# Contributions to the body of knowledge of groundnut fructification, calcium nutrition and its major pest, the groundnut leaf miner

The Professorial Inaugural lecture by Prof Godfrey E. Zharare

**Aim of Lecture**

1) To highlight my contributions to the body of knowledge on
   - Fructification and calcium nutrition.
   - Groundnut leaf miner pest.

2) To highlight areas for further research.

# Presentation outline

1. Introduction-Groundnut leaf miner and fructification/pops problems
2. Development of solution culture techniques for detailed studies on groundnut pops problem
3. Findings from studies on groundnut fructification and calcium nutrition
4. Research focus area for solving the groundnut pops problem
5. Research findings on the groundnut leaf miner
6. Research focus areas Identified for the groundnut leaf miner

# Introduction

**Rational for the research**

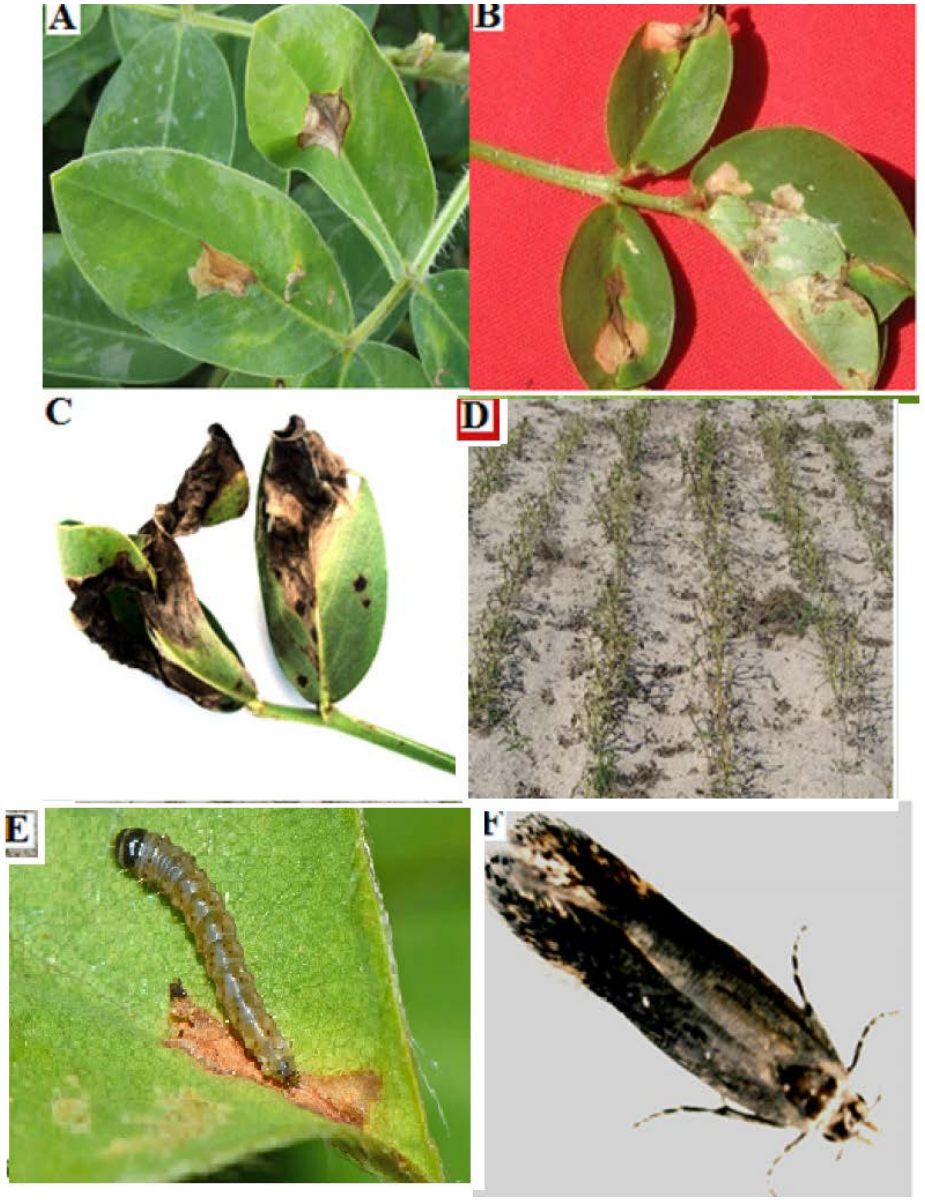
Groundnut is a food, oil and cash crop

Productivity  of the crop is seriously reduced by production of empty pods (pops).

Very limited information on the new devastating groundnut leaf miner pest.

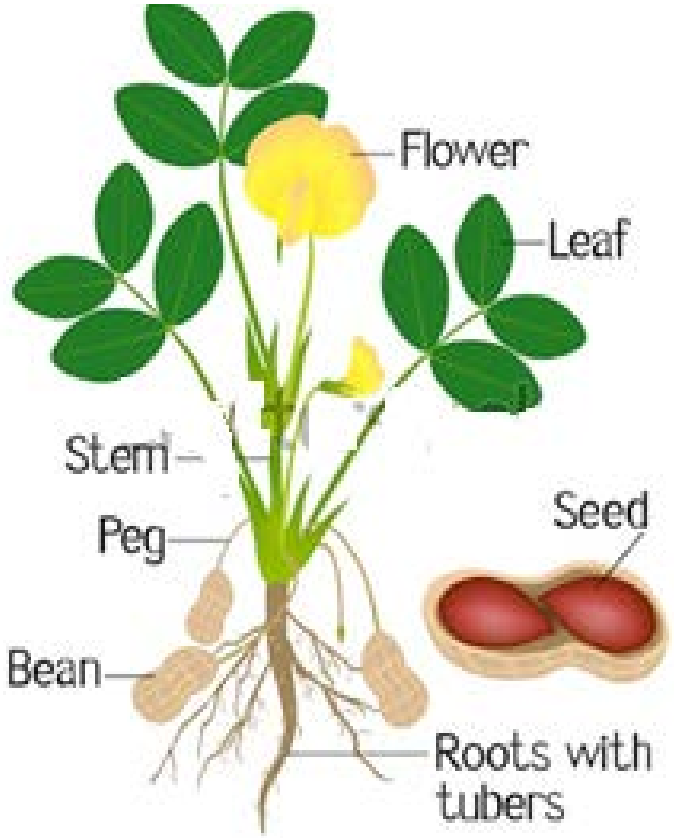
# Introduction-Crop Damage by Groundnut Leaf Miner

- (A) and (B) early season leaf symptoms
- (C) late season symptoms
- (D) Complete crop defoliation
- (E) the destructive groundnut leaf miner larva
- (F) The adult groundnut leaf miner moth



# Introduction- The Empty Pods (Pops) Problem of groundnut

- Pops are a result of reproductive nature of groundnut
- Caused by calcium deficiency due to lack of xylem transport to pods.
- Soluble calcium source (gypsum) needs to applied at pegging to avoid pops
- *Response is inconsistent*
- *The aetiology of the disease and role of calcium were unknown*




The morphology of the groundnut plant.

Groundnut plants showing gynophore penetrating the soil

# Research on Groundnut Fructification and Calcium Nutrition

**Development of solution culture techniques for studying in detail the pops problem**

- Required solution culture techniques to study the pod-nutrient relations.

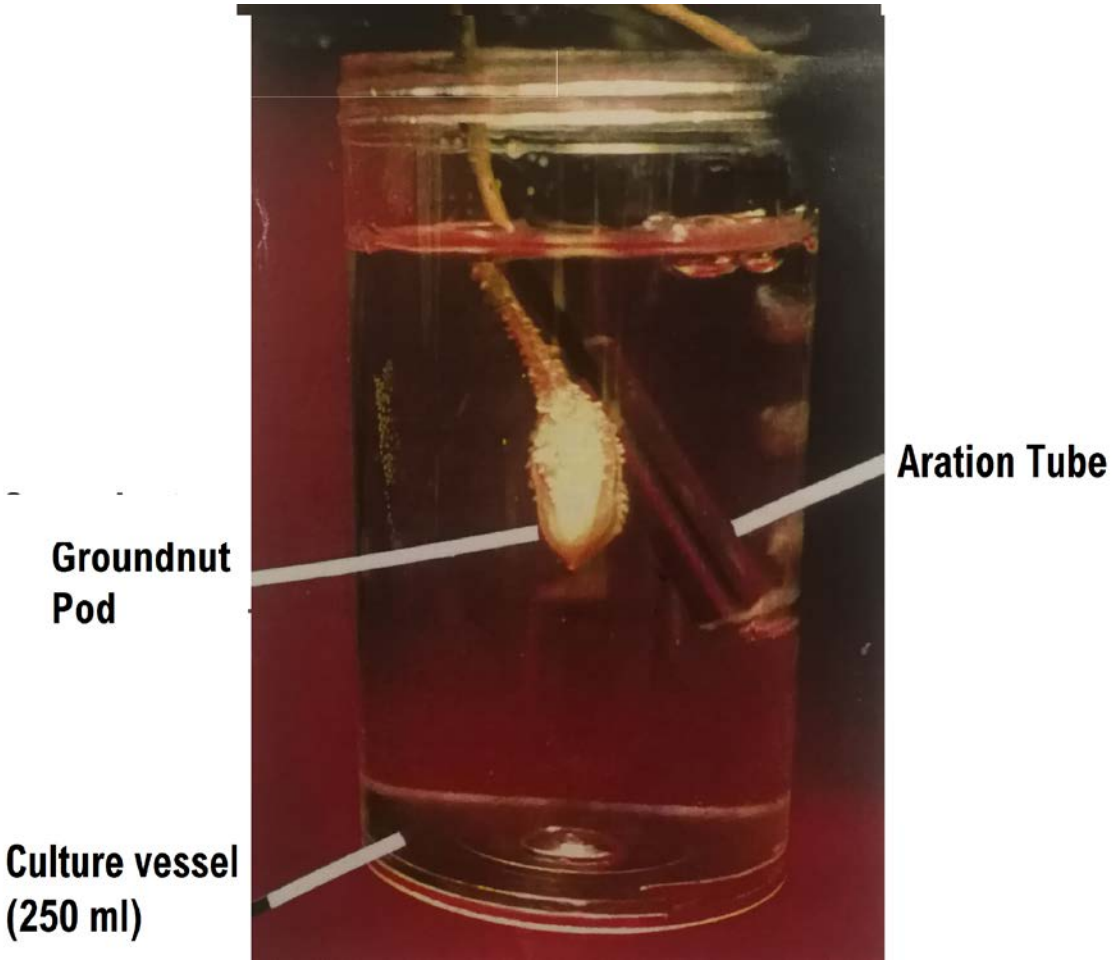
- First needed to overcome a barrier that has been identified since 1819.

  - Ability to grow normal groundnut pods in nutrient solutions.

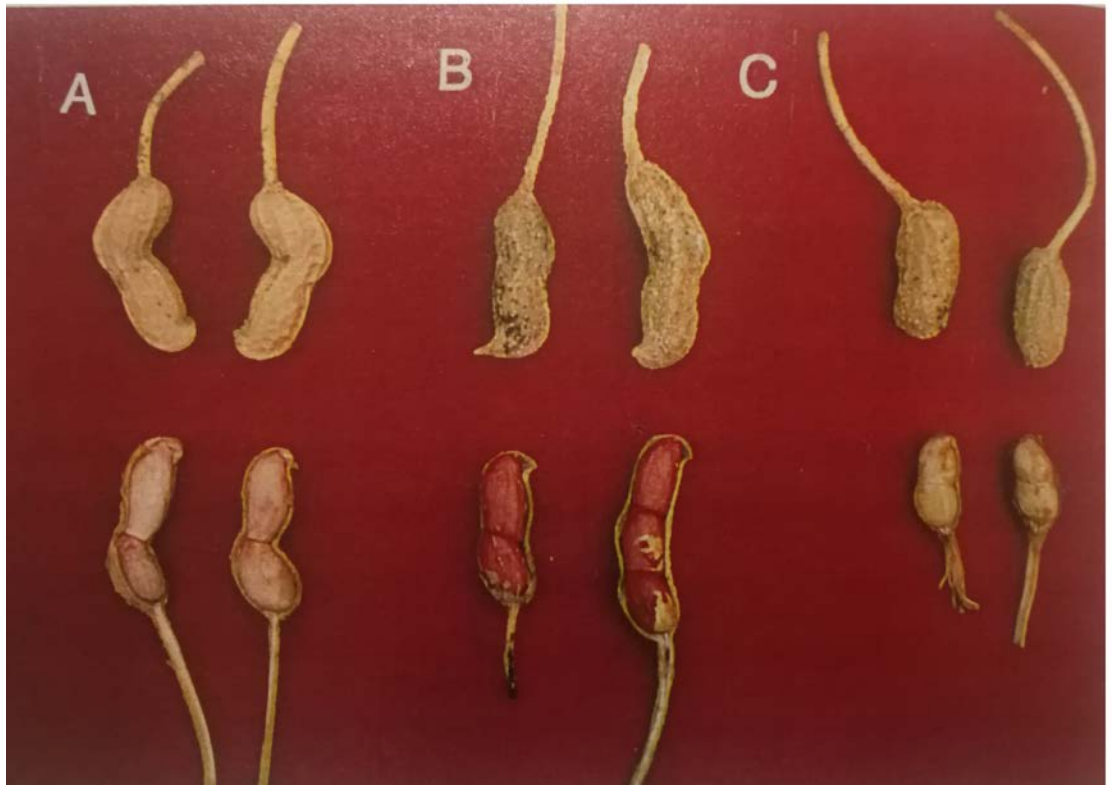
I set up a simple experiment to grow groundnut pods in nutrient solution

# Solution Culture Techniques……continued

First attempt to grow attached groundnut pods in nutrient solution—A BIG SUCCESSS




Single gynophore culture bottle




Mature pods and kernels of (A) Virginia Bunch, (B) CBRR4 and (C) TMV-2 cultured for the first time in solution using single gynophore culture bottles.

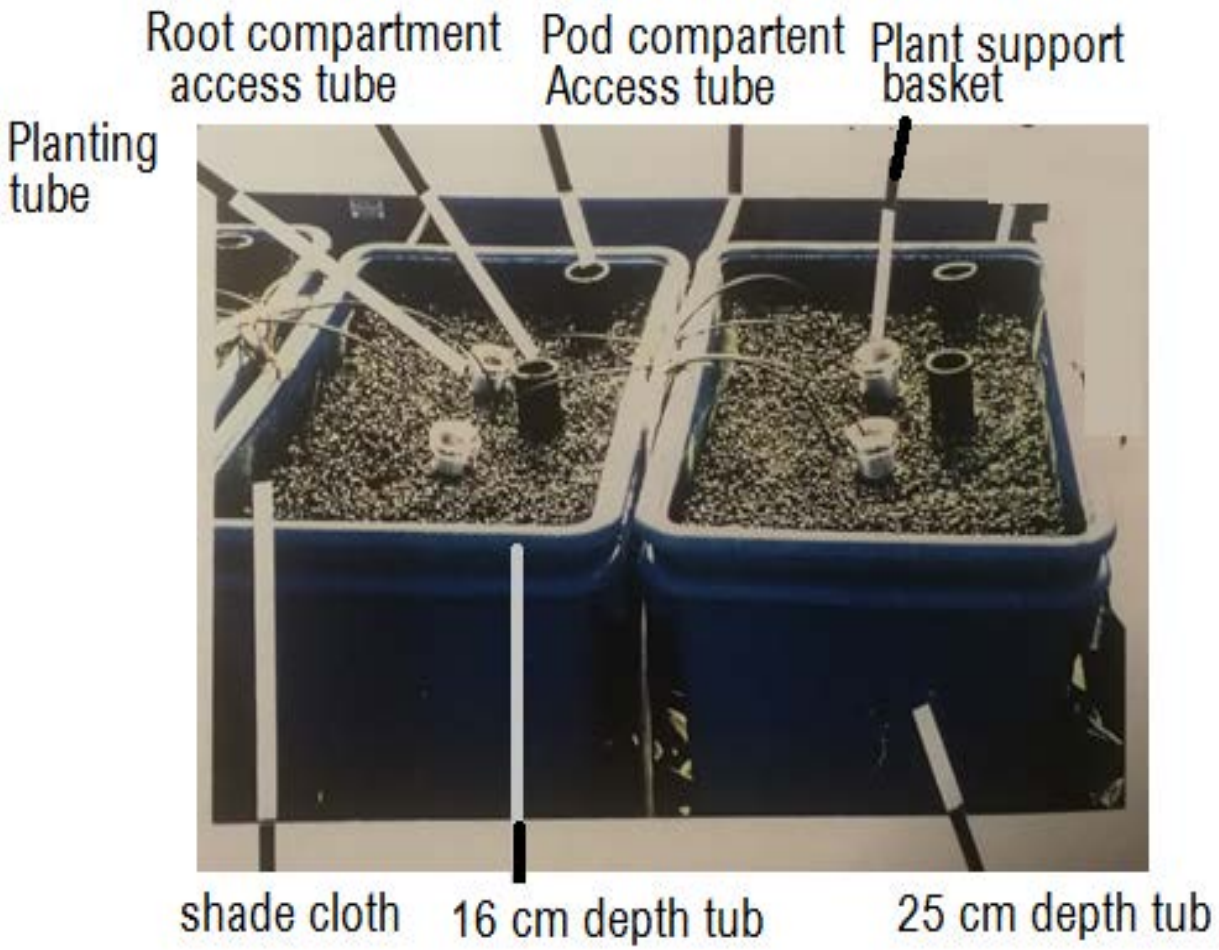
# Solution Culture Techniques……continued


Polysturene box with healthy groundnut plants

Flowing solution set-up for single gynophore cultures. The techniques was used to study the requirements of nutrients in the pod-zone environment.


Use of single gynophore culture in an experiment on potassium excretion by groundnut pods.

# Solution Culture Techniques……continued




. Split root-zone/pod-zone solution culture unit (left) which was used to study the effects of calcium on whole plant pod production (right).

# Solution culture techniques…….

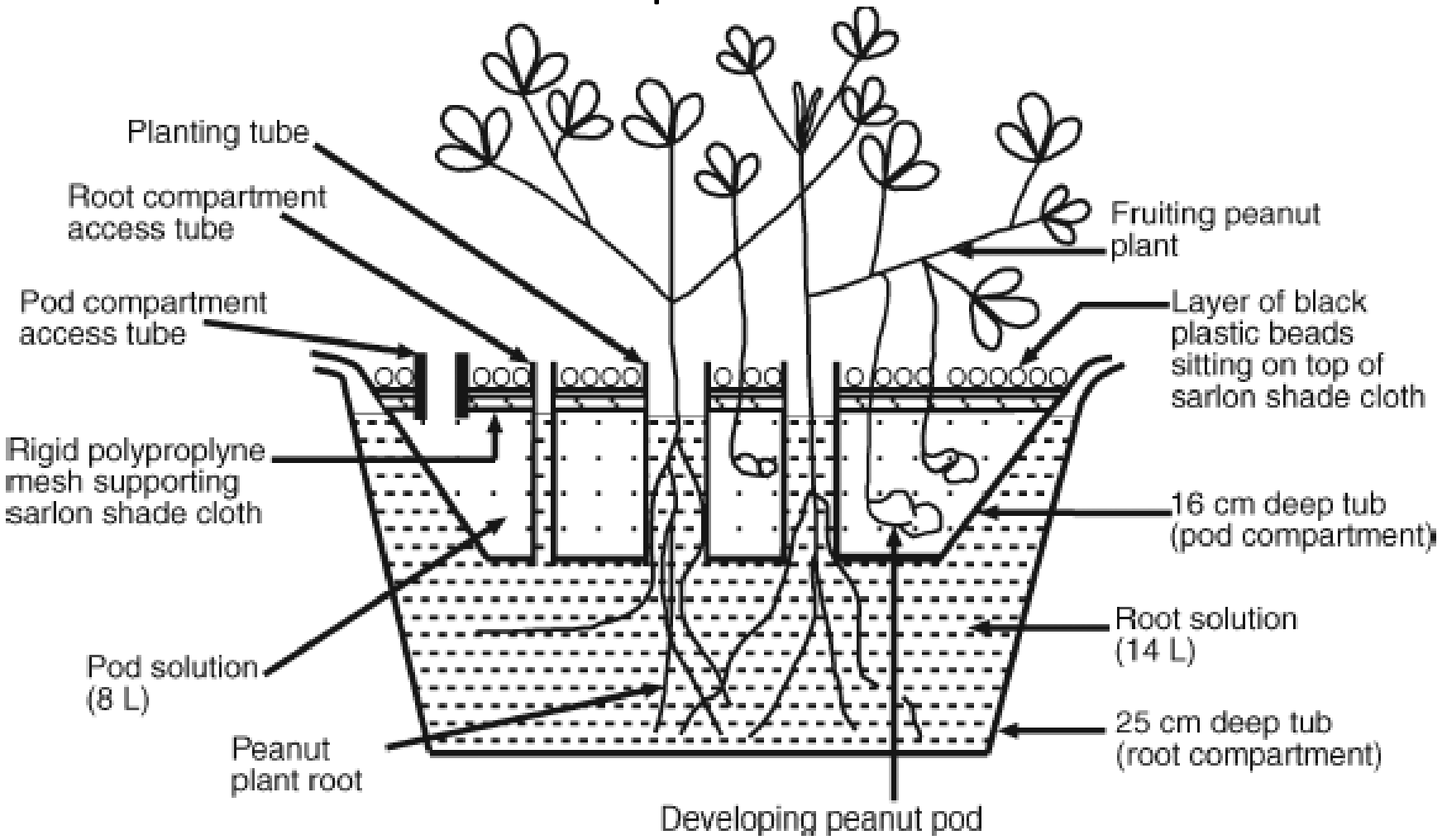



*Figure 1.* A split-medium pot used for the culture of peanut plants ensuring that the growth of roots and pods occurred in separate nutrient solutions.

# Findings from solution culture studies

## *Morphological development of groundnut pods*


Thirty-day old pods of (A) TV-2 and (B) Virginia groundnut cultivars. Note delayed development of apical seed compartment for the Virginia groundnut

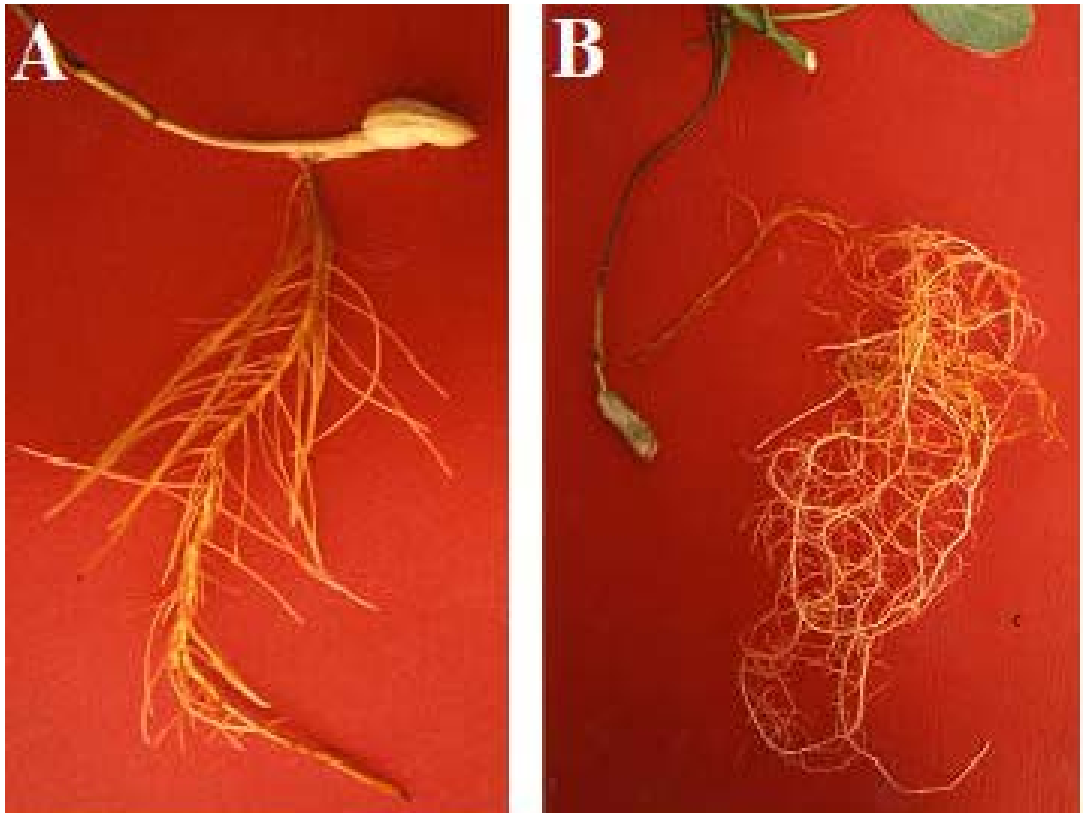
## *Development of Secondary gynophores*



Above; 30-day old pods of A116L4 grown at 2500 µM calcium. 30-day Old pods grown at (a) 0, (b) 5, (c) 112, (b) 550, (d) and (e) 2500 µM calcium. A

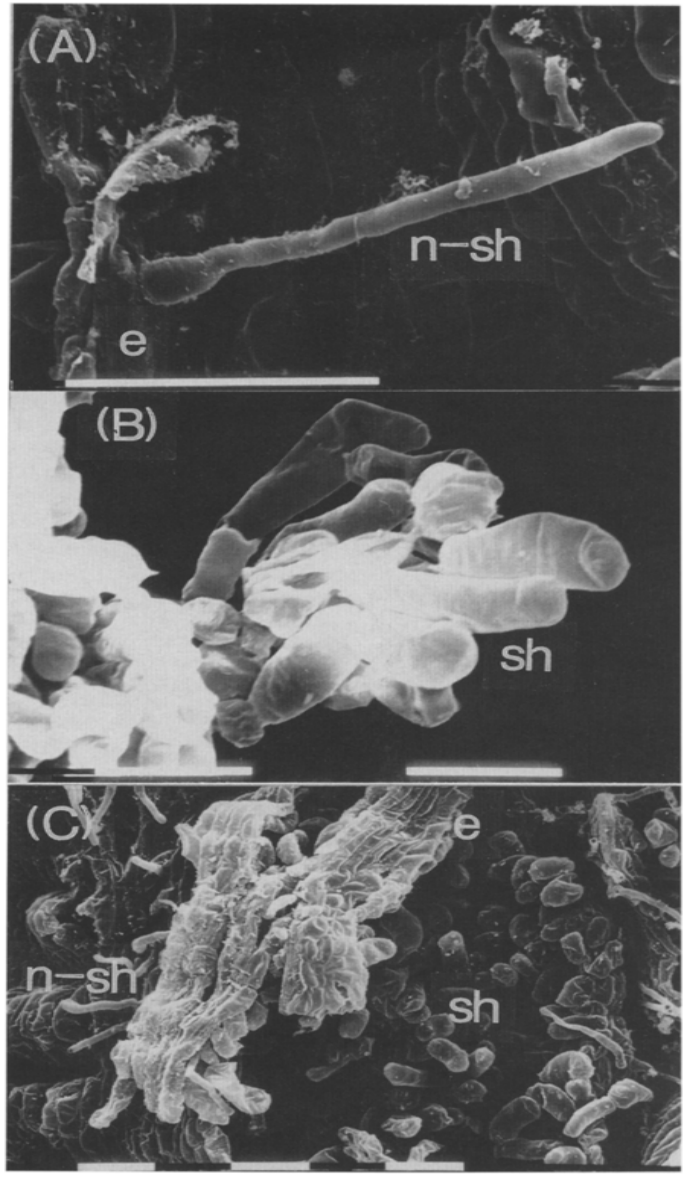
# Findings from solution culture studies…..continued

*Production of roots by gynophores*




Root development on attached gynophores of CBRR4

*The nature of Pod hairs*




Scanning electron micrograph of pod surface showing;

(A) a non-septate hair (n-sh)

(B) a cluster of septate hairs (sh);

(C) epidermal cells pealing off to expose septate hairs undernreath

# Findings from solution culture studies….continued

*Pod-zone zinc, manganese and magnesium relations of groundnut*

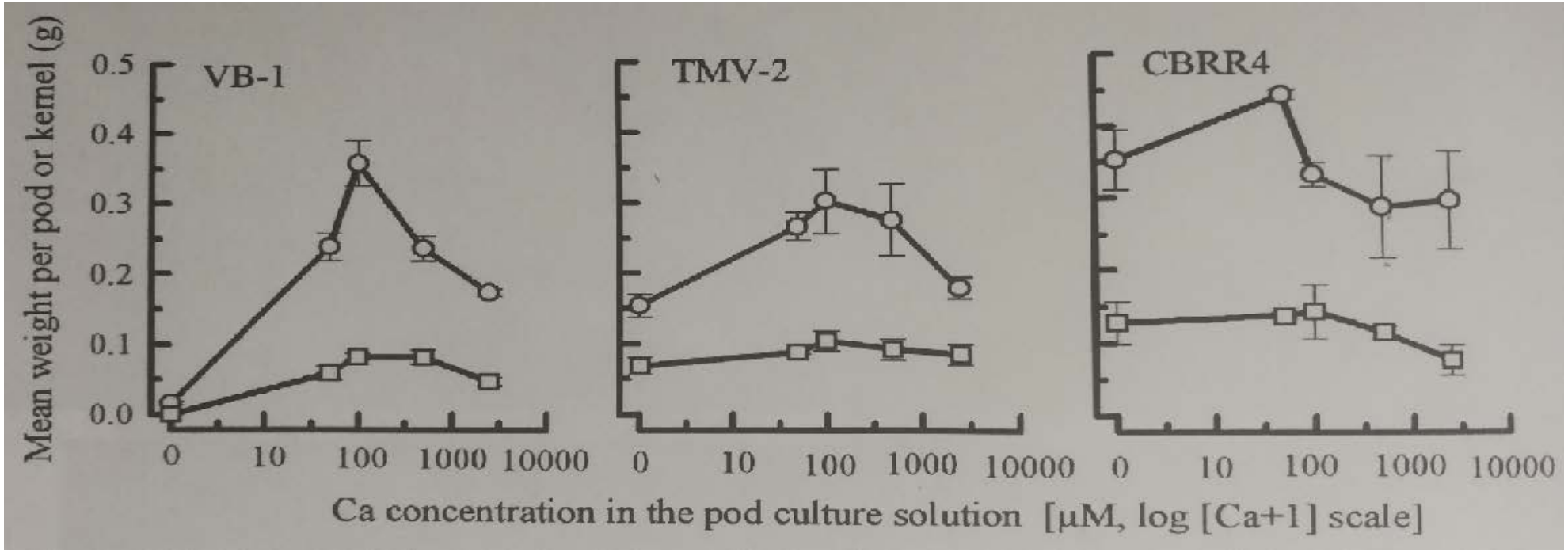
| Treatment | Mean pod weight (g) | Thousand seed weight(g) | Shelling percentage |
|---|---|---|---|
| Complete | 0.19 | 124.0 | 66.0 |
| Minus Mg | 0.23 | 153.0 | 66.6 |
| Minus Zn | 0.15 | 77.4 | 52.6 |
| Minus Mn | 0.24 | 176.0 | 71.8 |
| LSD (5%) | 0.02 | 20.6 | 8.3 |

Note that the omission of zinc is detrimental, but those of magnesium and manganese from the pod-zone are favourable for pod filling.

# Findings from solution culture studies….continued

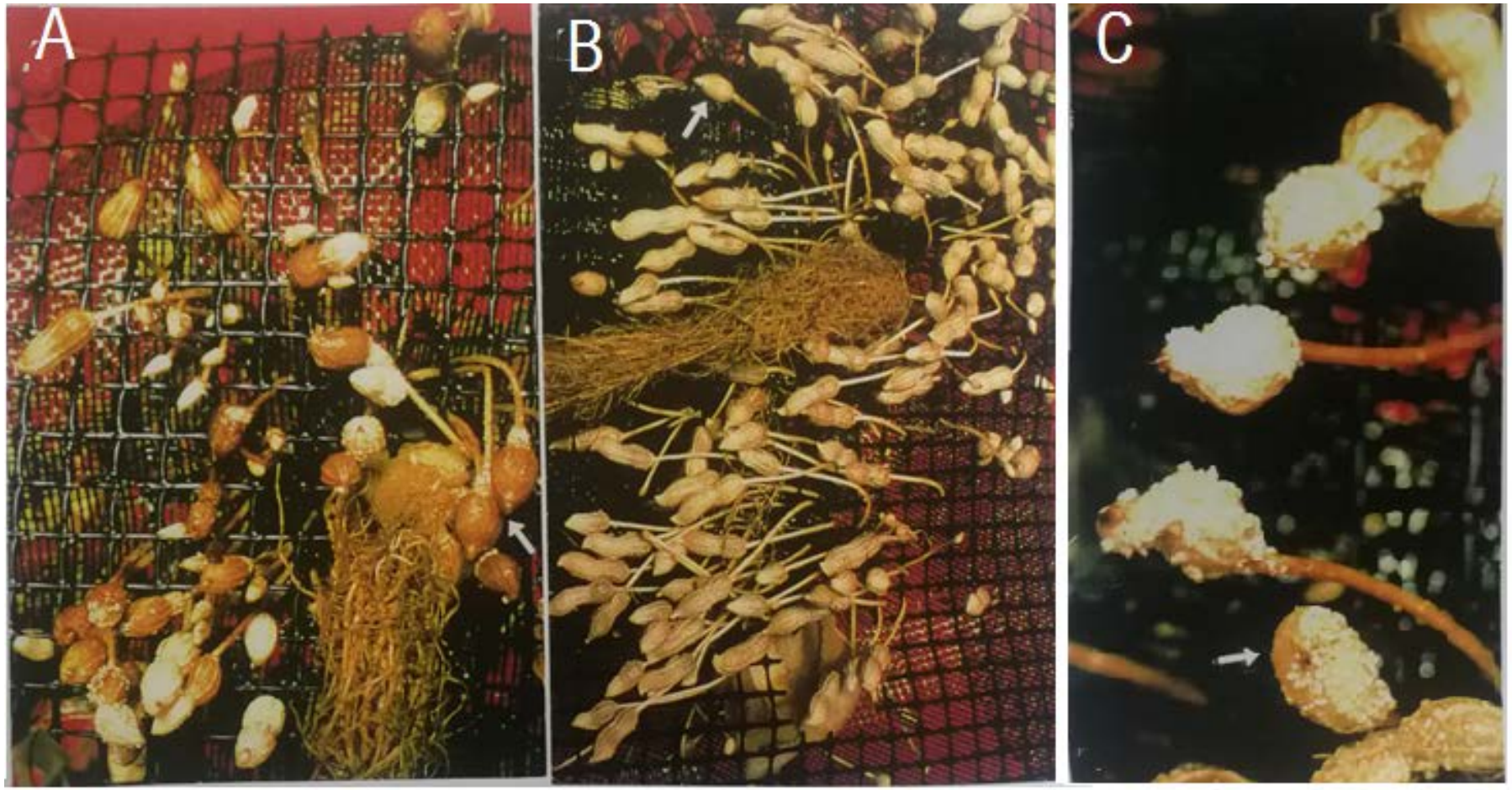
*Cause of inconsistent response to gypsum application)*

- Under and over supply of calcium in the pod-zone




Effect of increasing solution calcium on pod and seed dry weights of three groundnut lines.

# *Sources of inconsistent response….continued*

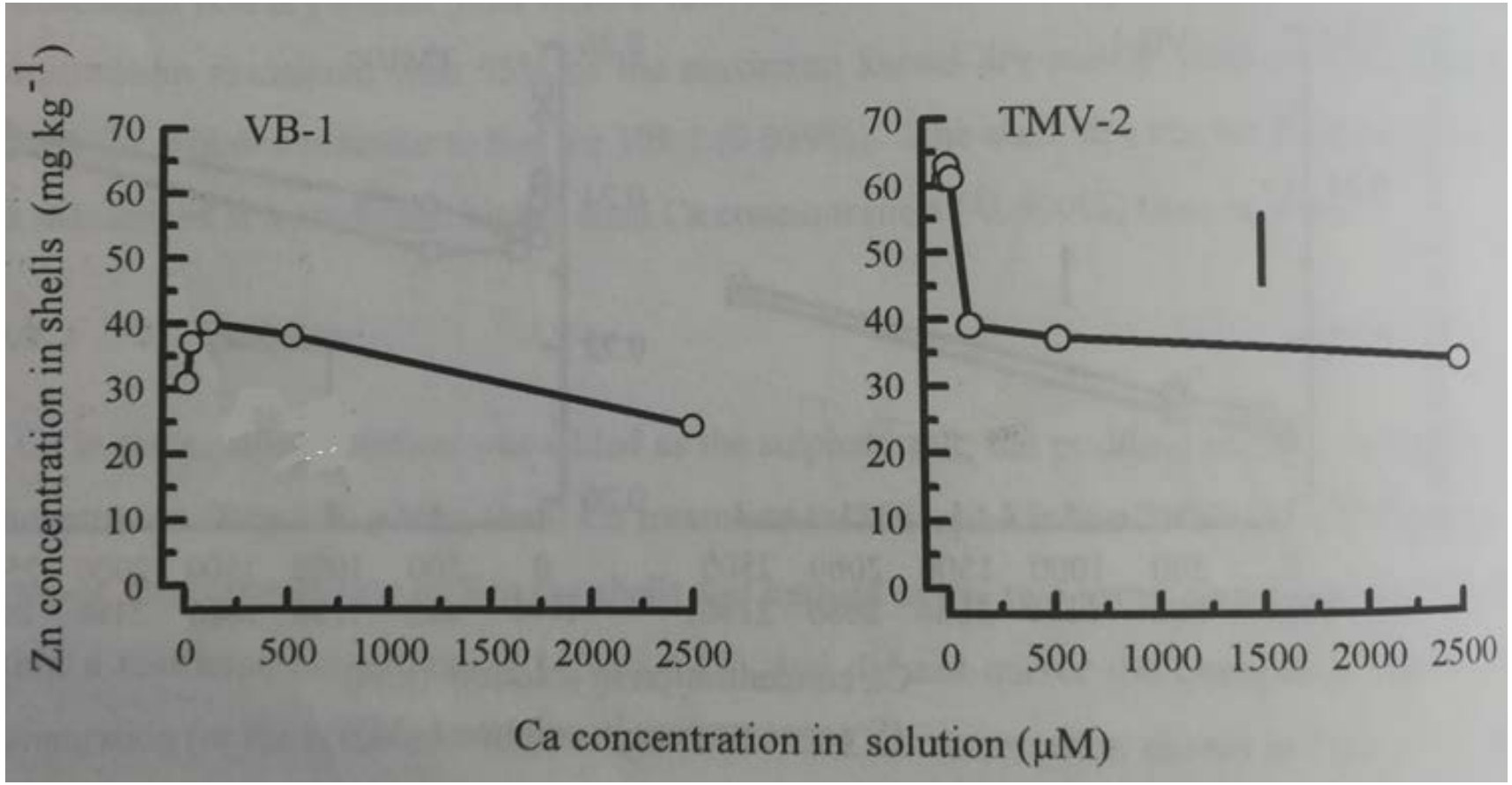



Effects of under and over supply of calcium in the pod-zone.

Pods of TMV2 produced at 0 µM calcium (deficient) (A); 112 µM calcium (optimal)(B); and 2500 µM calcium (over supply)(C) in the pod zone solution. Note the impaired pod development at 0 (A) and 2500 (C) µM calcium.

# Causes of inconsistent response....continued

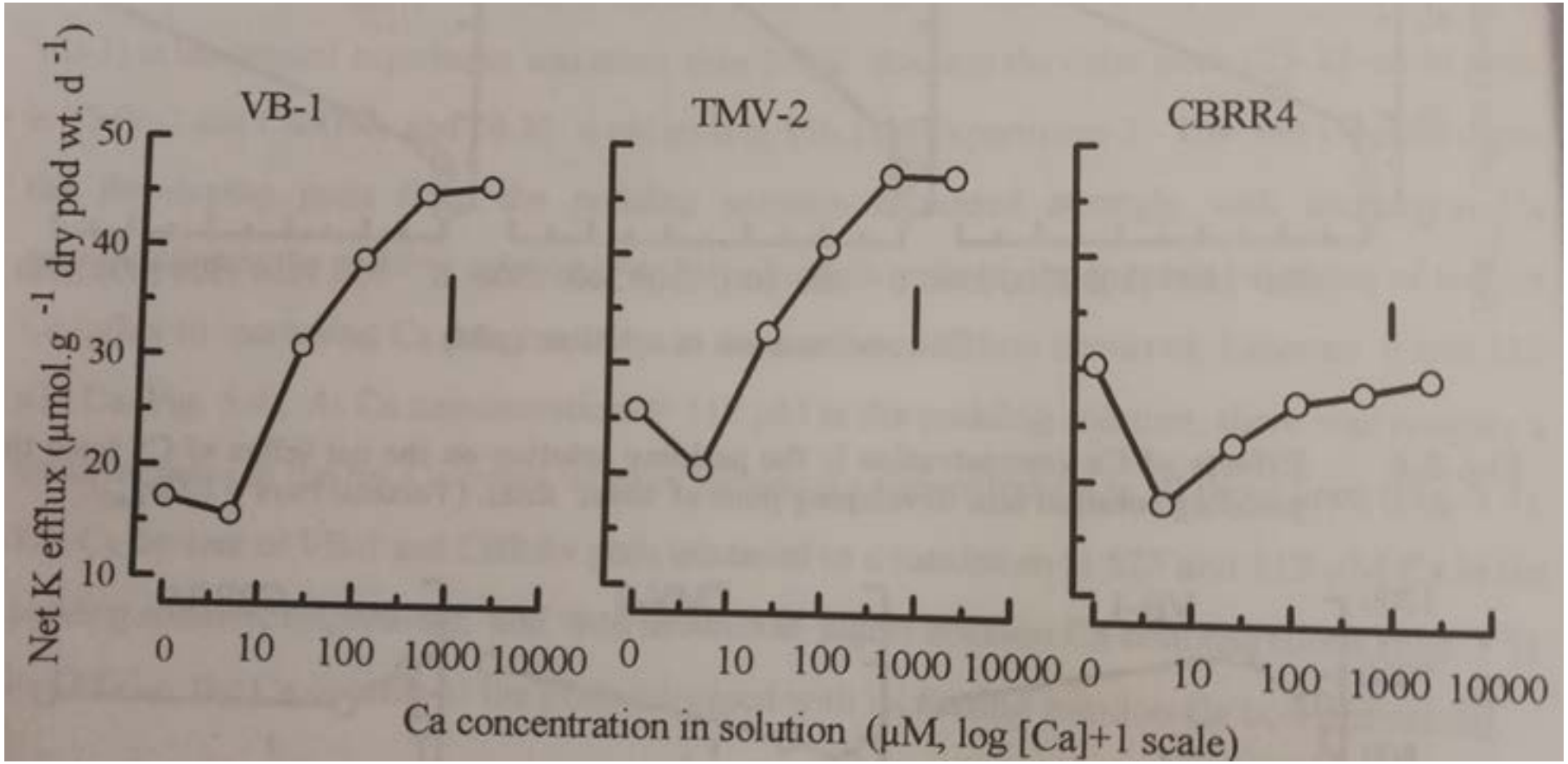
## Calcium induced zinc deficiency




Effects of over calcium supply in the pod-zone on tissue Zinc .

Effects of solution calcium concentration on pod tissue zinc concentration in two groundnut cultivars

# Findings ….continued ..The discovery of potassium excretion from the pods




*Relationship between solution calcium concentration and pod K efflux (excretion)*

- It occurred in the absence and presence of Ca
- In the absence of Ca, it is accompanied by alkalization of the solution
- In the presence of Ca, no alkalization of the solution occurs
- Large in the first 18 to 30 days which coincides with peak demand for Ca .

# Identified research areas for groundnut

- Characterization of the (functional) properties of ion channels involving K+/Ca2+ and K+/H+ exchange

- Identification and characterization of the proteins for root K+ channel and of pod $K^+$ /$Ca^{2+}$ and $K^+$/$H^+$ exchange transport

- Identification of genes encoding for the membrane proteins of the root potassium uptake channels and pod K + efflux /Ca2+ influx and K+efflux /H+ influx exchange transport

# Research on the groundnut leaf miner

The research produced three major outputs, wiz;

- **The identity and phylogeny of groundnut leaf miner in South Africa**

  Involved DNA analyses of specimens from Vaalharts, Brits, Manguzi, Nelspruit and Potchefstroom

- **The ecophysiology of GLM in South Africa**

  Involved experiments on crop host preferences, monitoring flight activities with pheromone traps and correlating the flight activities with temperatures, humidity and rainfall.

- **The host crop/plant range of GLM in South Africa**

  Involved surveys and planting date experiments of the host crops, and suspected wild host plants in the hot spots for GLM (Vaal Harts, Brits, Manguzi, Nelspruit and Potchefstroom)

# Research Findings-Identity and phylogeny of the groundnut leaf miner

- Has long been present in Africa as an insect of uneconomic significance and known as (*Stomopteryx subsecivella* (Zeller)

- A BLAST (Basic local alignment search tool) search on BOLD (barcode of life data base) produced a 100% match of our specimens' mtCO1 gene with that of a soybean moth *Aproaerema simplixella* (Walker) from Australia.

- Specimens of *Aproaerema modicella* (Deventer) from India also matched 100% with *Aproaerema simplixella* (Walker)

**Conclusion**. The three species are congeneric and constituting a cosmopolitan species complex. We synonymized them under one name *Bilobata subsecivella* (Zeller) (Lepidoptera: Gelechiidae)

# Research findings-Host preferences

A comparison of host crop ranges of *Bilobata subsecivella* populations in India, South Africa and India

| **Crop Plant** | **Indian population** | **South African population** | **Australian population** |
|---|---|---|---|
| Soybean | √ | √ | √ |
| Groundnut | √ | √ | X |
| Pigeon Pea | √ | √ | X |
| Lucerne | √ | X | X |
| Dolicos (Lablab) | √ | X | X |
| Wild soybean (glycine wightii) | unknown | √ | √ |

# Research Findings- Ecophysiology of *B. subsecivella* in South Africa

- Present in all area tested (Vaalharts, Potchestroom, Brits, Manguzi, Neslpruit)
- Flight activity present in very low numbers in winter, but there is no infestation of host crops.
- Infestation in groundnut starts after the crop has flowered (but only in summer planted crops).

*Flight activity of B. subsecivella at four sites in summer and winter*

| Location | Mean maximum Summer temperature | Flight activity in summer (male moth per 14 days) | Mean minimum Winter temperature | Flight activity in winter (Male moths per 14 days) |
|---|---|---|---|---|
| Manguzi | 26 | 380 | 16 | 12 |
| Brits | 25 | 210 | 4 (forst) | 0 |
| Nelspruit | 26 | 340 | 14 | 4 |
| Vaal harts | 26 | 440 | 12 | 7 |

# Research focus areas identified for *B. subsecivella*

- *Overwintering strategy of B. subsecivella i*n South Africa
- *Chemical ecology in relation to B. subsecivella's attraction to groundnut*
- *The genetic basis for the difference in host crop preference between B. subsecivella populations in India, Australia and South Africa*

Three biotypes of B. subsecivella exist (Indian, Australian and South African), with the Australian attacking soybean only. From this observation two important question need to be addressed;

- As groundnut is not a host for B. subsecivella population in Australia, was virulence inherited from the Indian population, or did an independent biotypification event occur?
- Can the lack of virulence for groundnut in the Australian population be utilized as a tool for searching for the virulence factor in African and Indian biotypes.

# Conclusions

**Groundnut pops problem**

- Most important research outcome is the discovery of the K+/H+ exchange transport that causes potassium excretion/efflux in exchange of H+ influx.
- It explains the cause of pops and the role of calcium in preventing pops,
- And provides a basis for genetically engineering the plant to avoid pops

**Groundnut leaf miner**

- Most important research outcome is the exposition of a cosmopolitan organism that is adapt to different climatic conditions and diets with three biotypes  that shave different crop preferences.
- Gives an opportunity to search for the genes that controls virulence for specific crops.