Emerging Technologies for *Striga* Control in Africa

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Striga spp have become the greatest biological constraint to crop production in Africa.

Steadily increasing their geographic and species domain, they have become great yield reducers.

They are now widely recognized as a scourge.

Striga as a Scourge

- Its bewitching effect devastates crops,
- Ravages many crops resulting in total crop loss in some ecologies,
- Farmers often left bewildered, and broken,
- Interventions beyond reach of the poor,
- Marginalizes efforts to food security,
- Perceived less as a biological constraint & more as ***a scourge handed from above.***

Heavy Infestation such as this is often a menace to rural life

The Striga Pandemic

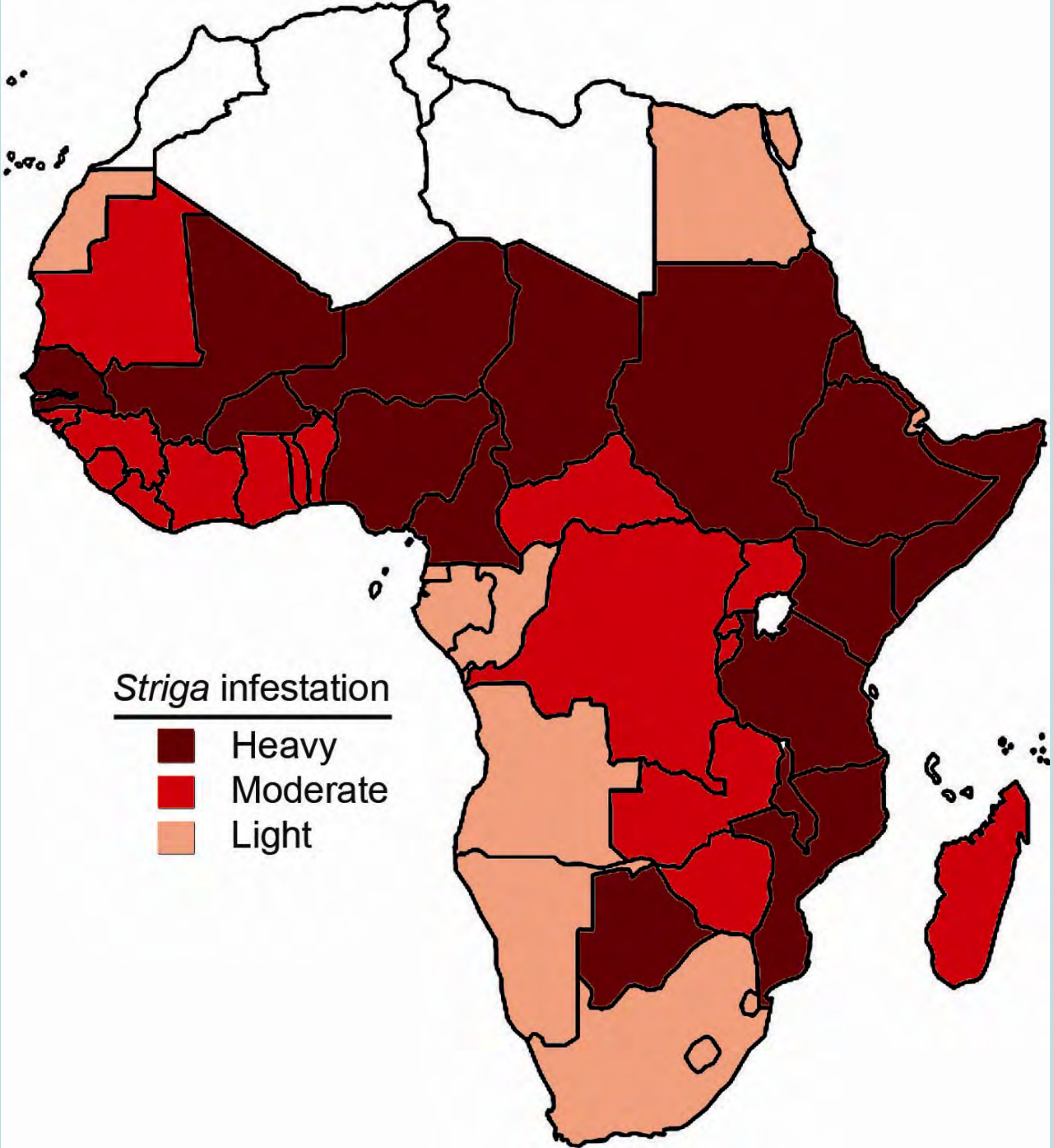
- Only a smattering of little surveys
- Estimate nearly 100 million of the African savannah is infested with Striga
- Found in nearly all of sub-Saharan Africa
- Increasing both in geographic domain and degree of crop damage
- Moving into very many new areas
- Moving to crops previously considered immune

Economic Impact

- Destroys millions of ha of crop lands in Africa each year (50 million hectares estimated)
- Results in revenue losses estimated @ > US $7 billions annually
- Affects welfare & livelihoods of some 300M people in sub-Saharan Africa
- Heavy investment required in future reclamation of lost crop lands!

THE STRIGA—POVERTY PARALLEL

- Striga is a poor man’s problem,
- Result of demographic pressure,
- Striga attacks a variety of host plants,
- Most severe on sorghum, millets, and maize,
- Predilection for inflicting more damage on crops under moisture and nutrient stress,
- Near perfect ecological overlap with where *the poor farm and reside, and where hunger prevails*.


Striga infestation
Heavy
Moderate
Light

Why THE STRIGA—POVERTY PARALLEL?

- Increased population: Smaller holdings,
- Reduced fallows: Mono-cropping,
- Increased frequency of drought,
- Declining soil fertility, limited use of inputs
- Below optimal cultural practices,
- Generally ominous trends for the poor
- Limited education and knowledge base,
- Reluctance to adopt new technologies,
- Aversion for risk discourages worthy investments.


Striga on Maize

Striga on Sorghum


Striga on Pearl Millet

Striga on Finger Millet and Tef

On tef

On Finger millet

Striga gesnerioides on Cowpeas

The State of Knowledge: What we know!

- Need for science based interventions,
- New knowledge of host-parasite biology,
- Molecular biological tools emerging
- Genomic sequences of major crops
- New and Appropriate Control Options,
- Genotype x Environment Interaction
- Recognition of Value of Integrating Control Options

The State of Knowledge: What we do not know!

- Erratic behavior of Striga,
- Species & Ecological Specialization of Striga,
- How Striga adapts to new lands, new crops,
- Basis for the soil fertility, moisture, and Striga nexus,
- Differential virulence among parasite populations,
- Why/how soil pH, soil microbial activity, soil organic matter, degree of soil mineralization impact infestation,
- Who would generate much of this knowledge,

Striga Management Options

- Striga Eradication
- Striga Containment
- Striga Control

Striga Control Measures

- Genetic Control
- Cultural & Mechanical Control
- Chemical Control
- Biological Control

- State of the Art: Mixed

Traditional hand weeding practice have little effect to reduce yield loss due to Striga

Hand weeded local variety

Striga resistant variety

Sorghum grown with and without *Desmodium intortum* intercrop (Suba District, Kenya)

Isolation of potential biocontrol agents for *Striga*

Emerging Technologies for Striga Control

Two technologies piloted and launched for scaled-up commercial application are highlighted:

1. Integrated Striga Management (ISM) on Sorghum,

2. Herbicide Resistant Maize

Integrated Striga Management (ISM) In Sorghum

Rationale:

Striga damage is more severe on host crops that are already under stress conditions

Major limiting factors

- host crop: susceptibility to striga infestation
- stress conditions:
  - drought
  - fertility depletion

ISM Program

Suggested ISM package:

- Striga Resitant Sorghum Cultivars
- Water conservation measure

  Use of Tied Ridges
- Fertility enhancement

  Inorganic Fertilizers

Program Countries: Tanzania, Eritrea, and Ethiopia

ISM: Why approach as a National Program Objective

- Light infestation can be managed with a variety of control options at the household level, but

- The Current Rampant Infestation in the Continent:
  - Requires New Research and New Knowledge,
  - Requires Significant Resource Commitment,
  - Requires Greater Resolve and Persistence
  - Needs Due Recognition as a (national/global) Natural Resource Crisis!!

In Tanzania, ISM Technology has been effective against the three major species of Striga

S. asiatica

S. hermonthica

S. forbesii

ISM-Program Objectives

1. Establish a nation wide ISM Program
   - Growing resistant crop varieties with fertilizer and under water conservation practice
2. Establish a functional seed program
   - Promote seed as an essential input
   - Promote an effective seed multiplication program
   - Promote seed production as a commercial entity
3. Increase profitability for participating farmers
   - Seed marketing
   - Grain marketing
   - Promote utilization
   - Enhance new product development

4. Goal: Durable & sustainable measure to control striga

Resistant variety, P9401 planted with the ISM package grows Striga free and produces high yield at Fedis, Oct., 2006

Susceptible variety

Striga resistant variety

Effect on *Striga* number (per 7.5 m^2) at harvest and sorghum grain yield (Kg ha^{-1}) at Melela and Hombola, Tanzania (Ilonga is a *Striga* free site).

Entry	Melela			Hombolo	
	S asiatica	***forbesii***	**Yield**	***S. asiatica***	**Yield**
P9405	**21.3**	**3.5**	**1900**	**2.0**	**453**
P9406	**16.8**	**8.0**	**2000**	**7.5**	**400**
SRN 39	114.0	55.5	900	23.8	180
Weijita	117.3	29.5	1200	12.0	147
Macia	216.8	29.8	1100	19.0	367
Pato	**190.0**	**17.5**	**1400**	**92.3**	**107**
S.E.	**28.3**	**5.9**	**120**	**8.14**	**38.0**

- Lines P9405 and P9406 supported lower numbers of emerged *S. asiatica, S. forbesii* than released cultivars Pato and Macia.

Data on *Striga* number (per 7.5 m^2) at harvest and sorghum grain yield Kg ha^{-1} at Ukiruguru, Tanzania. (Ilonga is a *Striga* free site).

Entry	Ukiriguru		Ilonga
	S. hermonthi	Kg ha^{-1}	Kg ha^{-1}
P9405	**42.8**	**783**	**2300**
P9406	**9.8**	**583**	**1800**[1]
SRN 39	77.5	87	2200
Weijita	122.0	60	3300
Macia	60.0	283	2100
Pato	**62.3**	**233**	**3200**
S.E.	**11.11**	**58.7**	**140**

Farmer preference criteria across regions in Tanzania: Cultivars were scored for each criterion 1 (best) to 10 (worst)

	Criteria	Tegemeo	Mhuputa	Sandala	Pato	Lugugu	P9406	P9405	Bangala	Lugugu Arusha
1	High yielding	4	8	5	1	9	2	3	7	6
2	Drought tolerance	4	7	5	3	9	1	1	8	6
3	Ability to withstand *Striga*	4	9	5	3	8	2	1	7	6
4	Shortness of plants	3	7	5	4	9	2	1	8	6
5	Ease of marketing	9	6	3	5	1	6	5	4	2
6	Resistance to birds	6	-	5	7	2	8	9	1	4
7	Pests tolerance	6	3	5	9	1	7	8	3	4
8	Not shattering	4	2	5	3	8	2	1	7	6
9	Storage pest tolerance	9	9	6	5	1	7	8	4	3
10	Good tasting of *ugali*	9	2	7	8	1	6	5	4	2
	Total	58	56	51	48	49	43	42	53	45
	Overall ranking	**9**	**8**	**6**	**4**	**5**	**2**	**1**	**3**	**7**

Striga infestation and grain yield from the ISM package vs. control plots, 2002

Region	Striga count (m^{-2})		Yield (t/ha)	
	Local practice	ISM package	Local practice	ISM package
Amhara	2052	10	0.8	3.40
Oromia	1109	8	0.12	1.12
Mean	1580	9	0.46	2.26

Striga infestation and grain yield from the ISM package vs. control plots, 2003

Region	Striga count (m^{-2})		Yield (t/ha)	
	Local practice	ISM package	Local practice	ISM package
Amhara	95	5	1.33	2.67
Oromia	110	8	0.29	2.02
South	128	4	0.00	0.53
Mean	111	6	0.54	1.74

Striga infestation and grain yield from the ISM package vs. control plots, 2004

Region	Striga count (m^{-2})		Yield (t/ha)	
	Local practice	ISM package	Local practice	ISM package
Amhara	158	12	1.55	2.61
Oromia	122	12	0.25	1.02
South	0	0	0.0	0.13
Tigray	213	24	0.87	2.13
Mean	123	12	0.67	1.47

Total Number of farmers and area covered with the ISM package 2002-2005

Region	No. Farmers	2002	2003	2004	2005	Total
Oromia	Area No. Farmers	63.1 150	98.7 483	402 1520	604 1458	1167.8 3611
Amhara	Area No. Farmers	29.31 120	170.27 383	194 746	111.5 416	505.1 1665
Tigray	Area No. Farmers	142 50	151.5 306	414.5 1550	414.5 1550	1122.5 3455.5
SNNPS	Area No. Farmers	32.5 60	76.8 166	94.3 321	118.8 421	322.3 968
Total	Area No. Farmers	99.25 380	497.7 1340	1159.25 4327	1248.75 4645	3004.95 10,684

The Power of the ISM Technology

- SR Cultivars with High Yield Potential
- A Water Conservation Measure to Enhance Fertilizer Response
- N Fertilization Increases Crop Yield and Complements in Striga Control
- Technology Provides Synergy
- Technology Powerful Even in Years of Low Striga Infestation

On farm seed multiplication (P-9401), 2006

Seed Multiplication at a Research Station, 2001

Released in the Amhara region of Ethiopia, 2001 under the name “Brhan”

Ethiopia, November, 2001

“Gubiye”

Local variety

Sustainable Adoption of Technology is Achieved Only When Productivity Gains are Translated to Profitability By Connecting Farmers to Markets ....

Need for Developing Markets

- Adoption of technology is an educational function,
- Sustainable Investment in inputs requires careful analysis of profitability and risk,
- Needs serious public-private partnership,
- ISM, IR Technology Market Efforts:
  – Seed Industry, Breweries, Food & Feed companies, Bakeries, Poultry etc.

Seed-coating of Imidazolinone Resistant Maize (IR Maize):

An Emerging Technology for Striga Control

An Example of Public-Private Partnership

Herbicide seed coats….

The IR-maize technology:

<u>IR-maize</u>

- A natural mutation in acetolactate synthase provides herbicide-resistance

<u>Imazapyr</u>

- A systemic herbicide coated to maize seeds, kills *Striga* attached to maize roots
- The maize crop is unharmed by the herbicide

The appeal of IR Maize technolgy

Herbicide resistance in maize varieties with low-dose application of a systemic herbicide

- The dose of herbicide used, 30 g imazapyr per ha, is 10 times lower than 'normal' rates
- Targets *Striga* control below the soil, before emergence

The power of IR Maize Technology:

- *Maize roots stimulate Striga germination,*
- As IR-maize germinates and grows it takes up herbicide from the seed coat and soil
- When the *Striga* germling attaches to the maize root, it is killed before it can damage the crop
- Some *Striga* is directly killed in the soil
- Striga seed bank is depleted via suicidal germination & direct action of herbicide on Striga seeds

Effect of IR Maize Technology

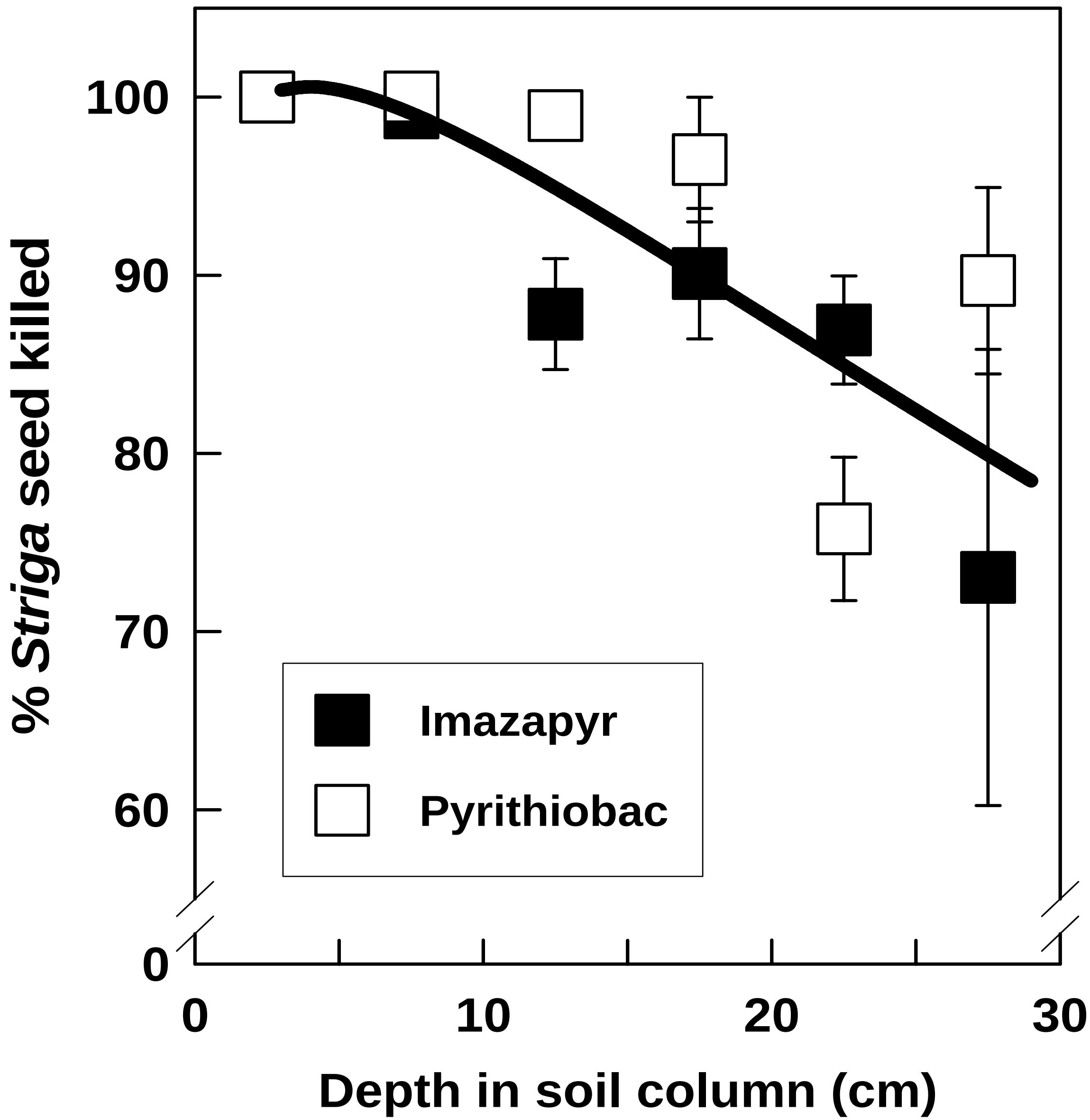


Figure 1. *Striga hermonthica* mortality from leaching of imazapyr and pyrithiobac through a soil column. Standard error bars are shown when larger than the symbols. The line drawn is a best-fit average of the data for both herbicides. y = -0.015x2 - 0.400x + 101.911; r2 = 0.908

Deployment Efforts

- Commercial Launch in 2003

>15,000 demos by a consortium of partners

> 100 tons of Commercial Seed Produced in 2007

Summary

- The *Striga* problem is expanding,
- Our biological Knowledge base is increasing,
- Technologies are available to offer relief and need to be scaled out,
- Sorghum ISM and IR Maize good examples of validated technologies,
- Parallel developments in market and entrepreneurial capacity badly needed,
- Support for public policy and advocacy of commercial agriculture need be promoted.

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