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ASH IN SOIL AMELIORATION

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Research, Technology and Innovation for **Sustainable Life with Land and Water**

INTRODUCTION

Surface Mined Land

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INTRODUCTION

Rehabilitated Surface Mined Land






LAND USE OPTIMISATION

Conditional prescription – Water, Energy and Food Nexus





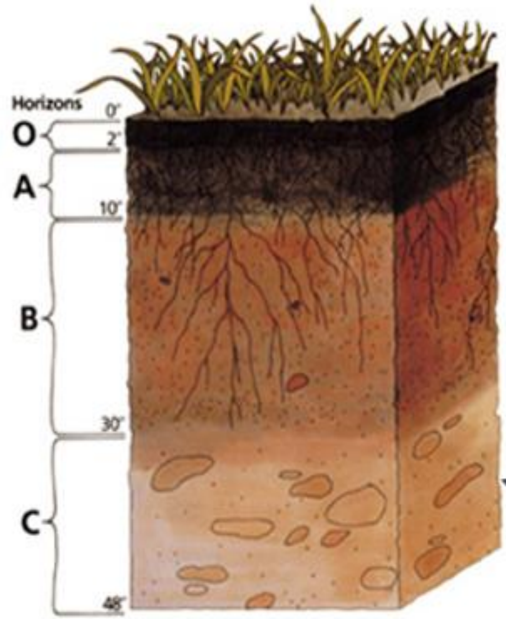



Rationale

RESEARCH QUESTIONS?

PLANT GROWTH RESPONSES

- Biomass production
- Botanical composition
- Basal cover



CHEMICAL Amelioration

- Soil pH
- Electrical conductivity
- Fertility

PHYSICAL Amelioration

- Bulk density
- Infiltration rate
- Water holding capacity

BIOLOGICAL Amelioration

- Microbial activity

SUSTAINABLE PLANT PRODUCTION ← **HEALTHIER SOIL**

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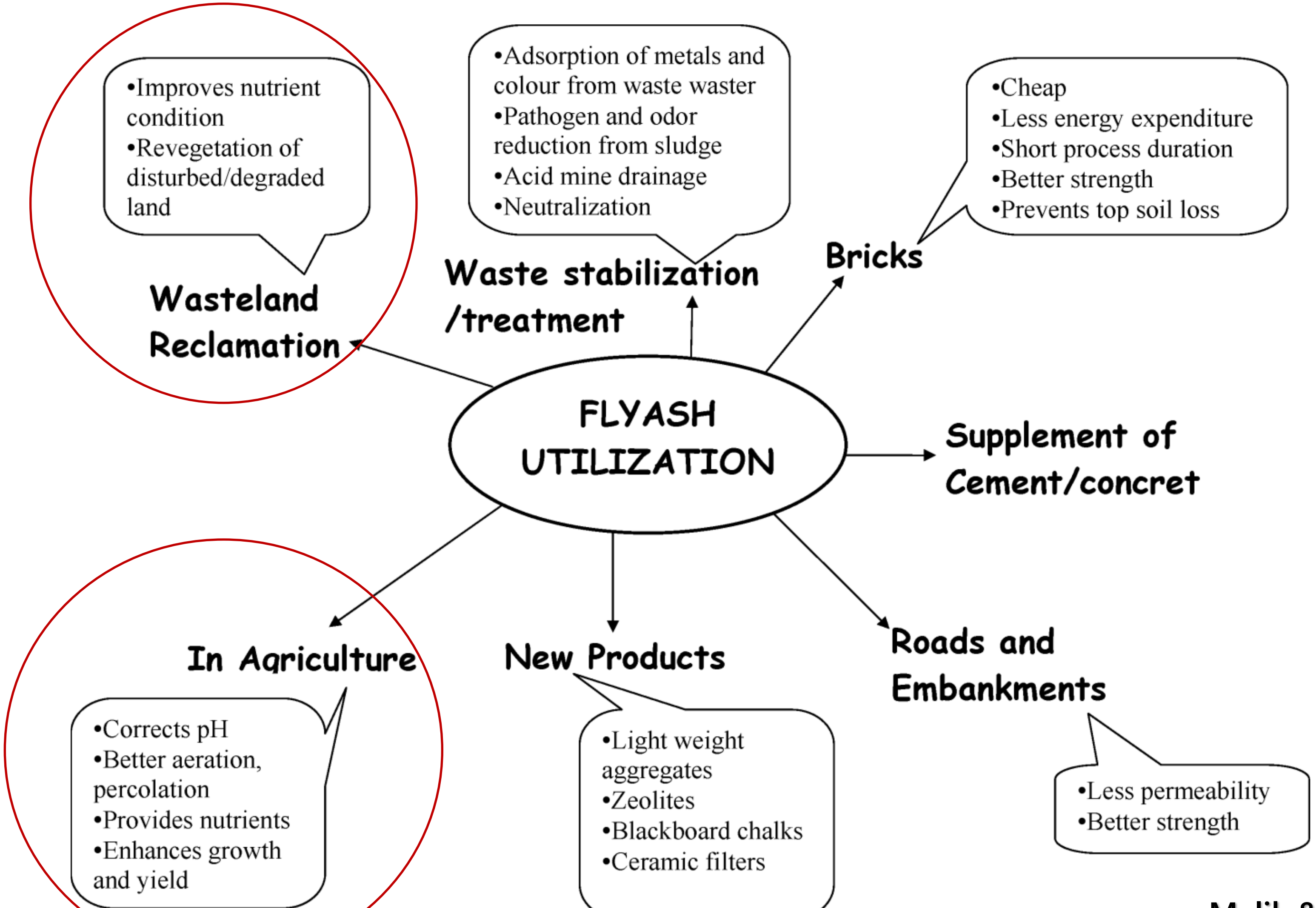
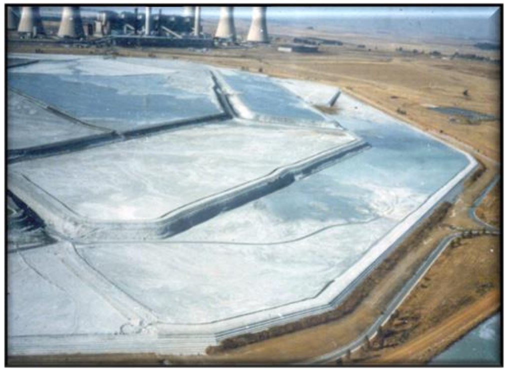
International Understanding

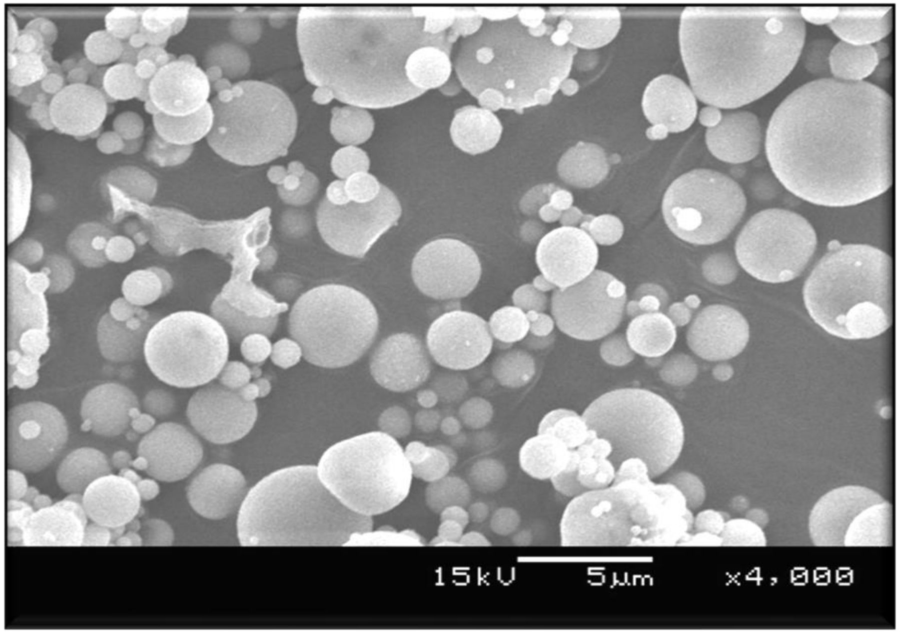


Malik & Thapliyal, 2009

INDUSTRIAL BYPRODUCTS

Beneficiation, application and safe use





- South African fly ash
  - **Class F** (Bitumious coal) – Silicious FA
- Calcium silicates
- Alkaline material $pH_{(H20)}$ = 8 - 10
- Fresh or weathered ash
- $CaCO_3$ equivalent ± 20% (Internationally referenced)
- Local Research findings ± 25 - 35 %

FLY ASH ?

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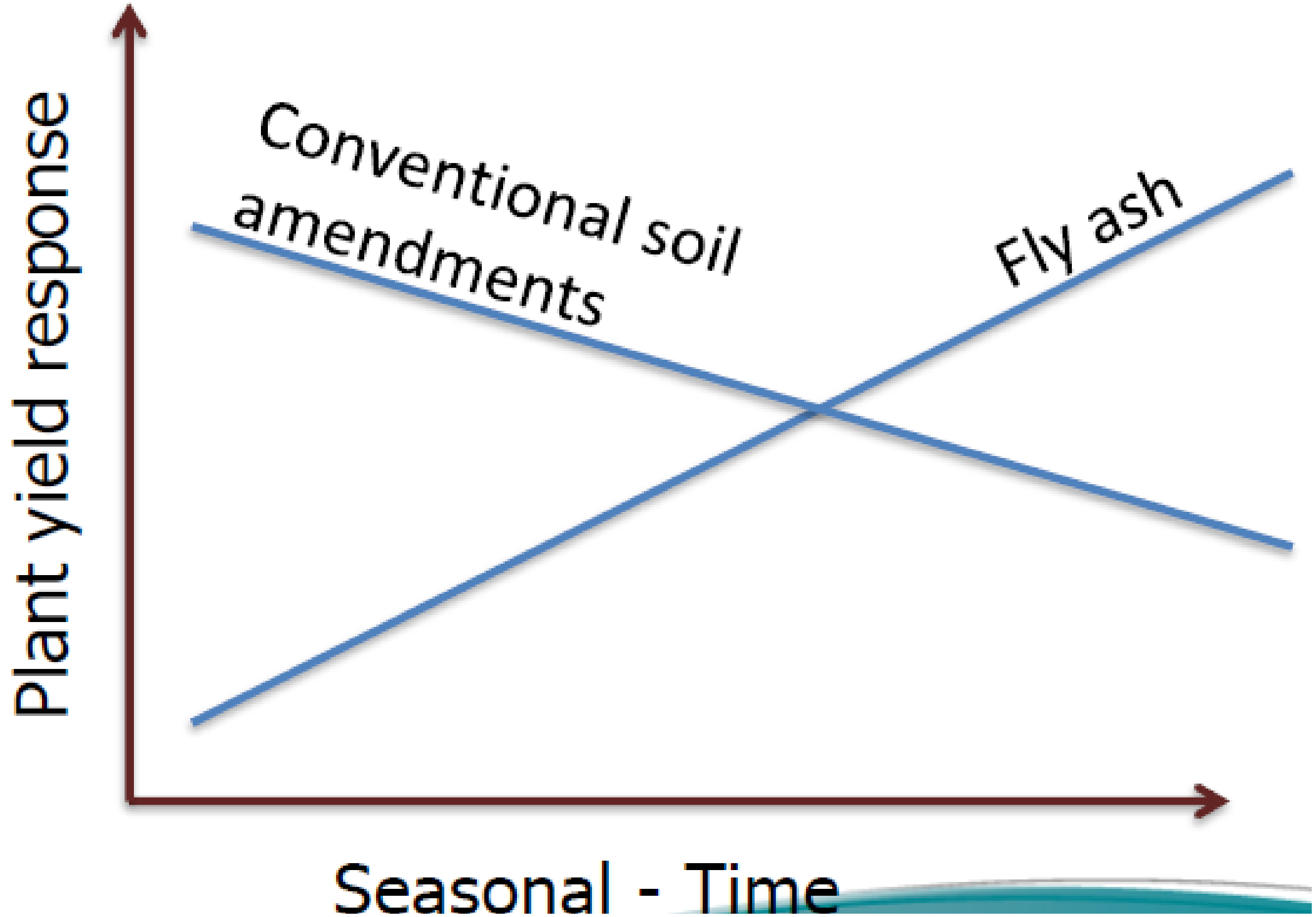
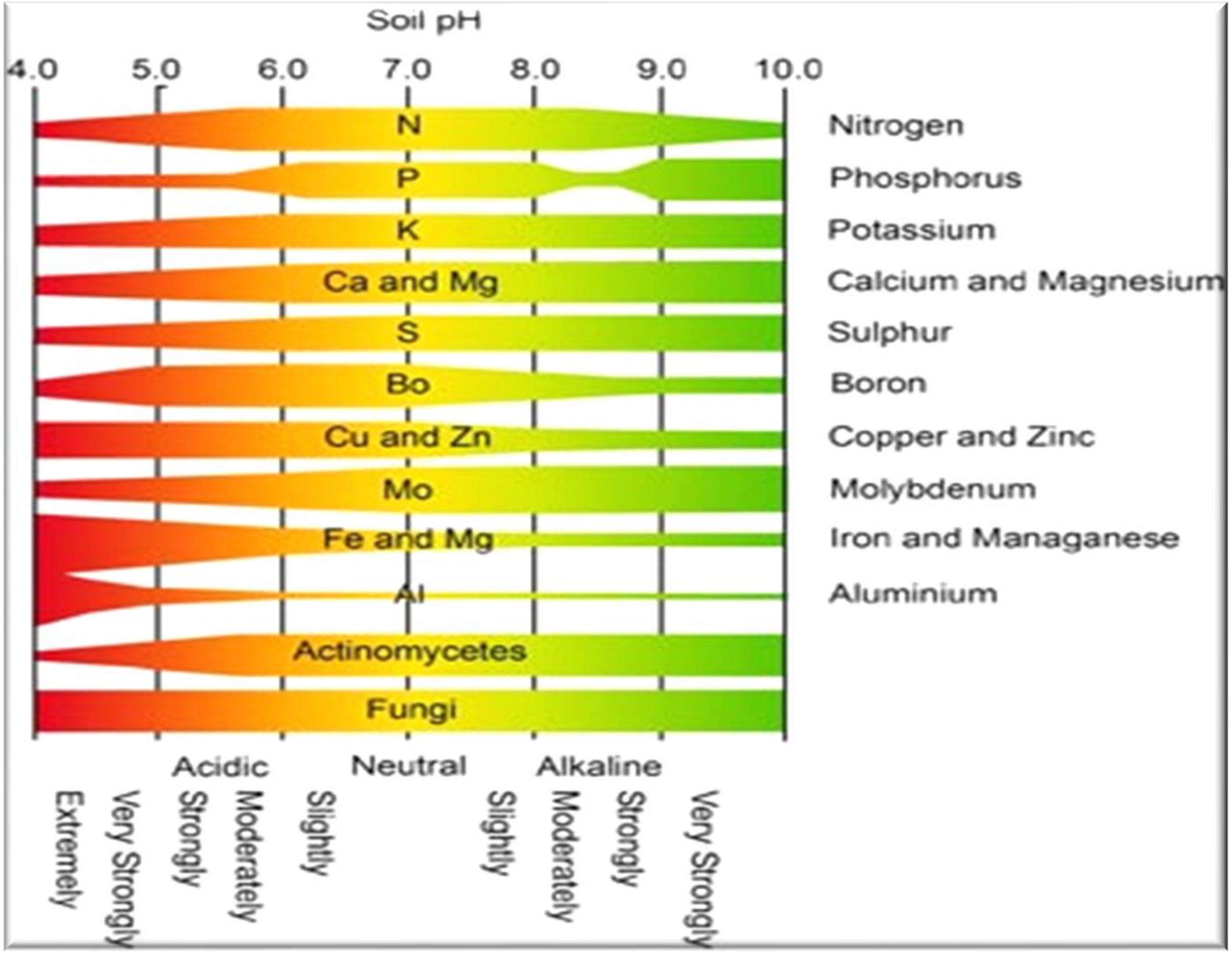
Proven Hypothesis



Aiken and Heidrich (2014) WACAU

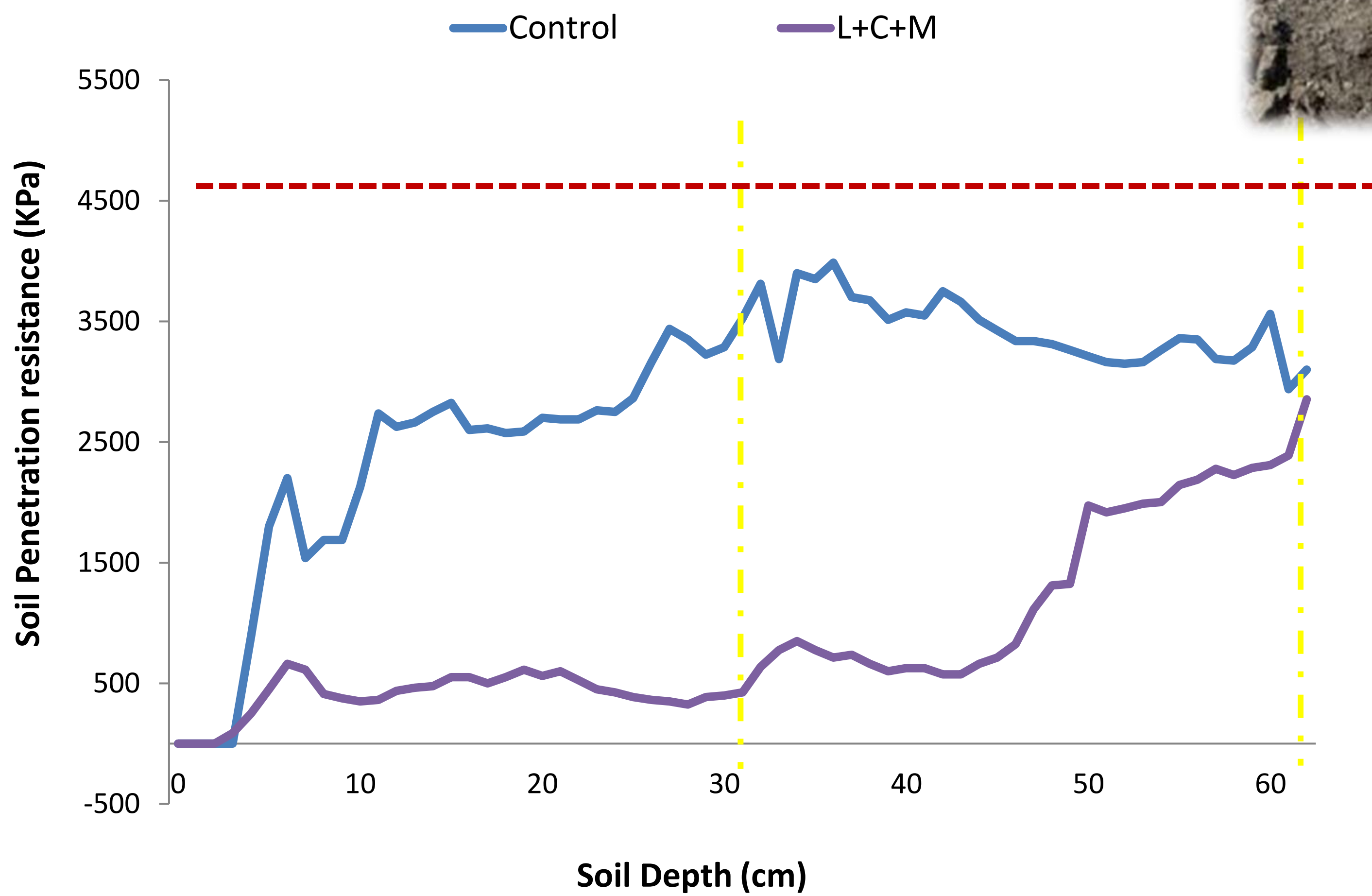
Hypothesis



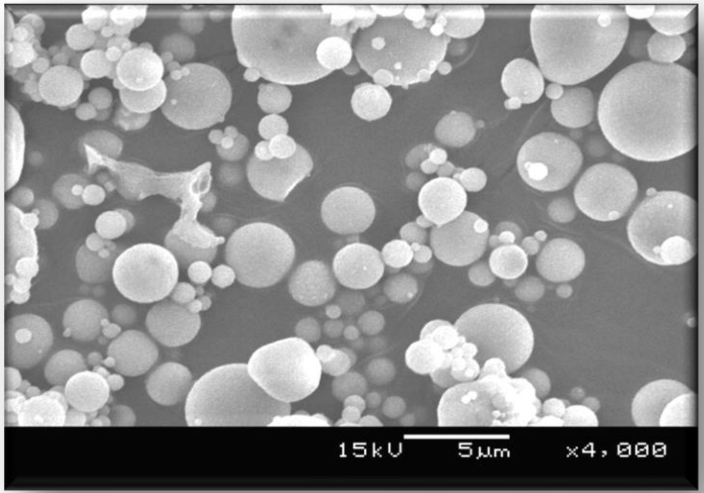
Soil pH
4.0
5.0
6.0
7.0
8.0
9.0
10.0
N
P
K
Ca and Mg
S
Bo
Cu and Zn
Mo
Fe and Mg
Al
Actinomycetes
Fungi
Nitrogen
Phosphorus
Potassium
Calcium and Magnesium
Sulphur
Boron
Copper and Zinc
Molybdenum
Iron and Managanese
Aluminium
Acidic
Neutral
Alkaline
Extremely
Very Strongly
Strongly
Moderately
Slightly
Slightly
Moderately
Strongly
Very Strongly

Healthy
Al toxicity

Proven Hypothesis



PHASE 1 - CFA Compositions



Basic bioavailable macro nutrient analysis

ASH	P (Bray I) $mg.kg^{-1}$	Ca $mg.kg^{-1}$	K $mg.kg^{-1}$	Mg $mg.kg^{-1}$	pH
FA (A)	194	3732	63	171	10.4
FA (B)	100	3765	33	159	11.7
Average soil requirement	30	600	80 -120	200	5.5 - 7.0

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PHASE 1 - Soil Compositions

SOIL	pH	CEC	P mg.kg^{-1}	Ca mg.kg^{-1}	K mg.kg^{-1}	Mg mg.kg^{-1}	Na mg.kg^{-1}	%C	Clay %
BLACK	2.8	27.49	3.1	54	14	12	9	5.09	38
BROWN	3.6	10.19	0.3	260	17	11	4	0.54	15

Application rates

- ***Cover soil***
  - **Lime :** Opt. (33%-) (**L-**) 6.7 tons ha^{-1}
    Opt. (**L**) 10.0 tons ha^{-1}
    Opt.(33% +) (**L+**) 13.3 tons ha^{-1}
  - **Fly ash :** Opt.(33%-) (**FA-**) 33.5 tons ha^{-1}
    Opt. (**FA**) 50.0 tons ha^{-1}
    Opt.(33%+) (**FA+**) 66.5 tons ha^{-1}
  - **Fly ash/ organic mixture** Opt.(33%-) (**OM-**) 112.0 tons ha^{-1}
    Opt. (**OM**) 167.0 tons ha^{-1}
    Opt.(33%+) (**OM+**) 222.0 tons ha^{-1}

  - **Control and Standard Mine treatment**
    - **4** tons ha^{-1} ($MgCO_3$)

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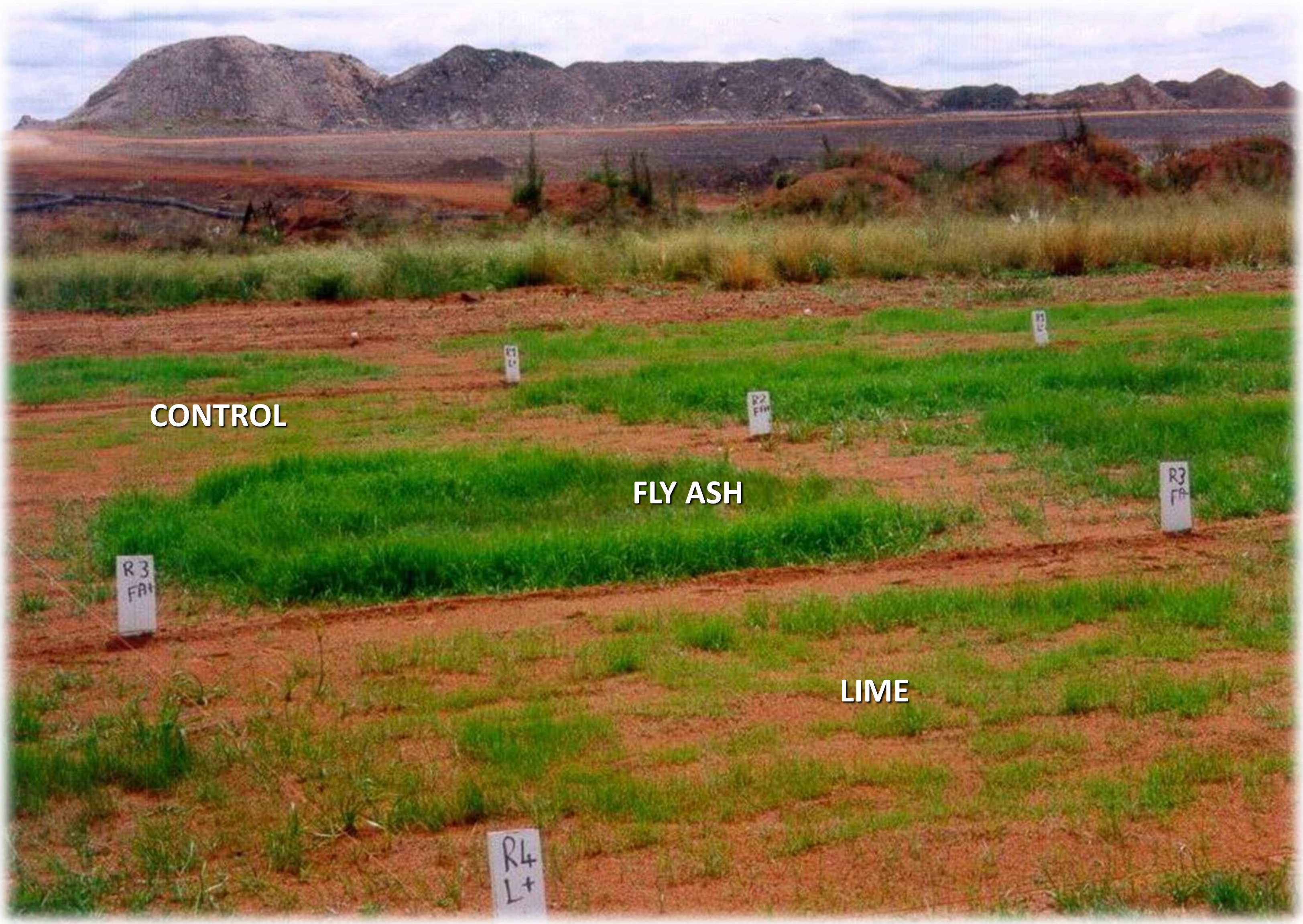
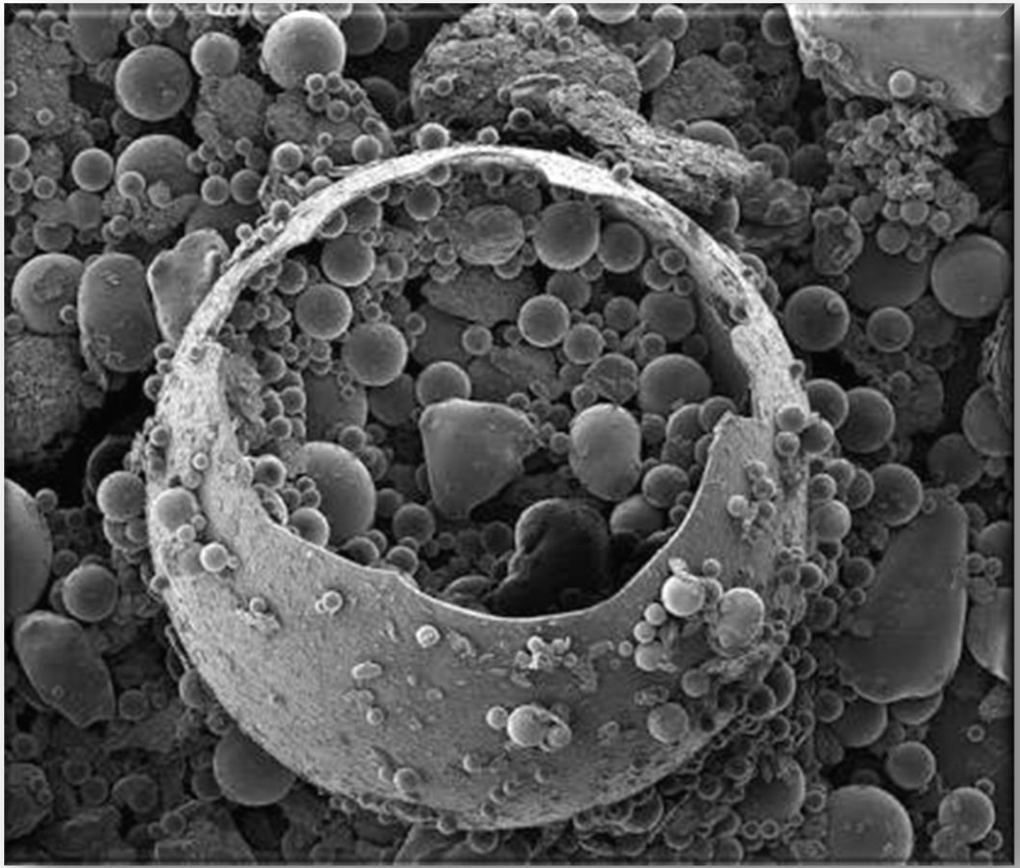

CONTROL
FLY ASH
LIME
R3
FA+
R4
L+

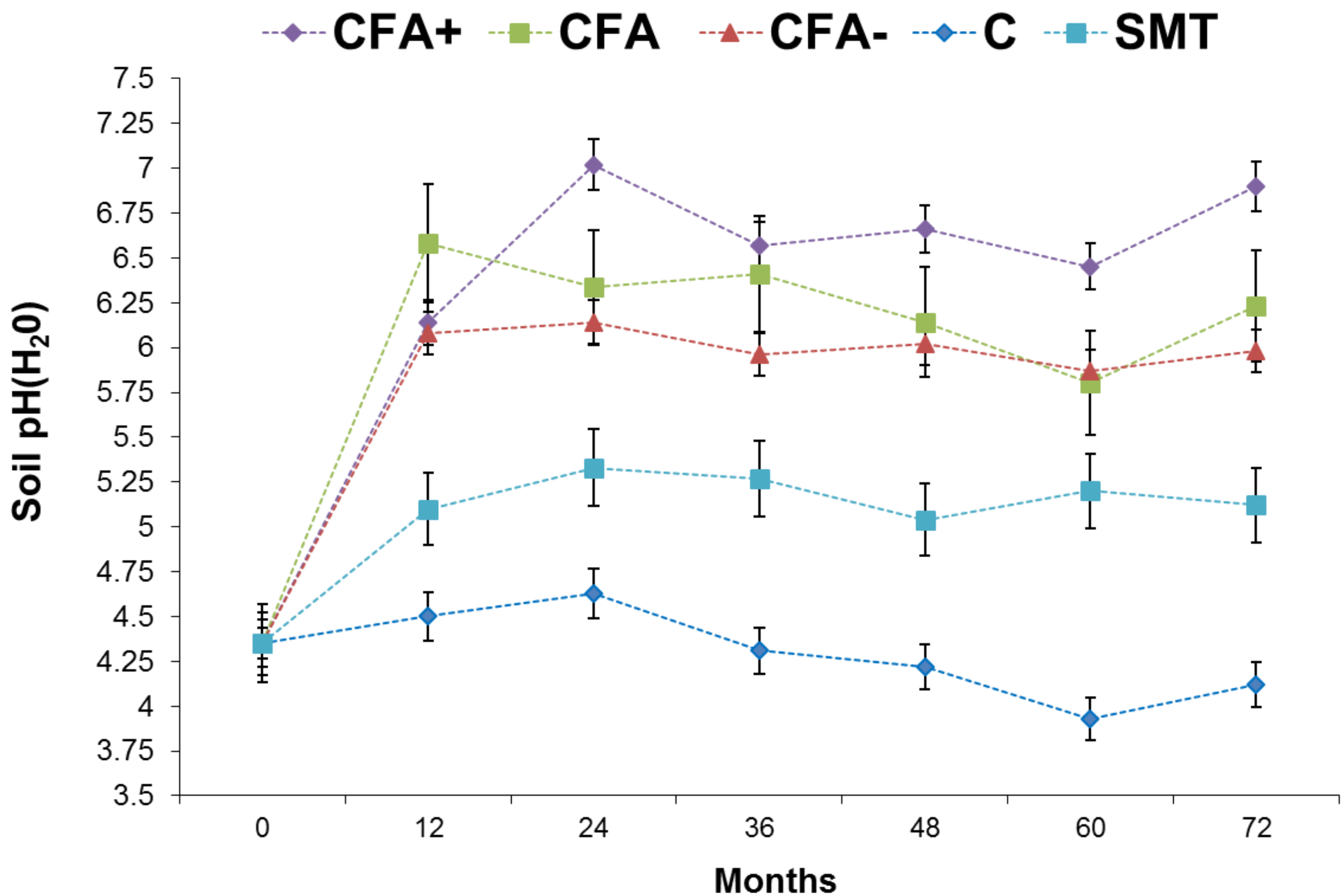
CHEMICAL AMELIORATION



http://matrixxco.net/other/fly-ash-concrete/

Residual Alkalinity (Glass Phase)

CHEMICAL AMELIORATION



Influence of CFA treatments, relative to C and SMT (Standard Mine Treatment) treatments, on soil $pH_{(H20)}$ over a 72-month period. *Note SMT treatment was augmented bi-annually*

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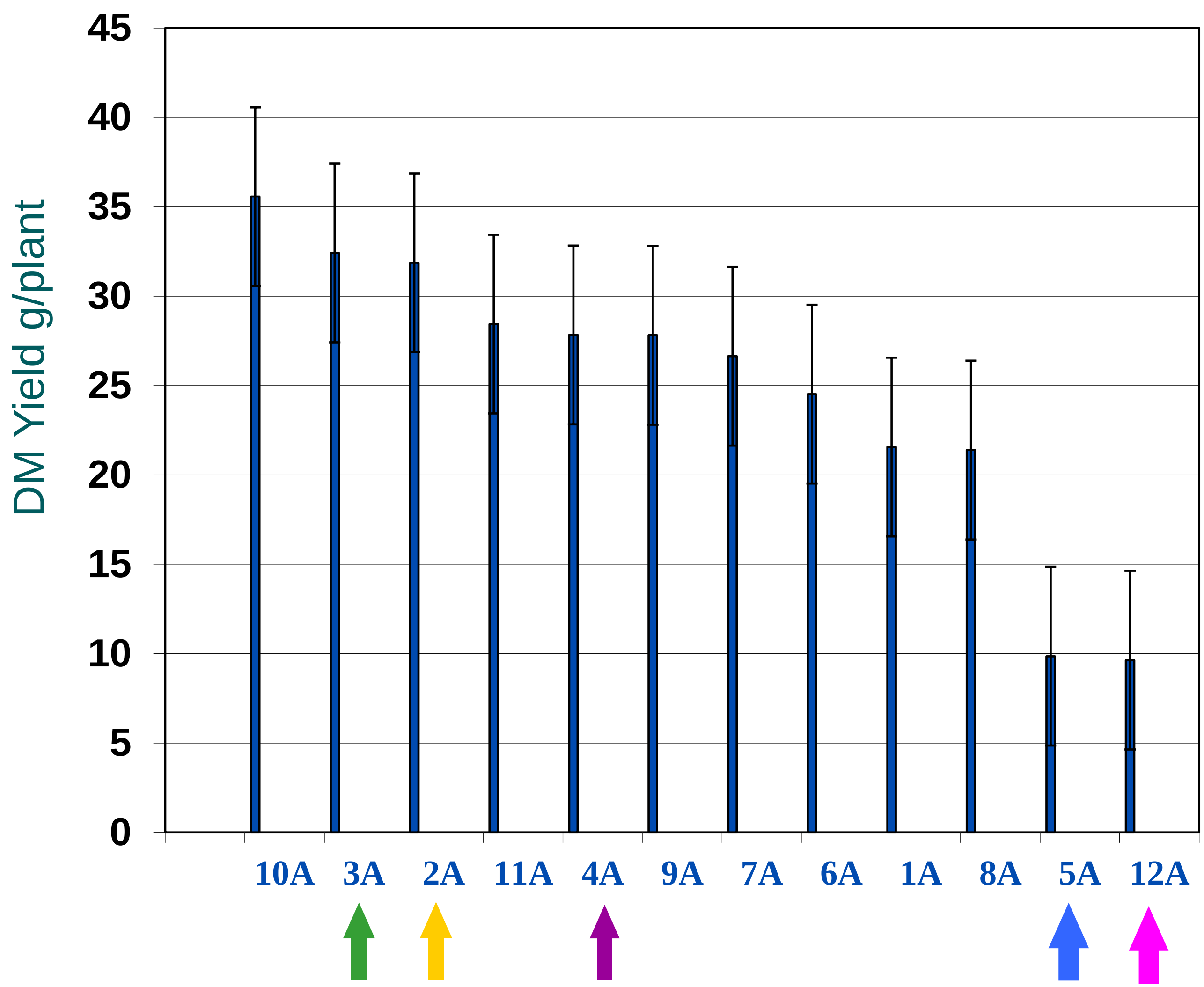
Influence of treatments on DM yields



1A = Fly ash

2A = Fly ash / NPK mix

3A = Fly ash / organic M1

4A = Fly ash / organic M2

5A = Lime

6A = Lime/ NPK

7A = Lime / organic M1

8A = Lime / organic M2

9A = NPK

10A = Organic M1

11A = Organic M2

12A = Control

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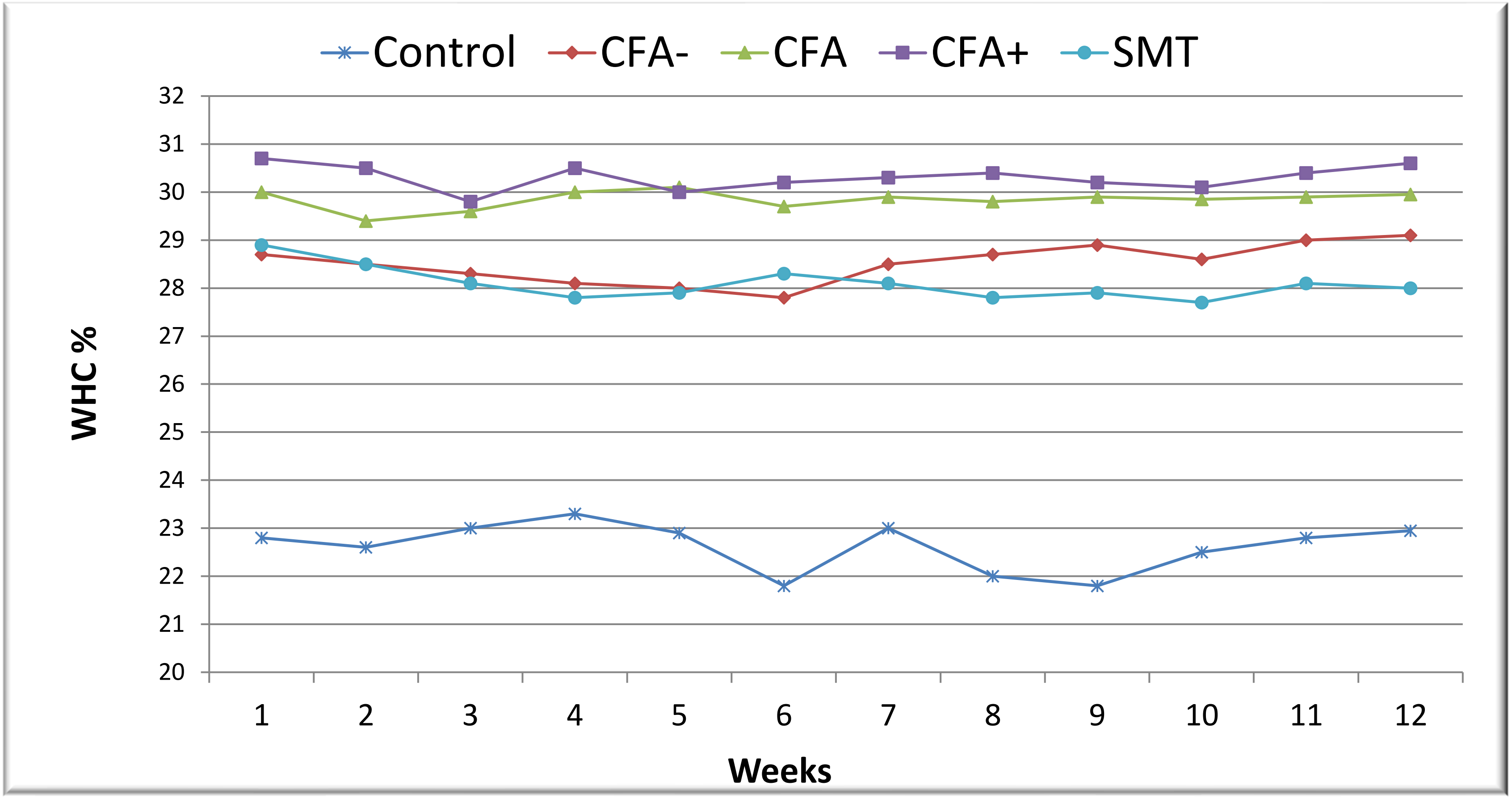
PHYSICAL AMELIORATION – Water holding capacity



The influence of CFA treatments, relative to C and SMT treatments, on the soil water holding capacity (WHC %)

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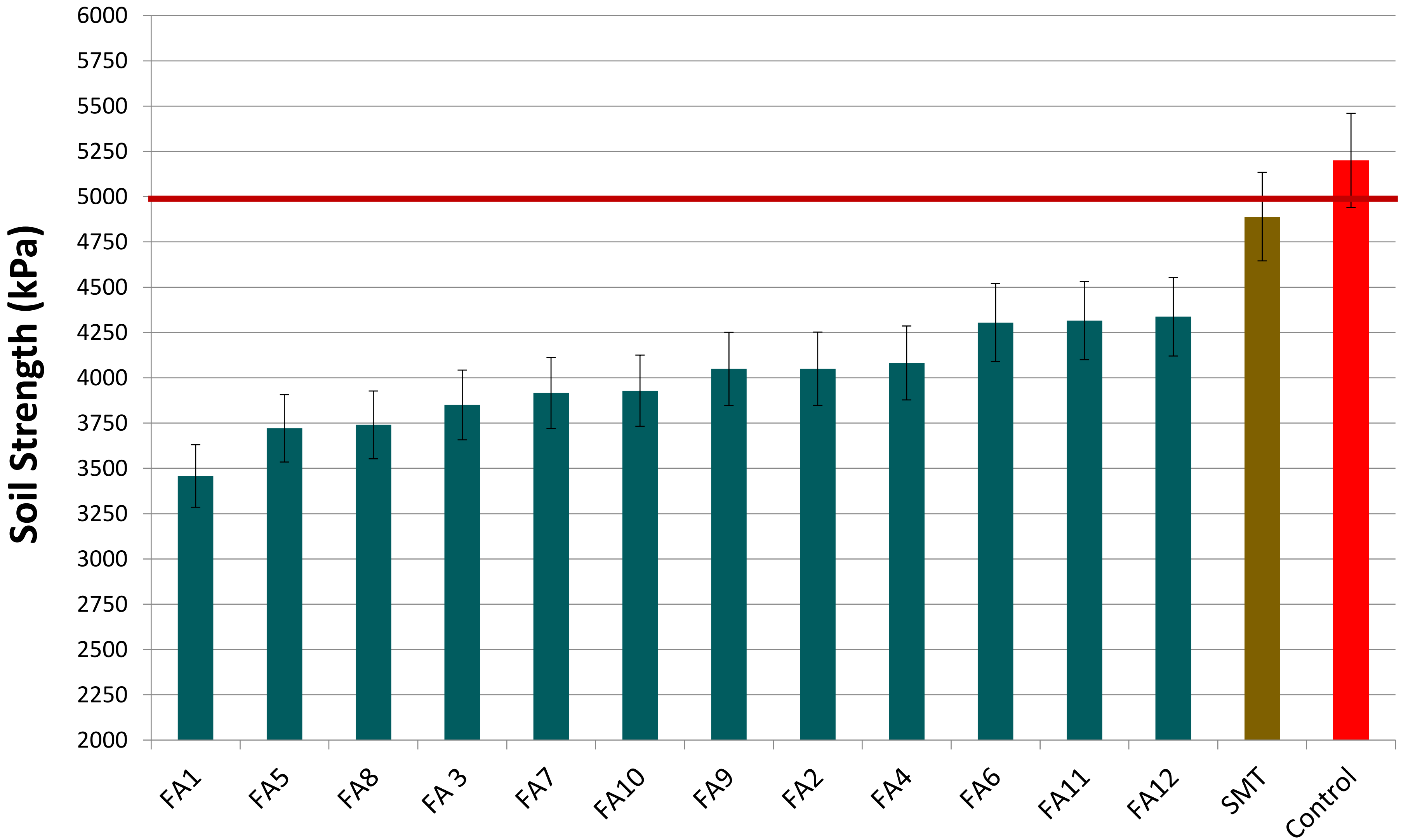

The effect of fly ash ameliorants on the soil strength (soil penetration resistance - kPa) of a sandy loam soil (30 cm depth)

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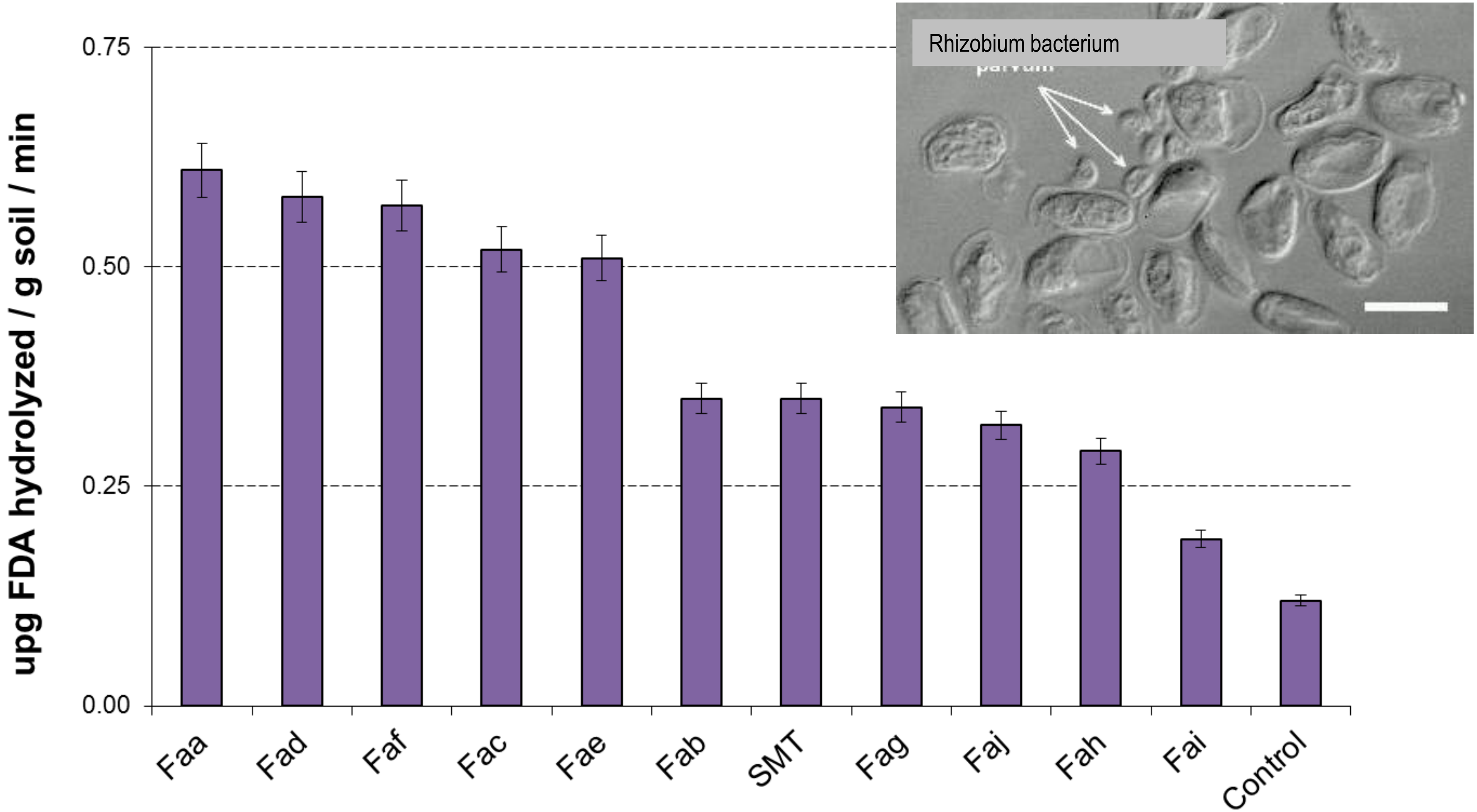
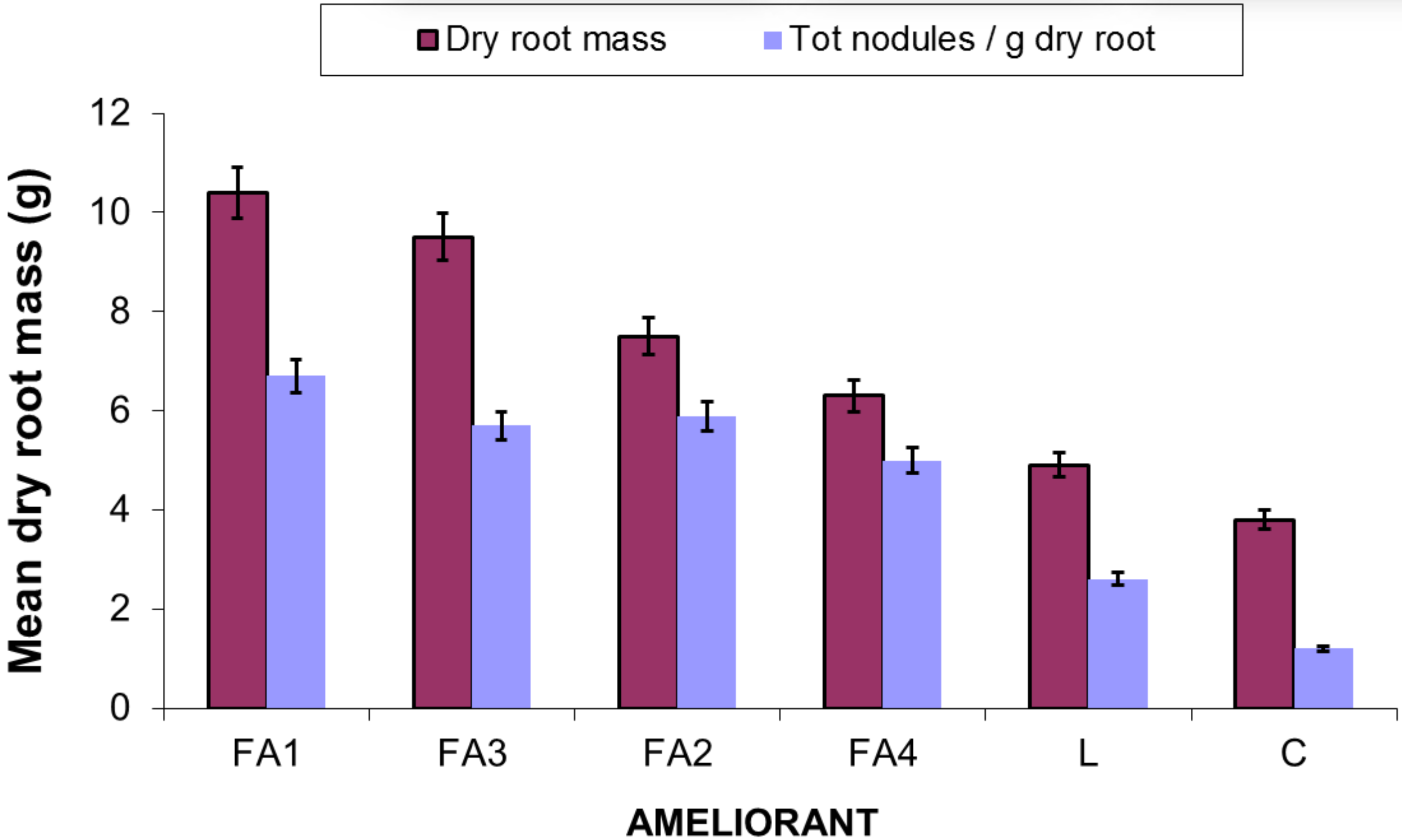
MICROBIOLOGICAL AMELIORATION



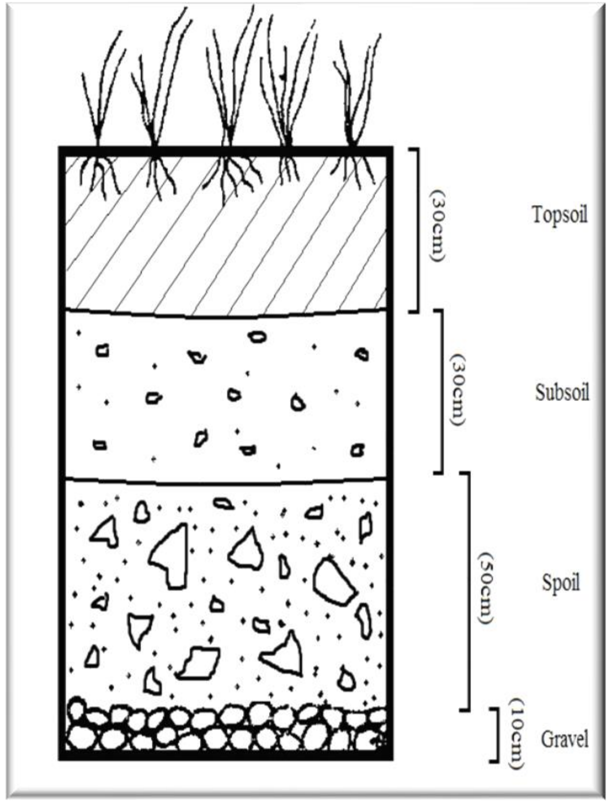
Mean microbial activity of class F fly ash ameliorated soil

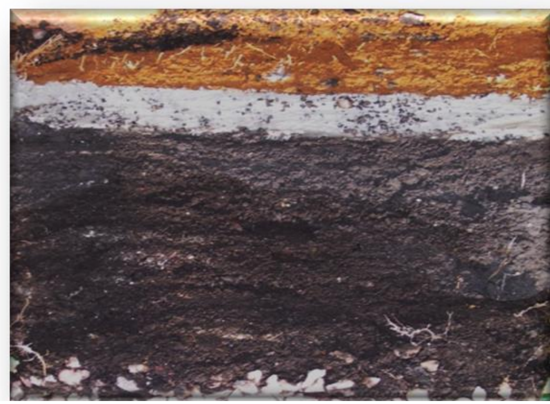
MICROBIOLOGY



Rhizobium nodulation in relation to root biomass for ameliorated soils

PHASE 2 – Research Bins

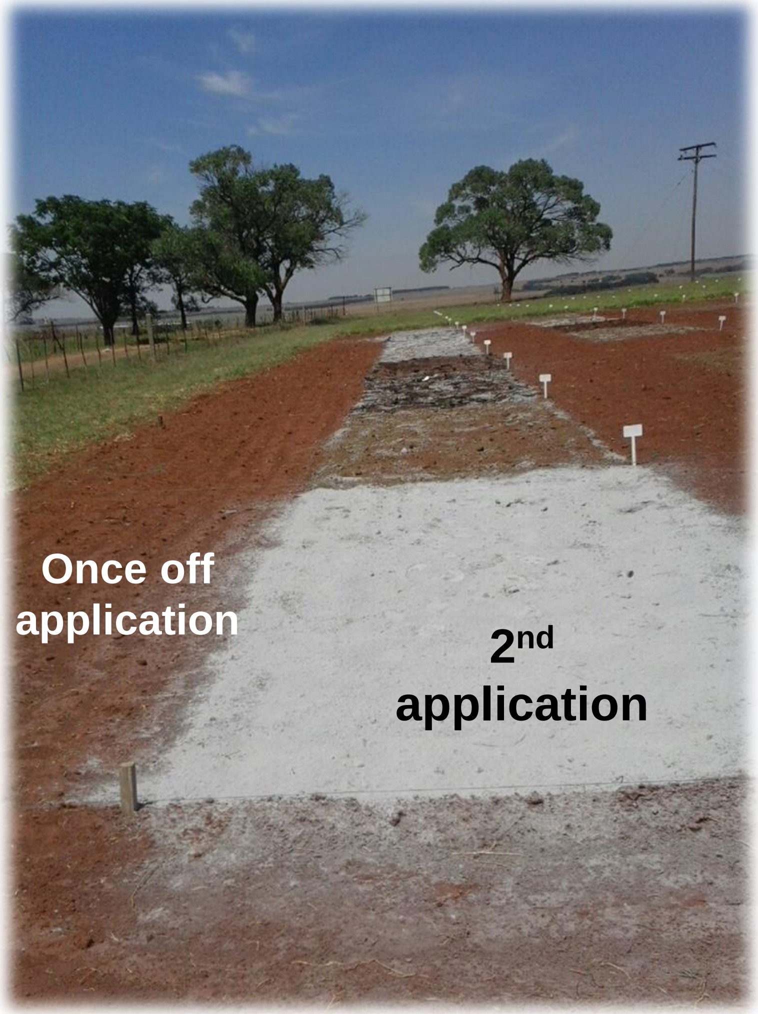




PHASE 2 – Research Bins Summer season

PHASE 2 – Open Air Phytotron Summer Season growth

PHASE 3 – Field Research - Season field preparation



PHASE 3 – Field Research (Pasture – Perennial crop)

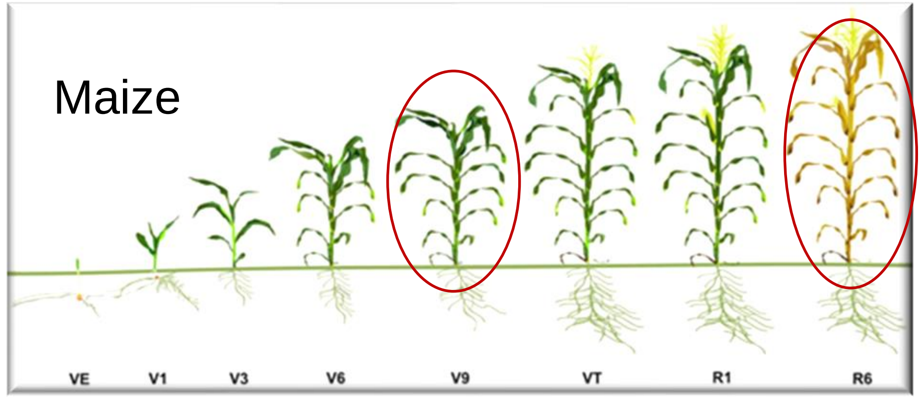
90 days after plant

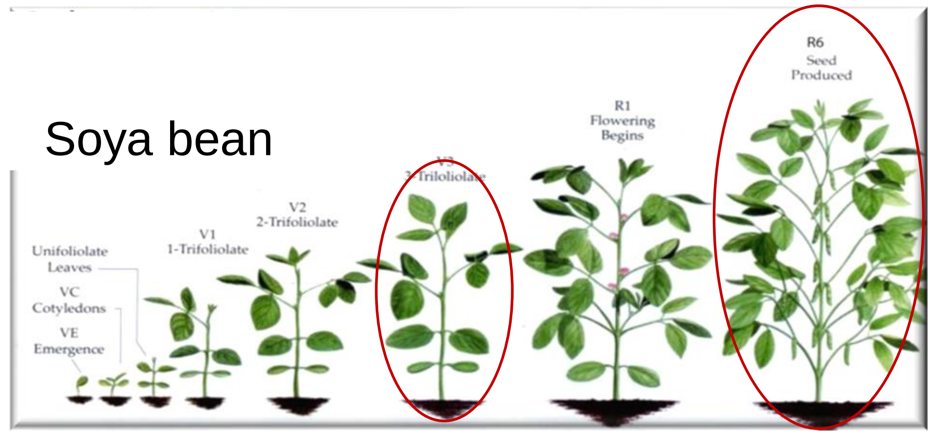
120 days after plant

PROCEDURE

- **Plants were evaluated at the following two phenological stages of each species**

- **Both soils and plant components are subjected to phytotoxicity analyses (+/- 3000 samples)**





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PHASE 3 – Field Research - Season field growth

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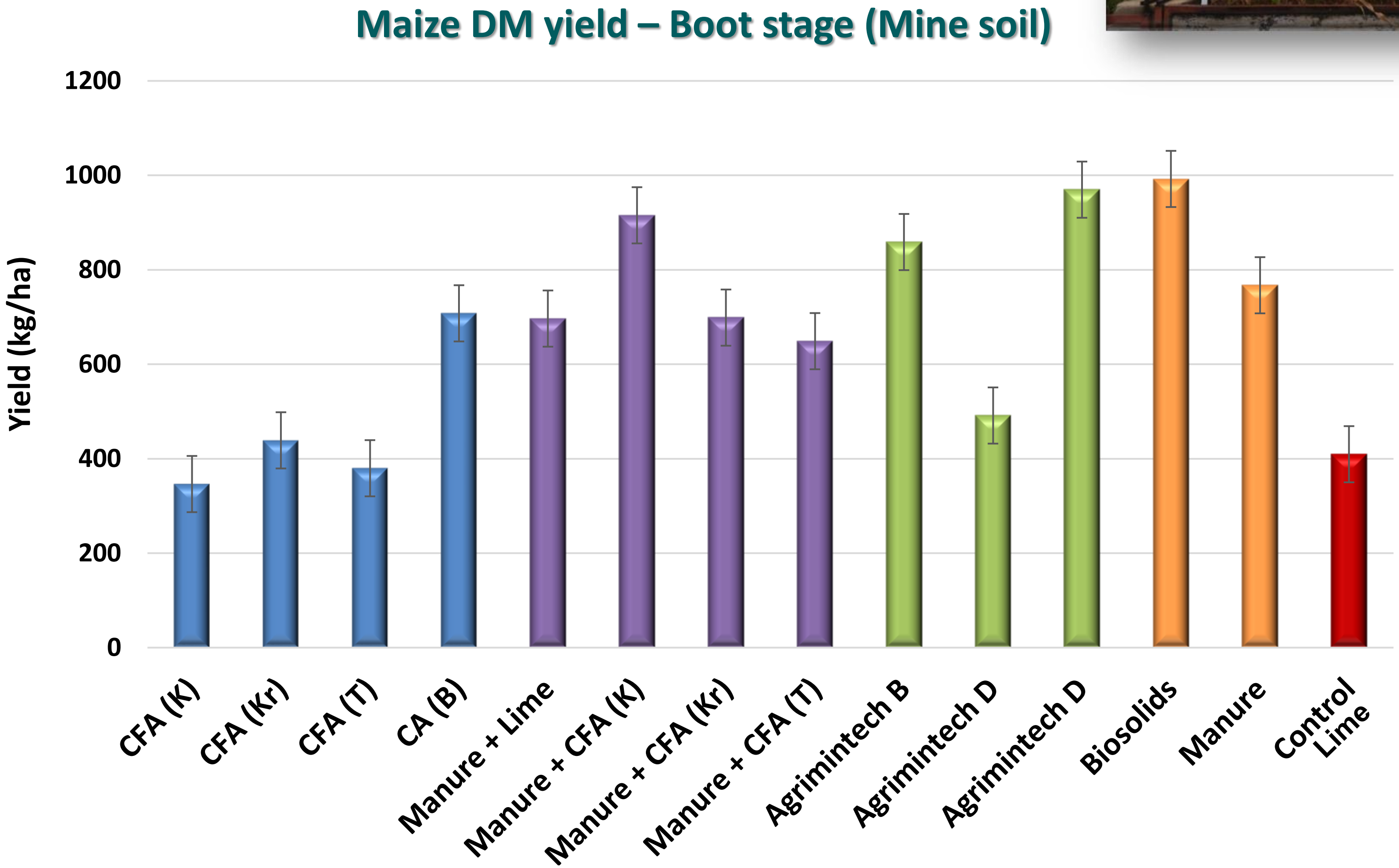
PHASE 3 – Field Research - Season field growth

PHASE 2 RESULTS



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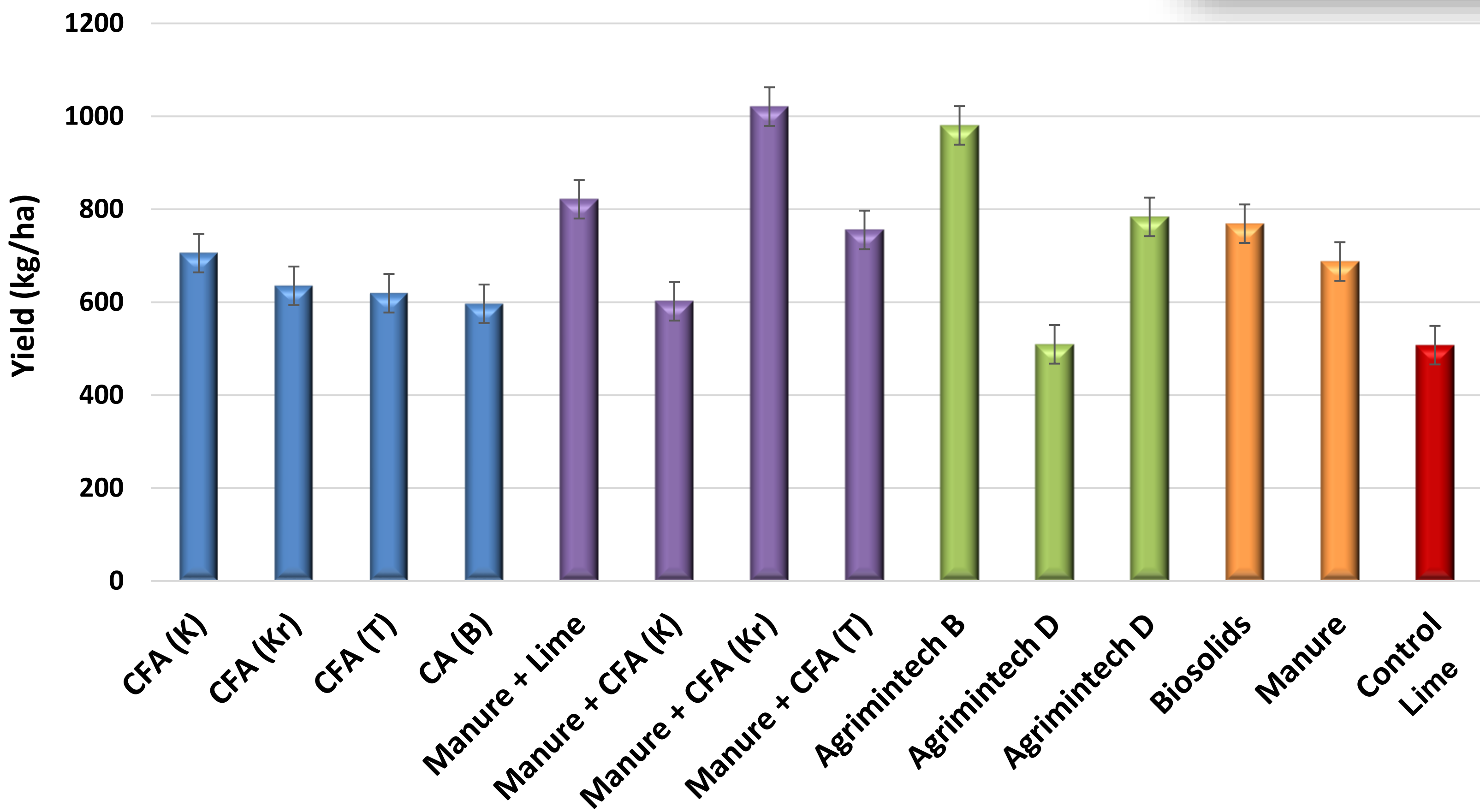
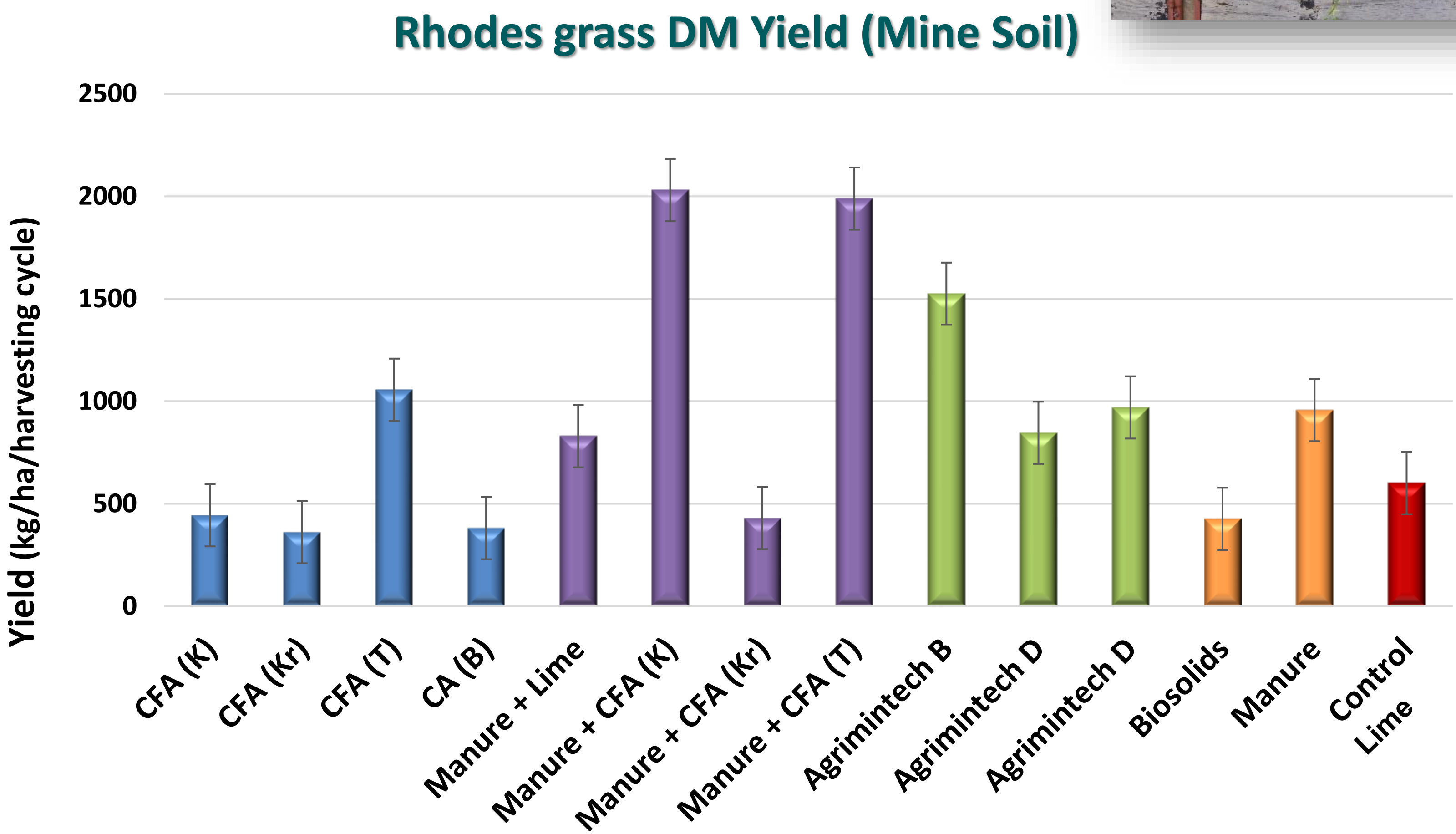
PHASE 2 RESULTS

Soya DM Yield V3 stage (Mine Soil)



PHASE 2 RESULTS



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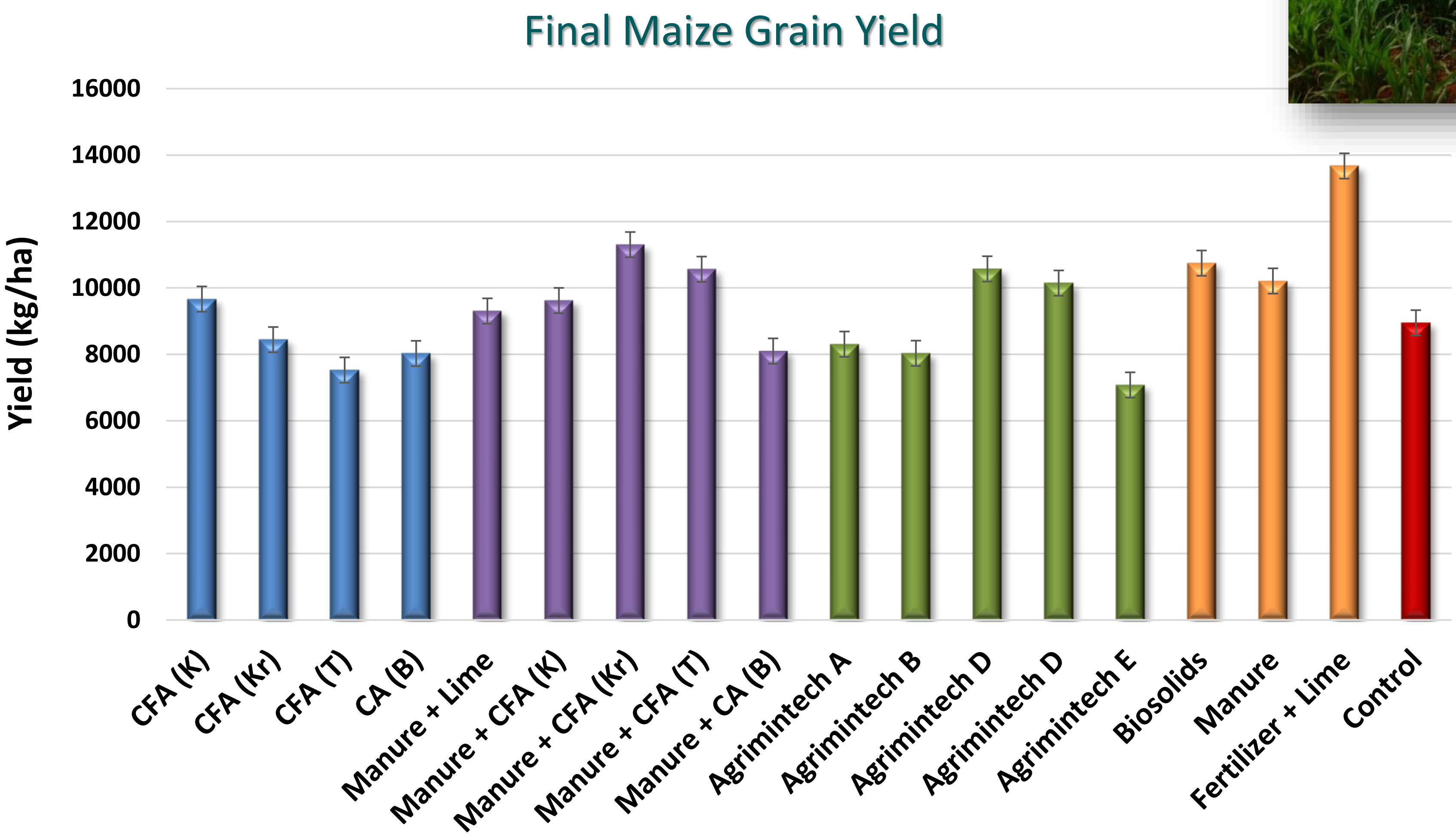
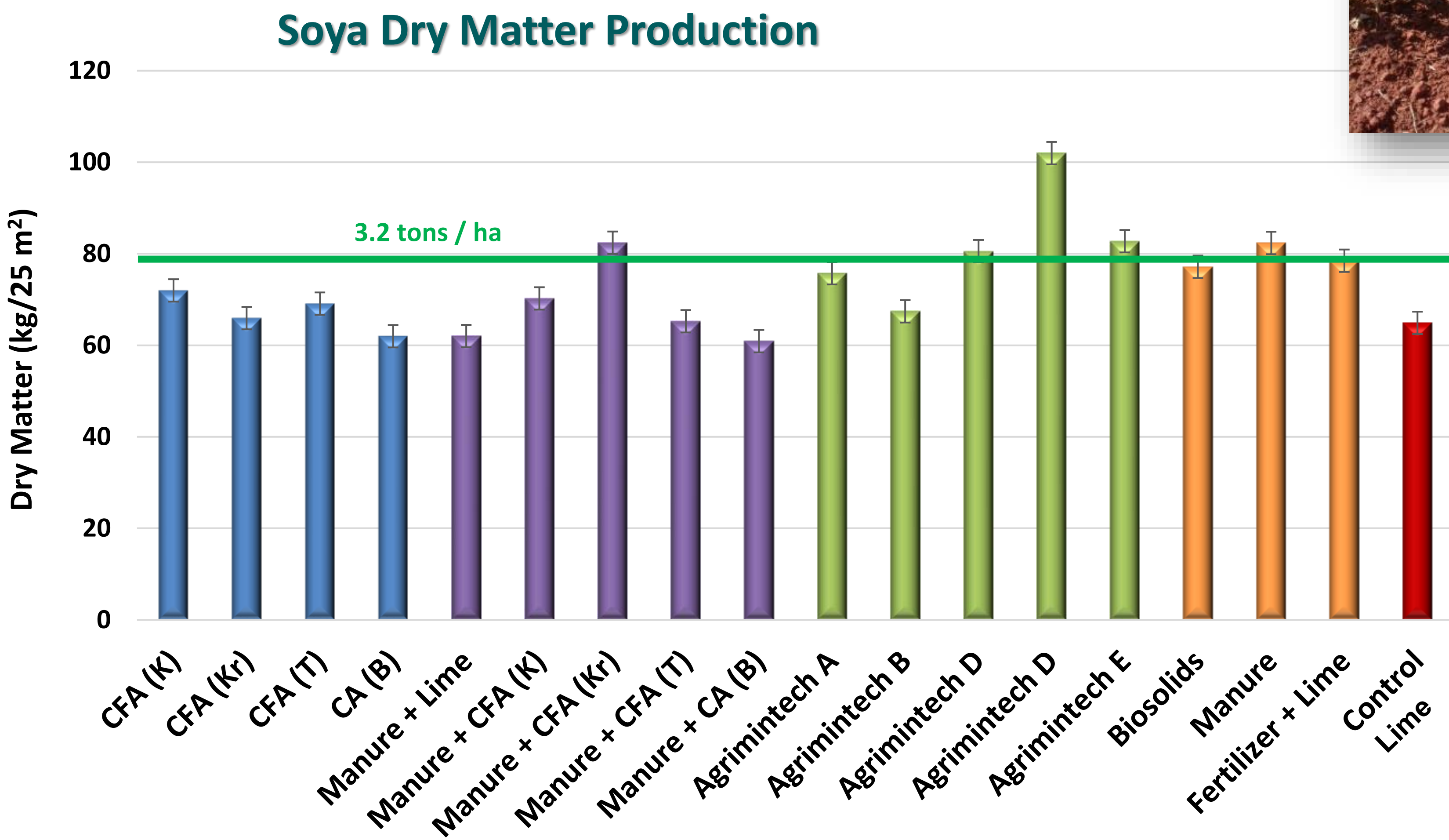
PHASE 3 RESULTS



PHASE 3 RESULTS



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PHASE 4 - LEACHING STUDIES – International Framework

L E A F
Leaching Environmental Assessment Framework

A Decision Support System for Beneficial Use and Disposal Decisions in the United States and Internationally…

- Four leaching test methods
- Data management tools
- Geochemical speciation and mass transfer modeling
- Quality assurance/quality control for materials production
- Integrated leaching assessment approaches

… designed to identify characteristic leaching behaviors for a wide range of materials and scenarios &
… provide a material & scenario-specific "source-term".

Kosson, D. and van der Sloot, H.A (2014) WACAU

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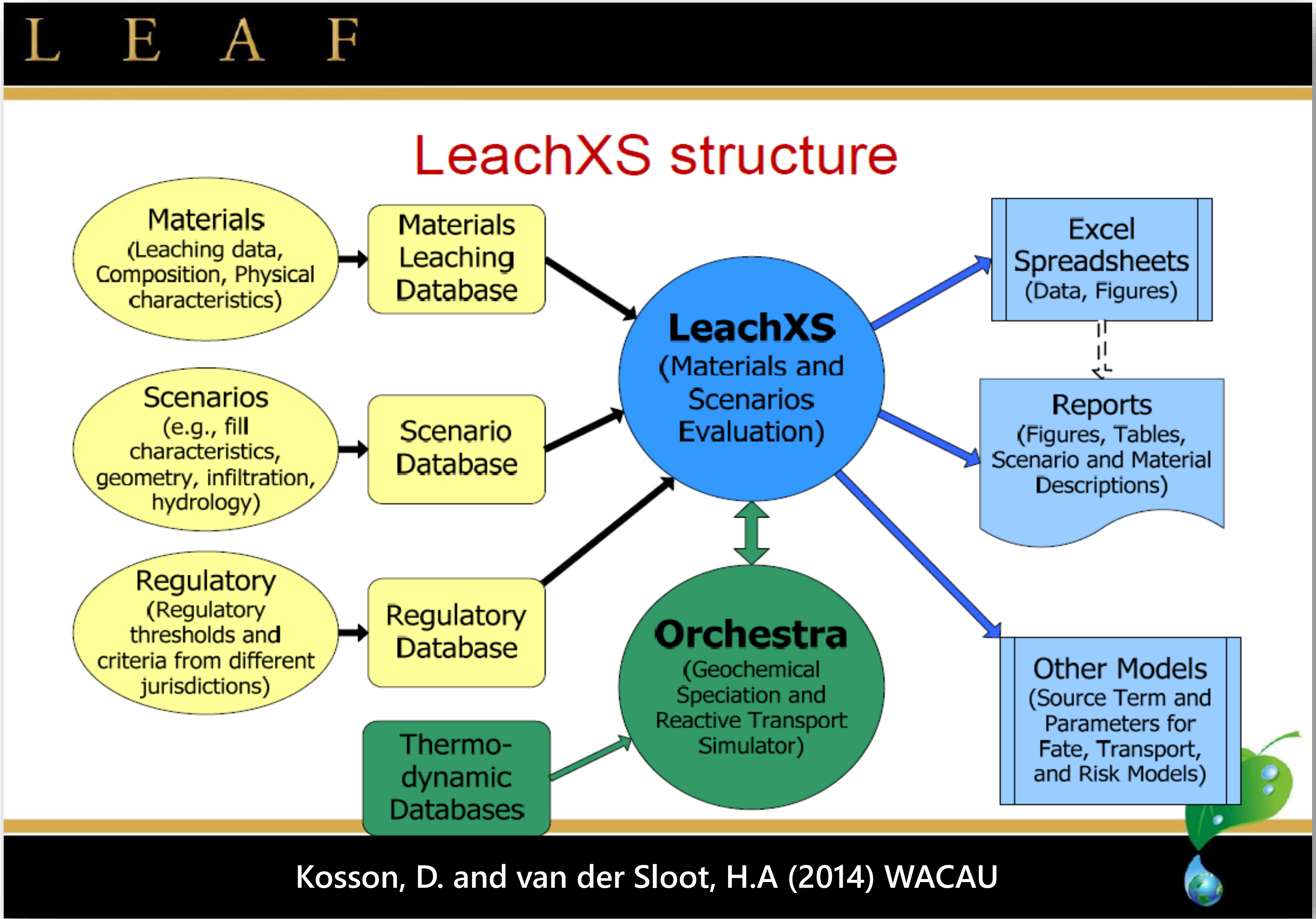
PHASE 4 – LEACH XS MODELLING



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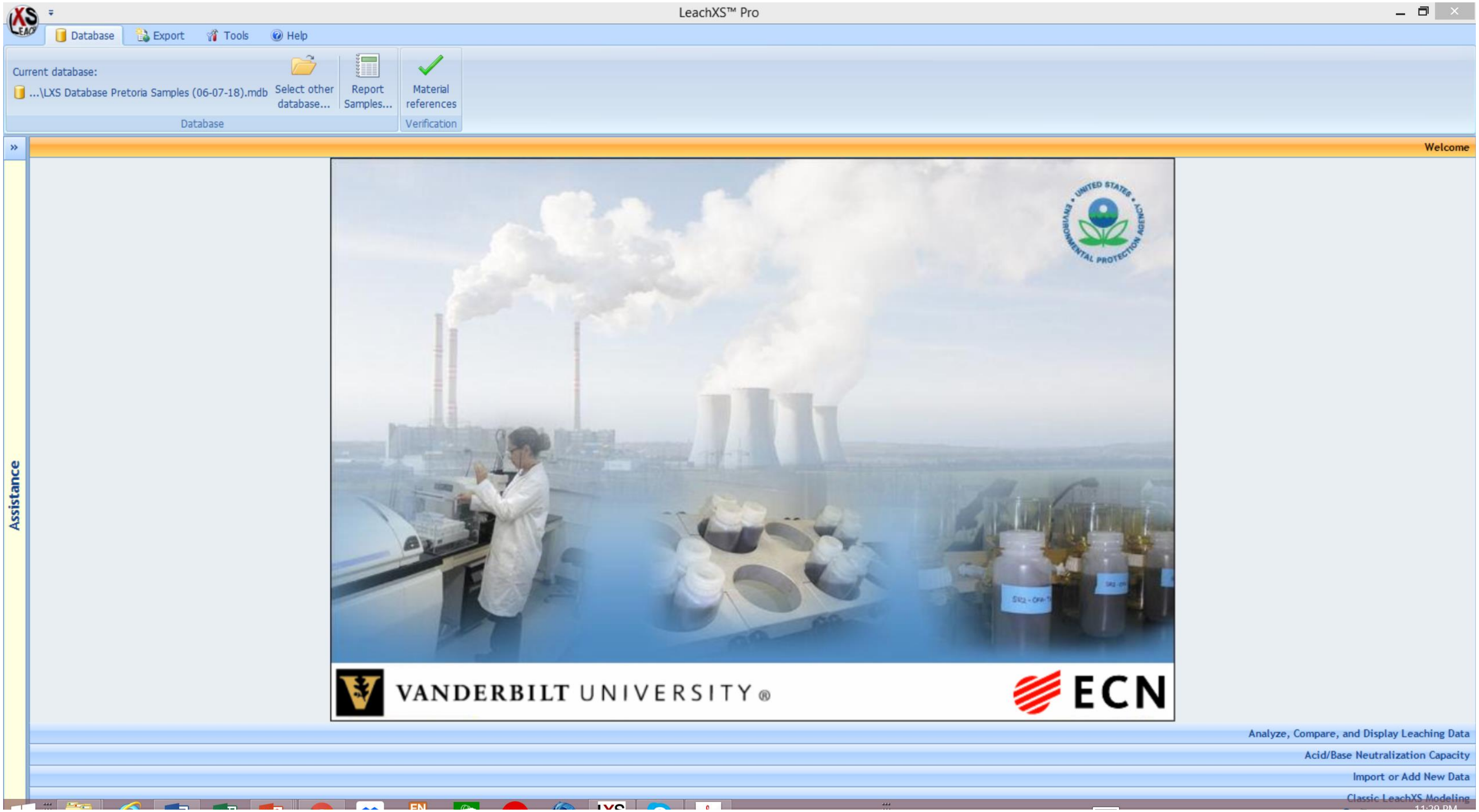
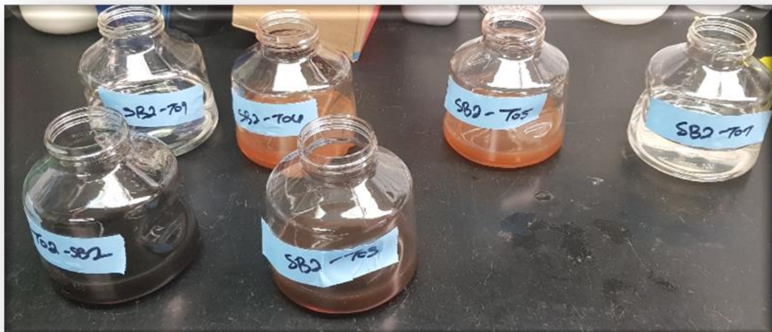
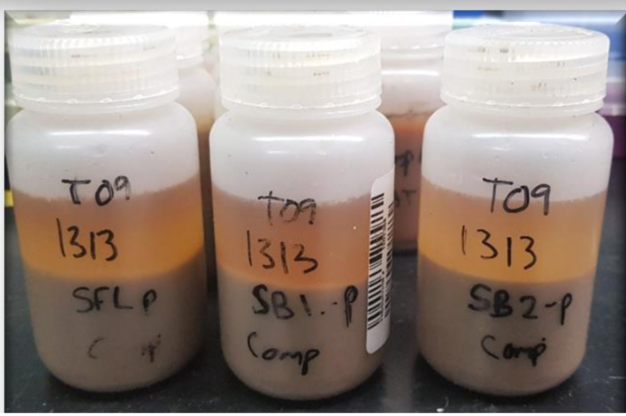
PHASE 4 - LEACHING STUDIES



PHASE 4 - LEACHING STUDIES

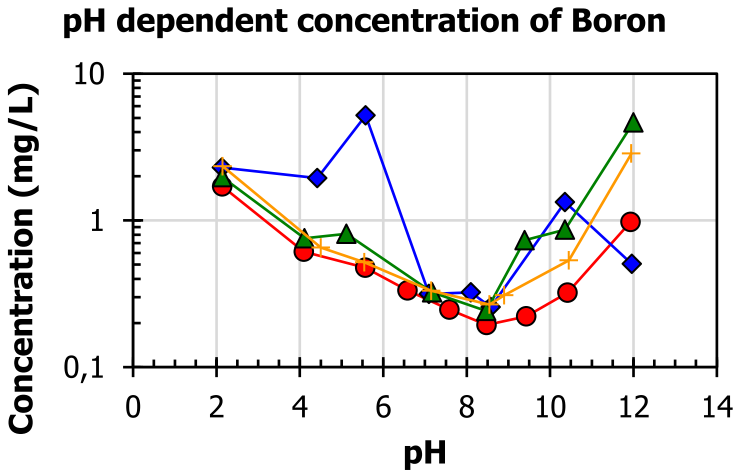
EPA 1313
pH Dependant Test

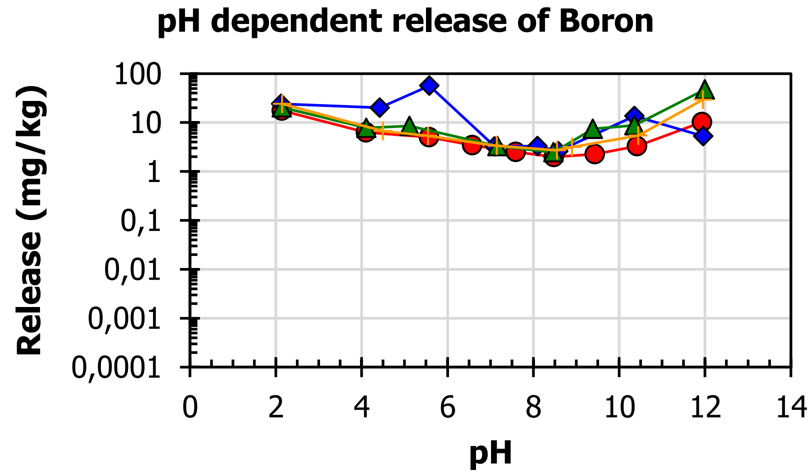


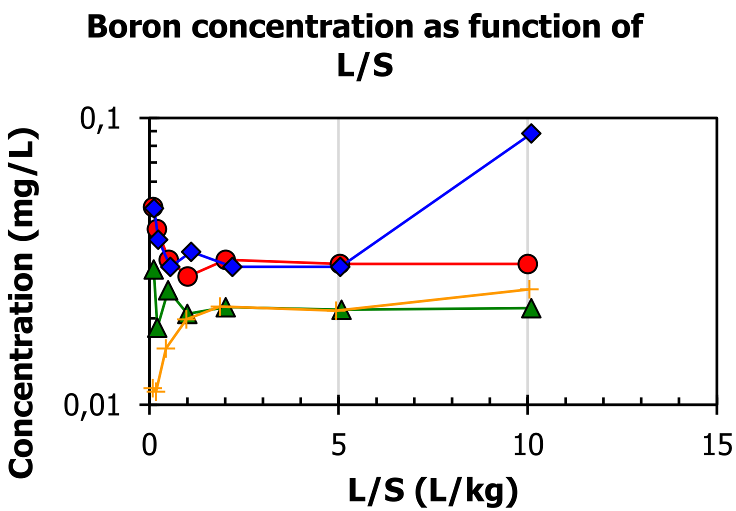


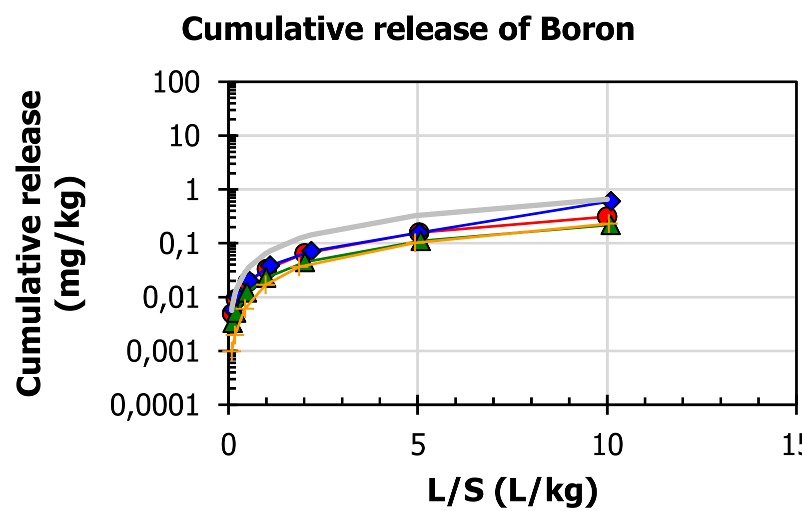
EPA 1314
Column Testing

Leaching Assessment Results









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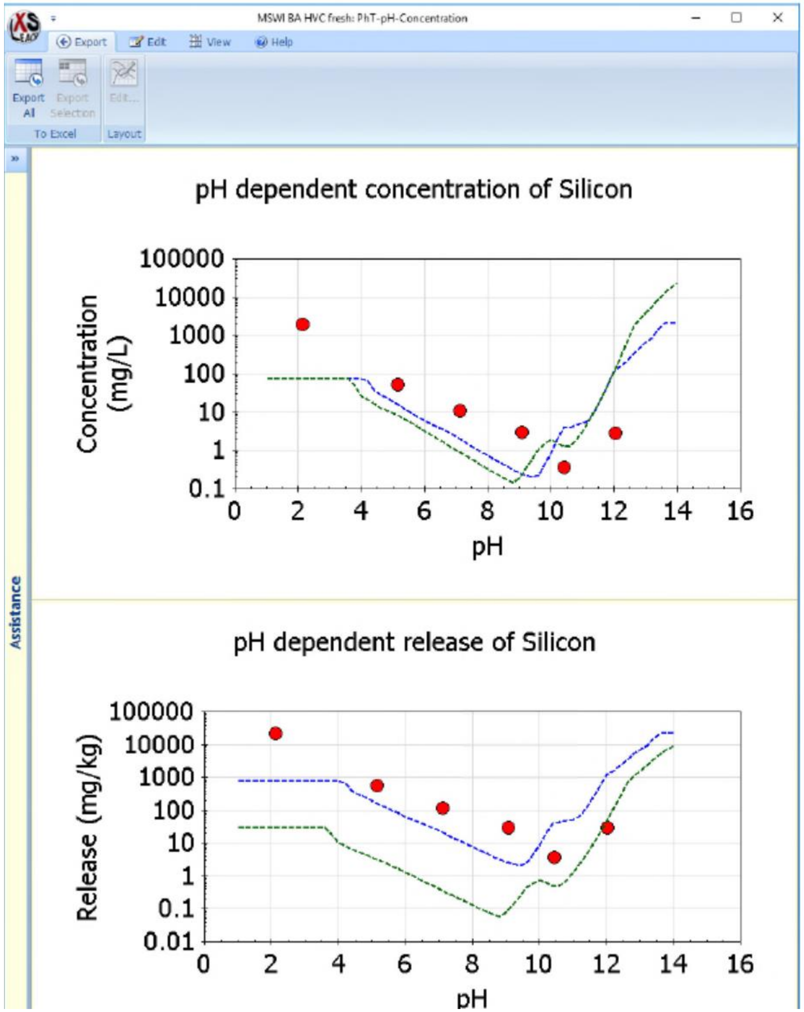
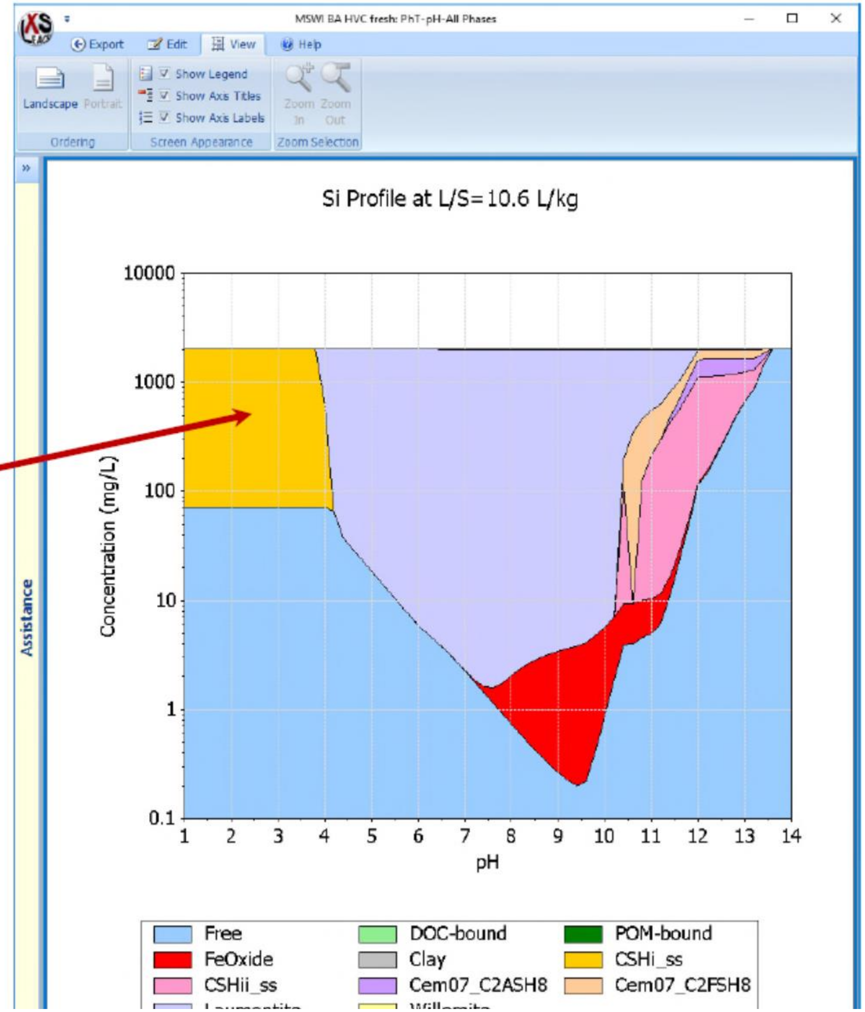


Take out



CONCLUSION

- **UNDERSTAND THE**
  - **Fly ash *properties***
  - **Soil chemical, physical and microbiological *properties***
  - **Soil condition**
    - *Deficiencies*
    - *Phytotoxicity and soil toxicity*
    - *Leaching risk*

  - Plant species *(growth requirements)*

***match* it to the**

PROPOSED AGRICULTURAL USE

ACKNOWLEDGEMENTS

Eskom Enterprises

SACAA
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AgriMinTech

FPLRI
RESEARCH, TECHNOLOGY AND INNOVATION INSTITUTE

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E ENTERPRISES University of Pretoria
Shifting knowledge to insight

VANDERBILT UNIVERSITY

AGRIVITALITY Research

AF4RICA LAB
ENTERPRISES University of Pretoria

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THANK YOU

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Inspiring excellence, transforming lives through quality, impact, and care.

CMBG CENTRE FOR MINERAL BIOGEOCHEMISTRY

VISION 130 Renew and Reimagine towards 2034

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