EFFECTS OF MANURE, SOIL TYPE AND CLIMATE ON N AND P SUPPLY TO SORGHUM AND PIGEONPEA:

A CASE STUDY IN COMBINING FIELD EXPERIMENTATION AND SIMULATION MODELLING

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Manure is a source of both P and N!

Research Issues

- What is the best use of manure inputs?
- How to deal with site and season specificity?

Research Approach

- Combine field experimentation and simulation modeling to study crop response and effects of;

1. Manure quality
2. Crop management
3. Climatic variability
4. Soil type (Alfisol & Vertisol)

Objectives of field experimentation:

- To assess chemical characteristics of manure for predicting nutrient supply
- To quantify relative response of legume and cereal crops to inputs of manure in kharif
- To assess N response of rabi cereal following legume receiving manure in kharif

Treatments:

Sorghum	Pigeonpea	Rabi-sorghum
1. Control	Control	0 kg N ha^{-1}
2. MA	MA	40 kg N ha^{-1}
3. MB	MB	80 kg N ha^{-1}
4. P20	P20	
5. N80		
6. N80+P20		

- *Kharif /Rabi* rainy season, 1998 & 1999
- Alfisol and Vertisol soils.
- Manure applications (2-3 tDM/ha, 17-26kgN, 11-18 kg P /ha)
- Irrigated rabi crop

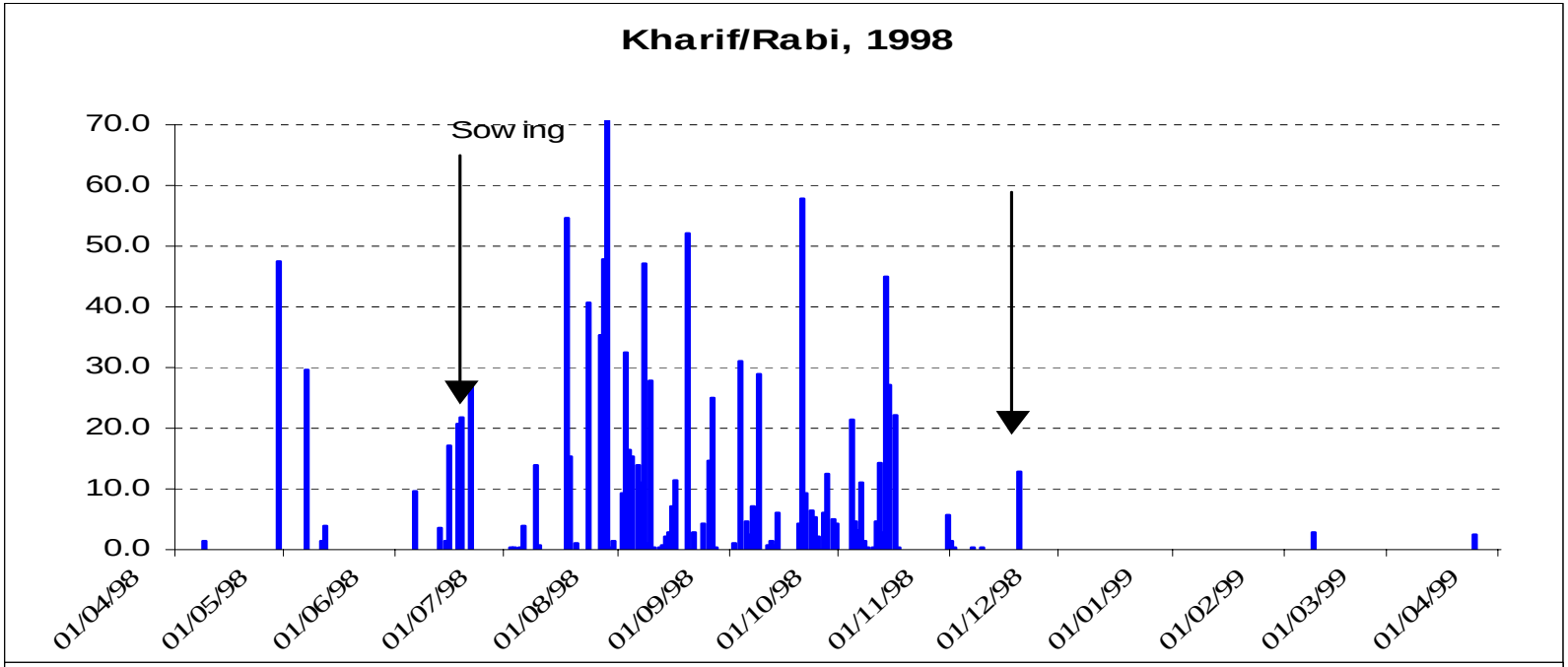
•Missing Sorghum/sorghum rotation.

Soil parameters

Parameters	RCE 12	BW5A	RCW 17B	BM 16 C
% C	0.29	0.40	0.49	0.34
% N	0.04	0.03	0.05	0.03
% P	0.03	0.02	0.02	0.03
PAWC (mm)	120	162	124	154

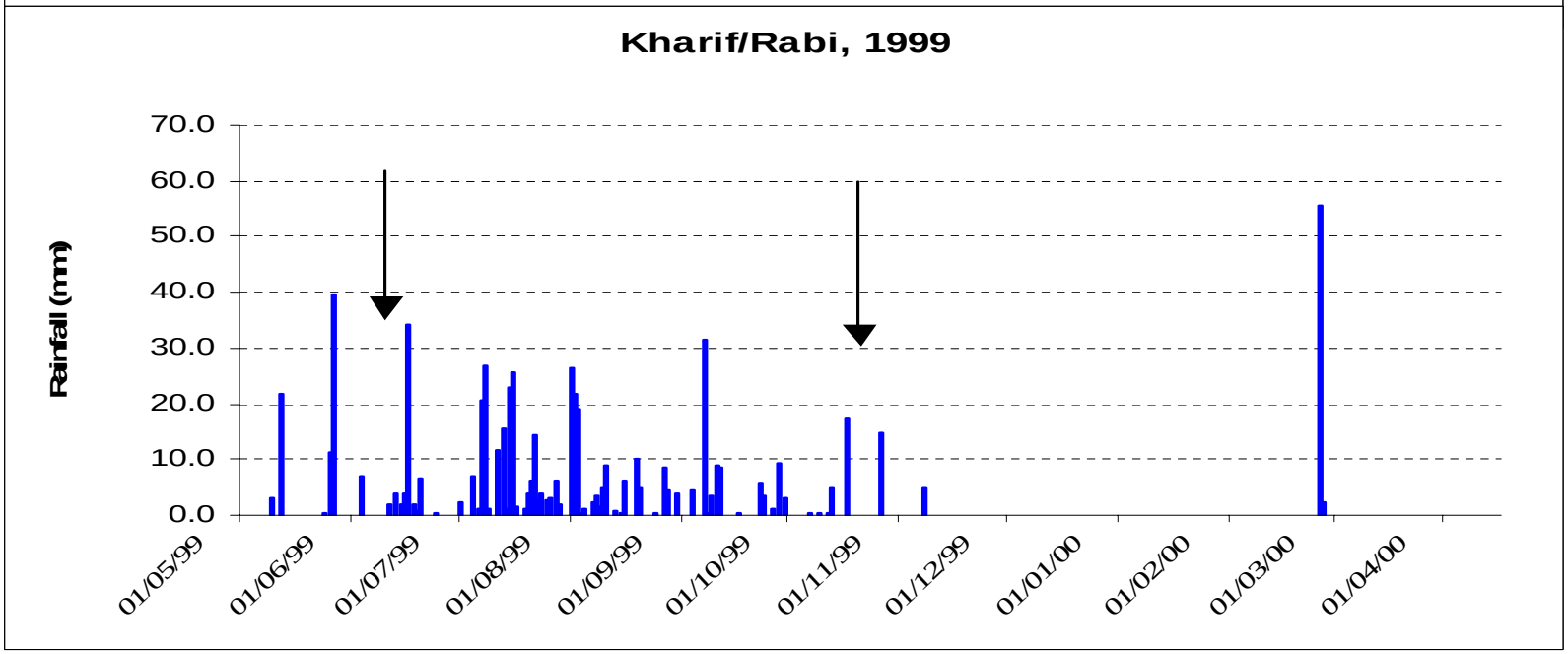
Also available – P sorption data for each soil type

Results: Rainfall



In-crop rainfall:

1000mm



440mm

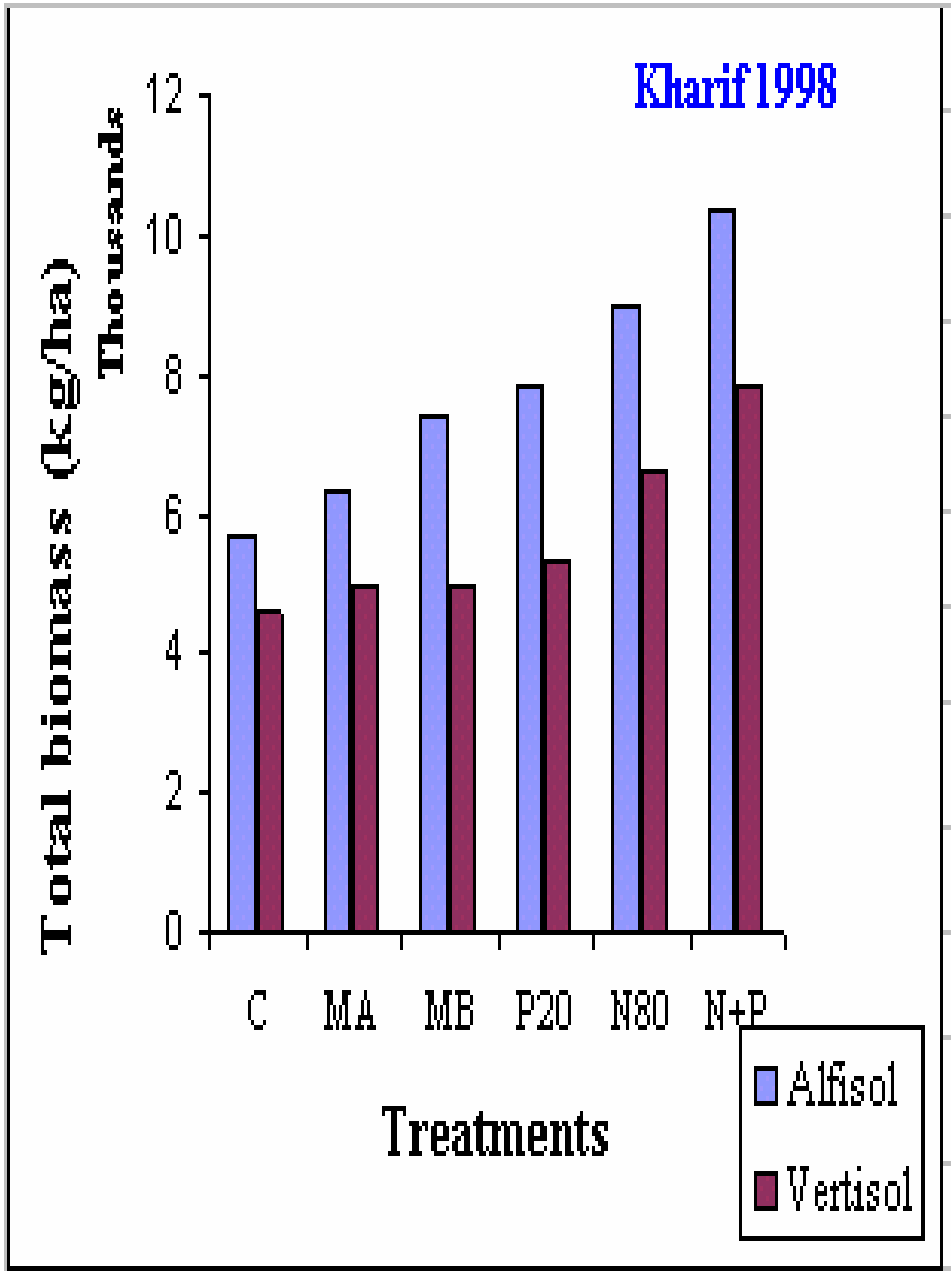
Results:

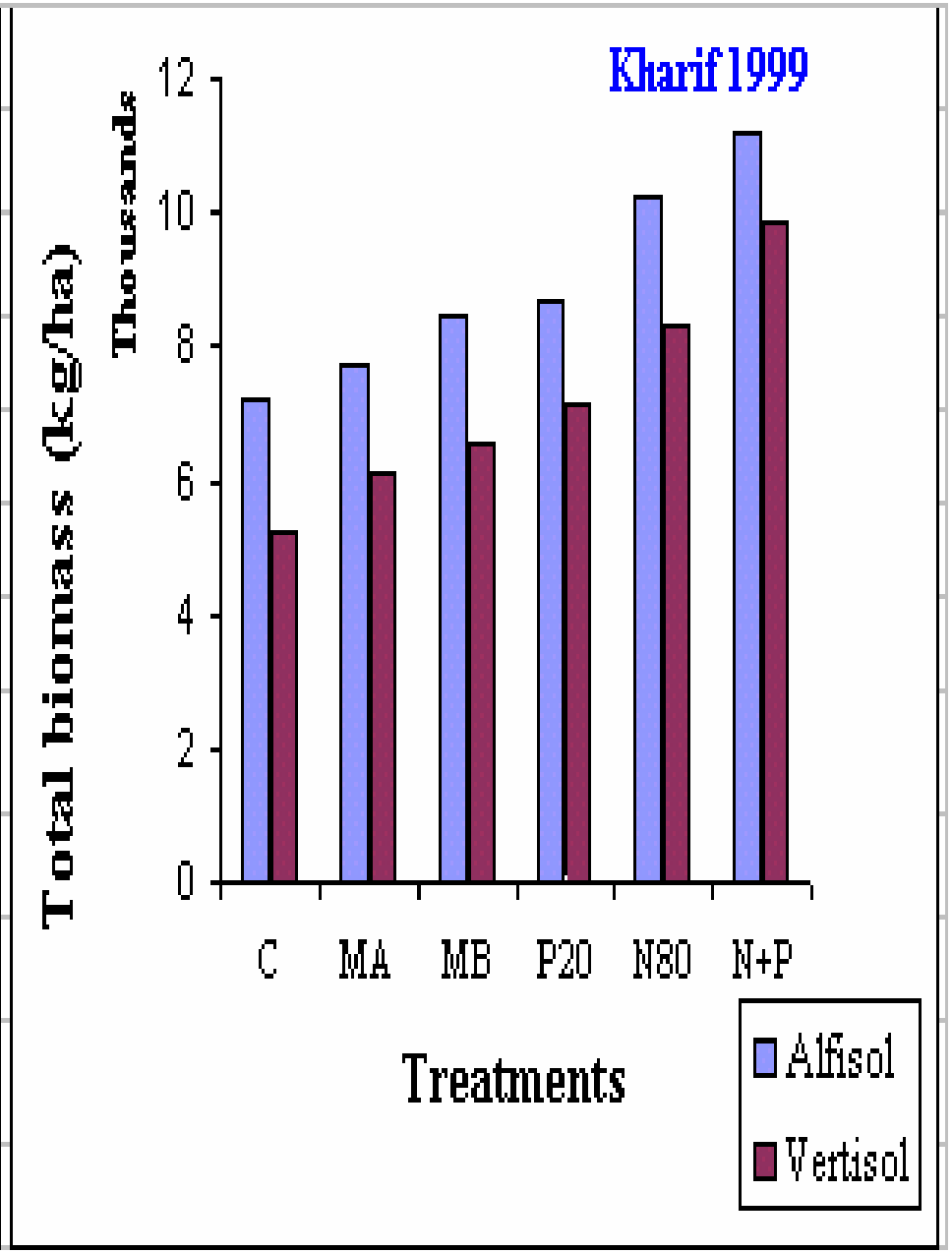
Chemical characteristics of applied manures

Year	1998		1999	
Manures → / Parameters ↓	MA	MB	MA	MB
%C	25.3	16.3	25.4	20.7
%N	0.7	0.8	1.0	1.2
C:N	35.0	22.0	26.7	16.7
%P	0.3	0.6	0.9	0.9
%ADF	72.0	67.0	57.7	50.7
%Lig	17.2	12.0	17.7	13.3
%Phe	0.8	0.4	1.4	1.1

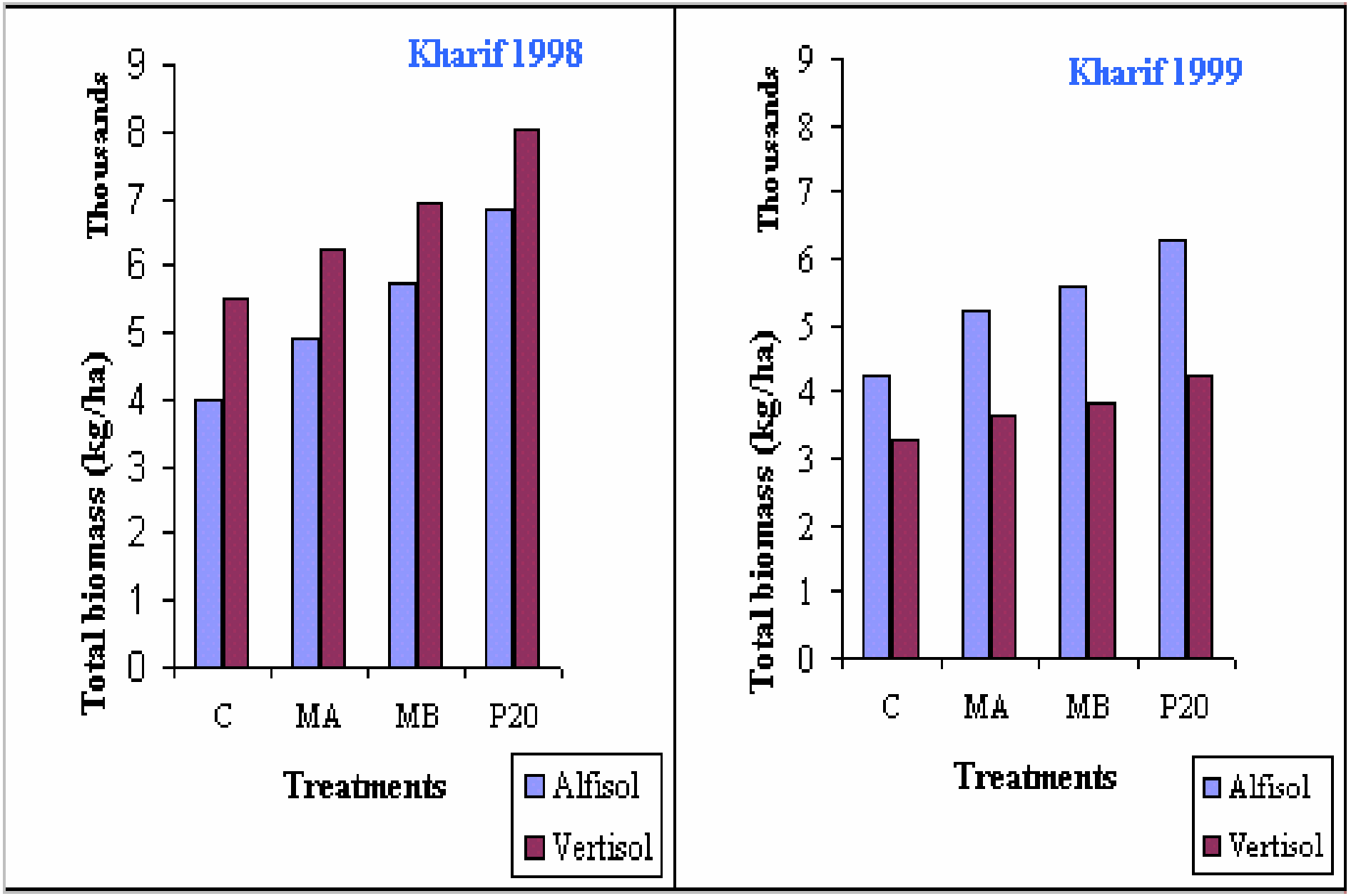
Patancheru manures: High P content (common range: 0.07- 0.55 % P)

Results: Sorghum biomass (Kharif)





Pigeonpea biomass



Pigeonpea Root biomass yield

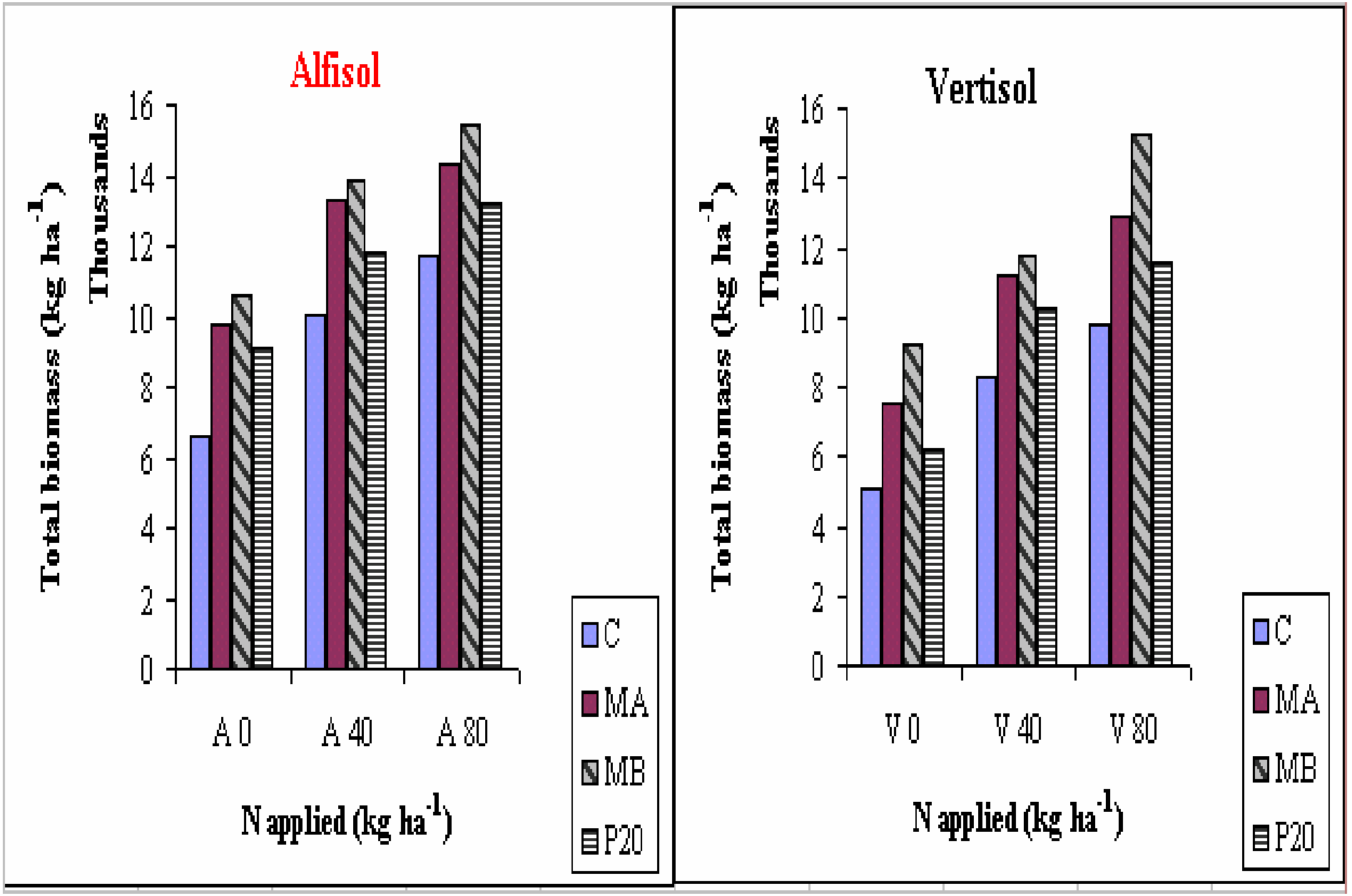
1998

Treatment	Alfisol	Vertisol	Mean
Control	1386	1002	1194
P20	1984	1536	1760
Mean	1685	1269	1477

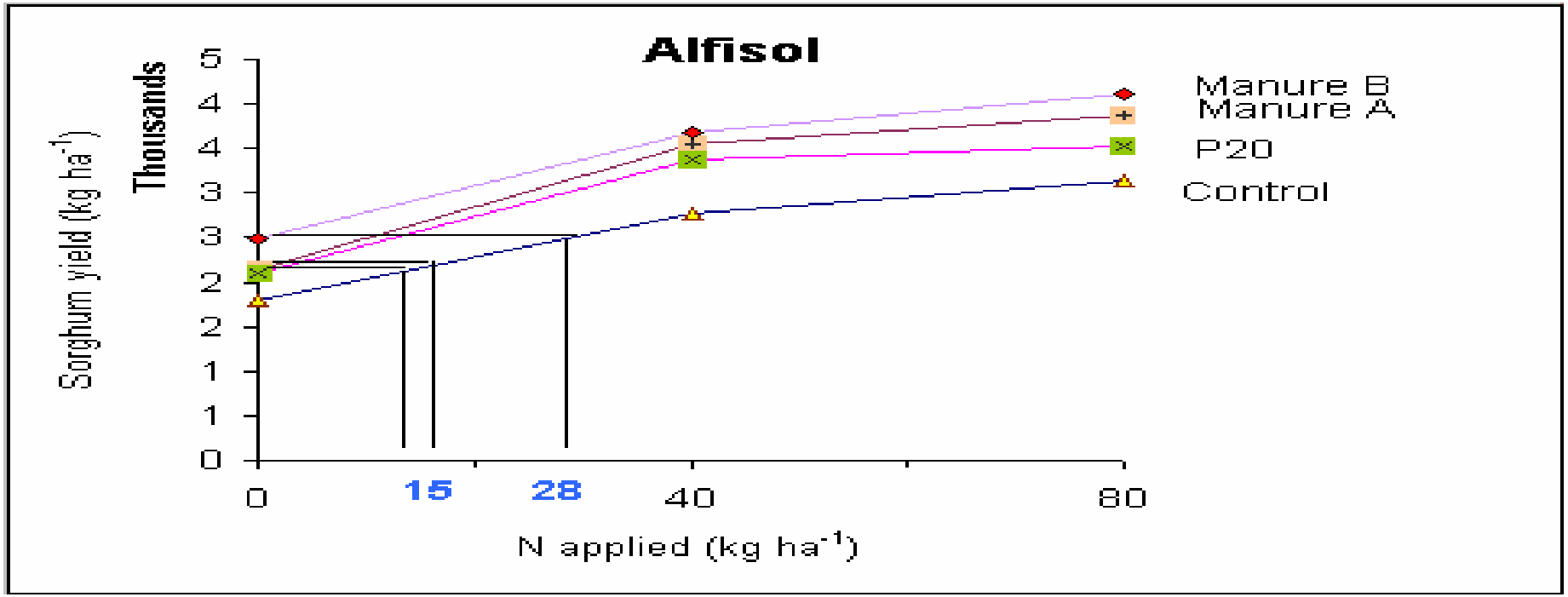
1999

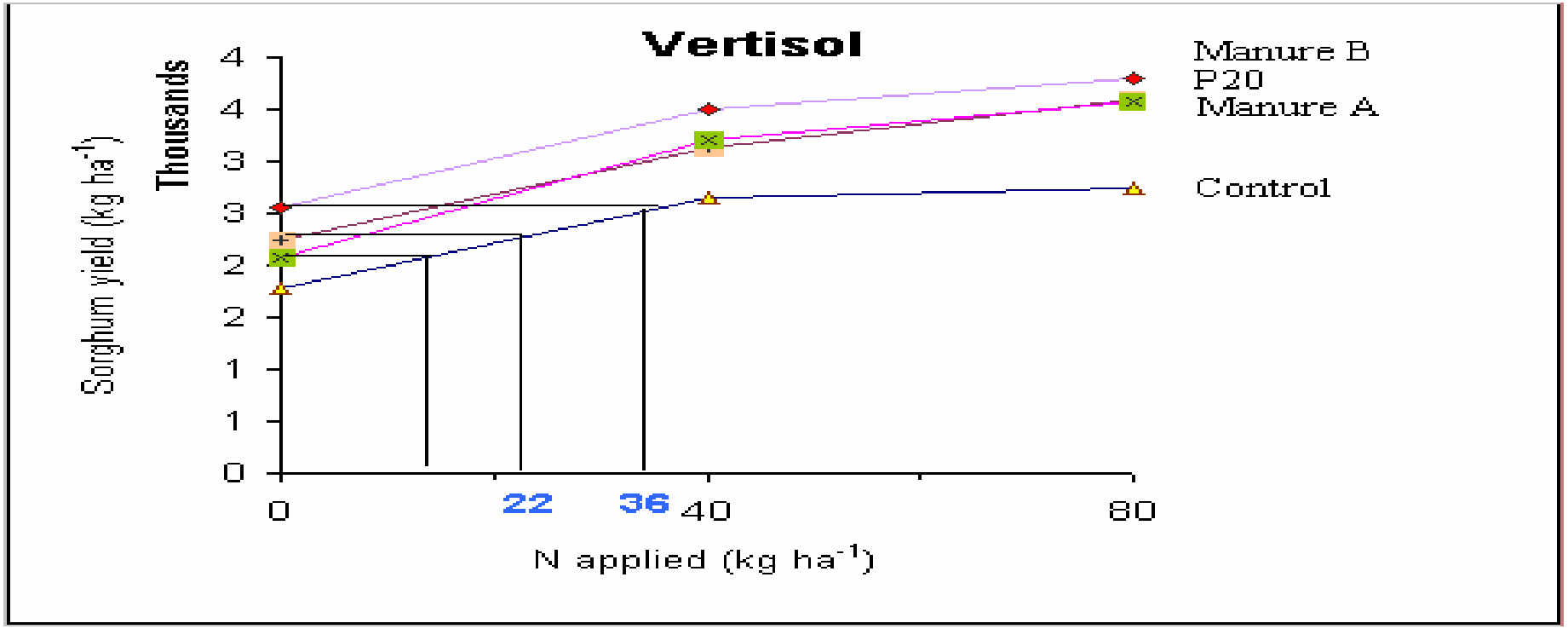
Treatment	Alfisol	Vertisol	Mean
Control	965	412	688.5
P20	1899	682	1290.5
Mean	1432	547	989.5

Sorghum biomass yield (Rabi 1998)



Fertilizer substitution values for manures





Relative value of manure applied to sorghum and pigeonpea

Method

The maximum yield achieved by pigeonpea and sorghum with application of the inorganic fertilizers can be used as an 'optimal' benchmark.

The relative yield benefit of the manures (and any other sub-optimal treatments) for each crop species is then determined as follow;

Proportional benefit $_{pigeonpea}$ = (treatment – control yield) / (P20 – control yield)

Proportional benefit $_{sorghum}$ = (treatment – control yield) / ((N80+P20) – control yield)

Assumptions

Manure benefits are related to its N and P content only,

for pigeonpea, any benefit derived from the different N content of the manures is negated by the compensatory effects of BNF.

Relative value of manure applied to sorghum and pigeonpea

Pigeonpea

Year	**1998**		**1999**		
Soil	**Alfisol**	**Vertisol**	**Alfisol**	**Vertisol**	MEAN
LQM	**0.32**	**0.29**	**0.48**	**0.37**	0.37
HQM	**0.61**	**0.57**	**0.65**	**0.58**	0.60

Sorghum

Year	**1998**		**1999**		
Soil	**Alfisol**	**Vertisol**	**Alfisol**	**Vertisol**	MEAN
LQM	**0.13**	**0.12**	**0.13**	**0.18**	0.14
HQM	**0.36**	**0.12**	**0.33**	**0.29**	0.27
P20	**0.45**	**0.23**	**0.37**	**0.40**	0.36
N80	**0.71**	**0.61**	**0.76**	**0.67**	0.69

Summary of field results

- PP and sorghum responded to manure inputs
- Crop response to manure inputs less than inorganics
- Enhanced legume benefit to rabi sorghum with manure applied to legume (15-30kgN/ha)
- In N&P defic situation, nutrient demand gap is filled to a greater extent if manure is applied to pigeonpea cf. sorghum.

(qualifier – high P manures)

Application of simulation model

- To evaluate simulation capability
  - simulation of ESD Pigeonpea (new PP module)
  - simulation of PP and sorghum response to inputs of organic and inorganic N&P (manure and soilP modules)
- To fill cereal-cereal gap in treatments
- Assess responses in rainfed system over longer time frame

Simulation analysis

- Good data sets for testing APSIM-Manure and APSIM-SoilP (along with other component modules)
- Separated out the N&P responses in addition to the manure response.

But

- **APSIM-Sorghum & APSIM-Pigeonpea not P-aware**.

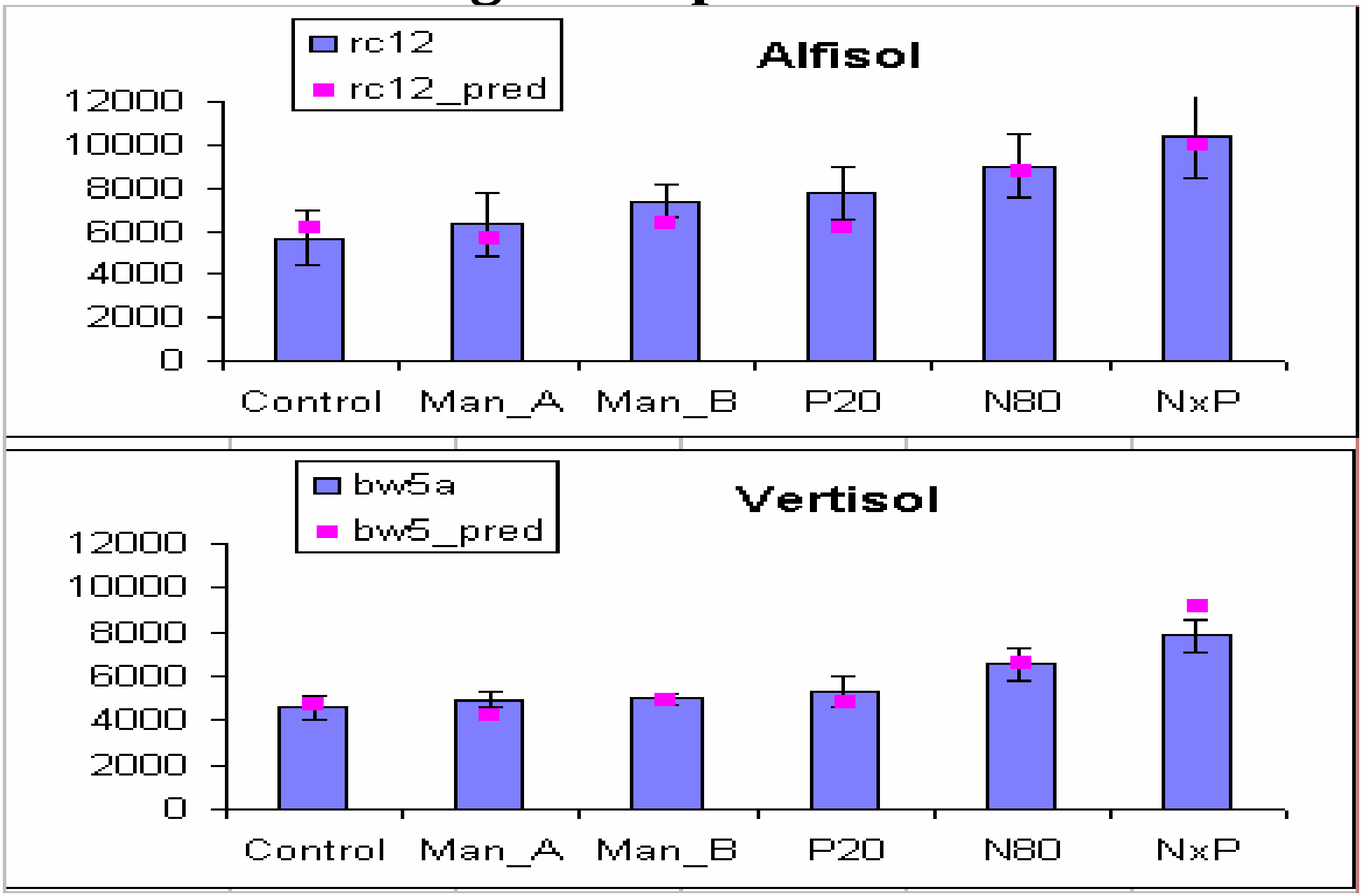
Simulation strategy

1. Use APSIM-Maize as cereal surrogate for sorghum growth responses to manure, N&P in kharif.
2. Simulate kharif-PP (compare to P20 yields)
3. Simulate cereal N response following legume
4. Use climate record and model to simulate seasonal variations for legume-cereal sequence for rainfed systems

Simulation requirements

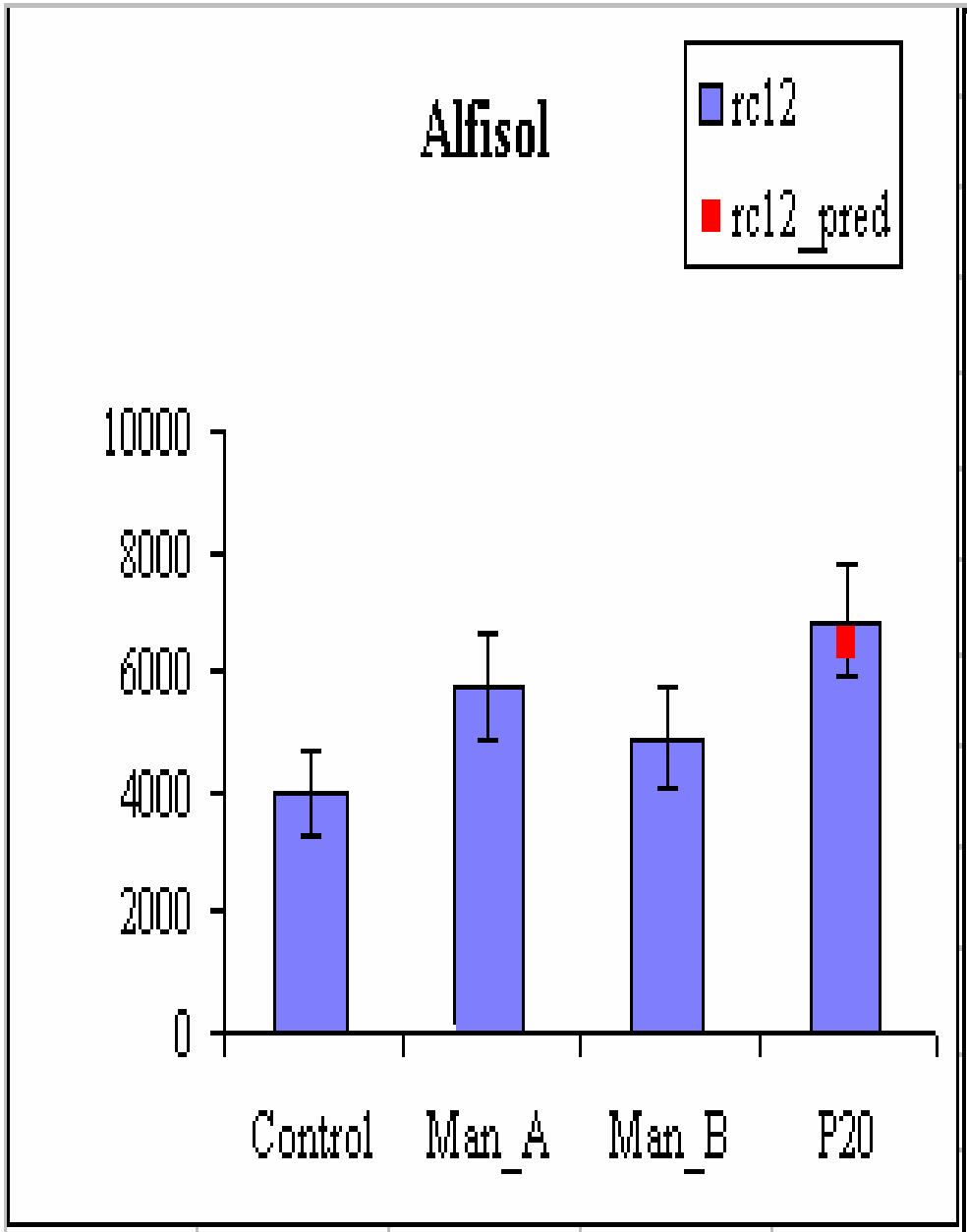
- **soil water parameters (PAWC, drainage, evap and runoff coefficients)**
- **N, C, and P parameters of the experimental soils**
- **cultivar parameters (MV135, ESD PP)**
- **daily climate data for temperature, radiation and rainfall.**
- **management of test crop** and inputs

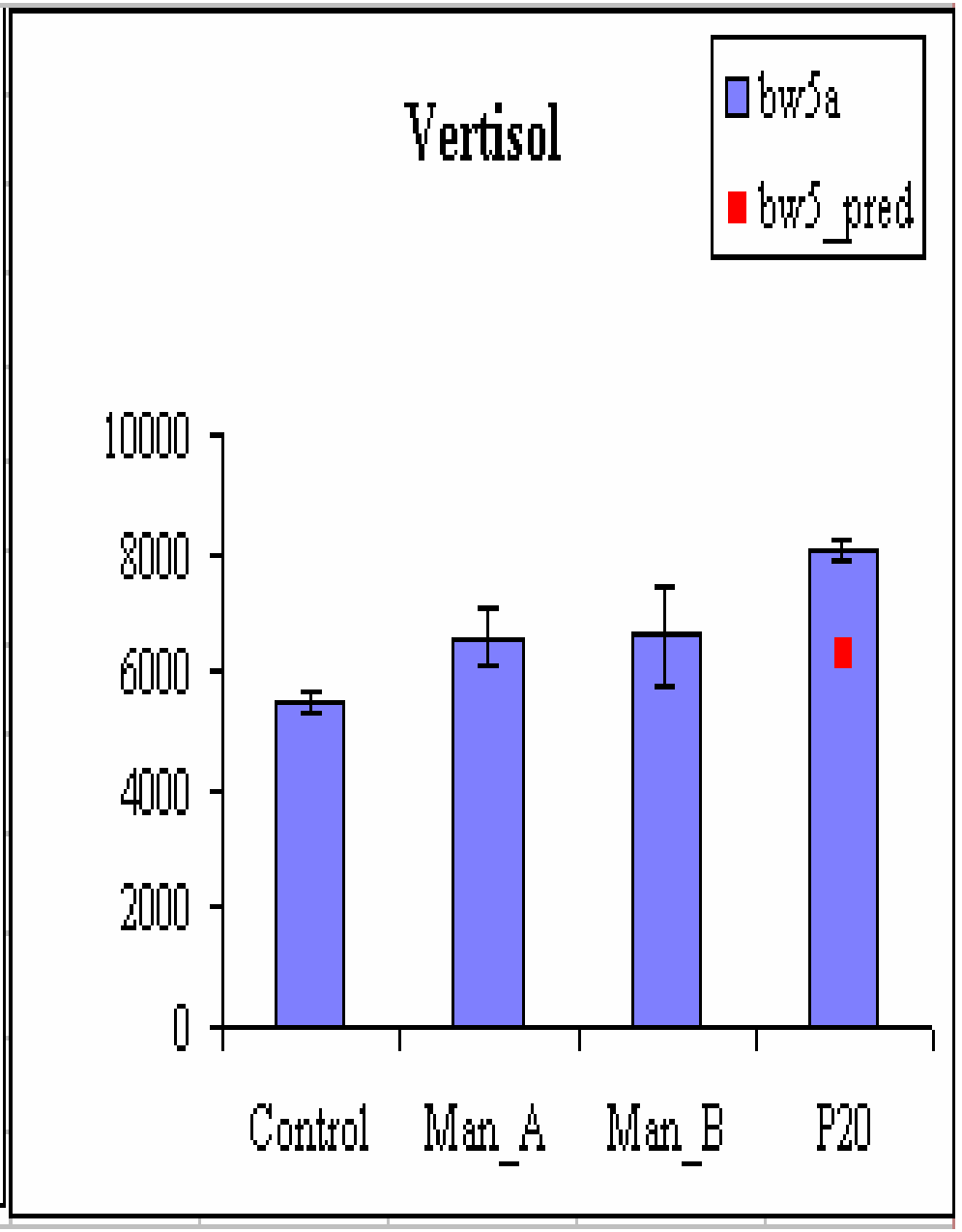
Simulation of N and P response to organic and inorganic inputs on 2 soils



Y = 1.0172x – 502.35, r.m.s.d. = 767 kg ha^{-1}, Atm accession – 15 kgN/ha?

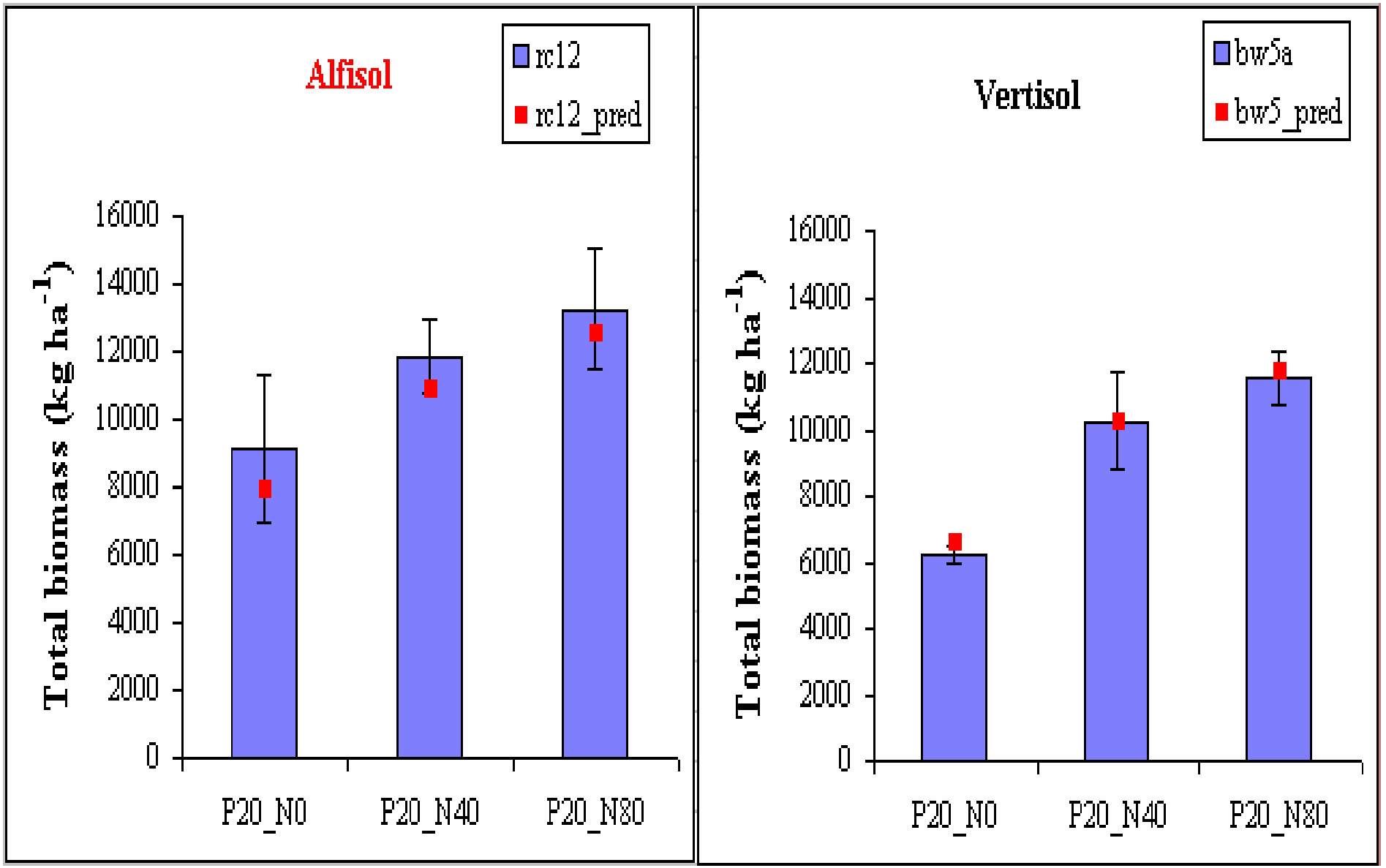
Simulation of Pigeonpea response on 2 soils.





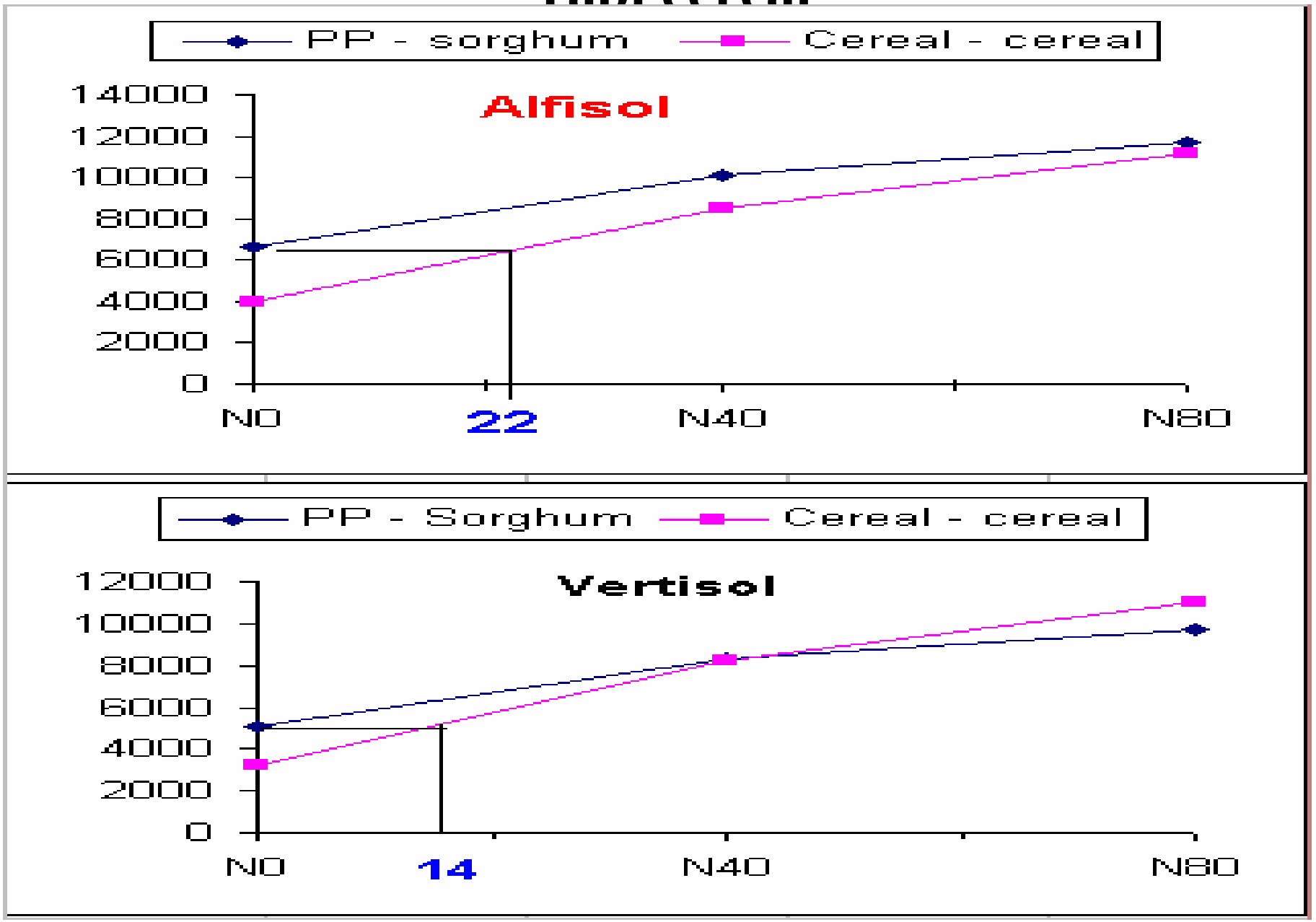
Water-logging stress

Simulation of cereal N response following Pigeonpea

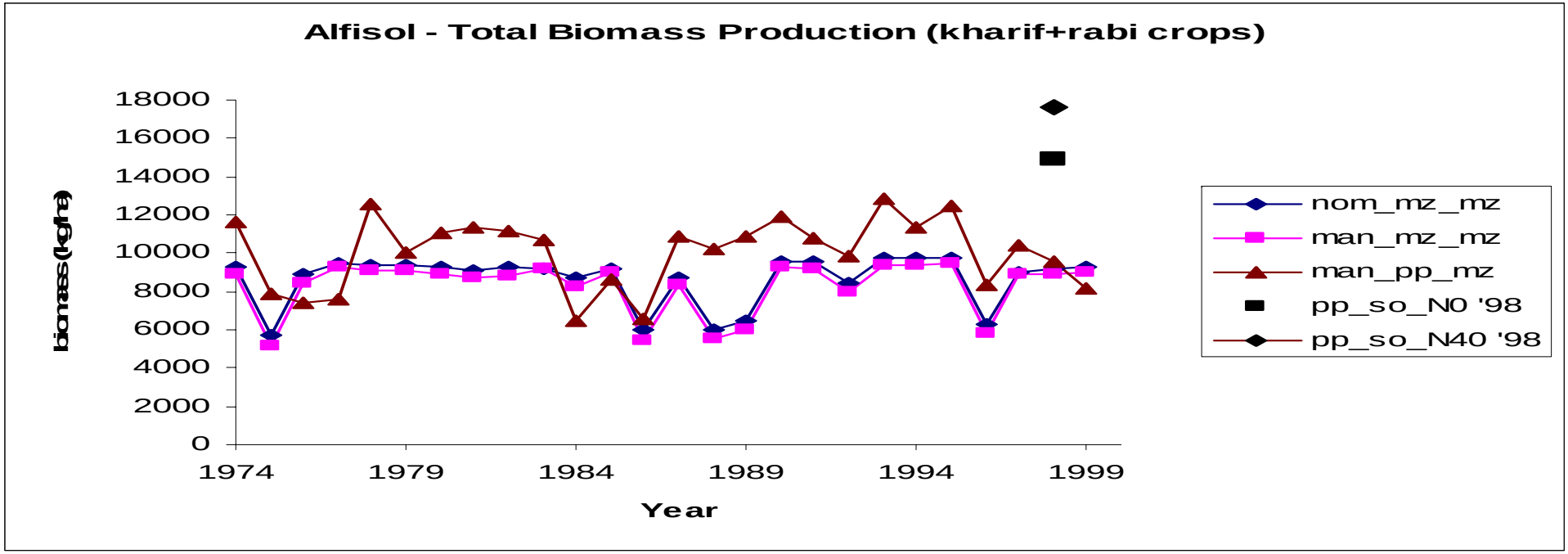


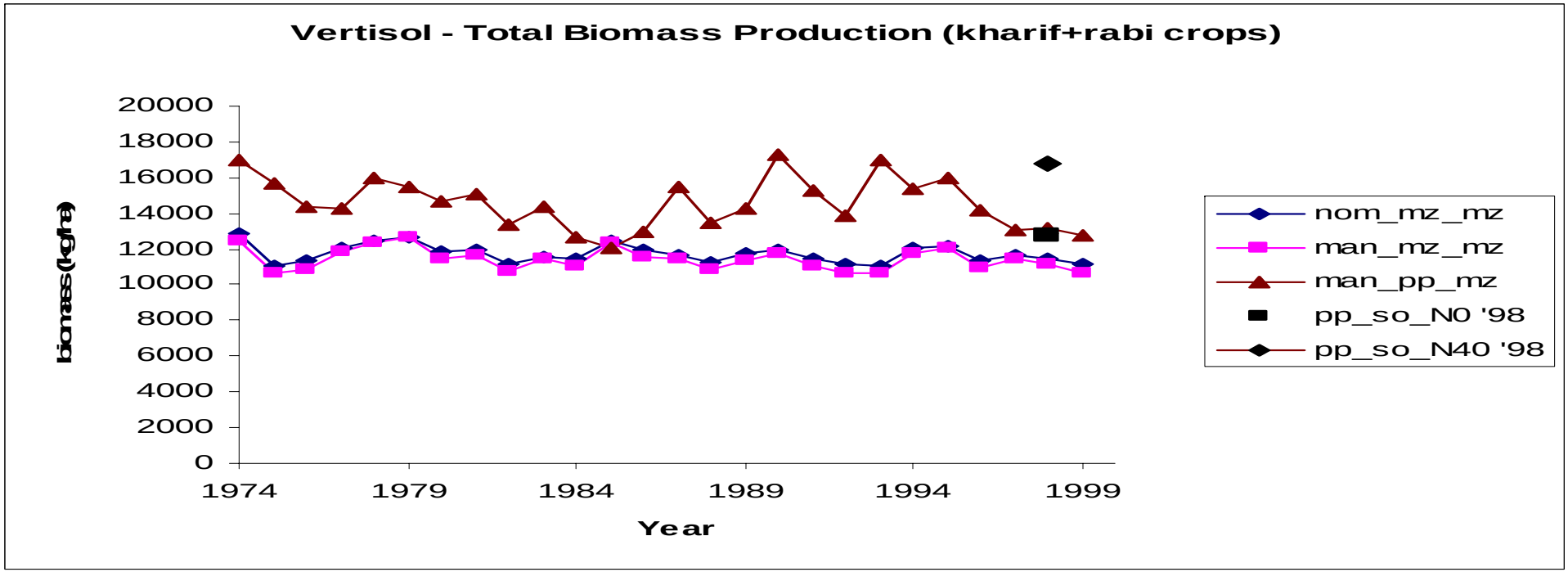
Initial result – under-prediction, 22kgN retained on PP plant, residue removal

Filling Gap – residual benefit of kharif legume on rabi cereal



Simulation of rainfed legume-cereal cropping systems on alfisol and vertisol soils (farm management conditions)





Summary of simulation results

Models simulated

- Yield response of organic and inorganic inputs of N and P for cereal and legume crops
- Helped fill gaps in experimental data
- Provided estimates of expected variability in rainfed systems

Outcome of this work

- Need APSIM - Sorghum and APSIM - Pigeonpea modules P-aware (plus other crops)
- **2002 - 2003**
- ICRISAT started field experiments for sorghum, groundnut and pigeonpea
- P-aware versions of modules provided by APSRU as part of ACIAR/TSBF project
- Work at the verge of completion.
- **2003**
- Supported by DFID/TSBF project on modelling crop-livestock interactions
- Initiated on-farm work in Zimbabwe – PhD student (TSBF/WAU/ICRISAT)

No more slides, Whew!!!