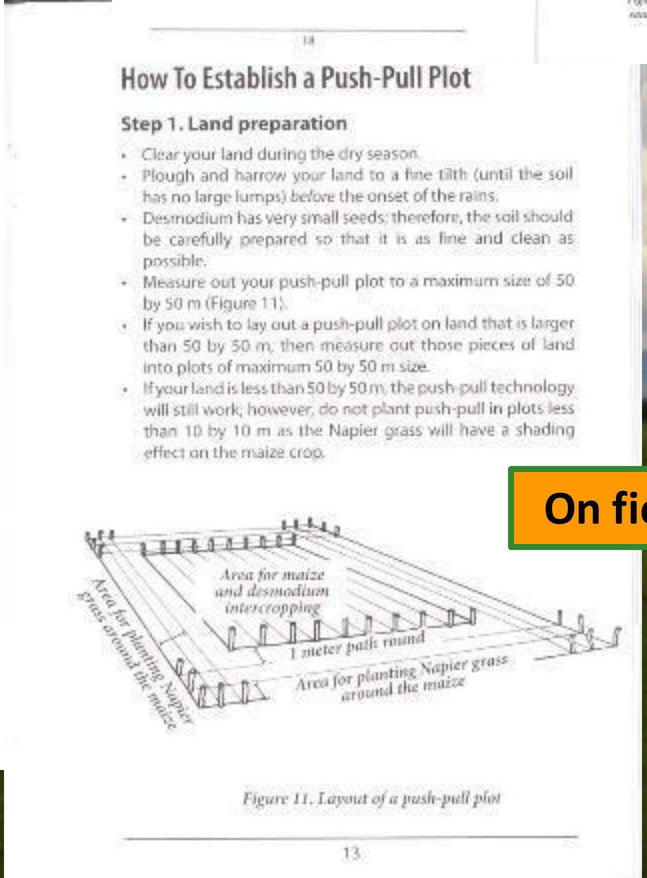

How To Establish a Push-Pull Plot

Step 1. Land preparation

- Clear your land during the dry season.
- Plough and harrow your land to a fine tilth (until the soil has no large lumps) *before* the onset of the rains.
- Desmodium has very small seeds; therefore, the soil should be carefully prepared so that it is as fine and clean as possible.
- Measure out your push-pull plot to a maximum size of 50 by 50 m (Figure 11).
- If you wish to lay out a push-pull plot on land that is larger than 50 by 50 m, then measure out those pieces of land into plots of maximum 50 by 50 m size.
- If your land is less than 50 by 50 m, the push-pull technology will still work; however, do not plant push-pull in plots less than 10 by 10 m as the Napier grass will have a shading effect on the maize crop.

Figure 11. Layout of a push-pull plot

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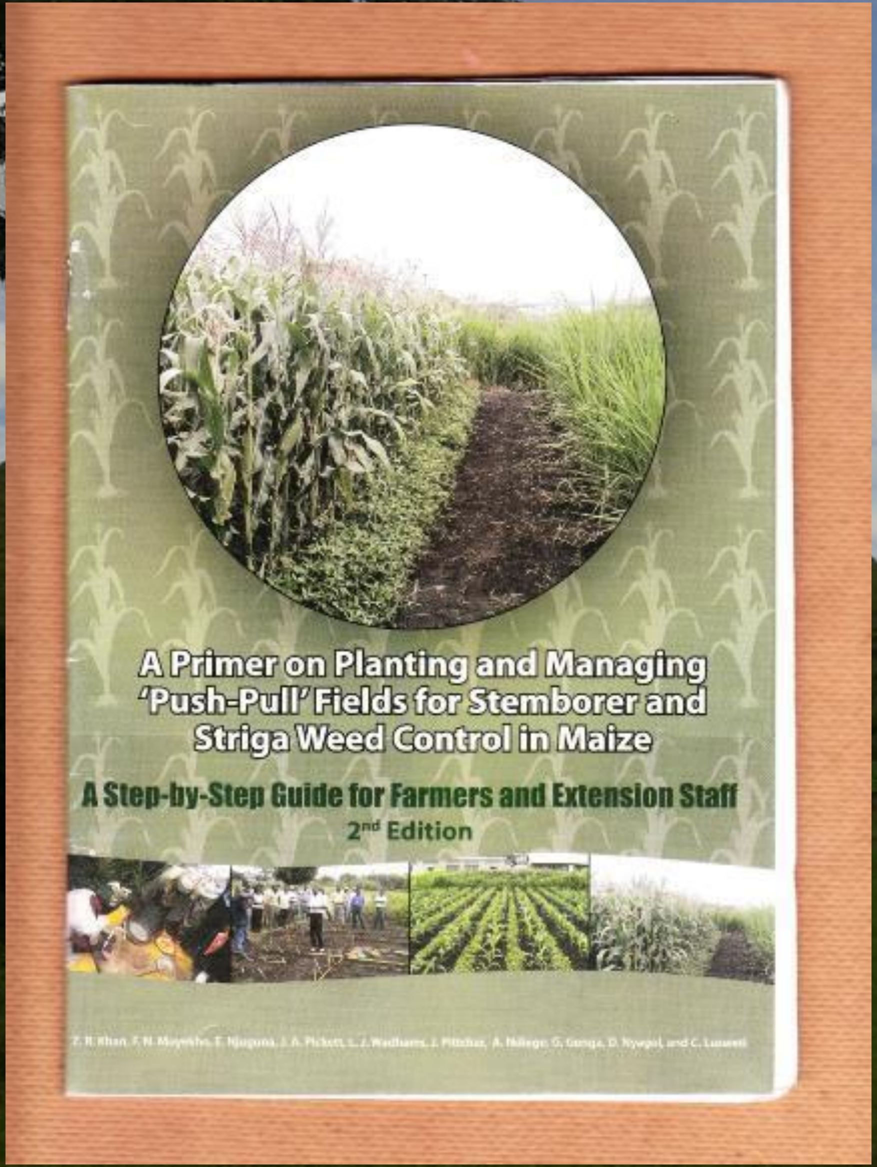
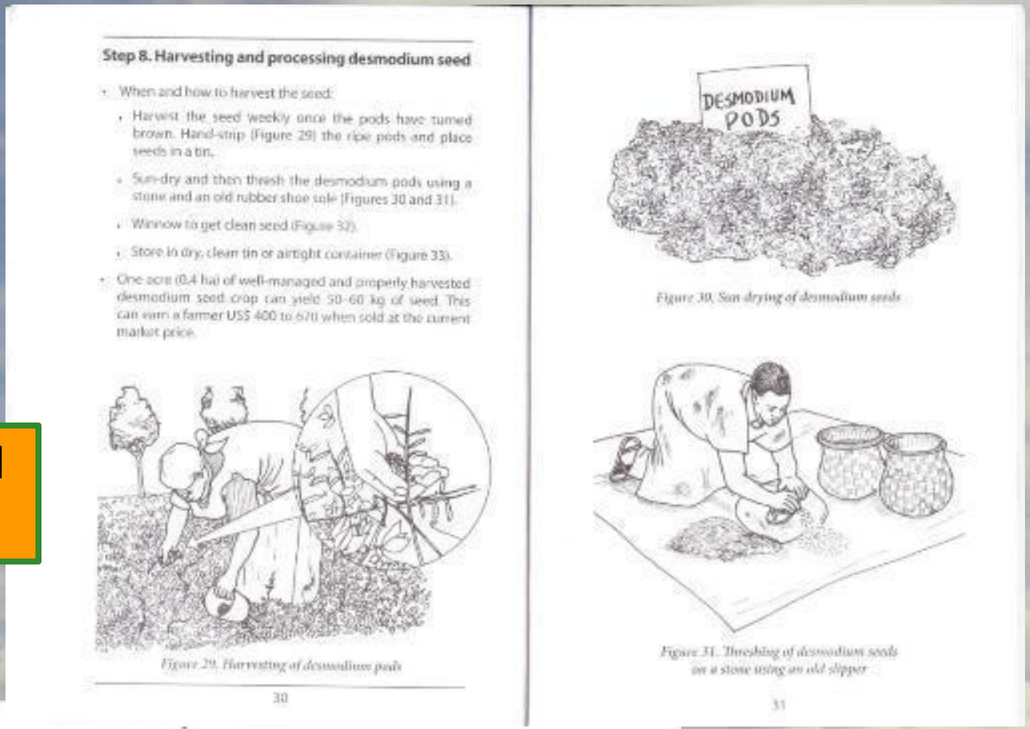
On field preparation

Farmer handbook



Seed harvesting and storing



Step 8. Harvesting and processing desmodium seed

- When and how to harvest the seed:
  - Harvest the seed weekly once the pods have turned brown. Hand-strip (Figure 29) the ripe pods and place seeds in a tin.
  - Sun-dry and then thresh the desmodium pods using a stone and an old rubber shoe sole (Figures 30 and 31).
  - Winnow to get clean seed (Figure 32).
  - Store in dry, clean tin or airtight container (Figure 33).
- One acre (0.4 ha) of well-managed and properly harvested desmodium seed crop can yield 50-60 kg of seed. This can earn a farmer US$ 400 to 670 when sold at the current market price.

Figure 29. Harvesting of desmodium pods

30

DESMODIUM PODS

Figure 30. Sun drying of desmodium seeds

Figure 31. Threshing of desmodium seeds on a stone using an old slipper

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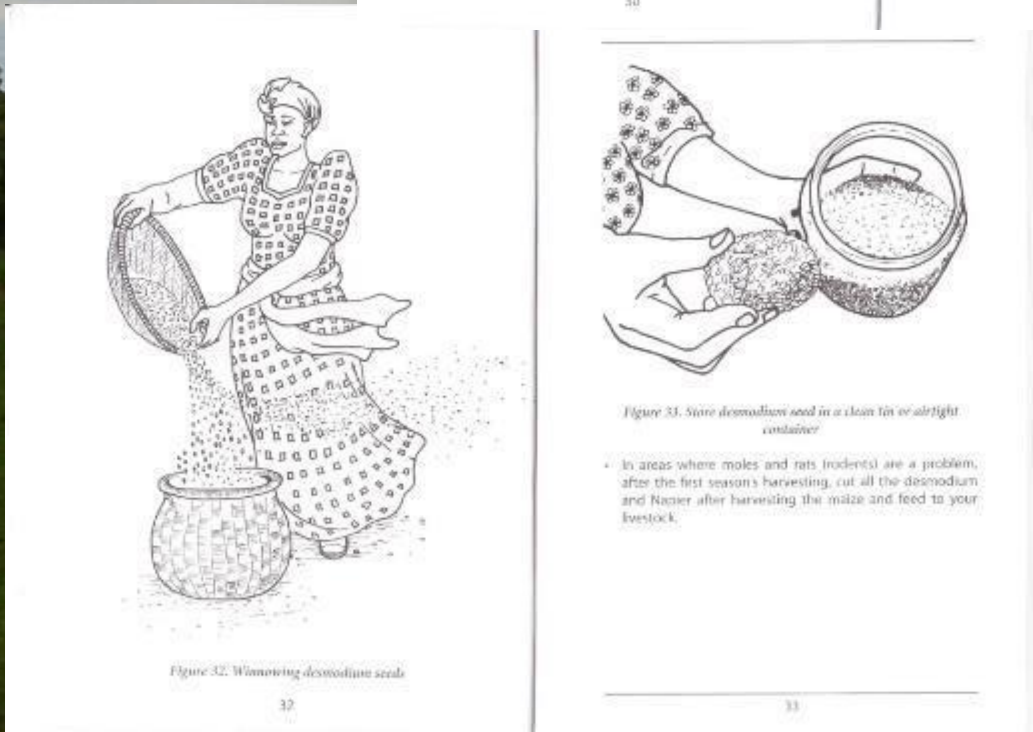

Figure 32. Winnowing desmodium seeds

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Figure 33. Store desmodium seed in a clean tin or airtight container

- In areas where moles and rats (rodents) are a problem, after the first season's harvesting, cut all the desmodium and Napier after harvesting the maize and feed to your livestock.

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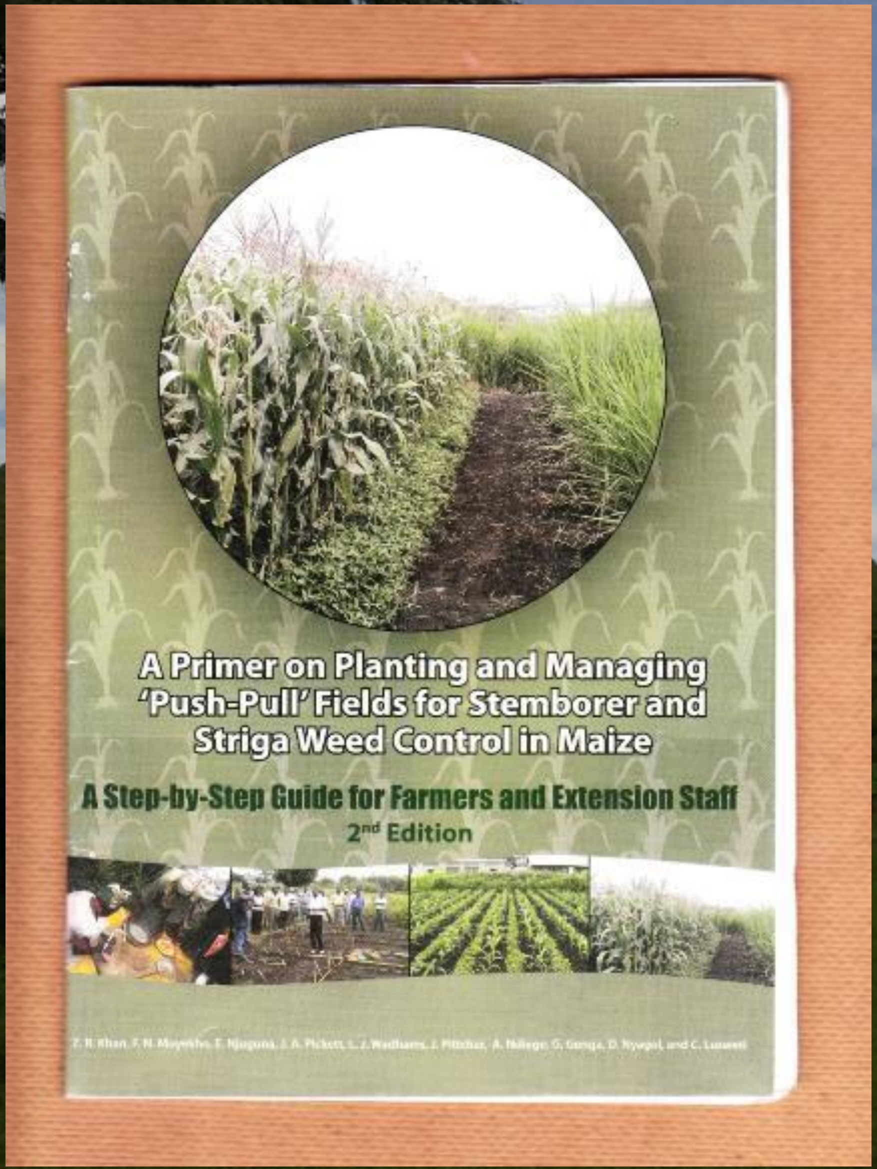
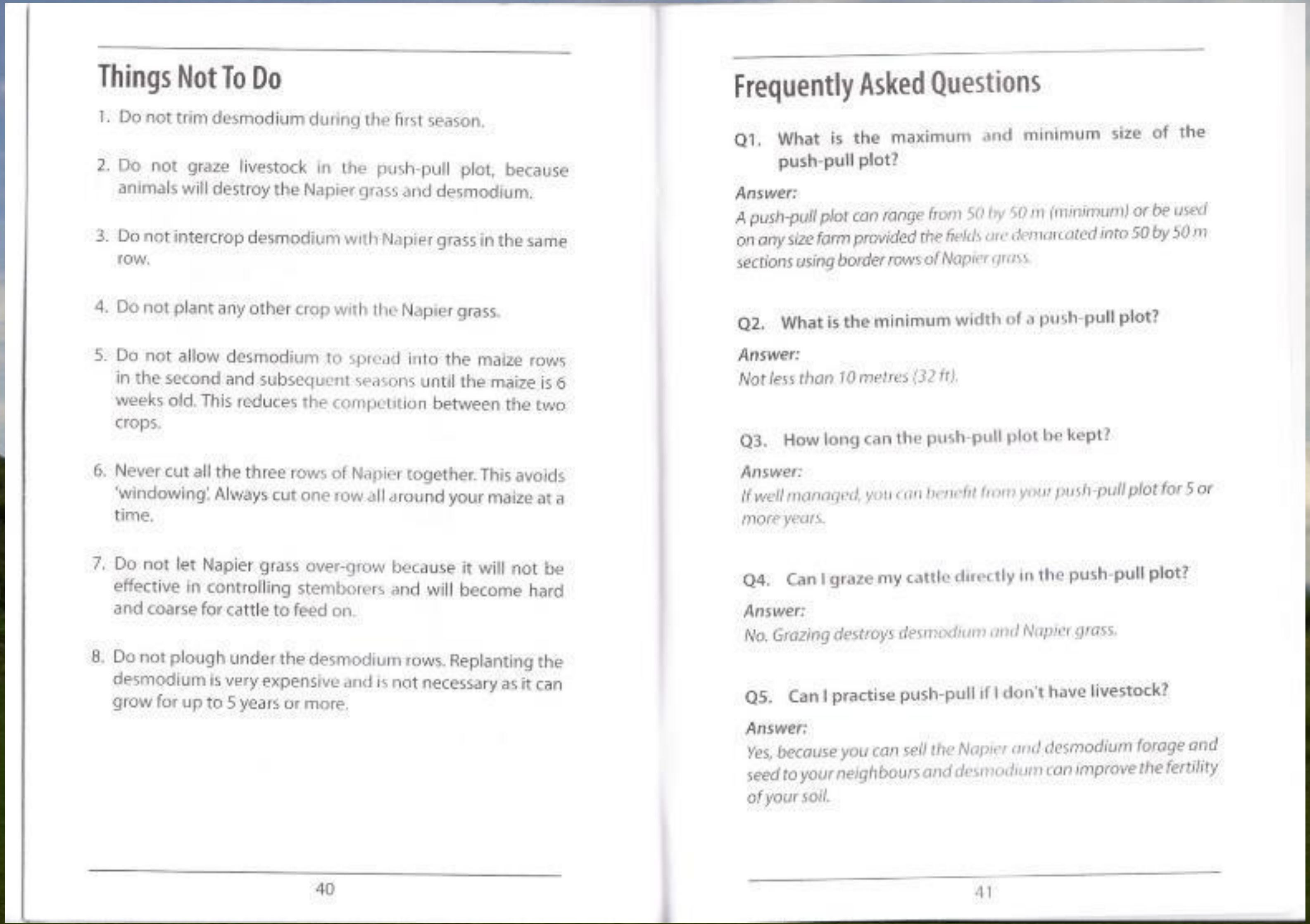
Farmer handbook

Hints and unfailing FAQs!





Things Not To Do

1. Do not trim desmodium during the first season.
2. Do not graze livestock in the push-pull plot, because animals will destroy the Napier grass and desmodium.
3. Do not intercrop desmodium with Napier grass in the same row.
4. Do not plant any other crop with the Napier grass.
5. Do not allow desmodium to spread into the maize rows in the second and subsequent seasons until the maize is 6 weeks old. This reduces the competition between the two crops.
6. Never cut all the three rows of Napier together. This avoids 'windowing'. Always cut one row all around your maize at a time.
7. Do not let Napier grass over-grow because it will not be effective in controlling stemborers and will become hard and coarse for cattle to feed on.
8. Do not plough under the desmodium rows. Replanting the desmodium is very expensive and is not necessary as it can grow for up to 5 years or more.

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Frequently Asked Questions

Q1. What is the maximum and minimum size of the push-pull plot?

Answer:
A push-pull plot can range from 50 by 50 m (minimum) or be used on any size farm provided the fields are demarcated into 50 by 50 m sections using border rows of Napier grass.

Q2. What is the minimum width of a push-pull plot?

Answer:
Not less than 10 metres (32 ft).

Q3. How long can the push-pull plot be kept?

Answer:
If well managed, you can benefit from your push-pull plot for 5 or more years.

Q4. Can I graze my cattle directly in the push-pull plot?

Answer:
No. Grazing destroys desmodium and Napier grass.

Q5. Can I practise push-pull if I don't have livestock?

Answer:
Yes, because you can sell the Napier and desmodium forage and seed to your neighbours and desmodium can improve the fertility of your soil.

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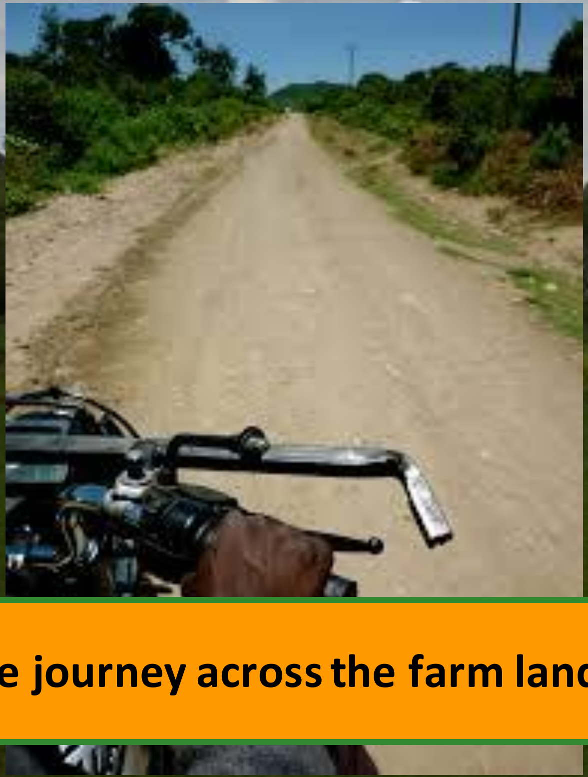
From farmers' perspective

As my friend Aloice Ndiege, ICIPE technician, told me «Ok, now you got how it works. And there's plenty of material where you can read about to deepen into the study, if you want to.
But, if you really want to understand it, you have to see it. You have to talk to the farmers.
Come to see it!»



And so the journey across the farm lands started…

Mary Onyango

Kamsama

With her husband part of group of farmers, *Umbrella A*, counting 22 women and 8 men.
The group born around push-pull

She started in 2009 with classical push-pull, the she switched to climate-smart in 2012, when this was avilable

30-centimetres suspended little stable to easely retrieve manure

Highly energetic manure is utilised to fertilise her field, thus completing the cycle

Before adoption:

- Her 21x21 metres highly pest-infested field used to produce 4 kg of maize per season
- Her only dairy goat, with low energetic forage supply, produced 1 litre of milk per day

After adoption:

- 1 bag (90kg) per harvesting
- 5 litres of milk per day

Colette

Ogongo

Joined push-pull after seeing its results on her husband and her brother-in-law fields

Before push-pull adoption:

- Her 21x21 metres highly pest-infested field used to produce 4 kg of maize per season
- Shortage of forage for their few bulls

After push-pull adoption:

- Her 21x21 metres highly pest-infested field used to produce 180 kg of maize per season
- Now bulls are properly fed!

They solved most of drought-related problems after switching to climate-smart

Samuel

He came into push-pull on a farmer meeting in 1999 and then in 2000 decided to experiment it on a little 10x10 m trial maize field

Godjope area, 'Buffalos' mountain'

Results were so impressive he adopted it following year on a 30x30 m field. Then extended it to 30x60 m the subsequent season

His maize crop now is really efficient, where there was nothing to do before and all his efforts were in vain.

He also has some poultry, few dairy goats, a cow and a calve feeding on green-leaf desmodium and *Brachiaria* harvesting and uses to save a part of storing it for the harsh season. And extras are sold at the local market

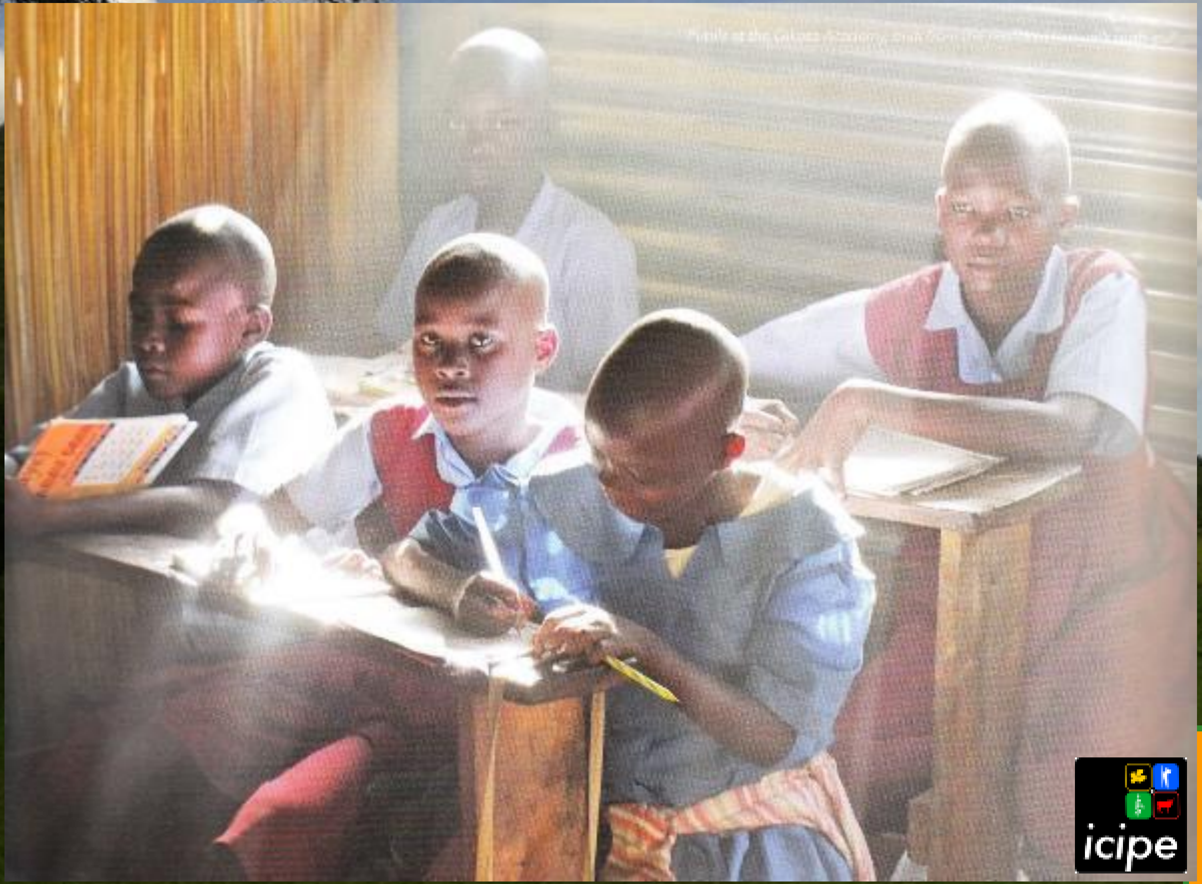
He has a system too to collect his animal droppings and produce fertilising compost

He was also able to vegetatively propagate desmodium and *Brachiaria* from iniatial plants splits thus avoiding new investments for seeds acquisition

School… from push-pull!

With some of the income from maize and fodder surplus sold Samuel built besides his fields a little school academy for primary education. Here more than 200 orphanes are provided a chance of an education

Samuel is now a farmer teacher and is actively collaborating in spreading the push-pull. He also promotes reviving traditional farming techniques trying to refine them with the new findings too.



Samuel also uses to host farmers interested in push-pull learning in his house and show them how to deal with it in his old little 10x10 push-pull trial plot, converted now to teaching field

Johnson

Back to Kamsama

Johnson Ngige Min Arot Village, Suba District, Kenya

"Ever since I started practicing Push-Pull technology and seasons passed by, my situation started to improve. The problem of Striga infestation drastically reduced and this led to more improved land fertility as can be seen from better yields of maize that I harvested afterwards. I could now realize surplus maize yields and even have some to sell in the local market".

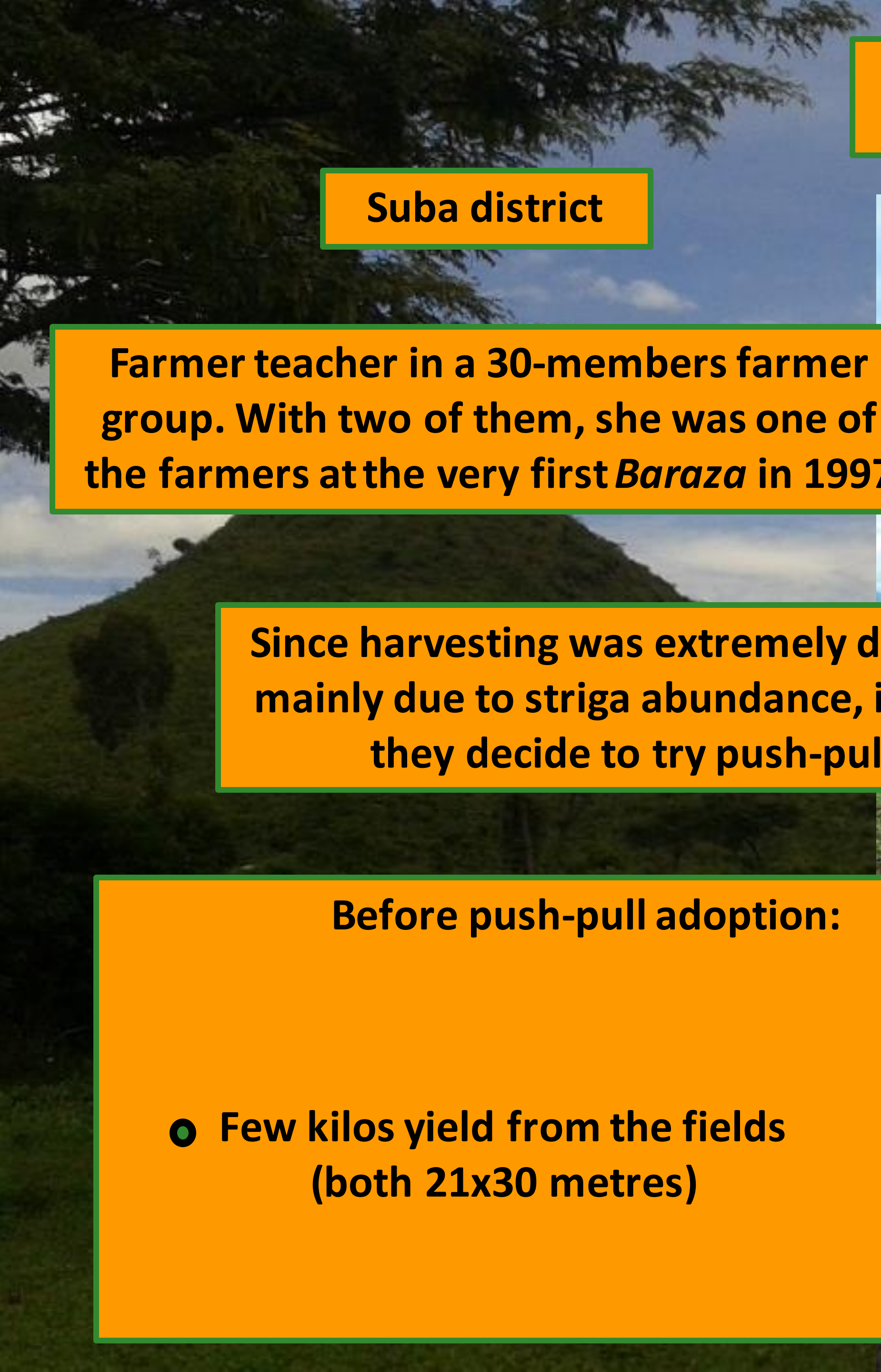
He joined push-pull in 2000 and he's now one of the elder and most experienced push-pull farmers of the Wapa farmer group.
He's a farmer teacher too and the passion he shows passion when he talk about push-pull is amazing

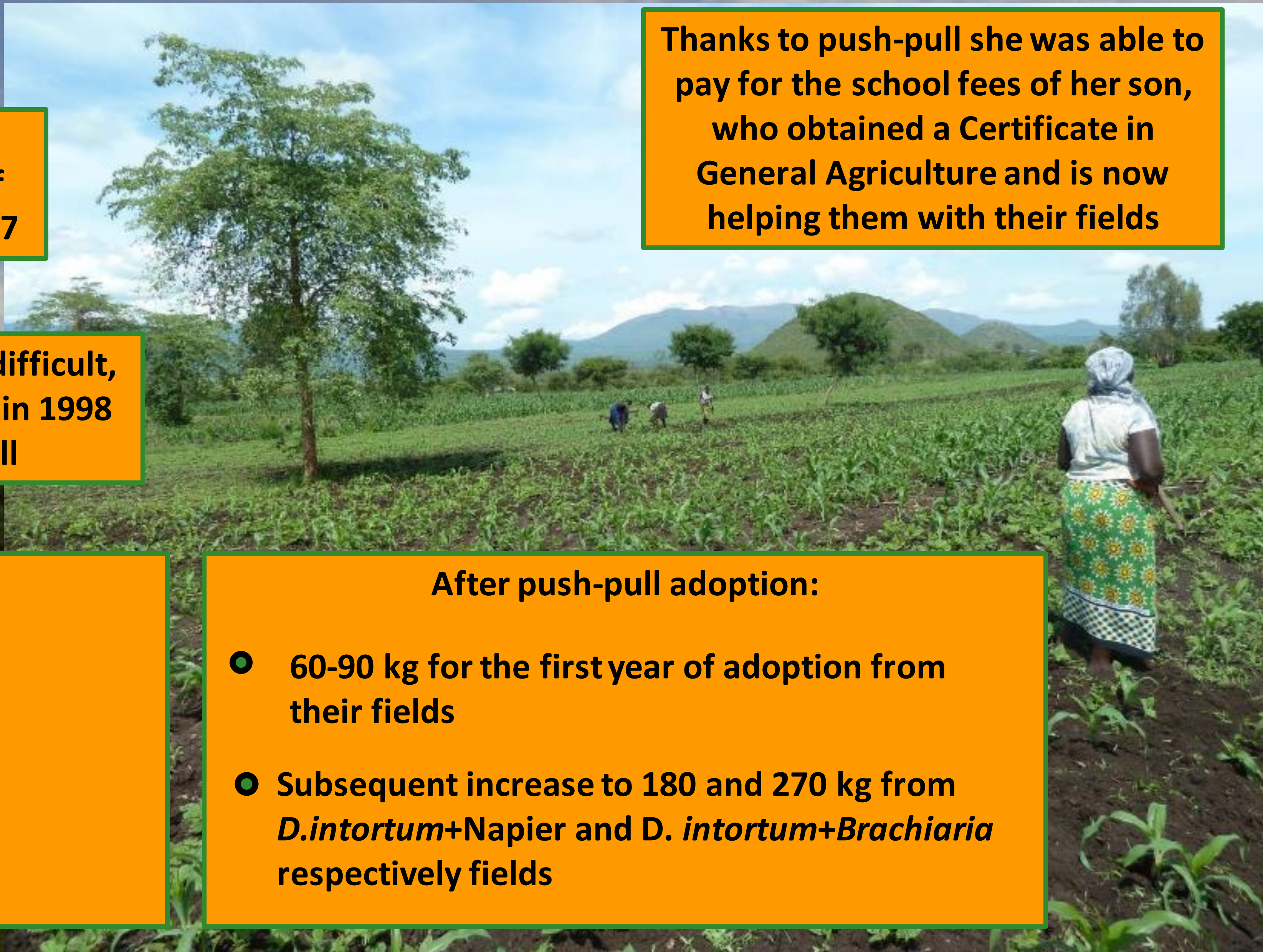
He's life really improve after push-pull adoption as his family and his livestock were no more under food shortage conditions:

"It is also important that I got some good benefits like availability of fodder for my cows at home and this led to more milk production. The diet of the family improved as there was an extra income to diversify the meals presented on the table. There appeared to be more stability and joy in the family."

Wapa farmer group

Rispa





Suba district

Farmer teacher in a 30-members farmer group. With two of them, she was one of the farmers at the very first *Baraza* in 1997

Since harvesting was extremely difficult, mainly due to striga abundance, in 1998 they decide to try push-pull

Thanks to push-pull she was able to pay for the school fees of her son, who obtained a Certificate in General Agriculture and is now helping them with their fields

Before push-pull adoption:

- **Few kilos yield from the fields (both 21x30 metres)**

After push-pull adoption:

- **60-90 kg for the first year of adoption from their fields**
- **Subsequent increase to 180 and 270 kg from *D.intortum*+Napier and D. *intortum*+*Brachiaria* respectively fields**

Mary 'Chelsea Flower'

Ogongo

Teacher and leader of a 27-farmer youth group

She partecipated to 1997 *Baraza*. Bacause her field was completely infested by striga and she was harvesting literally nothing

Since her field was totally plenty of striga she had to wait for the second year of desmodium intercrop to see some results. But by the third one results started to be great as striga seed bank present in the soil heavily decreased

She turned to climate-smart due to NSD

Now she's planning to buy a dairy cow with extra money and fodder from push-pull

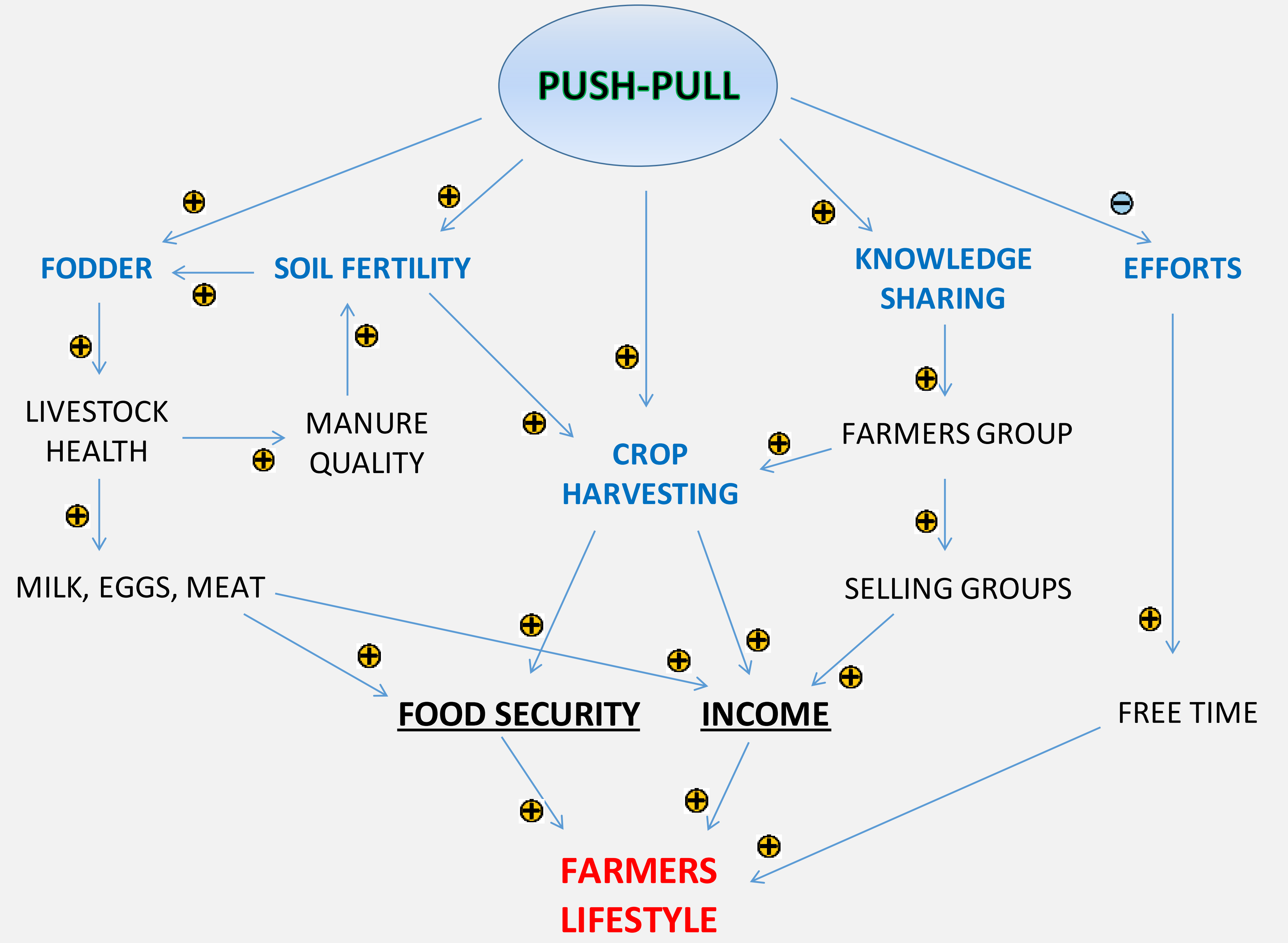
She was invited as Push-pull witness at 2005 Chelsea Flower Show

Before push-pull adoption:

- No harvesting at all

After push-pull adoption:

- Her 21x30 metres isextremely healthy and produces three bags of maize (270kg)


PUSH-PULL
FODDER
SOIL FERTILITY
KNOWLEDGE SHARING
EFFORTS
LIVESTOCK HEALTH
MANURE QUALITY
CROP HARVESTING
FARMERS GROUP
MILK, EGGS, MEAT
SELLING GROUPS
FOOD SECURITY
INCOME
FREE TIME
FARMERS LIFESTYLE

Aknowledgemets and notoriety

Winner of the 2010 Innovation and Creativity in Entomology prize of ESA

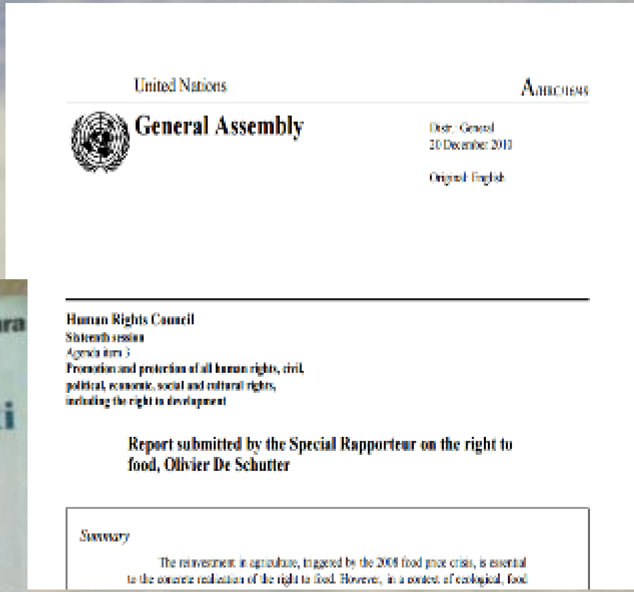
Donation to Mama Sarah Obama Foundation (MSOF)

Prized at 3rd Global Science Conference on Climate-Smart Agriculture (Monpellier, 2015)

CLIMATE-SMART Agriculture 2015

International attention started risining…

From UN…



United Nations

General Assembly

Distr.: General

Original: English

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, Olivier De Schutter

Summary

L'Espresso, 10 Dec 2015

Agricoltura

Né veleni né Ogm per cacciare gli insetti

Il Kenya ha sviluppato una tecnologia del tutto naturale per proteggere le piante dai parassiti. E più di 100 mila contadini africani l'hanno già adottata

di Giovanni Sabato

…to non-specialized weekly!

An exemple, an inspiration

What, although extremely brilliant, might resemble to some extent like a lucky fairy tale and an isolated case, is instead the result of continuous efforts to understand complex and multiple organism interactions with an ambitious goal kept in mind: contribute to reduce alimentary insecurity and extreme poverty while respecting and preservating the environment biotic and abiotic compounds in order to ensure at the same time sustainability.

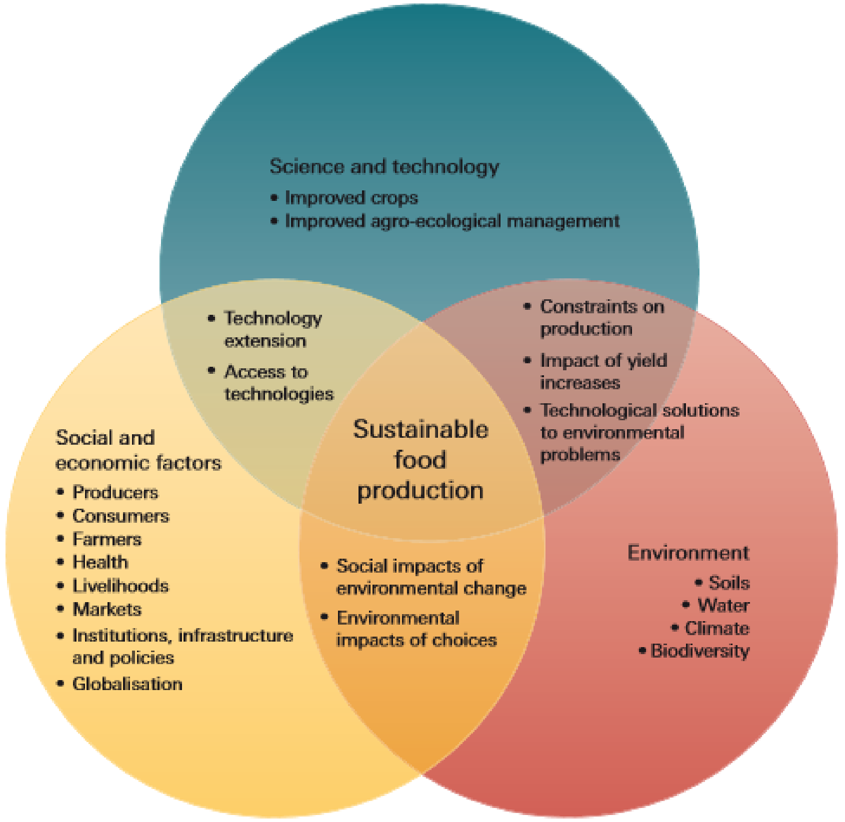
World population projections estimate 9 billion poeple by the year 2050, most of which in developing countries

Urgent international effort with a clear sense of long-term challenges and possibilities is necessary and to do this a change of perspective in agriculture and environment management is crucial

A multidisciplinary approach taking into account the huge amount of variables to meet growing population demand whilst also maintaining and enhancing the diversity of species genetic resources, that is vital to facilitate environmental resilience, conservation and productivity, is thus required.

For this reason reserchs like push-pull have to be encouraged and taken as an exemple of the path to undertake

The complexity of agricultural systems



The Royal Society, 2009

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Thanks

Special thanks to all ICIPE staff, in particular to Professor Khan and Aloice Ndiege for being so willing and passionate to show me this brilliant project

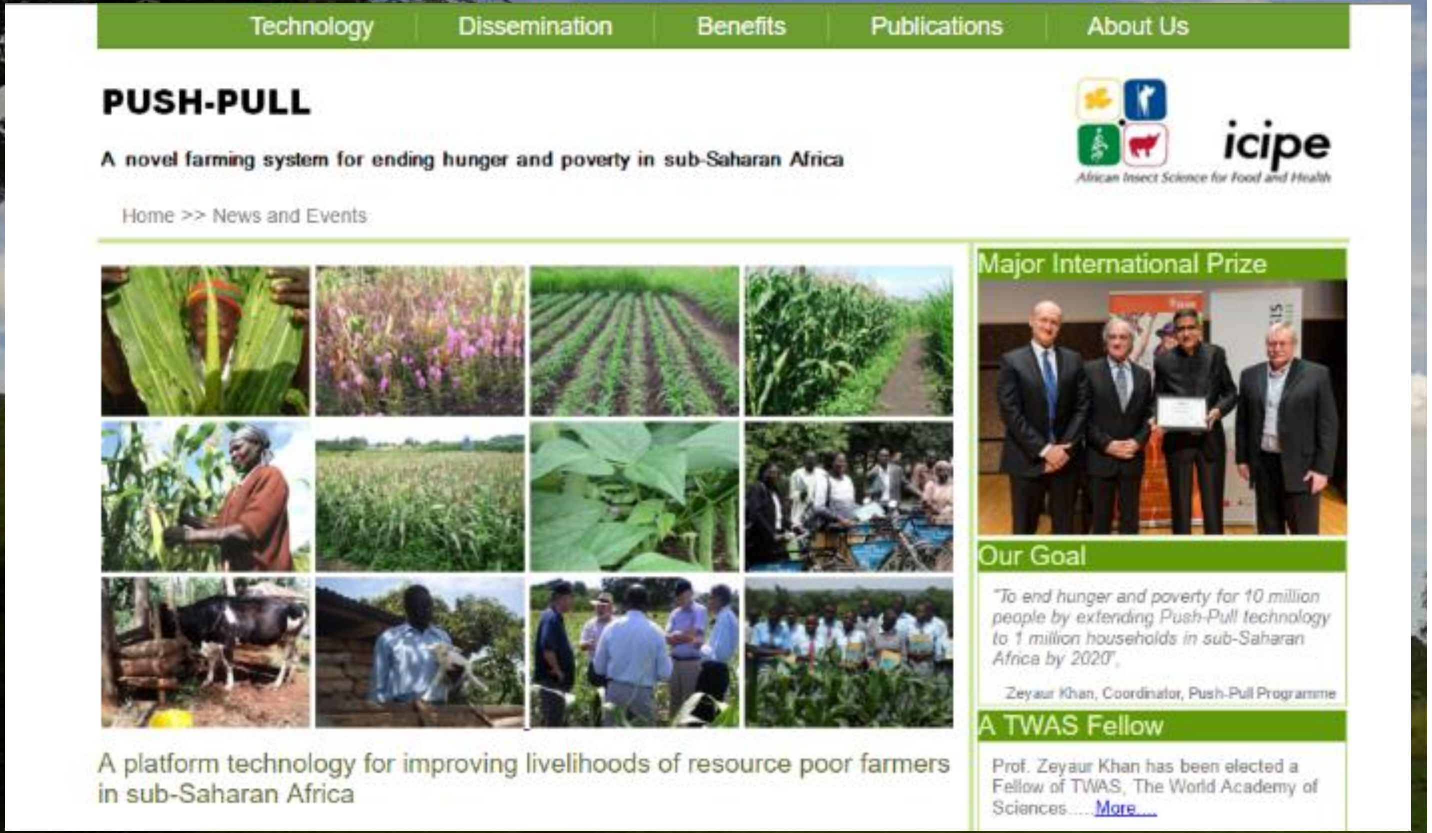
Thanks also to World Friends NGO (Nairobi) that made the journey possible

Thanks to Maurice Mwanga and all other friend I've met!

And of course thanks to Prof Lara Maistrello (Dept. Life Sciences, UNIMORE) and Reggio Emilia University for the invitation!

Thank you!

Infos



http://push-pull.net

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Review

Cite this article: Khan ZR, Midega CAO, Pittchar JO, Murage AW, Birkett MA, Bruce TJA, Pickett JA. 2014 Achieving food security for one million sub-Saharan African poor through push–pull innovation by 2020. *Phil. Trans. R. Soc. B* **369**: 20120284. http://dx.doi.org/10.1098/rstb.2012.0284

One contribution of 16 to a Discussion Meeting Issue 'Achieving food and environmental security: new approaches to close the gap'.

Subject Areas:
behaviour, ecology, plant science

Keywords:
food security, pests, climate change, push–pull technology, sub-Saharan Africa

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Achieving food security for one million sub-Saharan African poor through push–pull innovation by 2020

Zeyaur R. Khan[1], Charles A. O. Midega[1], Jimmy O. Pittchar[1], Alice W. Murage[1], Michael A. Birkett[2], Toby J. A. Bruce[2] and John A. Pickett[2]

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[2]Department of Biological Chemistry and Crop Protection, Rothamsted Research, Harpenden AL5 2JQ, UK

Food insecurity is a chronic problem in Africa and is likely to worsen with climate change and population growth. It is largely due to poor yields of the cereal crops caused by factors including stemborer pests, striga weeds and degraded soils. A platform technology, 'push–pull', based on locally available companion plants, effectively addresses these constraints resulting in substantial grain yield increases. It involves intercropping cereal crops with a forage legume, desmodium, and planting Napier grass as a border crop. Desmodium repels stemborer moths (push), and attracts their natural enemies, while Napier grass attracts them (pull). Desmodium is very effective in suppressing striga weed while improving soil fertility through nitrogen fixation and improved organic matter content. Both companion plants provide high-value animal fodder, facilitating milk production and diversifying farmers' income sources. To extend these benefits to drier areas and ensure long-term sustainability of the technology in view of climate change, drought-tolerant trap and intercrop plants are being identified. Studies show that the locally commercial brachiaria cv mulato (trap crop) and greenleaf desmodium (intercrop) can tolerate long droughts. New on-farm field trials show that using these two companion crops in adapted push–pull technology provides effective control of stemborers and striga weeds, resulting in significant grain yield increases. Effective multi-level partnerships have been established with national agricultural research and extension systems, non-governmental organizations and other stakeholders to enhance dissemination of the technology with a goal of reaching one million farm households in the region by 2020. These will be supported by an efficient desmodium seed production and distribution system in eastern Africa, relevant policies and stakeholder training and capacity development.

Push-pull idea spreading…

University of Reading

Could the *Desmodium* 'push-pull' system for *Striga* control in Africa work on *Phelipanche ramosa* and *Orobanche crenata*?

Mohamed Shrif • Alistair Murdoch • Irene Mueller-Harvey

RESEARCH ARTICLE

Field Evaluation of a Push-Pull System to Reduce Malaria Transmission

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Abstract

Malaria continues to place a disease burden on millions of people throughout the tropics, especially in sub-Saharan Africa. Although efforts to control mosquito populations and reduce human-vector contact, such as long-lasting insecticidal nets and indoor residual spraying, have led to significant decreases in malaria incidence, further progress is now threatened by the widespread development of physiological and behavioural insecticide-resistance as well as changes in the composition of vector populations. A mosquito-directed push-pull system based on the simultaneous use of attractive and repellent volatiles offers a complementary tool to existing vector-control methods. In this study, the combination of a trap baited with a five-compound attractant and a strip of net-fabric impregnated with micro-encapsulated repellent and placed in the eaves of houses, was tested in a malaria-endemic village in western Kenya. Using the repellent delta-undecalactone, mosquito house entry was reduced by more than 50%, while the traps caught high numbers of outdoor flying mosquitoes. Model simulations predict that, assuming area-wide coverage, the addition of such a push-pull system to existing prevention efforts will result in up to 20-fold reductions in the entomological inoculation rate. Reductions of such magnitude are also predicted when mosquitoes exhibit a high resistance against insecticides. We conclude that a push-pull system based on non-toxic volatiles provides an important addition to existing strategies for malaria prevention.