Understanding soil carbon dynamics for sustainable land management

Yeboah[1], E., Abekoe[2], M.K., Dowuonna[2], G.N.N., Sohi[3], S.P., Vanlauwe[4], B., and Six[5], J.

1. Soil Research Institute, Academy Post Office, Kwadaso, Kumasi.

2. Soil Science Department, Faculty of Agriculture and Consumer Sciences, University of Ghana, Legon.

3. Rothamsted Research, UK.

4. Tropical Soil Biology and Fertility Institute of CIAT, Nairobi, Kenya.

5. University of California, Davis, USA.

Background

Climate change is already occurring and future changes are inevitable

Given that the soil represent the largest pool of terrestrial C, understanding the dynamics of Soil Organic Matter (SOM) is pertinent for climate change concerns and greenhouse gas mitigation efforts (Cole, 1994)

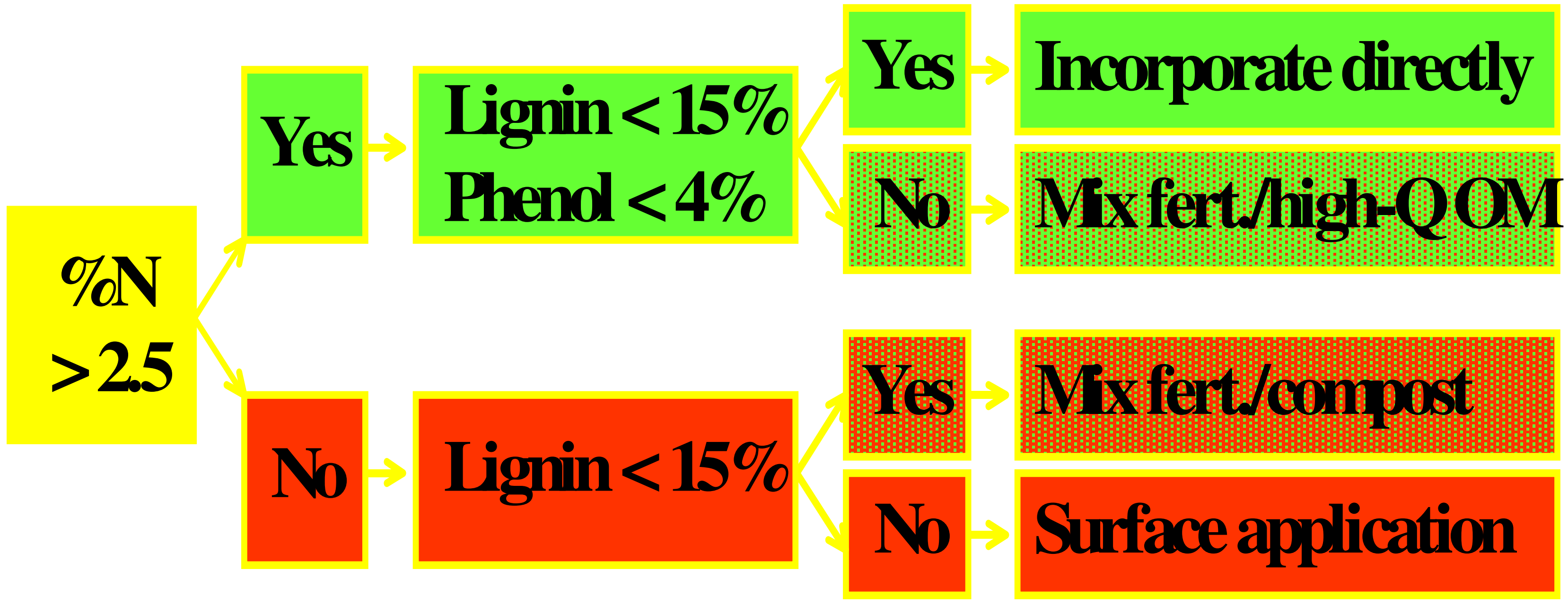
Changes in SOM is slow and takes several decades to observe minimal changes.

However, there are fractions/ pools that are sensitive to management practices

(Sohi et.al.2001)

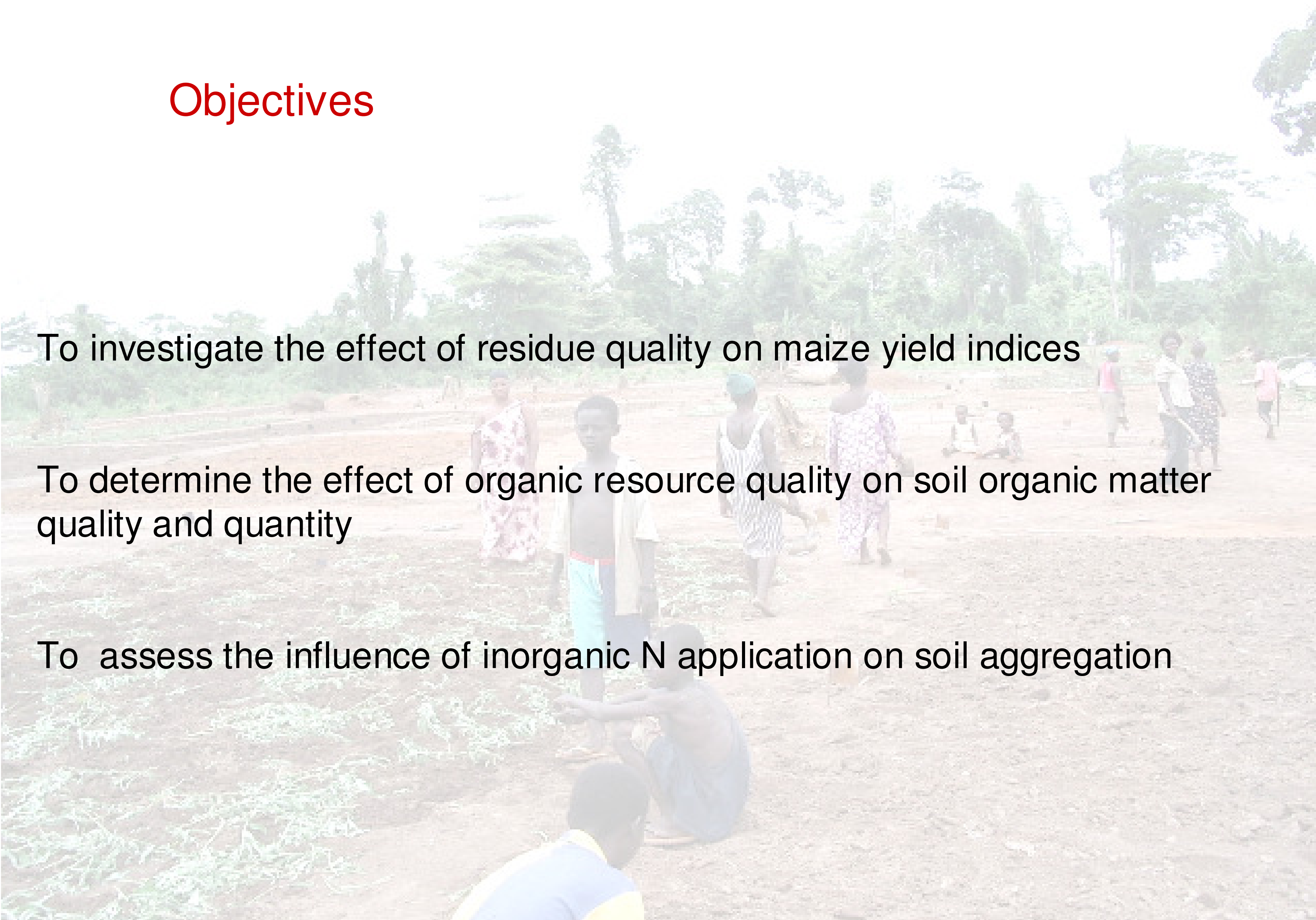
Organic matter

Decision tree for organic N management



Palm et al. 2001

Objectives



To investigate the effect of residue quality on maize yield indices

To determine the effect of organic resource quality on soil organic matter quality and quantity

To assess the influence of inorganic N application on soil aggregation

Methodology

Field experiment

Density fractionation of soil (Sohi et.al. 2001)

Aggregate fractionation (Six et al. 2001)

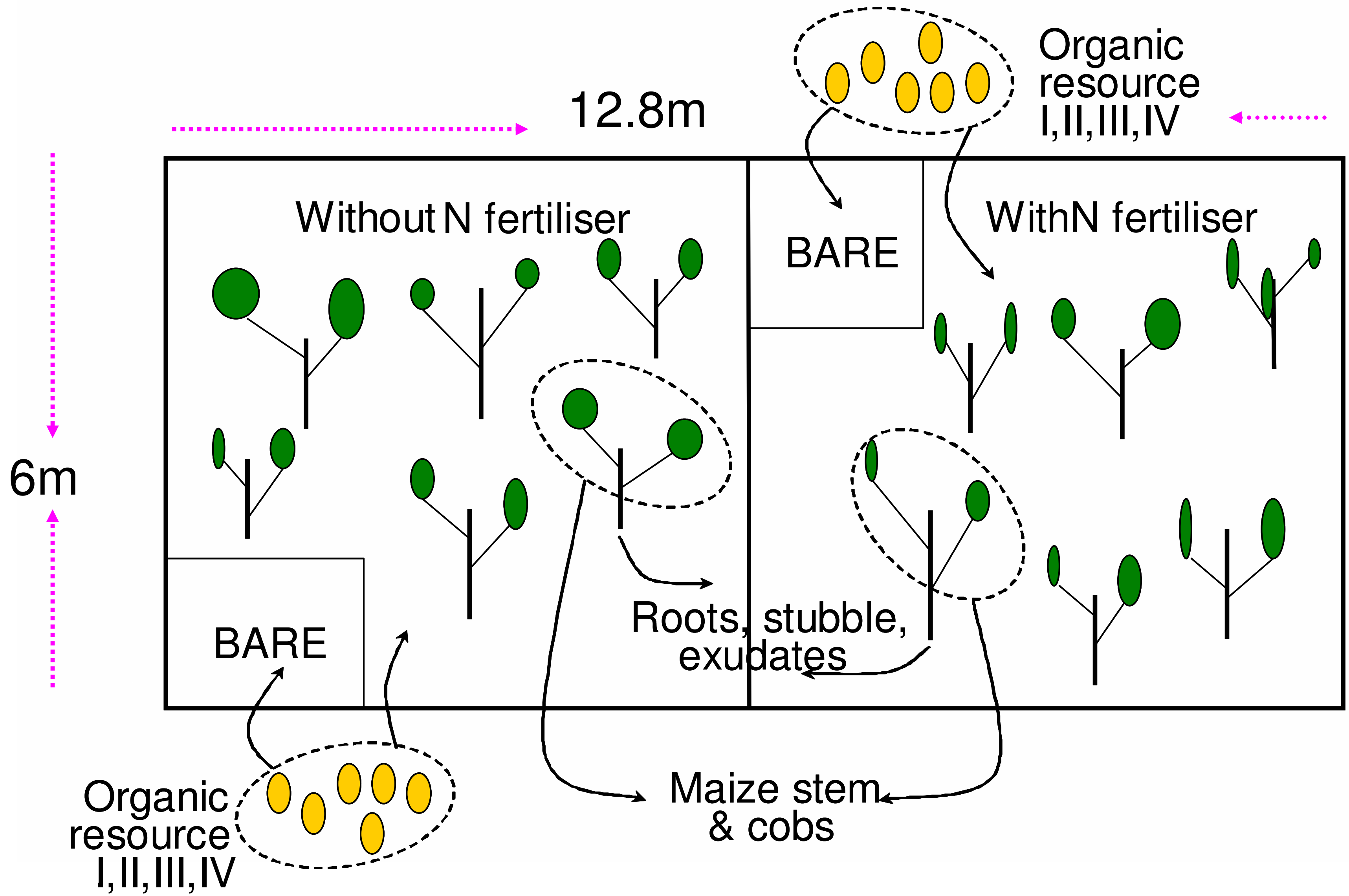
RothC Model

Field experiment

- Six organic materials (*C.juncea*, *L.leucocephala*, Maize stover, Sawdust, manure and control)
- Two application rates (1.2 t C/ha and 4 t C/ha)
- Two rates of N (0 and 120kg N/ha)
- Two cultivation types (cropped and Bare)
- Three replicates of each treatment
- Organic inputs applied once a year in the major season and residual effect evaluated in the minor season
- Continuous cultivation of hybrid maize (*mamaba*), twice per year
- Basal application of 30kg P/ha and 60kg K /ha once a year in the major season

N source was urea and P source triple super phosphate (TSP)

The field experiment resource



Organic resources

C. juncea (Class I)

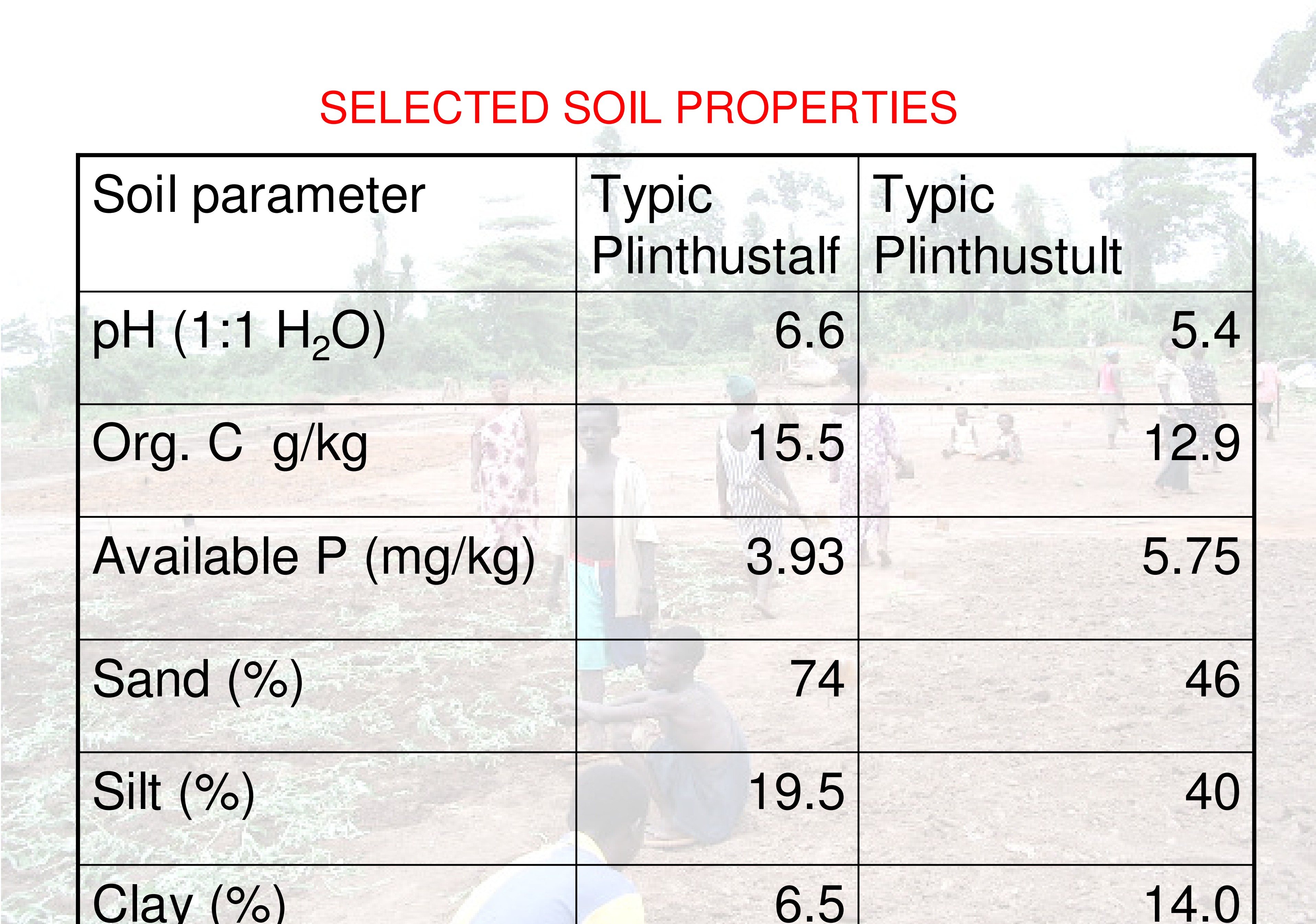
L.leucocephala (Class II)

Fractionation methods

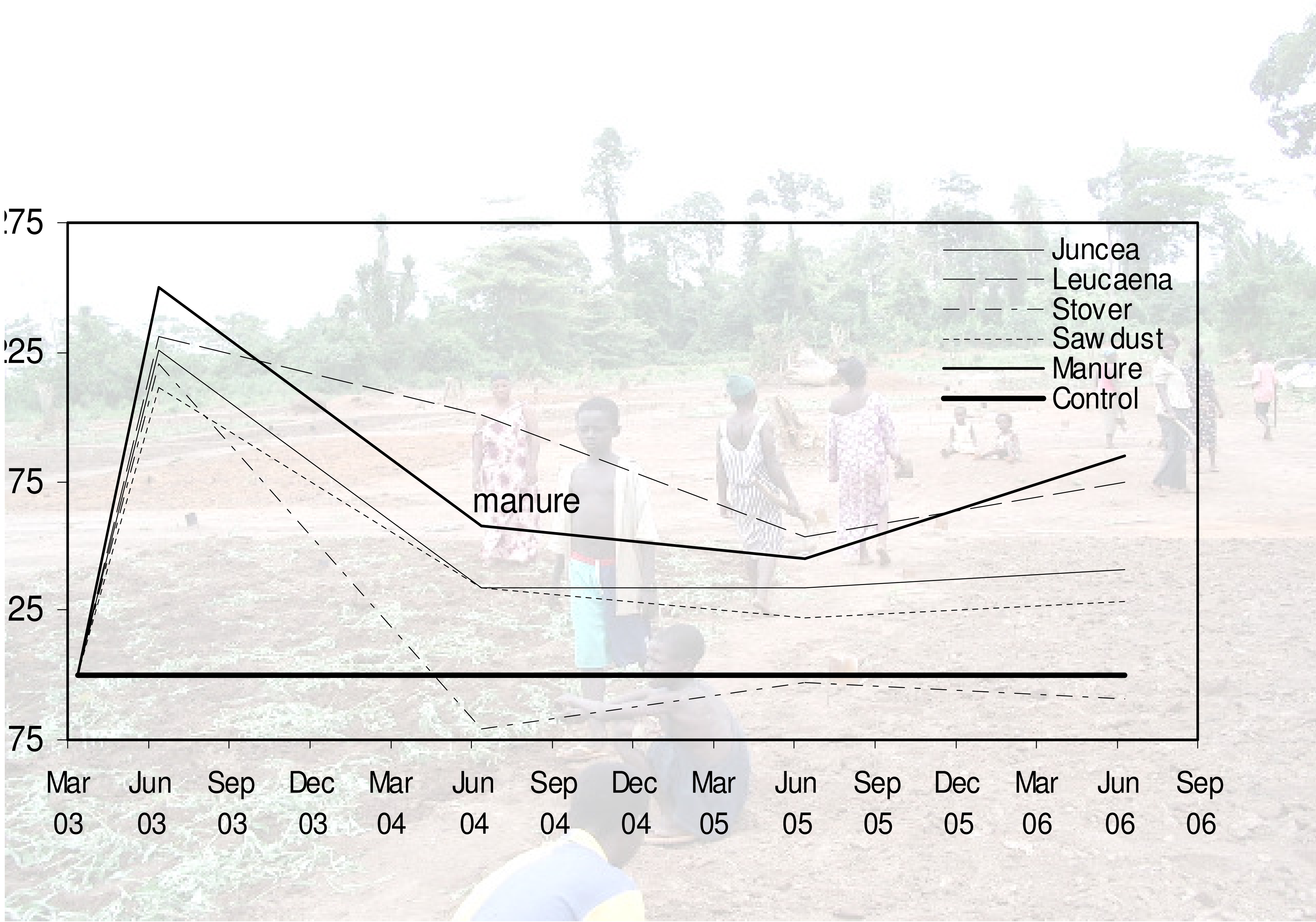
- Density fractionation
- Free light fraction (FRLF)
- Intraaggregate light fraction (IALF)
- Organo-mineral (OM)
- Soluble fraction (Sol)

- Aggregate size
- Large Macroaggregates >2000µm
- Small macoraggregates 250-2000µm)
- Microaggregates (53-250 µm)
- Silt and clay fraction (<53 µm)

SELECTED SOIL PROPERTIES

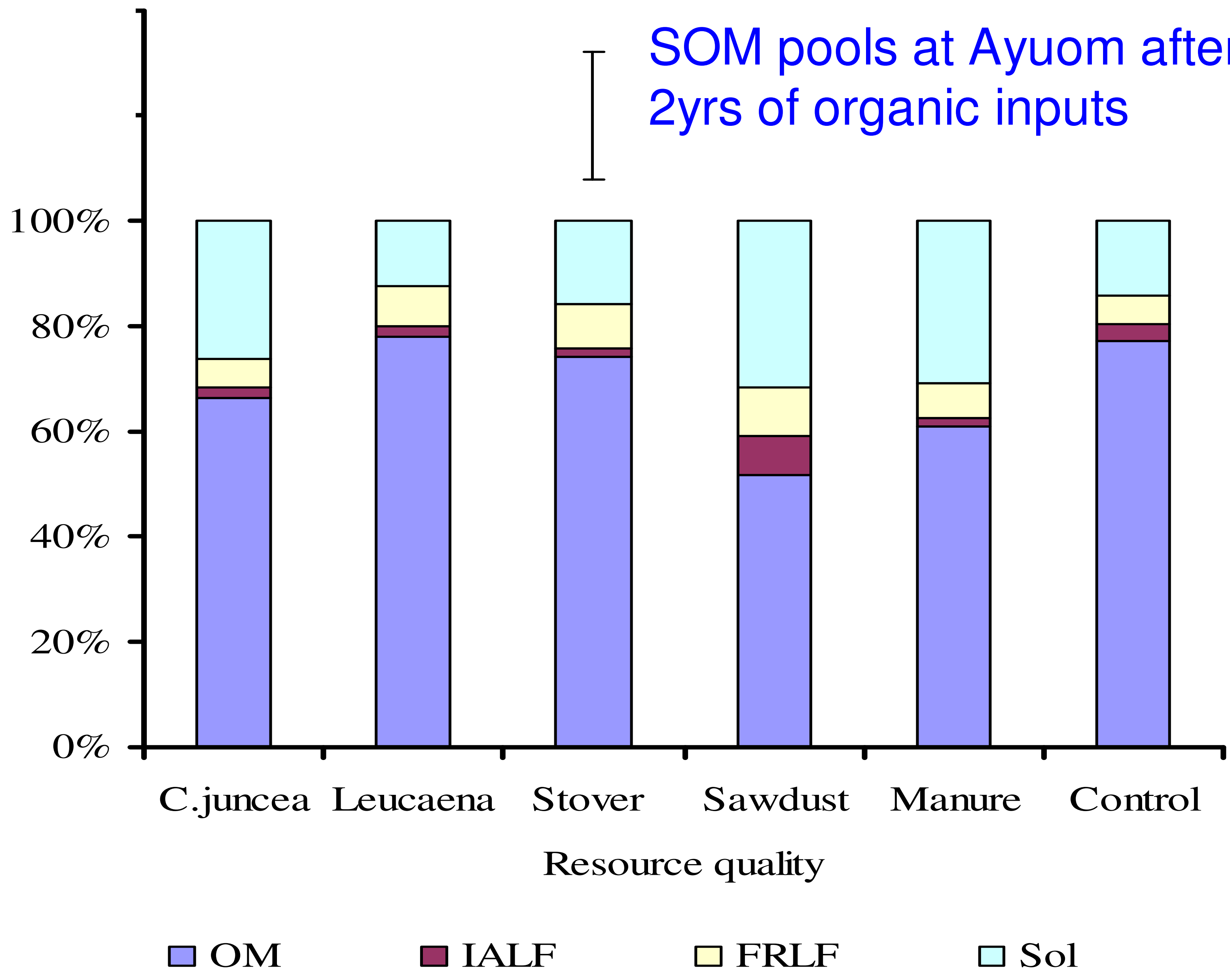


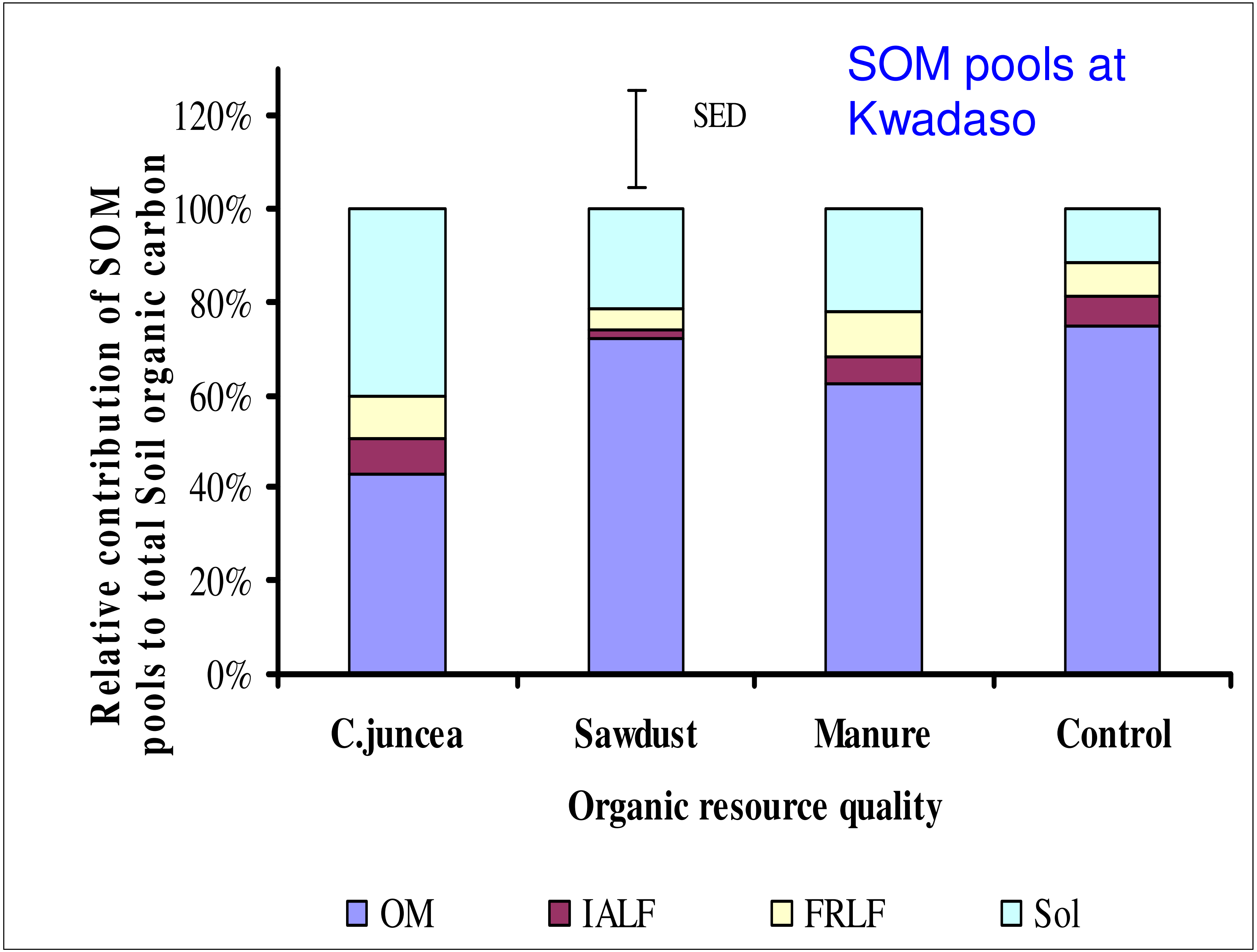
Soil parameter	Typic Plinthustalf	Typic Plinthustult
pH (1:1 H_2O)	6.6	5.4
Org. C g/kg	15.5	12.9
Available P (mg/kg)	3.93	5.75
Sand (%)	74	46
Silt (%)	19.5	40
Clay (%)	6.5	14.0



75
25
75
25
75
Juncea
Leucaena
Stover
Saw dust
Manure
Control
manure
Mar 03
Jun 03
Sep 03
Dec 03
Mar 04
Jun 04
Sep 04
Dec 04
Mar 05
Jun 05
Sep 05
Dec 05
Mar 06
Jun 06
Sep 06

SOM pools at Ayuom after 2yrs of organic inputs

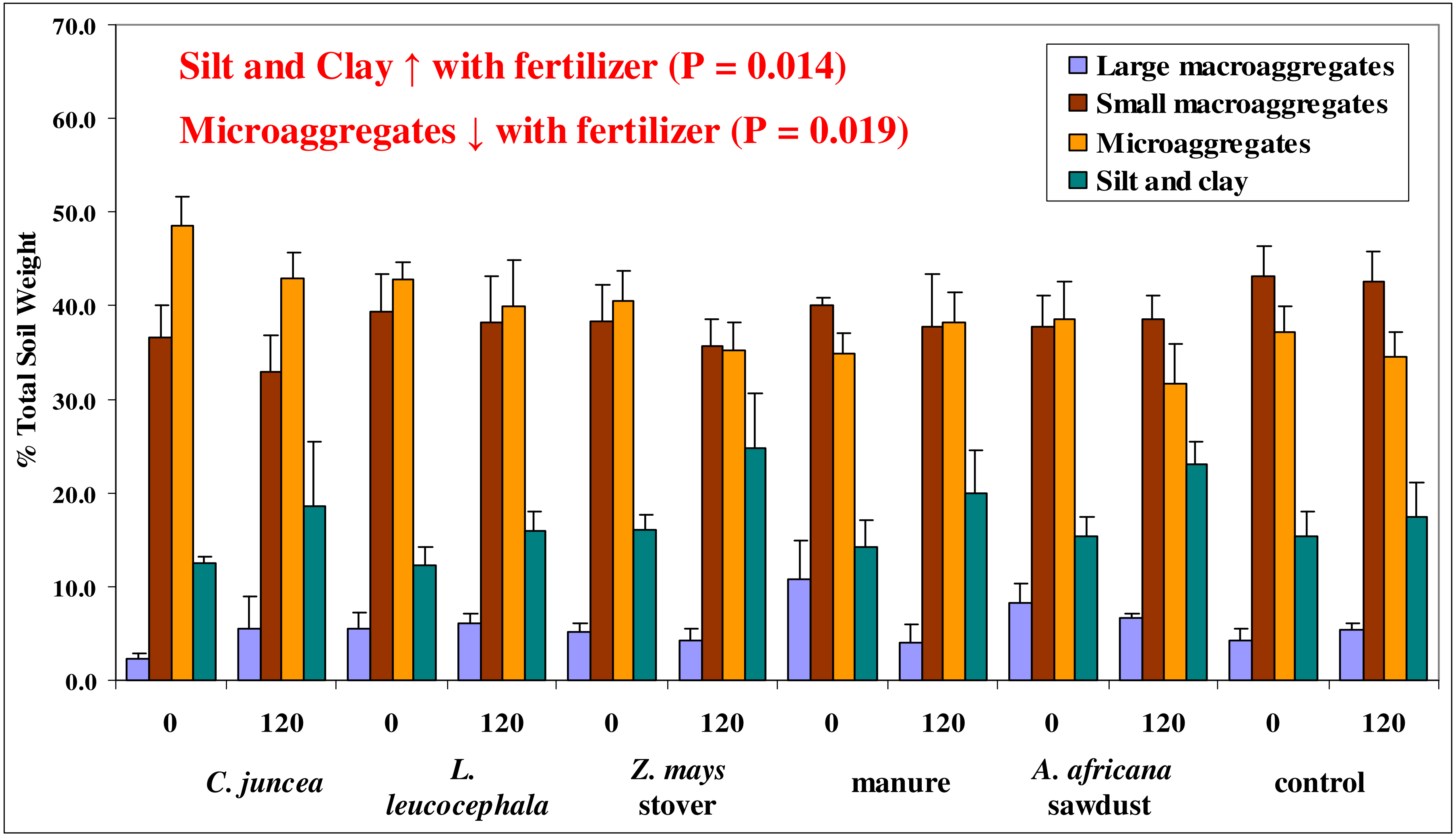




SOM pools at Kwadaso
SED
120%
100%
80%
60%
40%
20%
0%
Relative contribution of SOM pools to total Soil organic carbon
C.juncea
Sawdust
Manure
Control
Organic resource quality
OM
IALF
FRLF
Sol

Results and Discussion

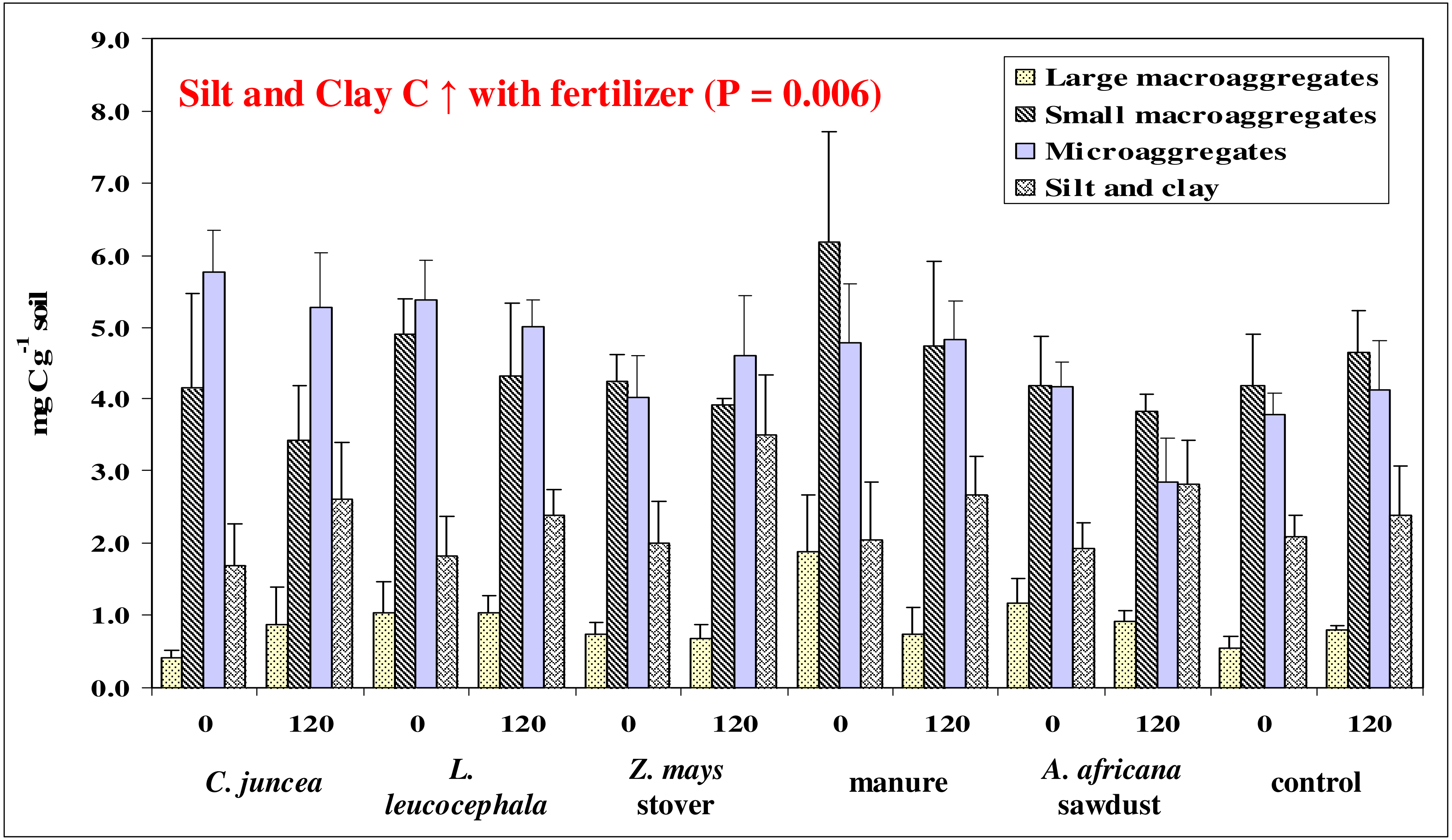
Free Aggregate Distribution



*Error bars represent standard error about the mean

Results and Discussion

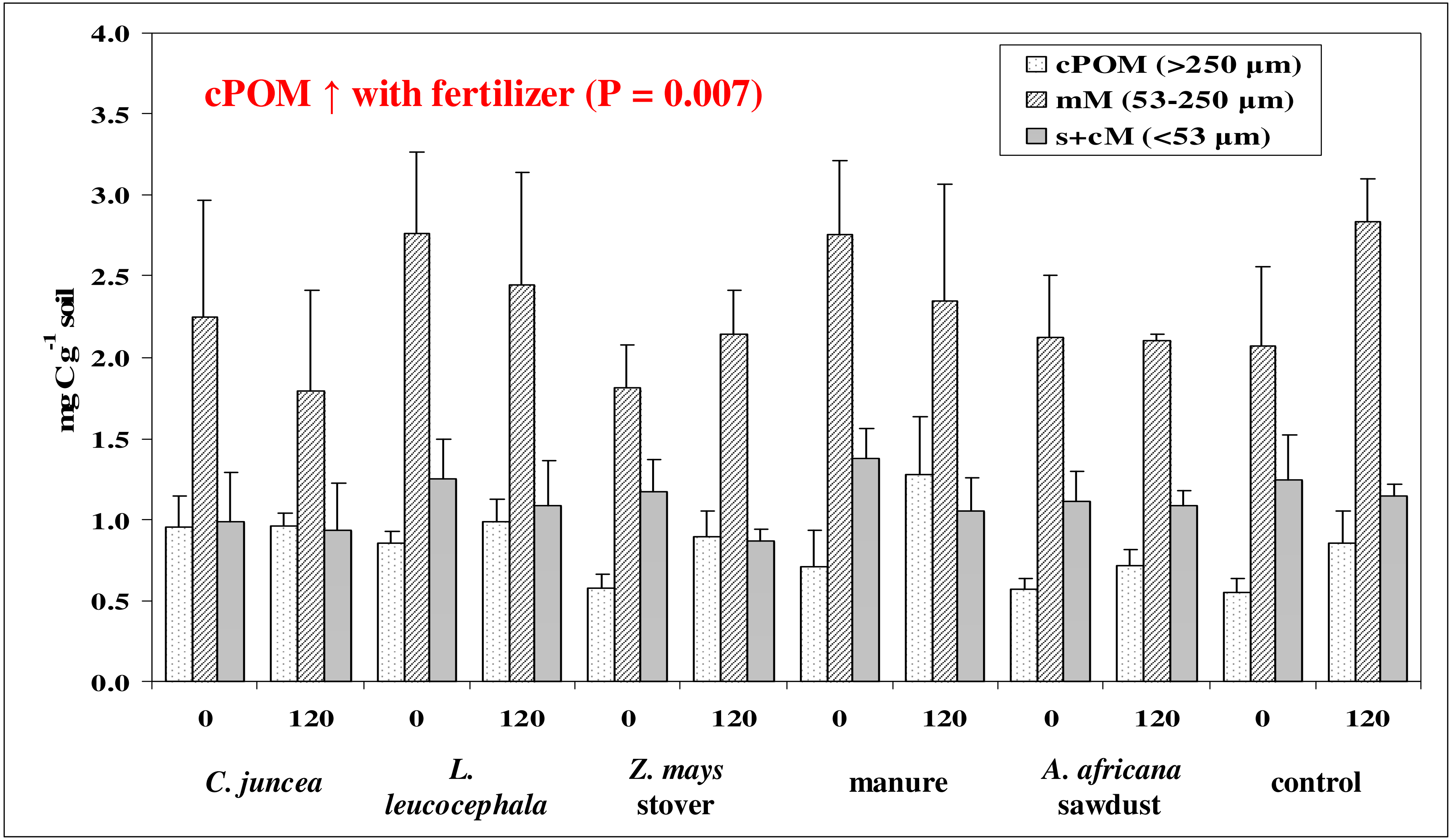
Soil Carbon in Free Aggregate Fractions



*Error bars represent standard error about the mean

Results and Discussion

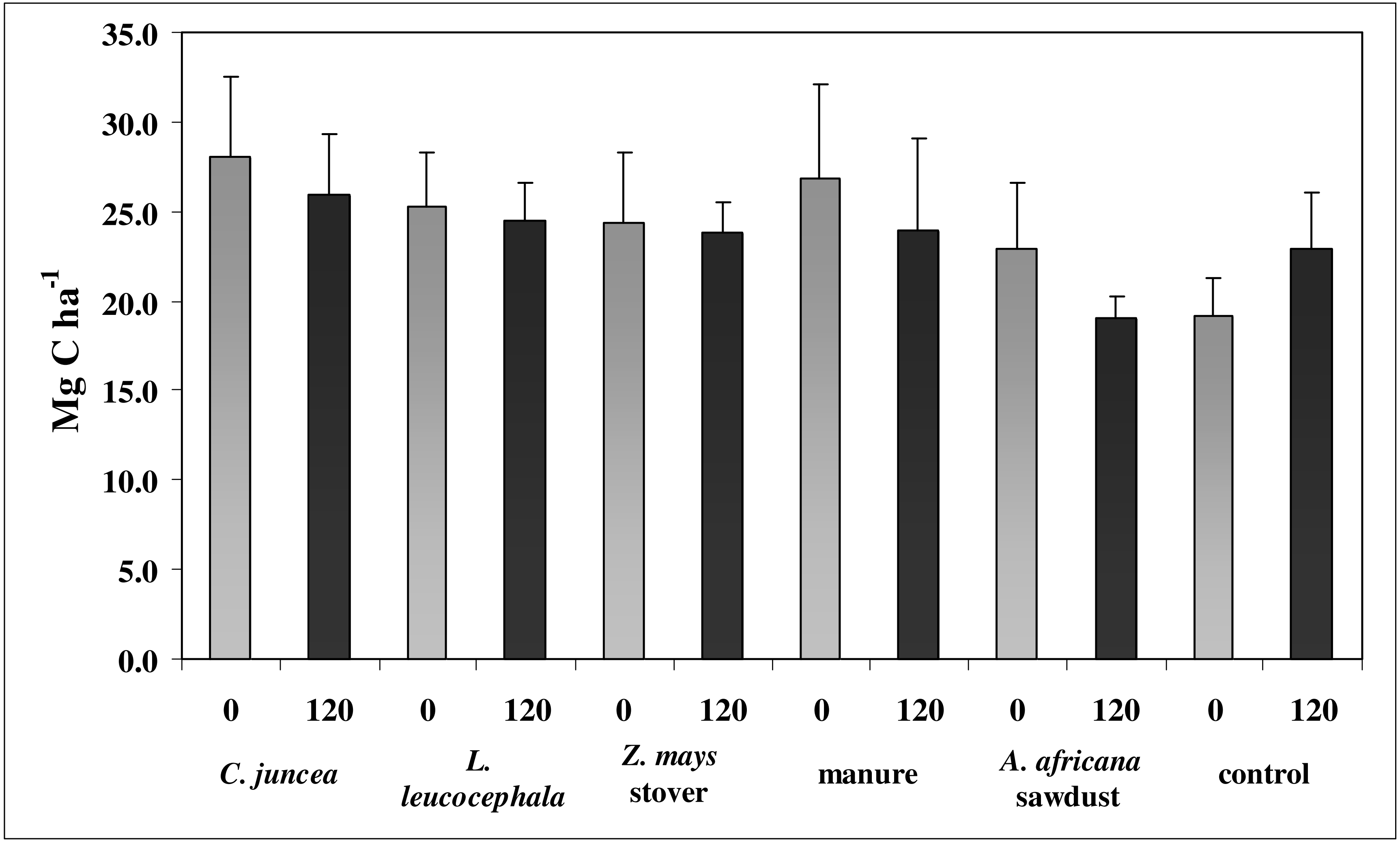
Soil Carbon in Macroaggregate Occluded Fractions



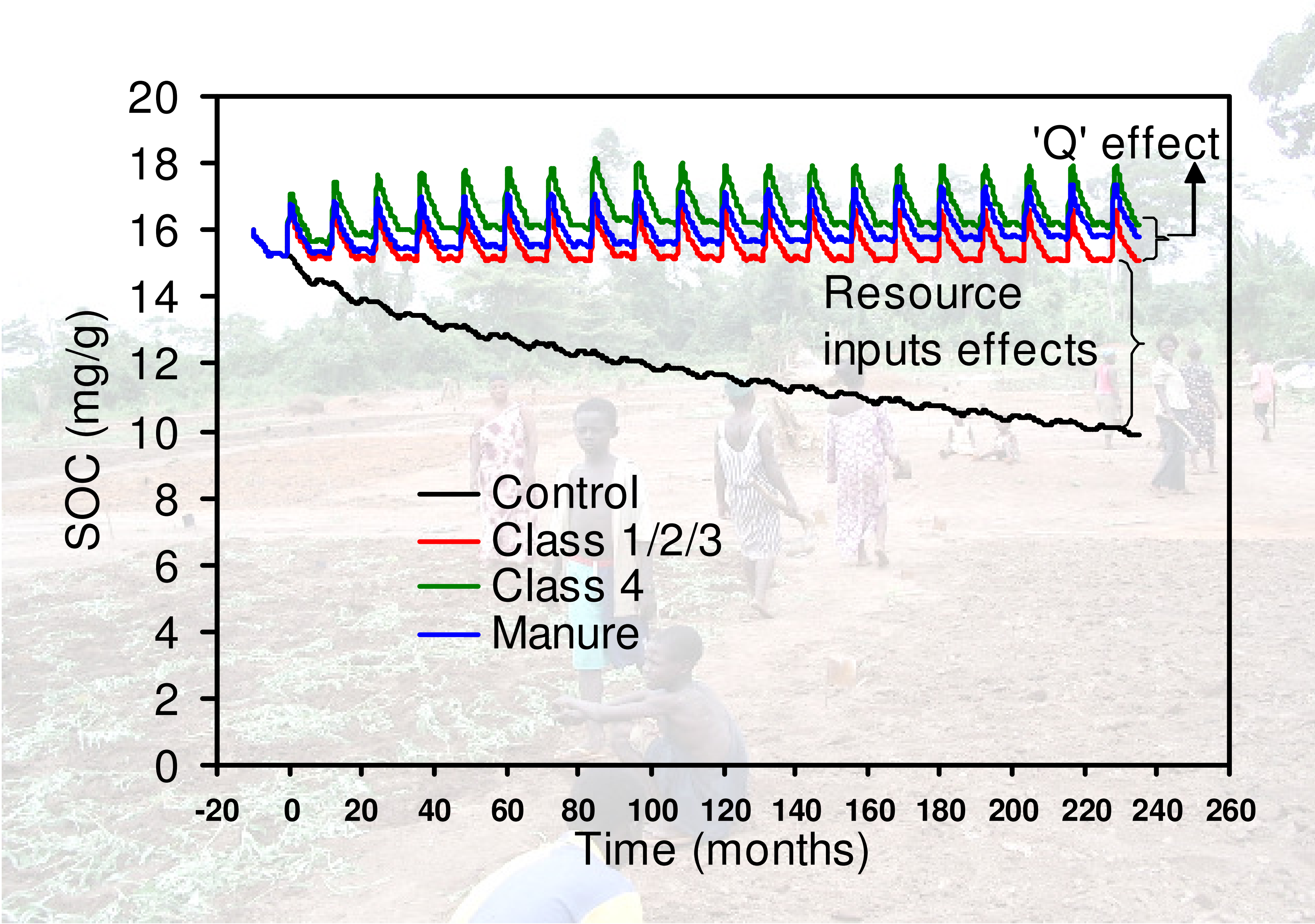
*Error bars represent standard error about the mean

Results and Discussion

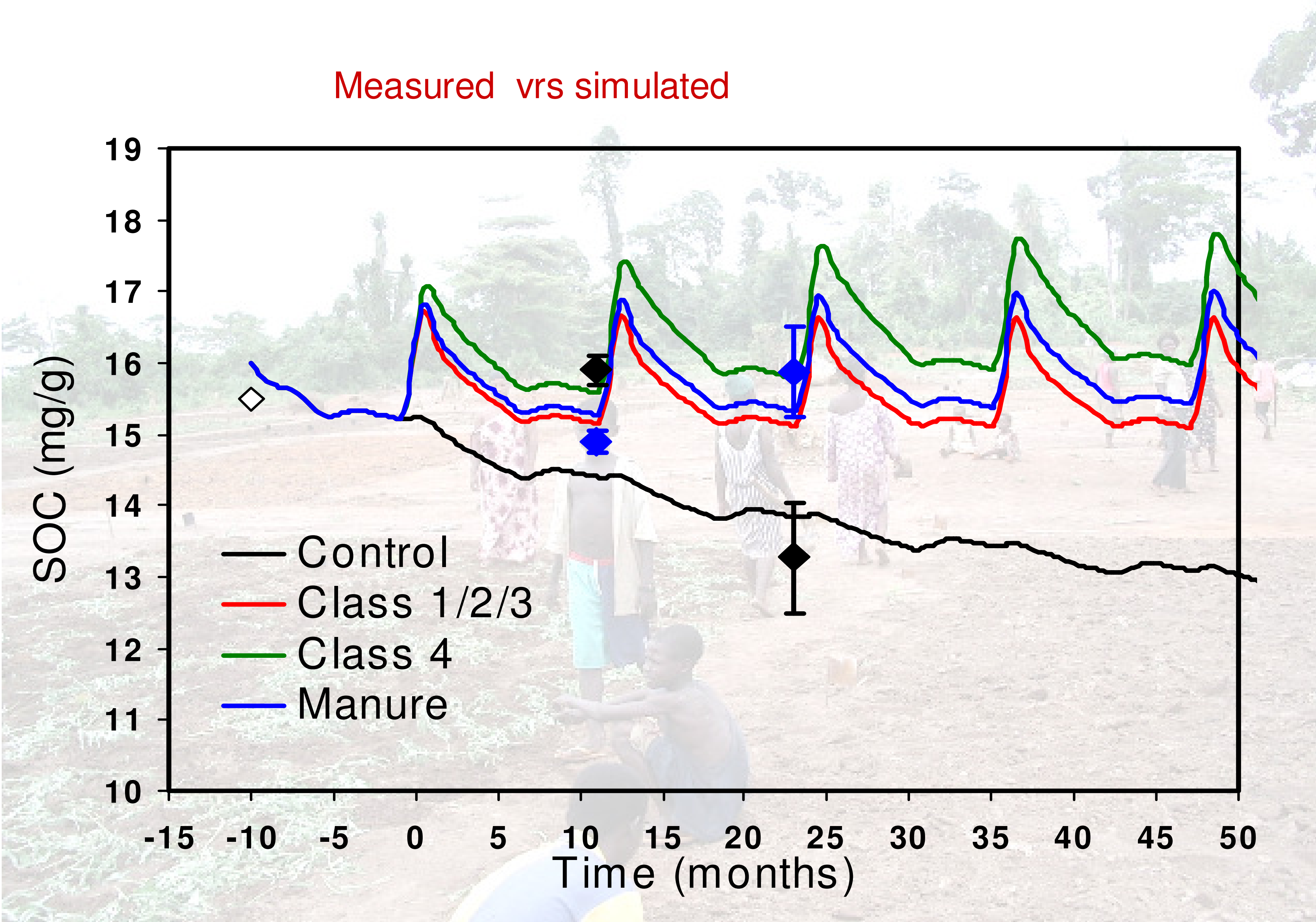
Total Soil Carbon



*Error bars represent standard error about the mean



'Q' effect
Resource inputs effects
Control
Class 1/2/3
Class 4
Manure
SOC (mg/g)
20
18
16
14
12
10
8
6
4
2
0
-20
0
20
40
60
80
100
120
140
160
180
200
220
240
260
Time (months)



Measured vrs simulated
SOC (mg/g)
19
18
17
16
15
14
13
12
11
10
-15
-10
-5
0
5
10
15
20
25
30
35
40
45
50
Time (months)
Control
Class 1/2/3
Class 4
Manure

Conclusions

- Inorganic N additions appear to accelerate rates of aggregate turnover leading to decreased aggregate-associated C stabilization and total soil C stores.

- Residue quality appears to affect aggregation but effects are less clear

- Site specific influence of inorganic N additions? …differing results at other field sites

Some thoughts for consideration

Can we improve the benefits of organic resources through pyrolysis to produce biochar or charcoal?