



**icipe**  
African Insect Science for Food and Health

## Growing vegetables in Eastern Africa – pest control in organic/integrated agricultural production, biodiversity, farmer economy and export markets



Markus Knapp



**About icipe**

A centre of excellence in Africa — for research and capacity building in insect science and its applications

An intergovernmental organization — charter signed by 12 countries worldwide






**About icipe**

Pantropical mandate but Africa-focused

Current activities in 24 African countries

Collaborative work in Middle East, South America, Asia

Core-funding mainly from the Governments of Sweden, Switzerland & Denmark






**About icipe**

4H paradigm

R&D on human, animal, plant & environmental health

Common denominator insects/arthropods






**Plant Health**

Improve food security, nutrition and farmers' income through Biological Control and Integrated Pest Management (IPM)

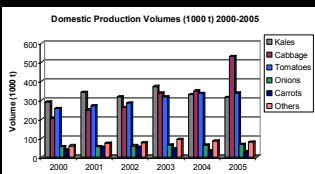
Horticulture:

- IPM for French beans
- Biological control of DBM
- Biological/integrated control of RSM in tomatoes
- Economic impact assessment

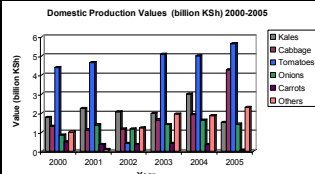



**Importance of vegetables - local markets**

Domestic Production Volumes (1000 t) 2000-2005




Domestic Production Values (billion KSh) 2000-2005




Total Production (2005): 1,358,000 t

Total value (2005): 15.19 billion KSh



## Importance of vegetables - export

Major foreign exchange sources 2005 (billion KSh)



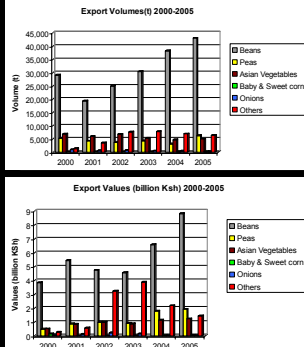
Tourism: 48.90  
Horticulture: 44.56  
Tea: 42.29  
Coffee: 9.70

Horticulture

Flowers: 38.84  
Vegetables: 13.57  
Fruits: 2.05

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## Importance of vegetables - export




Total Production (2005):  
61,000 t

Total value (2005):  
13.57 billion KSh

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## Importance of IPM and Biocontrol



Pesticide use is high in vegetable production


Pesticide applications are often ineffective (wrong or fake products, under-formulation/dosage, substandard application techniques)

Pesticide use harmful to farmers, consumers, environment

Export: More and more stringent rules on products allowed and MRLs

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## IPM for French beans



Guidelines

No pesticides in WHO toxicity class I and II

Avoidance of foliar pesticides applications wherever possible

No products that are not available in rural areas

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## Pests in the growing cycle of French beans

weeks	1st trifoliolate								Harvesting period No pesticide application				
	Primary leaf sowing		1st trifoliolate		full flower		1st flower		9	10	11	12	
	0	1	2	3	4	5	6	7	8				
Beanflies		***	***	***	***	**	*						
Aphids			*	**	**	**	**	***	***	***	***	***	***
Whiteflies		*	*	*	**	**	**	**	**	**	**	**	**
Spider mites		*	*	**	**	**	**	**	**	**	**	**	**
Flower thrips		*	*	**	**	**	**	**	**	**	**	**	**
Pod borers						**	**	**	**	**	**	**	**
Bean rust			*	**	**	**	**	**	**	**	**	**	**
Powdery mildew		*	*	**	**	**	**	**	**	**	**	**	**
Angular leafspot			*	**	**	**	**	**	**	**	**	**	**

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## The French bean IPM system

**No thresholds**

**Instead: pest risk during the different crop growth stages**

Basic principles:

- Use certified seed
- Never plant downwind of an old bean crop
- Use seed dressing instead of foliar sprays
- Scout at least once weekly until flowering
- Scout first flowers for presence of thrips
- Do not to apply any synthetic pesticides after pod formation

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## Farmers' practice and IPM system

Crop protection measure	Farmers' practice	US\$	IPM System	US\$
Seed treatment (2kg seeds)	Lindane /Thiram at 3g/kg seeds	3.04	Imidacloprid at 8ml/kg seeds, Thiram+Carboxim at 2.5ml/kg seeds	25.50 1.20
Spray application costs (0.35 US\$ per knapsack sprayer)	7 applications at 400l per acre	43.75	3 applications at 240l per acre	11.25
Fungicide application (product costs)	7 applications of Mancozeb at 50g/20l	39.38	1 application of Hexaconazole at 7.5ml/10l	13.29
Insecticide application against bean flies	4 applications of Dimethoate at 35ml/20	9.03	None	0
Insecticide application against bean flower thrips (Product costs)	3 applications of Lambda-cyhalothrin at 50ml/20l	25.0	2 application of Dimethoate at 35ml/ 20l and 1 application of Fipronil at 100g a.i. per hectare	5.58 56.25
<b>SUM</b>		<b>120.47</b>		<b>113.07</b> i.e. 94%

Applications in italics are based on scouting, reducing cost of the IPM system in the most favourable condition to US\$ 26.70 (22.2% of farmers' practice)



## Cost and gross margins

### Contribution of plant protection to overall production cost

IPM plot: 10.4%

Farmer managed plot: 15.9%

### Cross margins (KSh/acre):

IPM plot: 62,525

Farmer managed plot: 57,928

Zero plant protection plot: -3,731



Angular leaf spot



## Improved crop management of tomatoes



Farmers stake tomatoes in some areas but not in others

Red spider mite (*Tetranychus evansi*) is the most serious pest

Substandard application techniques are a major problem



## On-farm pruning and staking trials

No-pruning, no staking; pruning only; staking only; pruning & staking

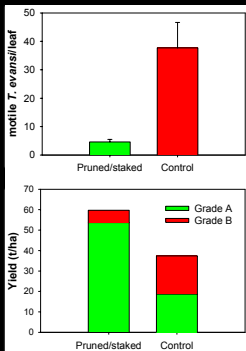


### Mite control:

Omite at weekly intervals after first infestation determined  
Mitac from 3 weeks before harvest  
Regular fungicide applications



## Effect of pruning and staking on mites and yield



### Revenue (US\$/ha):

Pruned/staked: 55,200  
Control: 33,100

### Additional cost for pruning/staking (US\$/ha):

Experimental system: 3,320  
Farmers' system: 1,104



## Two examples of biological control

### The "easy" one: Diamondback moth (*Plutella xylostella*)

Pest known  
Parasitoid(s) known  
Successful in SE Asia



### The "difficult" one: Tomato red spider mite (*Tetranychus evansi*)

Pest not known (mis-identified)  
No natural enemies known  
Area of origin unclear



## Comparison cabbage - tomato

	cabbage	tomato
ecological requirements	strict	flexible
number of important pests	few	very many
arthropods	DBM, cabbage aphid	> 5 species
fungal diseases	none	> 3 species
bacterial diseases	black rot	bacterial wilt
viral diseases	none	>5 species
nematodes	none	several
system complexity	relatively simple	highly complex
key pest	<i>Plutella xylostella</i>	<i>Tetranychus evansi</i>
natural enemies	widely known	none
major concern	pesticide resistance	invasive species

## Cabbage production in selected districts of Kenya

District	Kiambu	Nyeri	Nyandarua	Kisii North	Meru
Estimated number of cabbage farmers (N)	230	260	410	100	200
Farm size (ha)	1.3	1.0	3.0	1.5	1.6
Cabbage area (ha)	0.3	0.1	0.4	0.3	0.2
% Farmers with schedule spraying	50	71	73	75	80
Farmer-estimated yield loss under current control practices (%)	31.9	36.9	36.2	46.9	44.1
Farmer-estimated yield loss no control (%)	95.0	100	100	87.5	94.9

## Production cost and revenue

	Districts				
	Kiambu	Nyeri	Nyandarua	Kisii North	Meru
Cabbage area	0.3	0.1	0.4	0.3	0.2
Average yield (t/ha)	24.3	15.2	18.2	11.2	41.6
Price/ton	58.8	85.3	59.9	56.1	55.1
Gross sale/ha	1429	1297	1092	629	2292
Cost of production	649	933	471	420	266
% chemicals & labour	11	29	15	16	15
Gross margin	780	365	623	209	1727
Production cost/ton	26.7	61.4	25.9	37.5	13.6

## Impact of *D. semiclausum* on DBM populations

Sampling period	Werugha			Tharuni		
	Overall parasitism	DBM/plant	% plants with damage score > 2	Overall parasitism	DBM/plant	% plants with damage score > 2
Before release	14.4±0.9c	5.4±0.27a	21.4±1.21b	4.2±0.56d	5.9±0.25a	39.7±1.54a
After release						
Year 1	23.9±1.7b	3.6±0.24b	28.3±1.60a	10.2±0.84c	4.3±0.25b	15.7±1.17b
Year 2	51.9±3.3a	0.7±0.09c	11.4±1.60c	26.6±2.07b	3.0±0.21c	9.2±1.27c
Year 3	52.5±2.6a	0.8±0.09c	5.3±1.07d	40.6±2.07a	2.4±0.12c	4.5±0.77c

## Economic impact of biocontrol

Comparison of before to after release production costs and revenue, cabbage farmers, Wundanyi Division

Parameter	Average over both seasons		Z- test <sup>1</sup>
	Farmer meeting, before	Farmer meeting, after	
Cabbage area (ha)	0.12 (0.01)	0.16 (0.02)	-2.26*
Sprays per crop (#/ crop)	4.5 (0.4)	1.3 (0.3)	-5.29***
Yield (t/ ha)	28.4 (5.3)	33.1 (4.7)	-2.33*
Gross sale (\$/ ha)	1,027.7 (135.4)	1,539 (235.7)	-2.40*
Production costs (\$/ ha)	376.0 (35.7)	289.7 (41.2)	-2.24*
Pesticide costs (\$/ ha)	198.2 (28.7)	71.2 (18.8)	-4.01***
Gross margin (\$/ ha)	685.5 (130.5)	1,124.0 (186.6)	-2.51*

<sup>1</sup> Compared by Wilcoxon Signed Ranks Test. Significance of differences: \* p = 0.05, \*\* p = 0.01, \*\*\* p < 0.01, ns = not significant. Numbers in parentheses are standard errors.

## Other benefits


Reduced use of organophosphates  
before release – used by 74%  
after release – used by 10%

Economic surplus: US\$ 32.1 million for  
25 years  
Benefit cost ratio: 28:1

improved farmers' health  
environmental benefits  
benefits to other countries



### Tomato red spider mite (*Tetranychus evansi*)



First record in Africa: 1979, tobacco Zimbabwe


Prefers Solanaceae

Can cause total yield loss in tomato

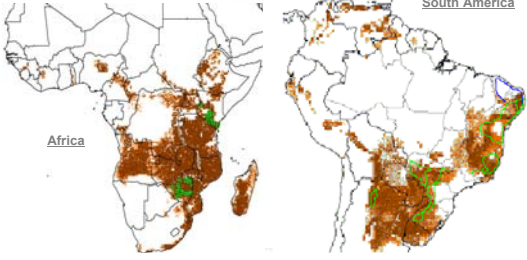
Now present all over East and Southern Africa

Also reported from West Africa


No natural enemies found in Africa



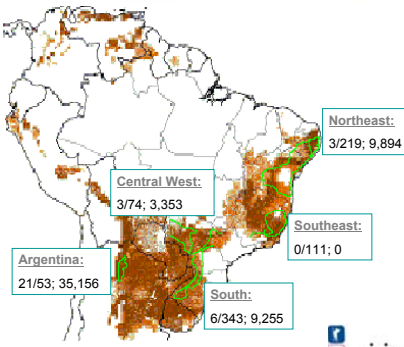
### Surveys for natural enemies



Areas in South America climatically similar to occurrence points of *T. evansi* in Kenya and Zimbabwe predicted by climate matching (Desktop-GARP)



### Abundance of *Tetranychus evansi*




**Northeast:** 3/219; 9,894

**Central West:** 3/74; 3,353

**Southeast:** 0/111; 0

**Argentina:** 21/53; 35,156


**South:** 6/343; 9,255



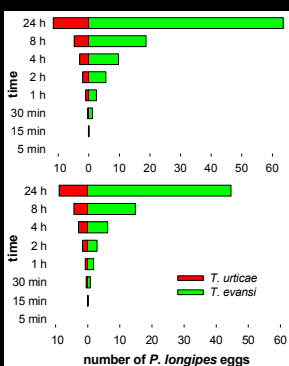
### Biology of *Phytoseiulus longipes*

Instar	Prey species	
	<i>T. evansi</i>	<i>T. urticae</i>
Egg	1.9 ± 0.12	1.9 ± 0.09
Larva	0.5 ± 0.11	0.5 ± 0.12
Protonymph	1.0 ± 0.20	1.2 ± 0.53
Deutonymph	1.2 ± 0.25	1.5 ± 0.16
Egg to adult	4.7 ± 0.25	4.8 ± 0.15
Survival	93.8%	79.7%
	Eggs/female/day	
Daily fecundity	3.9 ± 0.40 a	3.0 ± 0.50 b

25 °C, 80-90% rH, 12/12 hours




### Oviposition preference of *P. longipes*



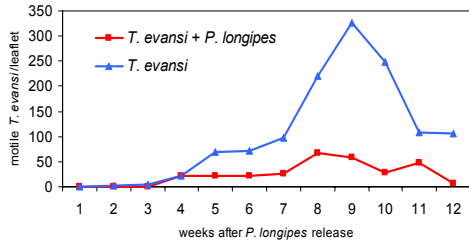
Number of eggs laid by *P. longipes* on leaflets infested with *T. urticae* or *T. evansi*.

*P. longipes* reared on *T. evansi*


*P. longipes* reared on *T. urticae*

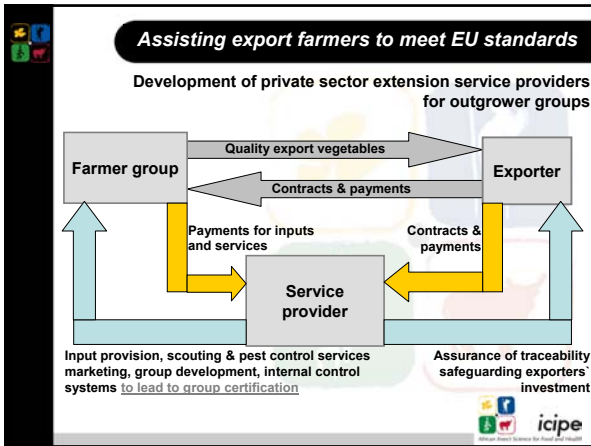


### Effect of *P. longipes* on *T. evansi* in the greenhouse



*P. longipes* is currently kept at icipe's quarantine facilities awaiting a release permit from the Kenya authorities





### Economic impact of DBM biocontrol

Ex post economic impact assessment of the biocontrol of DBM

By *Diadegma semiclausum*: in the highlands, mostly in cabbage production

By *Cotesia plutellae*: in the lowlands, mostly in kale production

Assess economic impact (Kenya, Tanzania)

Estimate impact of external factors, e.g. information, on success of biocontrol

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### Economic impact assessment of standards

Effect of EurepGAP standards: on small-holder and large-scale production on farm-worker welfare

Effect of training and sustainable production technologies on small-holder farmers

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### The future of IPM and biocontrol in vegetables

IPM and biocontrol improve yield and quality of vegetables and are a pre-requisite for vegetable export

IPM and biocontrol reduce risks for farmers, consumers and the environment and help to conserve biodiversity

Augmentative biocontrol will remain a niche product in East Africa

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### The future of IPM and biocontrol in vegetables

Classical biocontrol will remain an important strategy to control exotic/invasive pests

Classical biocontrol is facing increasing problems due to restrictions to collect and export biocontrol agents in many countries

Biocontrol is more difficult in vegetables than in staple food crops in Africa.

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### Thank you for your attention!

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