# Optimising Pesticidal Plant Use and getting research into use

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UNIVERSITY of GREENWICH | Natural Resources Institute

ADAPPT African Dryland Alliance for Pesticidal Plant Technologies

# Farmer surveys - Priority species list

## Farmer Surveys, Database & Lit.

**> 100 plant species of known potential value**

**Priority indigenous species list**

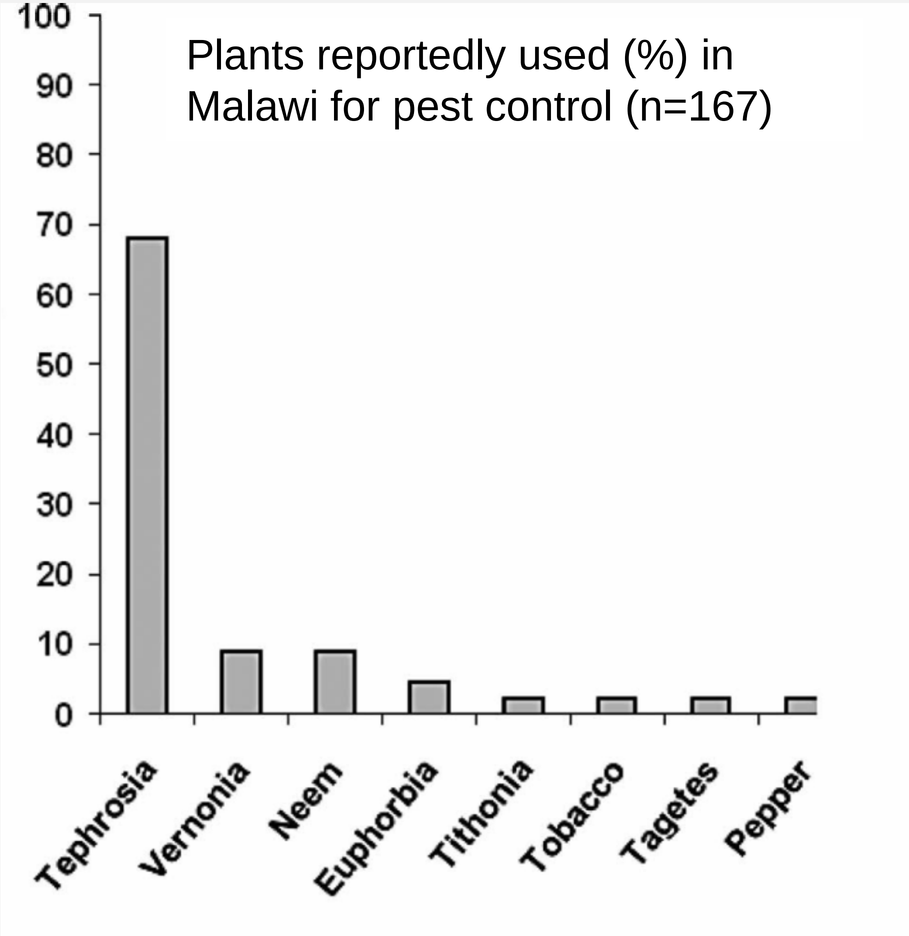
*Aloe ferox*
***Bobgunnia madagascariensis***
*Dolichos kilimandscharicus*
*Euphorbia tirucali*
***Lippia javanica***
*Neorautanenia mitis*
*Solanum panduriforme*
***Securidaca longepedunculata***
*Strychnos spinosa*
***Tephrosia vogelii***
*Vernonia* spp.
***Zanha africana***
***Chenopodium amboensis***
***Fagara heitzii***

**Non-indigenous species**

*Tithonia diversifolia*,
*Azadirachta indica* – Neem.
*Tagetes minuta*
*Cymbopogon* spp.

*Nyirenda, et al. (2011) African Journal of Agricultural Research 6: 1525-1537.*

# *Tephrosia vogelii*




*Kamanula et al., (2011) International Journal of Pest Management. 57: 41-49.*

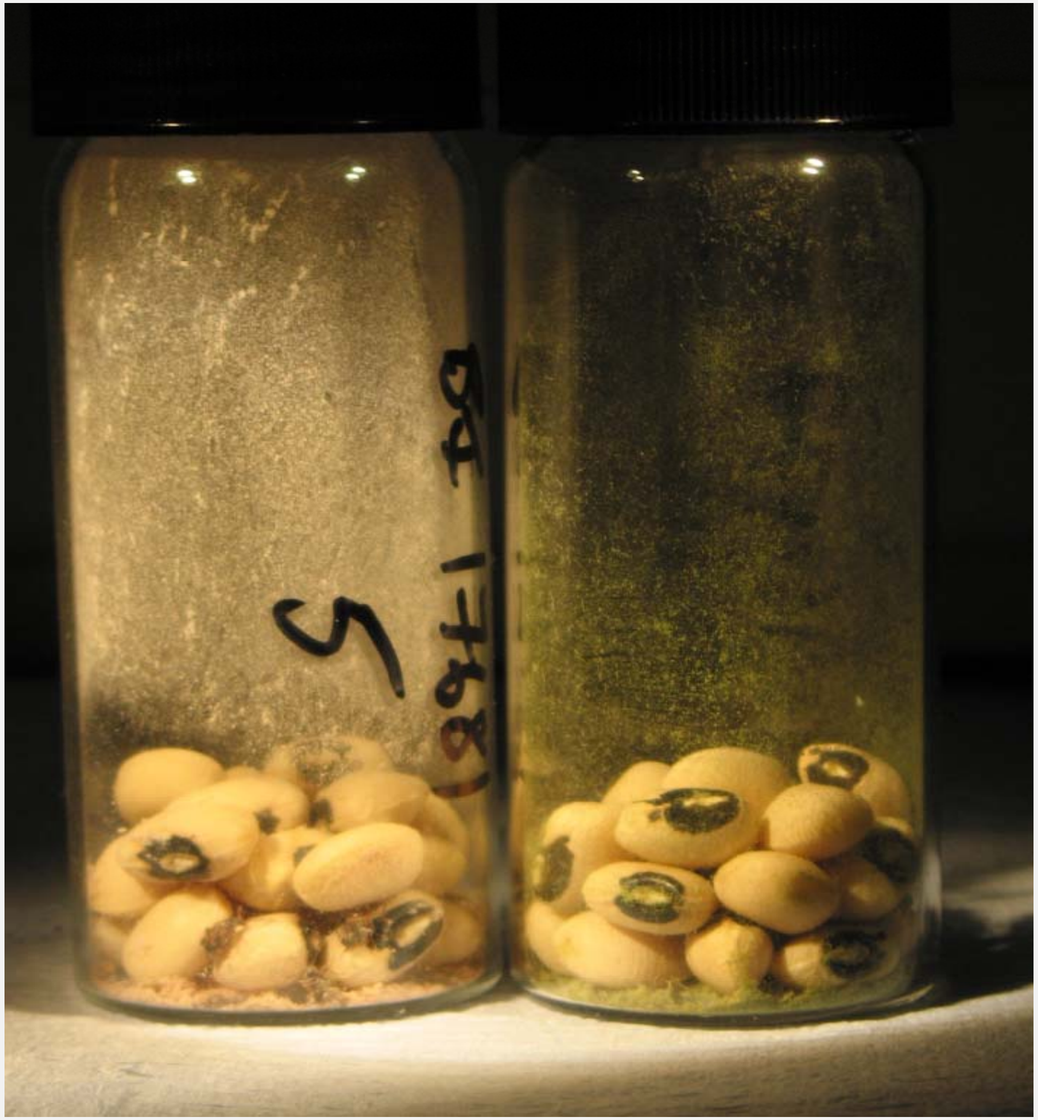
# Is *Tephrosia vogelii* an effective alternative to synthetics?

- Validation of *Tephrosia* spp. –
- Literature filled with assumptions
  - confusion about role of rotenoids & details of chemistry/bioactivity overlooked.
- Can we optimise use for farmers?

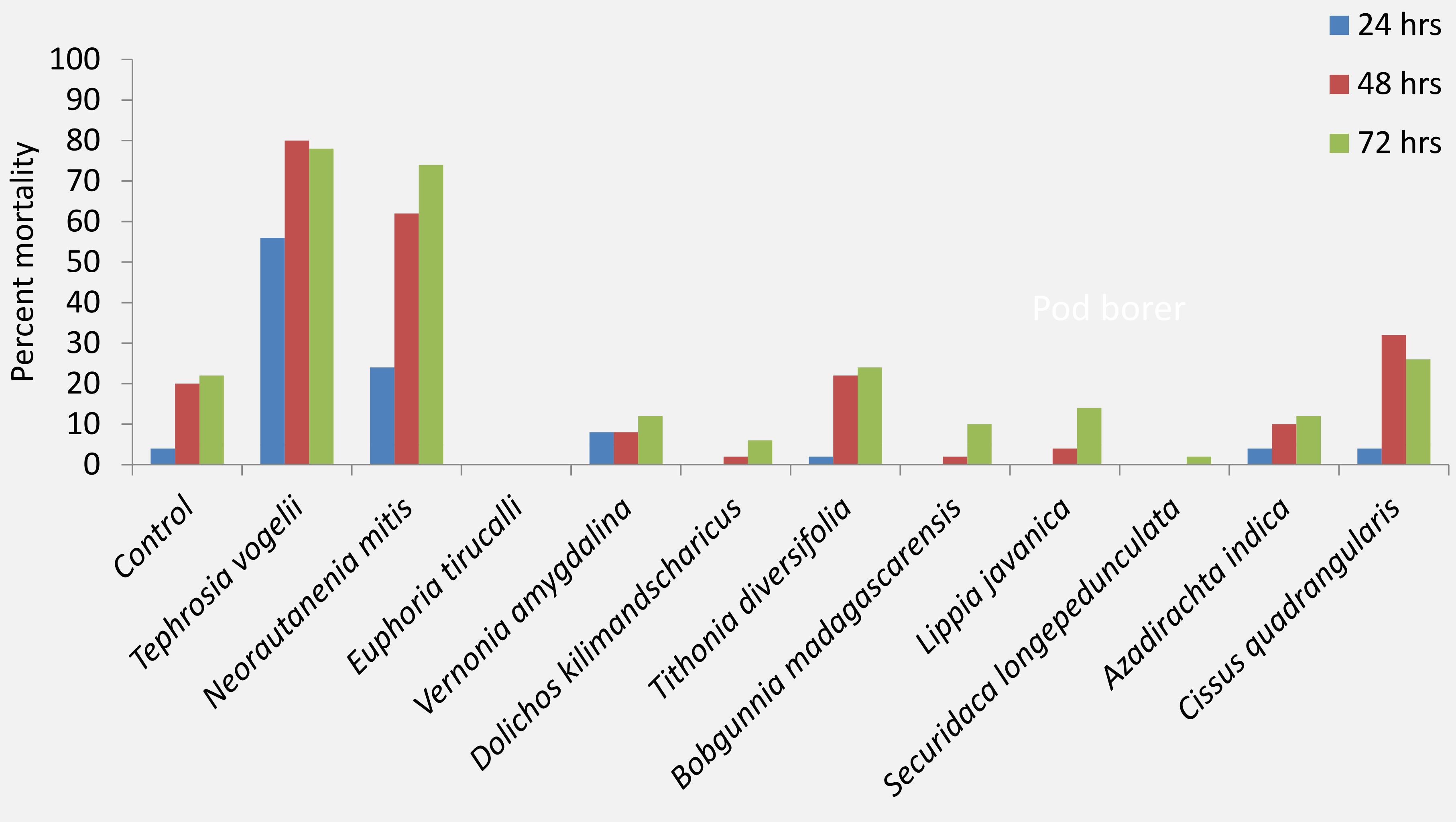
# *Callosobruchus maculatus*

# Bruchid bioassay

Treatments need to be small to enable small quantities of plant chemical to be tested.



# Effect of crude plant extracts (2%w/v) applied to cowpea on the mortality of adult *bruchids*



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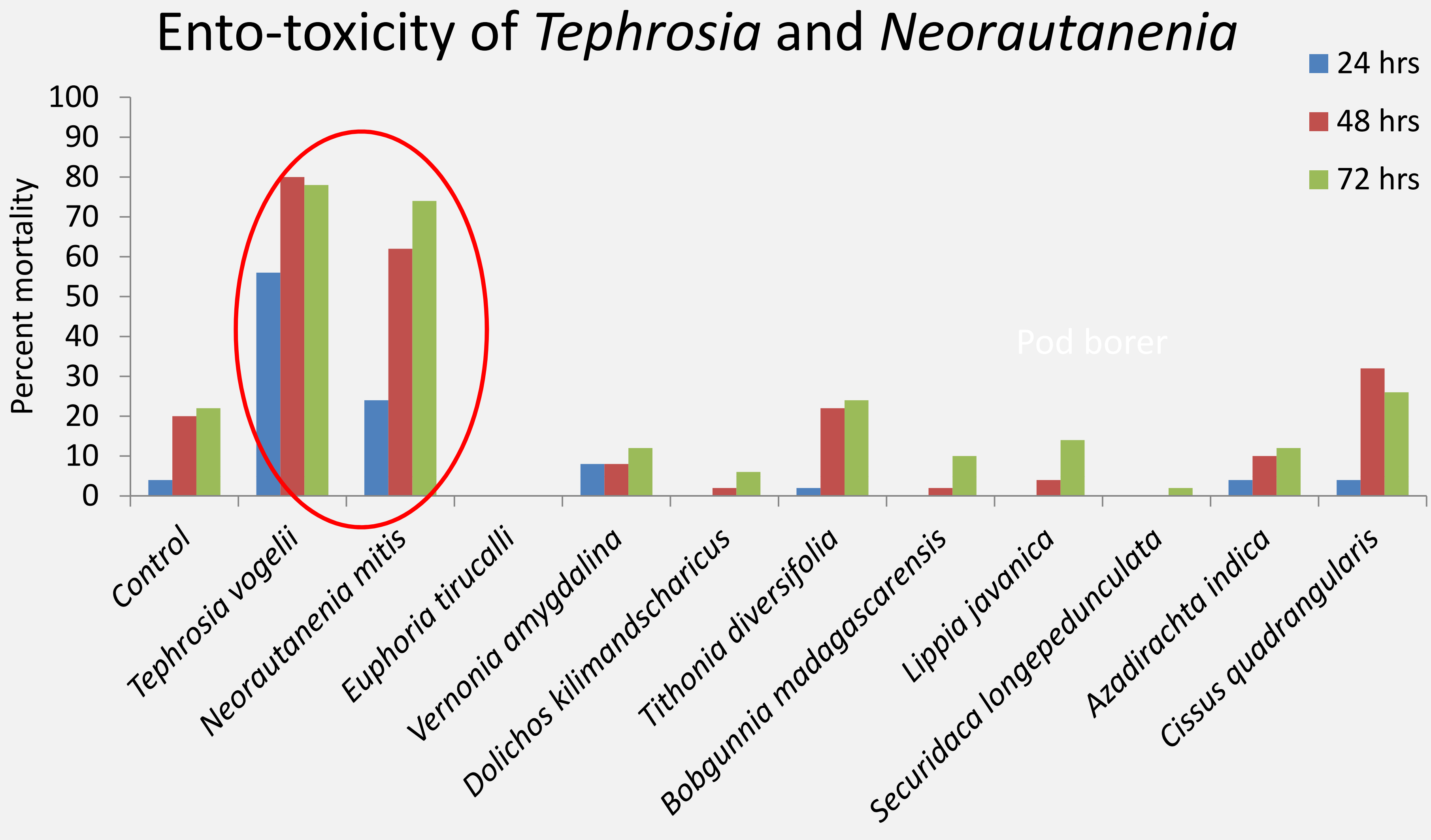
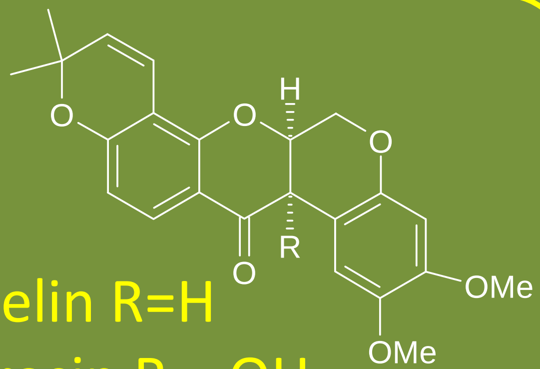


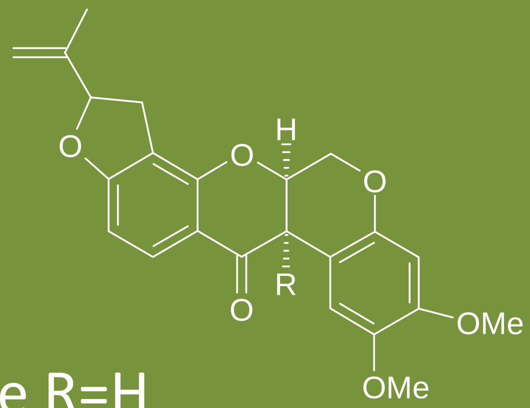
# Rotenoids from *Tephrosia vogelii* leaves

Main components in leaves



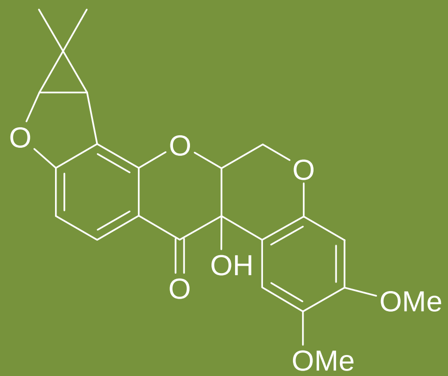

Deguelin R=H

Tephrosin R = OH

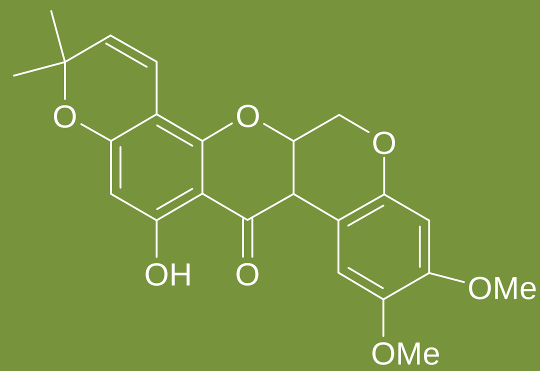



Rotenone R=H

12α-hydroxyrotenone R = OH

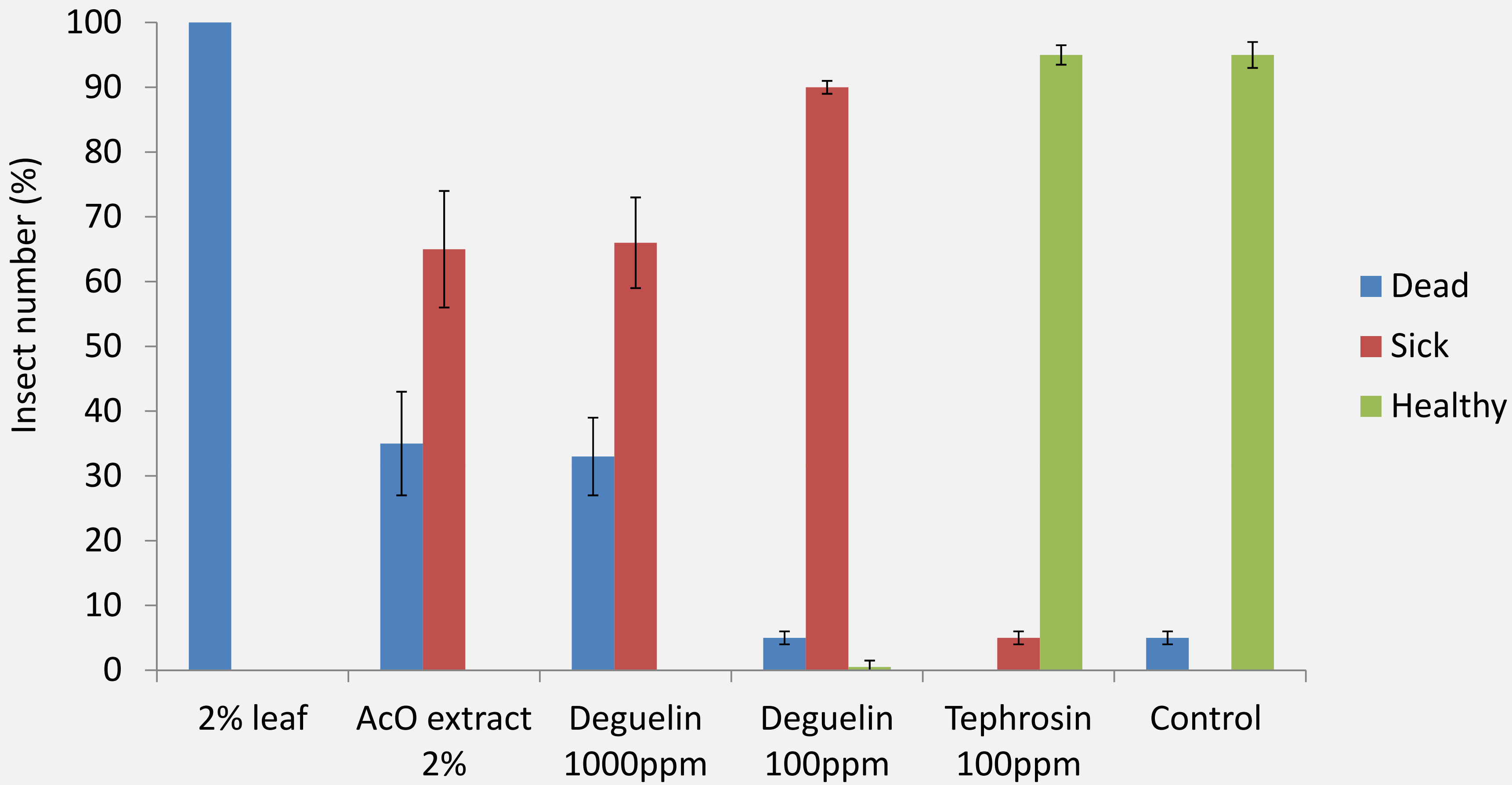



Sarcolobine



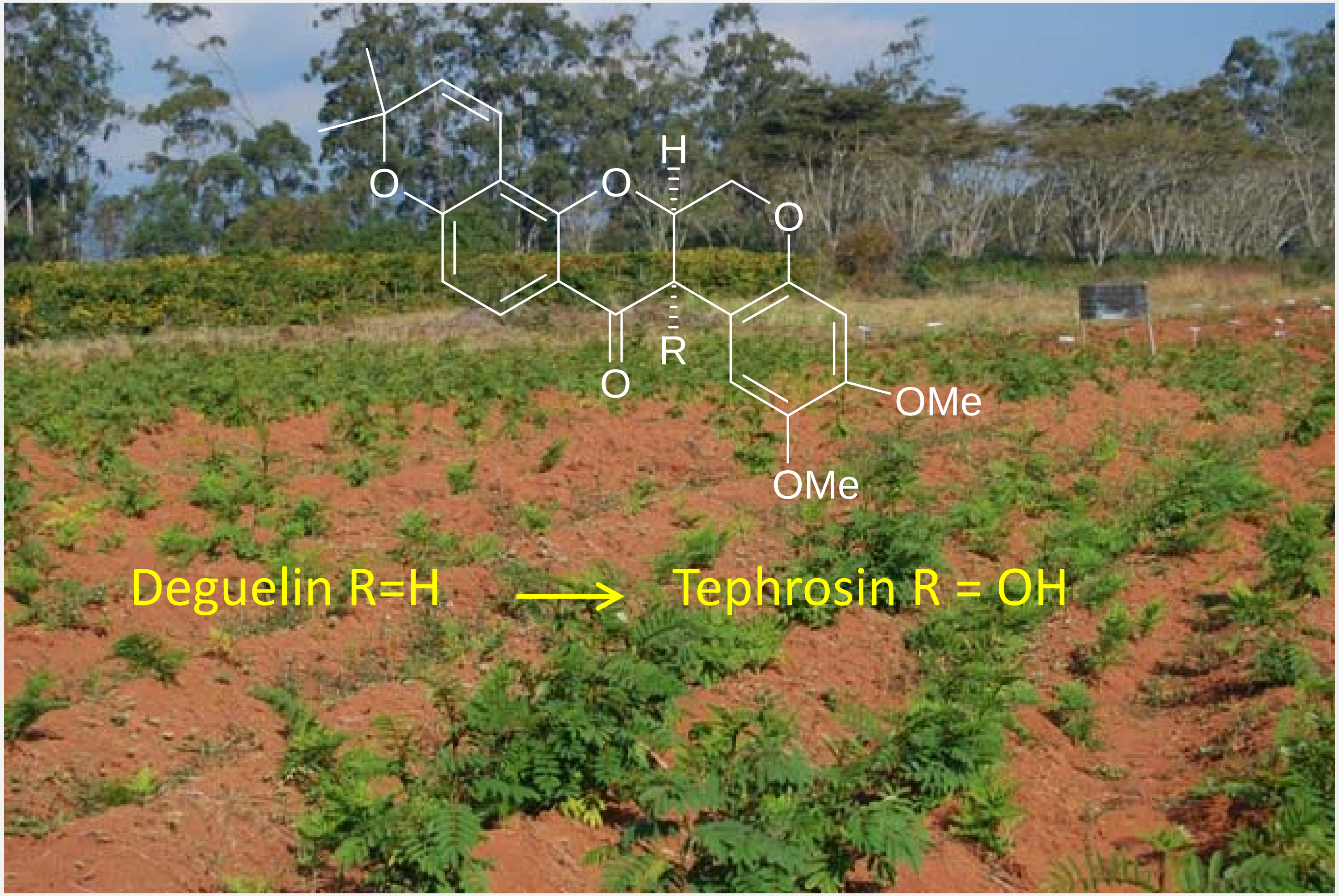

Toxicarol

# Effect on *C. maculatus* of cowpea seeds treated with *T. vogelii* leaf, leaf extract & rotenoids after 48 h




Sick insects are alive but incapacitated i.e., can not lay eggs.

# Chemical variation within *Tephrosia*?

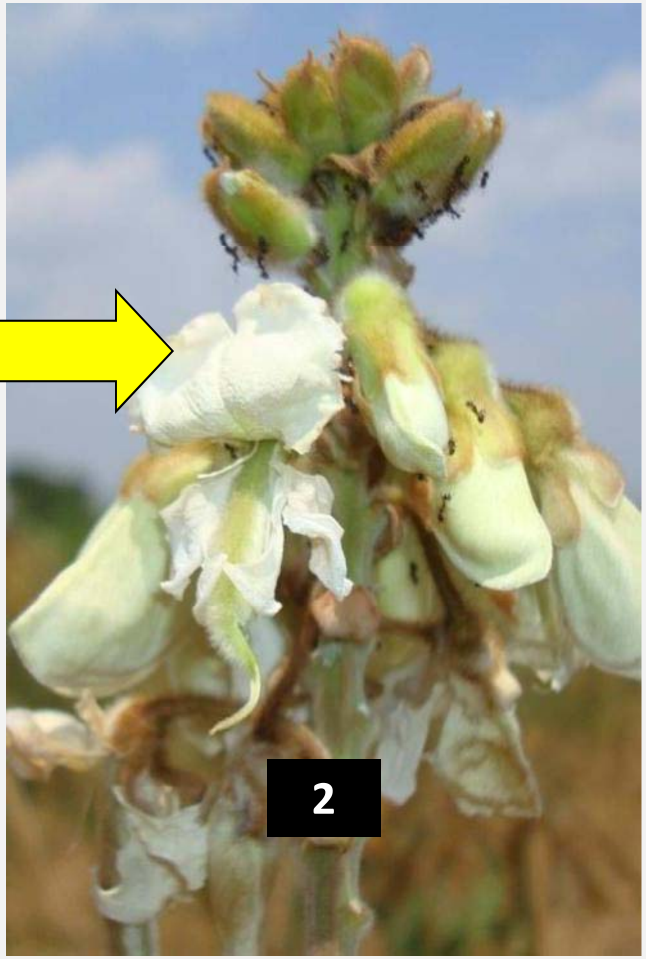


# Best species - *T. vogelii* or *T. candida* ?

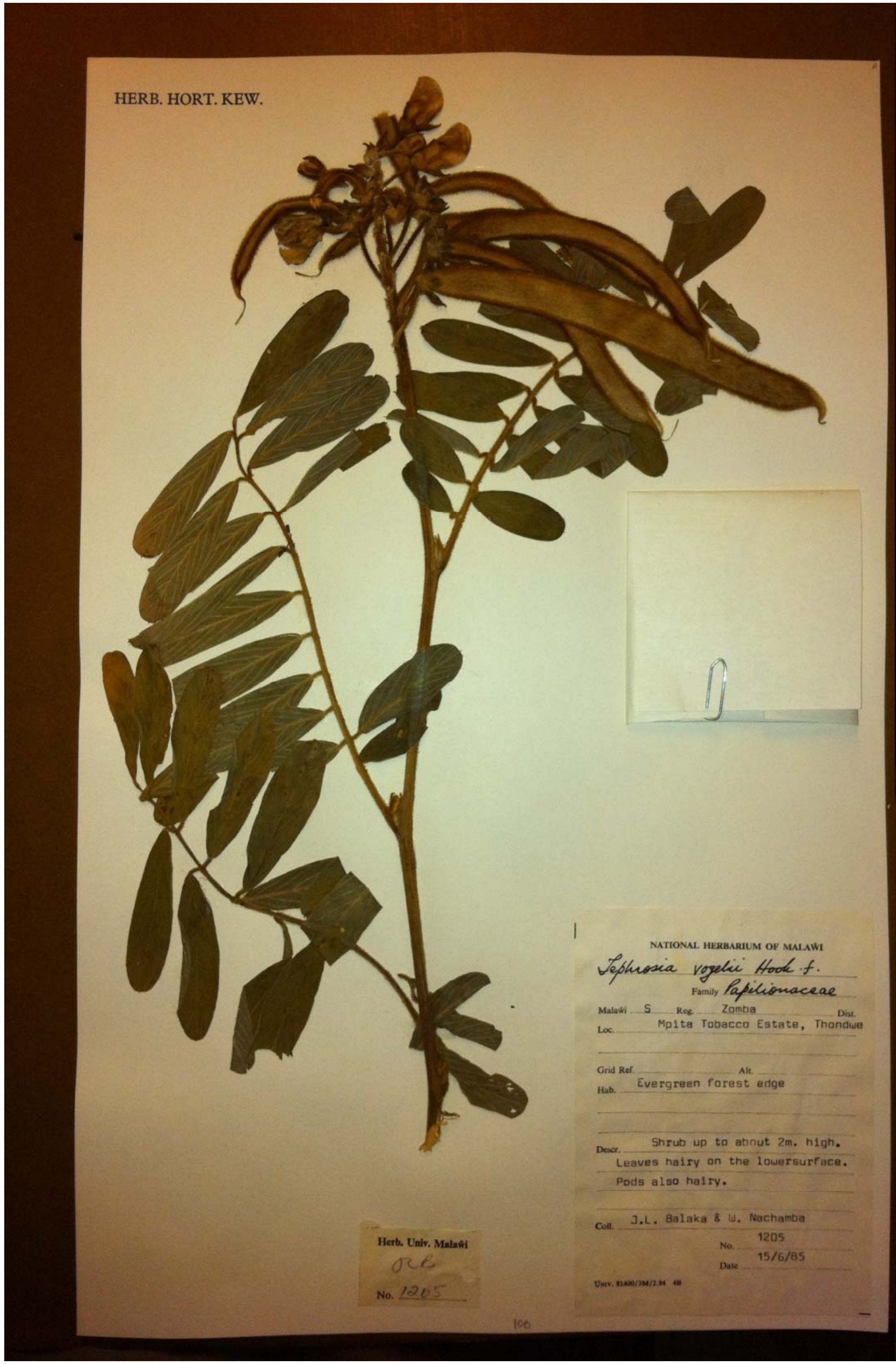
## *(growing at International Institute in Africa)*

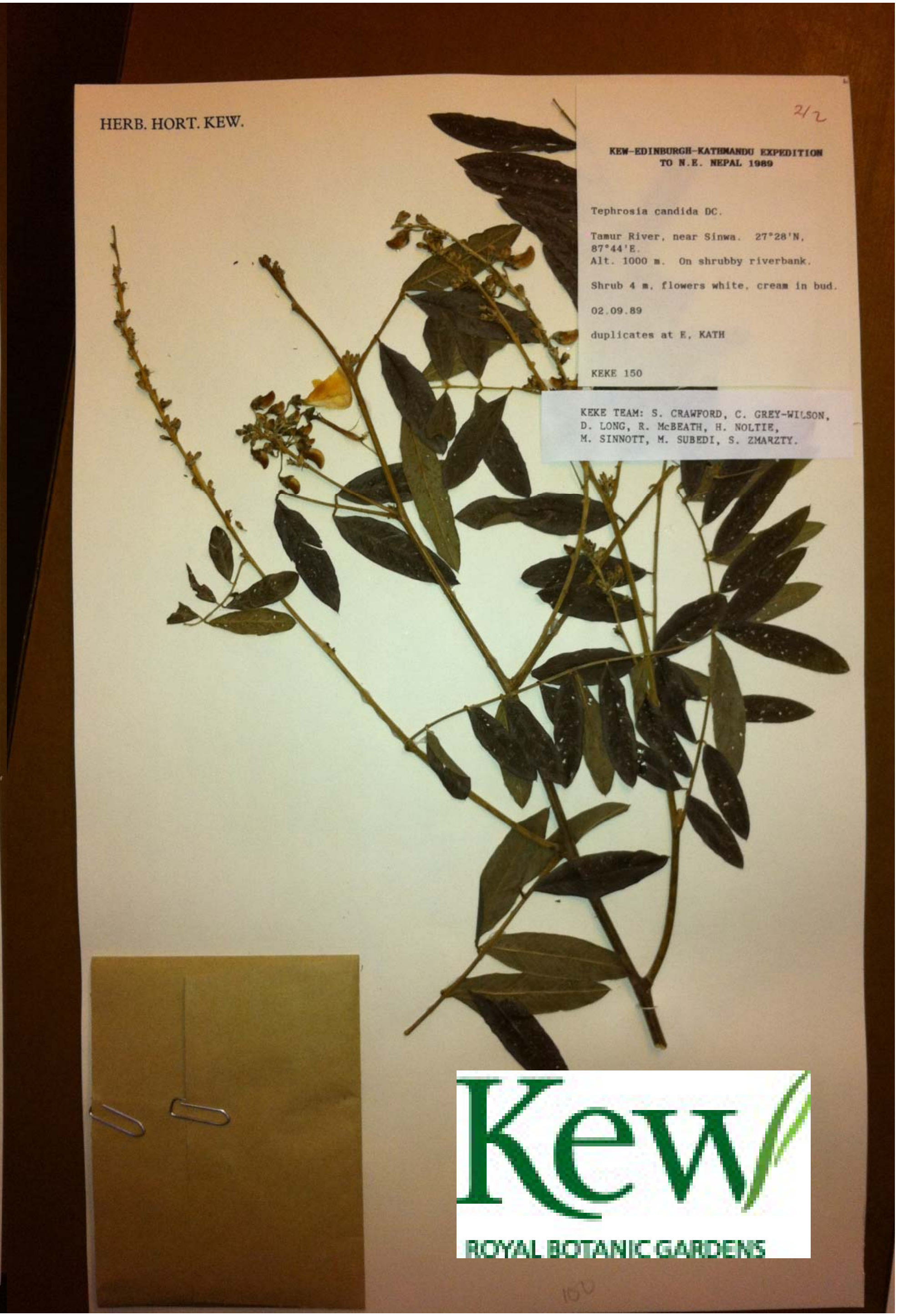

*Tephrosia vogelii*
Highly toxic to bruchids

*Tephrosia candida*?
Promoted for soil improvement ($N_2$ fixing, green mulch) and (assumed) pest control




**Is *T. candida* also effective at controlling bruchids?**



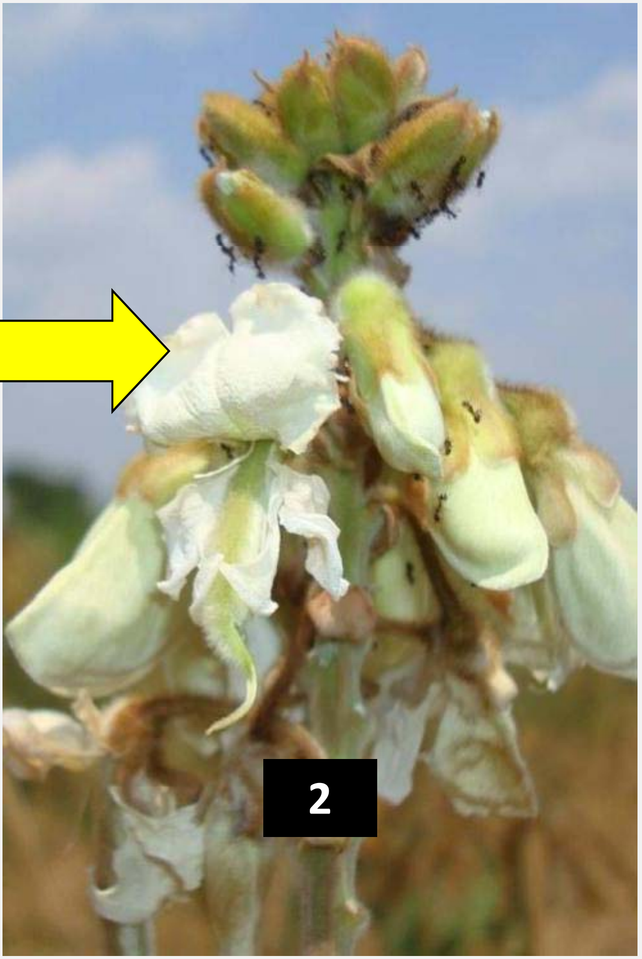




Kew
ROYAL BOTANIC GARDENS

# Both are in fact *T. vogelii*

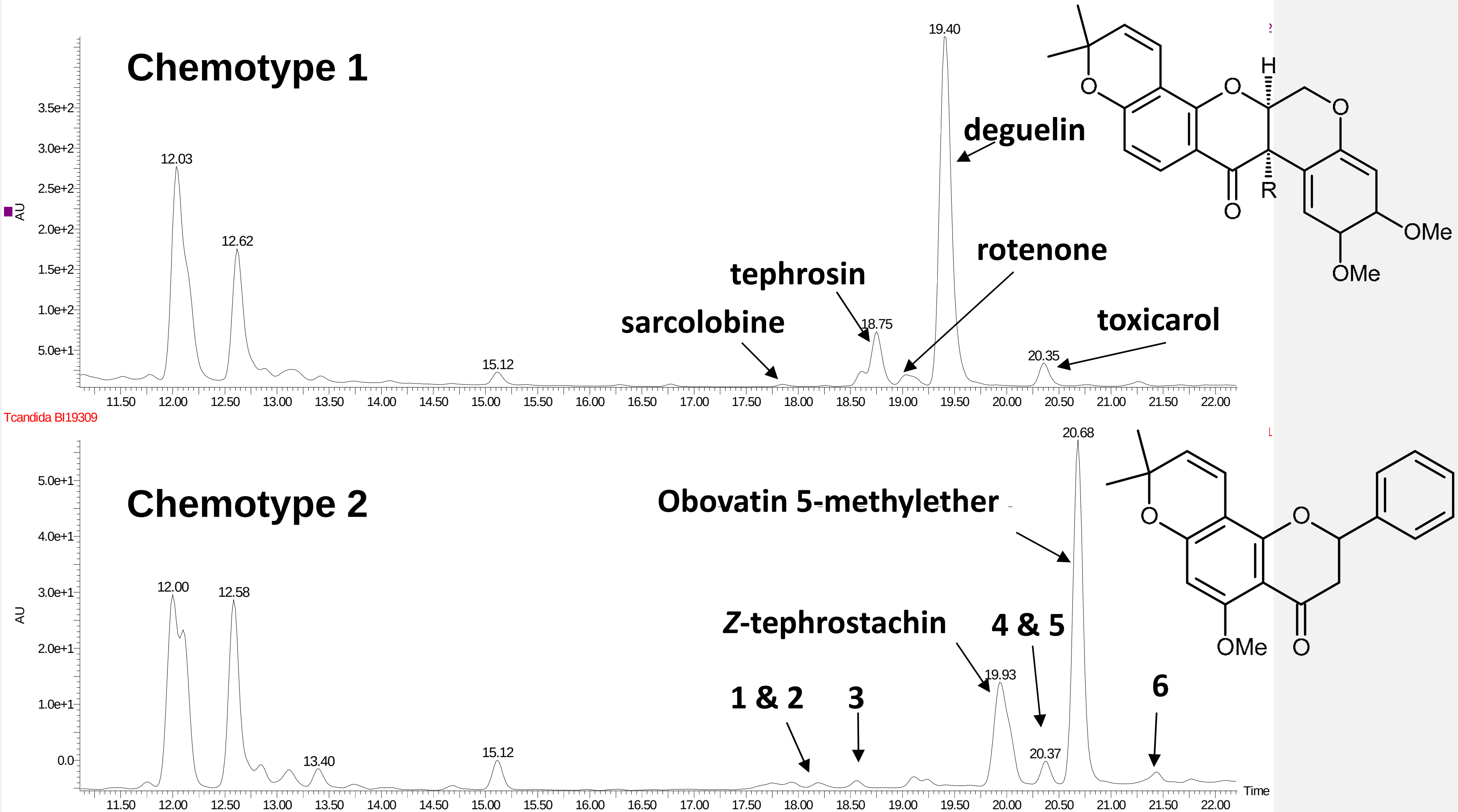

*Tephrosia vogelii*
Highly toxic to bruchids

*Tephrosia vogelii*
Promoted for soil improvement ($N_2$ fixing, green mulch) and (assumed) pest control



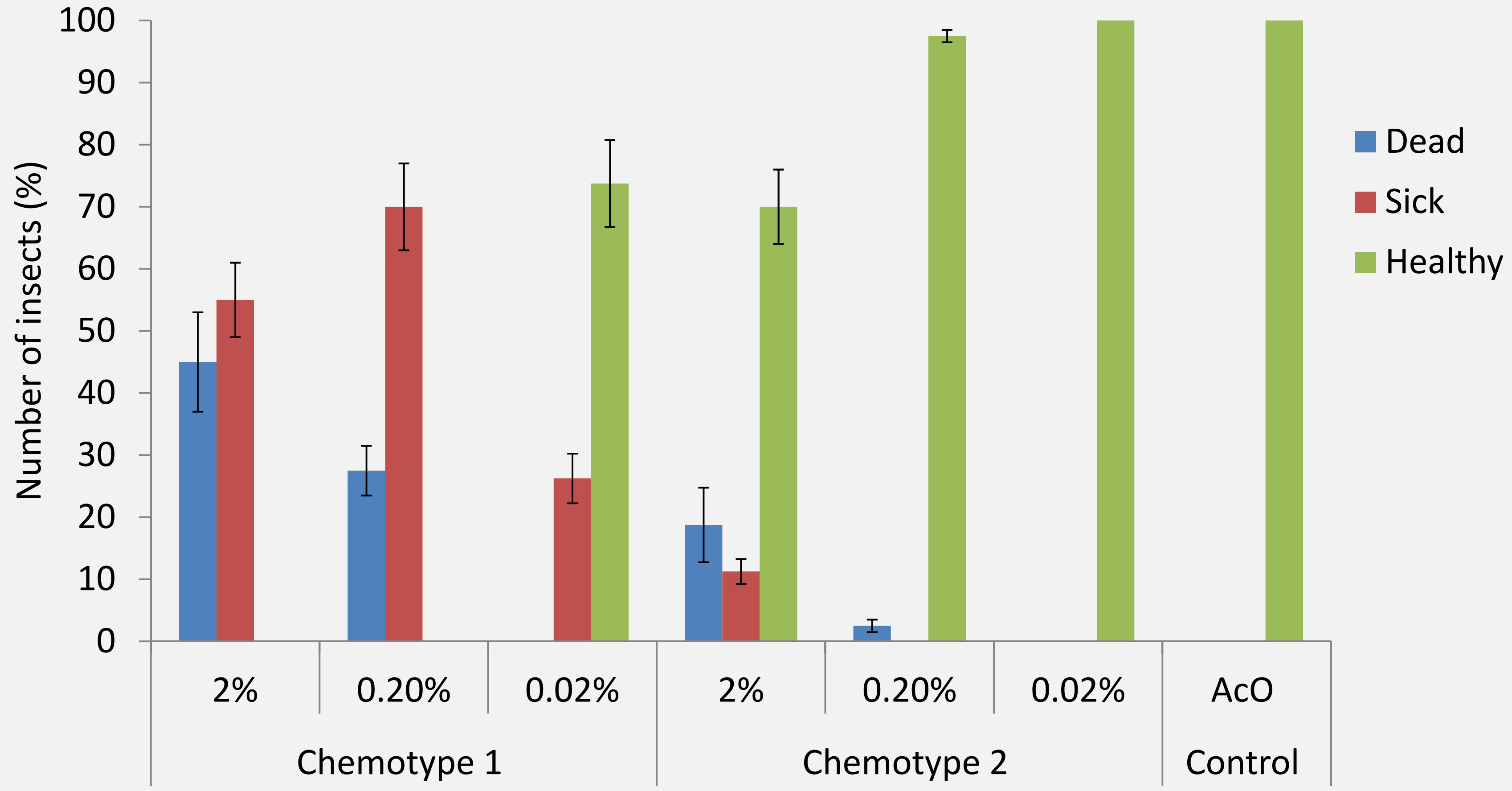

**Plastid L*trn* region, ITS nuclear DNA sequences & morphology indicate both to be *T. vogelii***

# LC-MS chromatograms of *T. vogelii* chemotypes 1 & 2



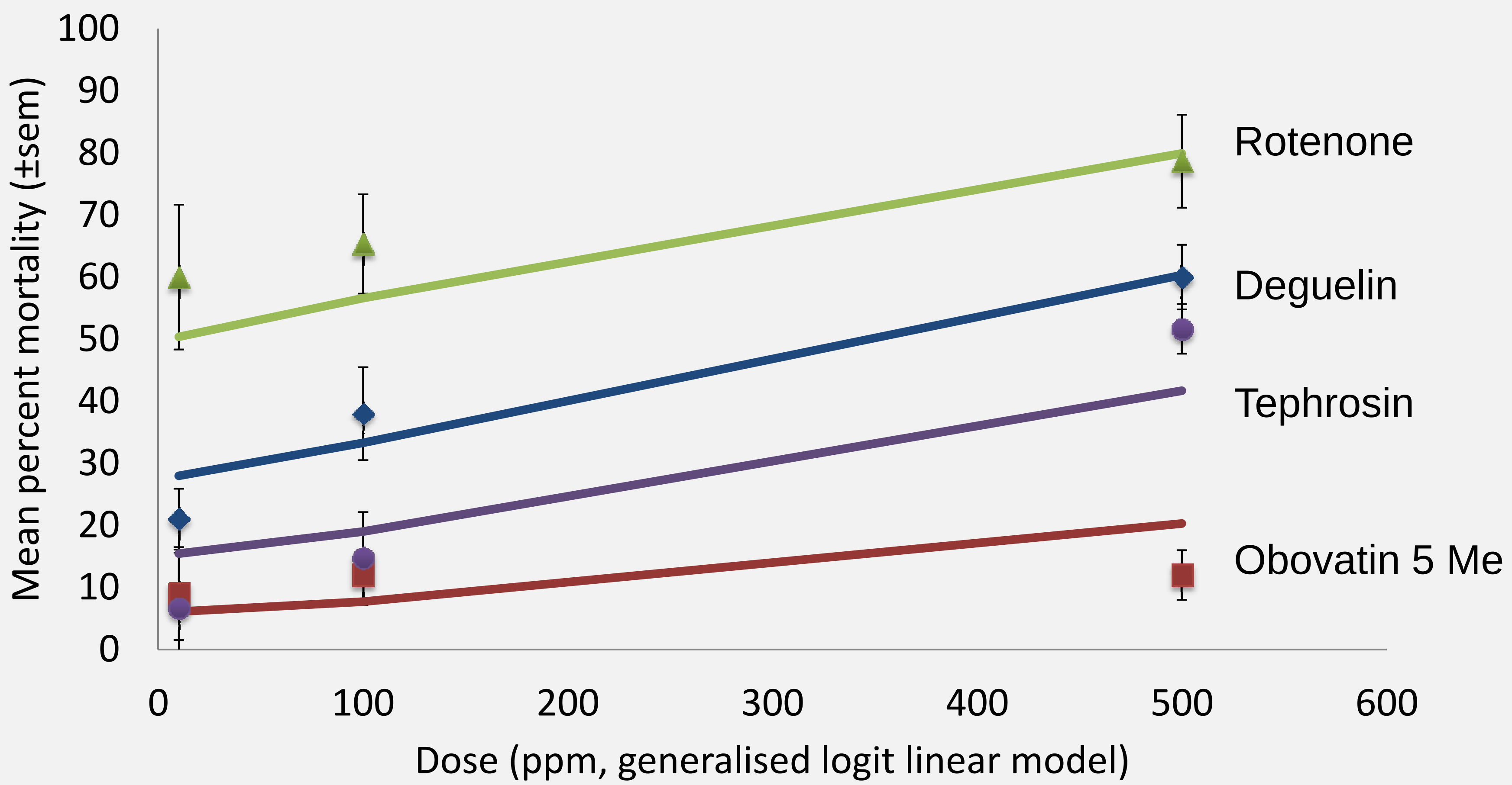

**Compound IDs based on 700MHz NMR and HR-EI MassSpec.**
**Compounds 1 – 6 are novel**

# Effect on *C. maculatus* of cowpea treated with acetone extracts of *T. vogelii* chemotypes after 48 hours




Sick insects are alive but entirely incapacitated

# Concentration dependent mortality of *C. maculatus* on cowpea treated with compounds from *T. vogelii*.

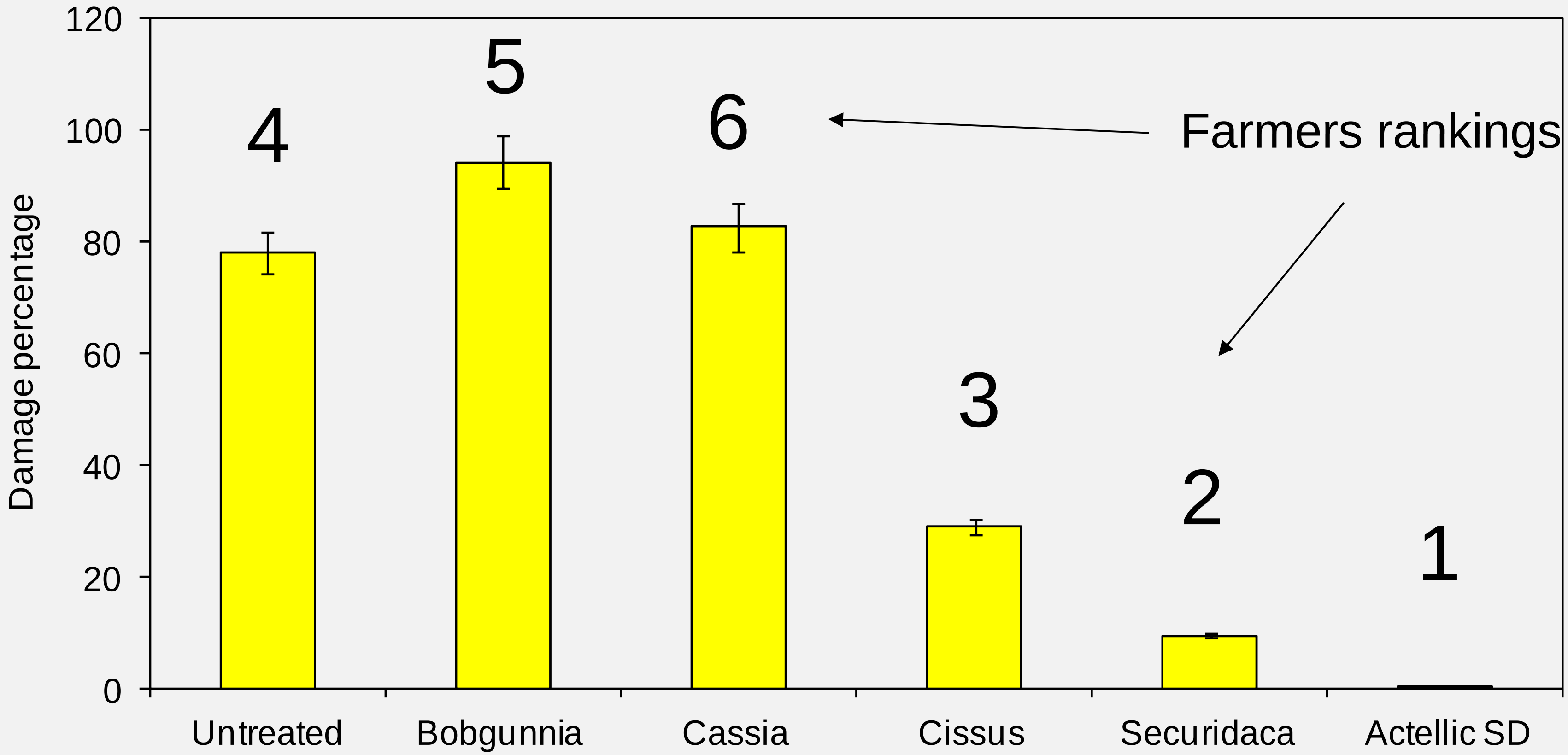


# *Securidaca longepedunculata*

- Effective stored product protectant
  - Ghana & Zambia.

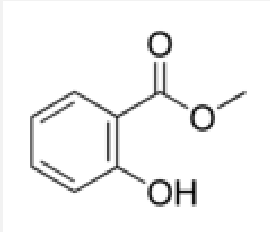
- Root bark pounded & mixed with grain
  - inefficient

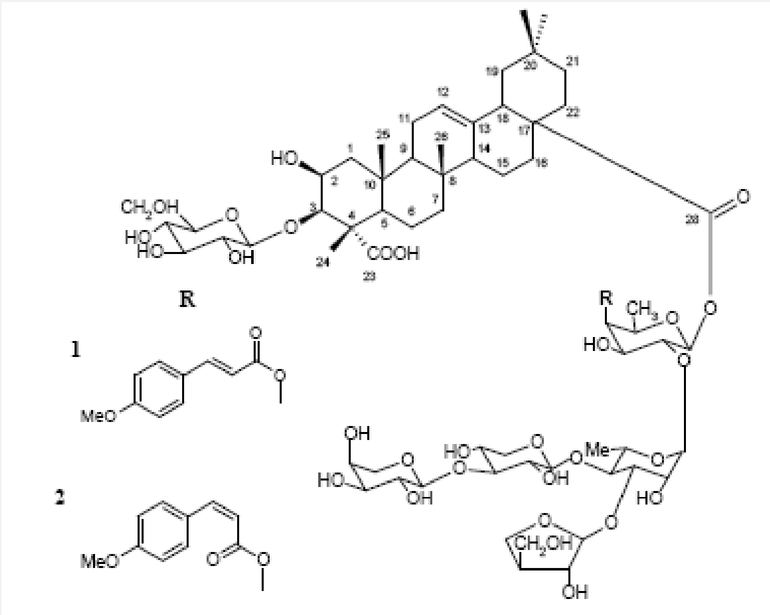
# Maize damage (%) by natural infestation of *S. zeamais* 20 wks after treatment with plants (2% w/w) reported to be pesticidal by farmers – Choma, Zambia.



# *Securidaca longepedunculata*

- Methylsalicylate
- Saponins

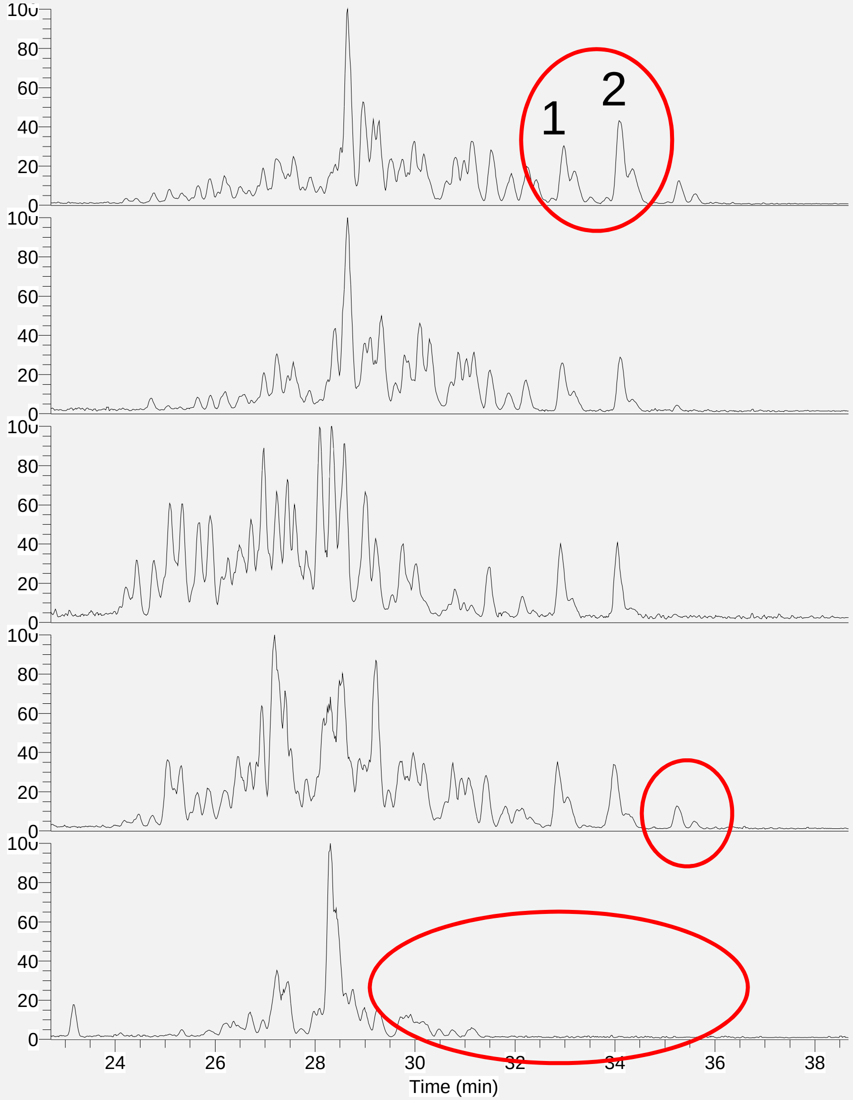



- Methyl salicylate deterrent and toxic to *Sitophilus zeamais* but volatile
- Saponins also active & occur in stem bark
- Can stem bark be used instead of root?
  - More sustainable

Stevenson et al., 2009 *J Ag Food Chem*, 57, 8860.
Jayasekera, Stevenson, Belmain and Hall, 2002 *J. Mass Spectrom*, 37, 577
Jayasekera, Stevenson, Belmain and Hall, 2005 *J. Chem. Ecol.*, 31, 303.

# LC-MS chromatograms of 5 specimens of *S.longepedunculata* from different locations showing variation in saponin chemistry




Tamale, Ghana. Effective

Bolgatanga, Ghana. Effective

Choma, Zambia. Effective

Root bark Nchenachena, Malawi, Effective

Stem bark Nchenachena Malawi
Ineffective in field trials

# *Securidaca longepedunculata*

Water extracts saponins

- More efficient use of plant
- Every grain coated

Submersion of grain in soapy extract for treatment & solarisation kills pre-storage infestation.

Farmers tried this

–50% less plant material used

Extracting *Securidaca* and treating grain

# Current field trial of water extract treated grain – Kasisi, Zambia


Extract requires less than half as much plant material as powdered but unpopular – too much effort!

But it works!!!!!

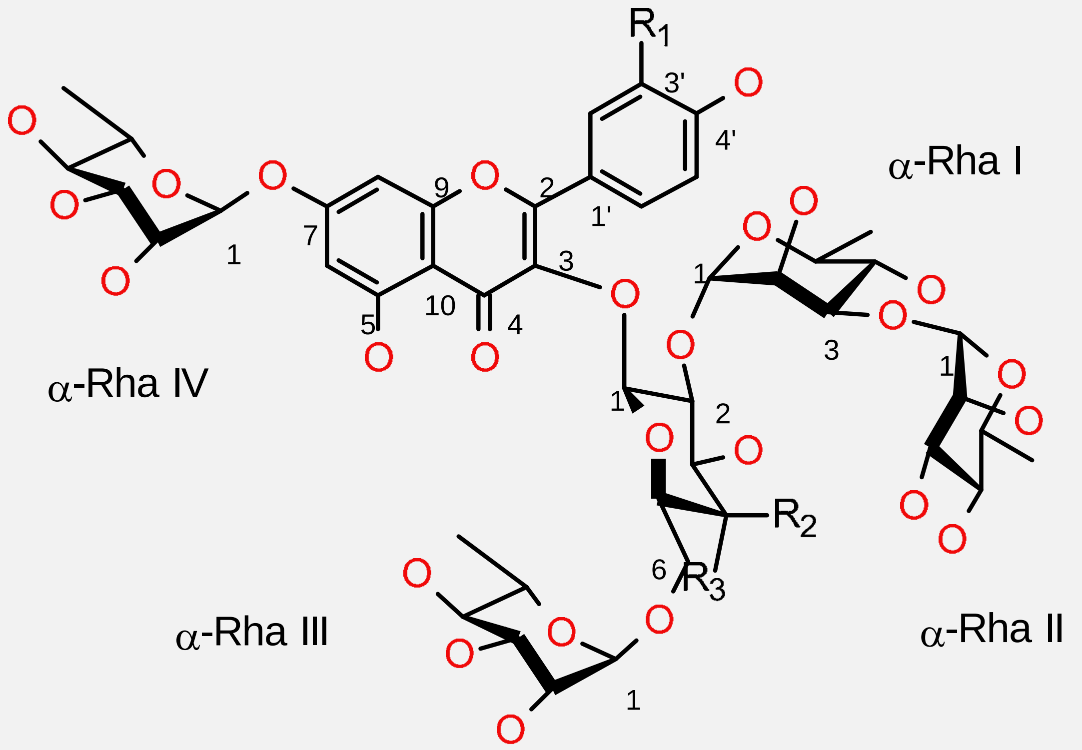
# *Bobgunnia madagascariensis*
# (Desv.) J. H. Kirkbr. & Wiersema (Leguminosae)

Syn. *Swartzia madagascariensis*

(Widespread across African semi arid woodlands except Madagascar).

Kamanula et al., (2011) Intl. J. Pest Manage, 57, 41-49

# Flavonoid pentaglycosides from *B. madagascariensis*

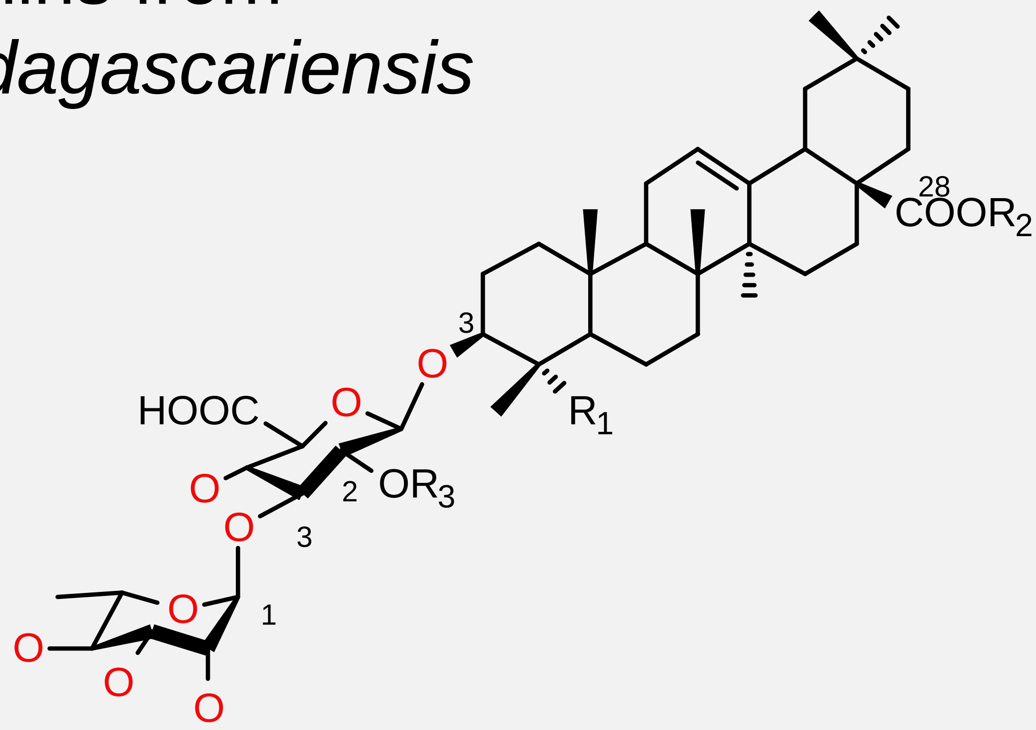



**1a** $R^1 = R^2 = OH$, $R^3 = H$
**1b** $R^1 = R^3 = OH$, $R^2 = H$
**2a** $R^1 = R^3 = H$, $R^2 = OH$
**2b** $R^1 = R^2 = H$, $R^3 = OH$

Between 5 and 20% by weight of dry pod!

Stevenson, Nyirenda & Veitch. (2010) *Tetrahedron Letters*, 51, 4727–4730.

# Saponins from *B.madagascariensis*



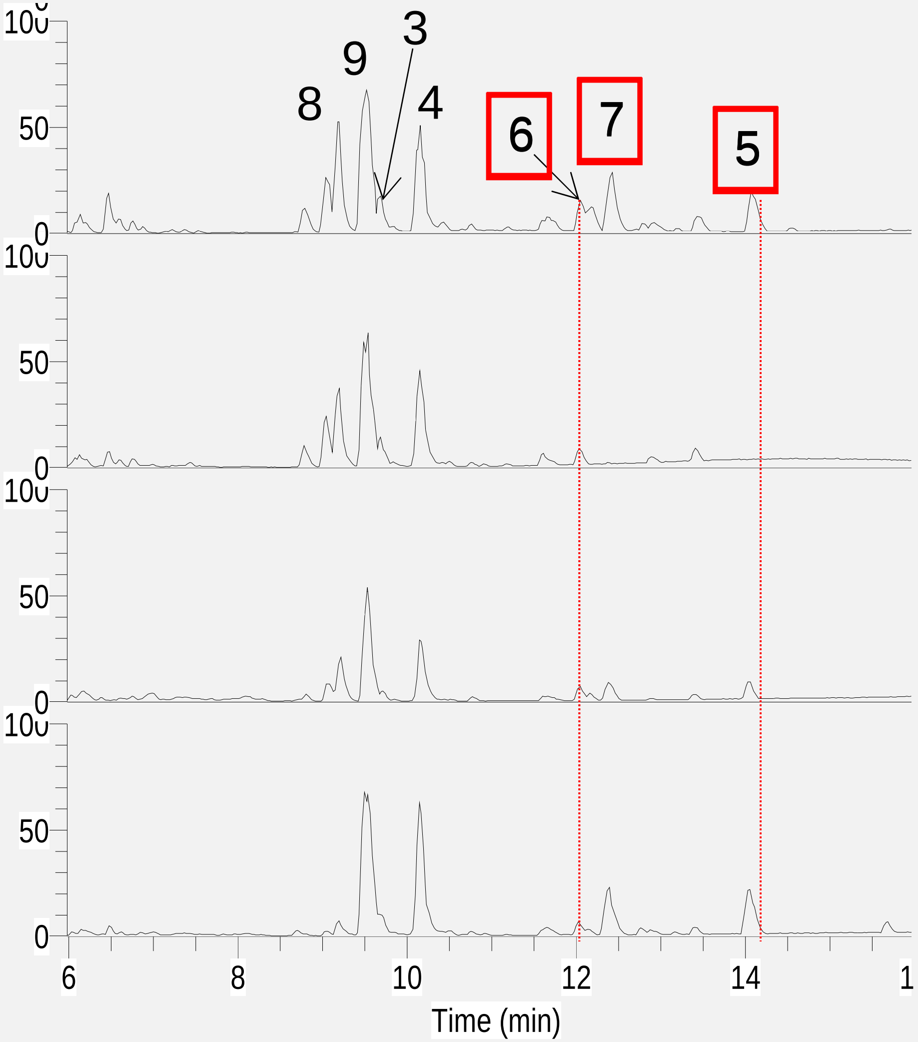

**3** $R_1 = CH_3$, $R_2$ = β-Glc, $R_3$ = β-Xyl
**4** $R_1 = CH_3$, $R_2$ = β-Glc, $R_3$ = H
**5** $R_1 = CH_3$, $R_2 = R_3$ = H
**6** $R_1$ = CHO, $R_2 = R_3$ = H
**7** $R_1 = CH_3$, $R_2$ = H, $R_3$ = β-Glc
**8** $R_1$ = CHO, $R_2$ = H, $R_3$ = β-Glc
**9** $R_1 = CH_3$, $R_2 = R_3$ = β-Glc

Most biologically active →

Polarity?

Marston et al., (1994)
Stevenson et al.(2010)

LC-MS chromatograms of *B. madagascariensis* at equiv. conc. from 4 locations showing qualitative and quantitative variation in saponins




Luhomero, Malawi. Effective in field trials

Choma, Zambia
Ineffective in field trials

Rhumphi, Malawi

Muzarabani, Zimbabwe
Effective in field trials

Sarasan, Kite, Sileshi and Stevenson 2011, Plant Cell Reports

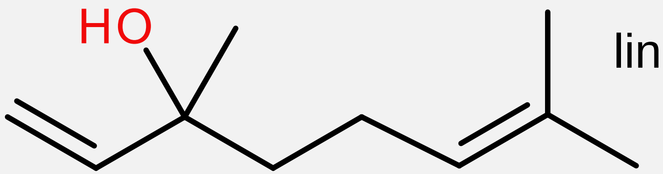
# *Lippia javanica*

# *Lippia javanica*

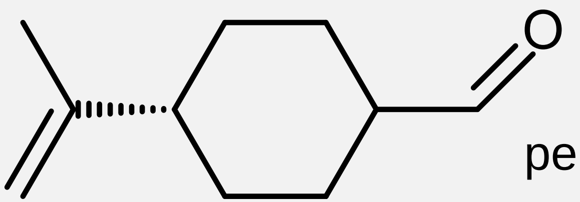
Effect on tick count / animal of treating cattle with 5% *Lippia javanica*


Madzimure et al., *Trop Anim Health Prod* (2011) 43:481–489

# *Lippia javanica*

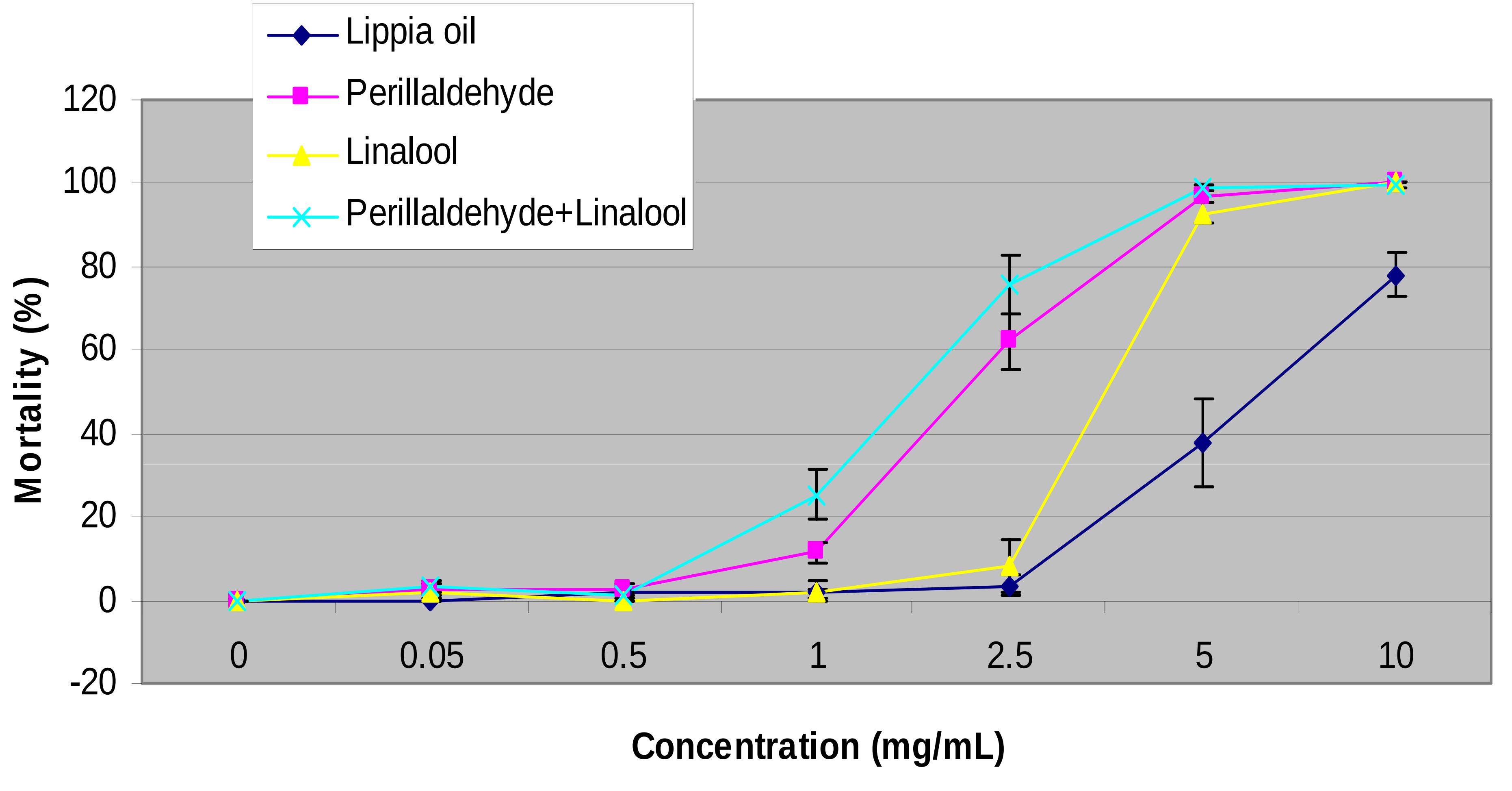



linalool

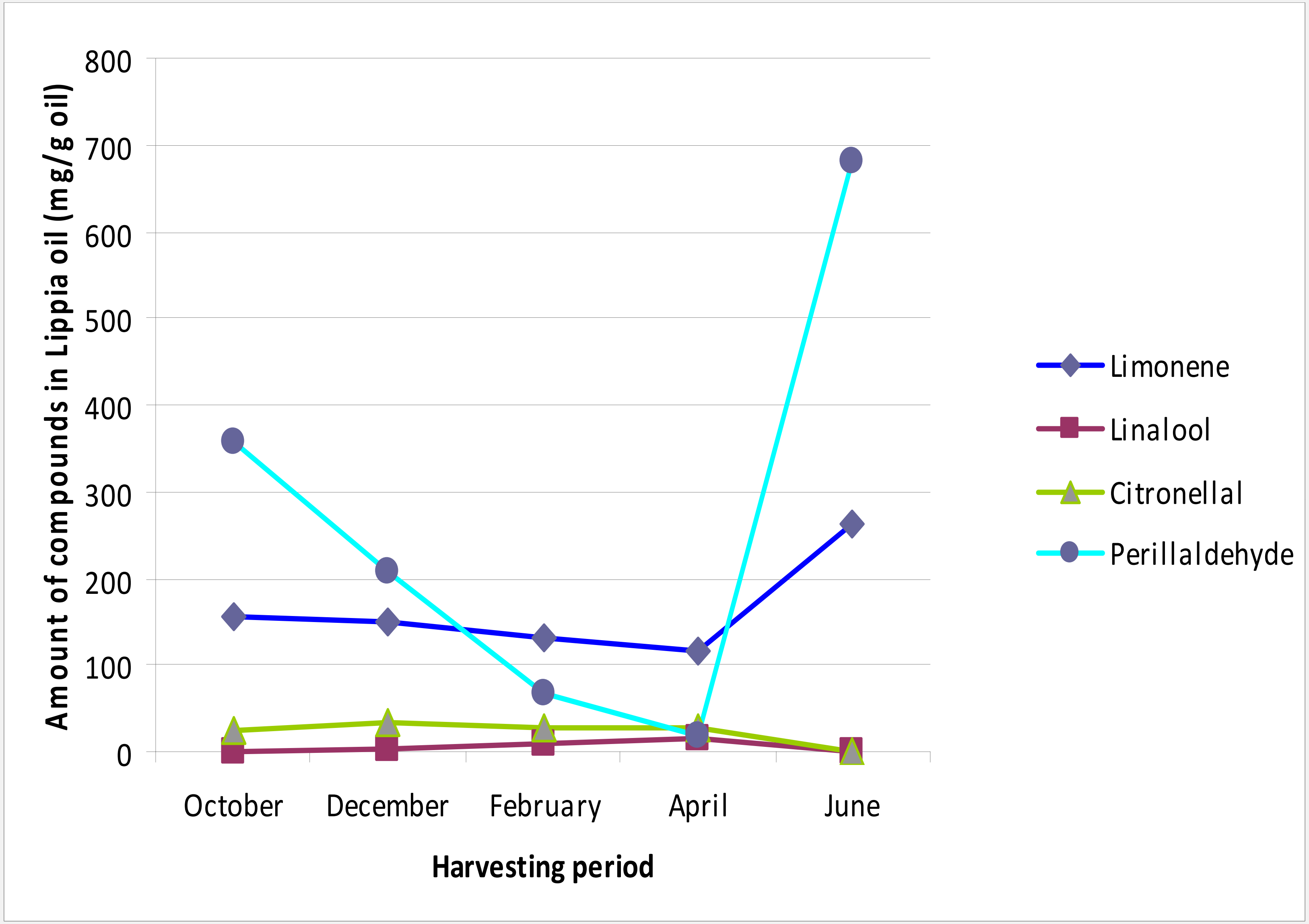



perilaldehyde

# Contact toxicity of Lippia oil, perillaldehyde, linalool and perillaldehyde+ linalool (1:1) against *S. zeamais* at 24hr



# Limonene, linalool, citronellal and perillaldehyde in Nchenachena Lippia leaf oil changes over time



# Some volatile compounds identified in Lippia oils from different locations in Malawi

| | Location | | |
|---|---|---|---|
| Compound | Nchenachena | Chikangawa | Jenda |
| Perillaldehyde | 44 % | 0 | 0.55 % |
| Limonene | 24 % | 0 | 13 % |
| Ipsdienone | 1 % | 52 % | 31 % |
| Piperitone | 2 % | 0 | 22 % |
| Germacrene D | 4 % | 5 % | 5 % |
| (+)-Carvone | 3 % | 0 | 0 |
| | | | |

# Summary

***Tephrosia vogelii*** **and other species provide highly effective bruchid control but efficacy is variable**

- Activity associated with presence of specific plant chemicals
- Occurrence of chemcials is variable between chemotypes but predictable

# Implications

Elite materials of pesticidal plants need to be promoted for pest control and propagation

Caution required when recommending use of pesticidal plants for pest control without chemotyping or validating in trials