Using organic matter in composted sweet potato mounds is a sustainable soil health and fertility management practice under climate change

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OUTLINE

* Background
* Objectives
* Methodology
* Results and Discussion
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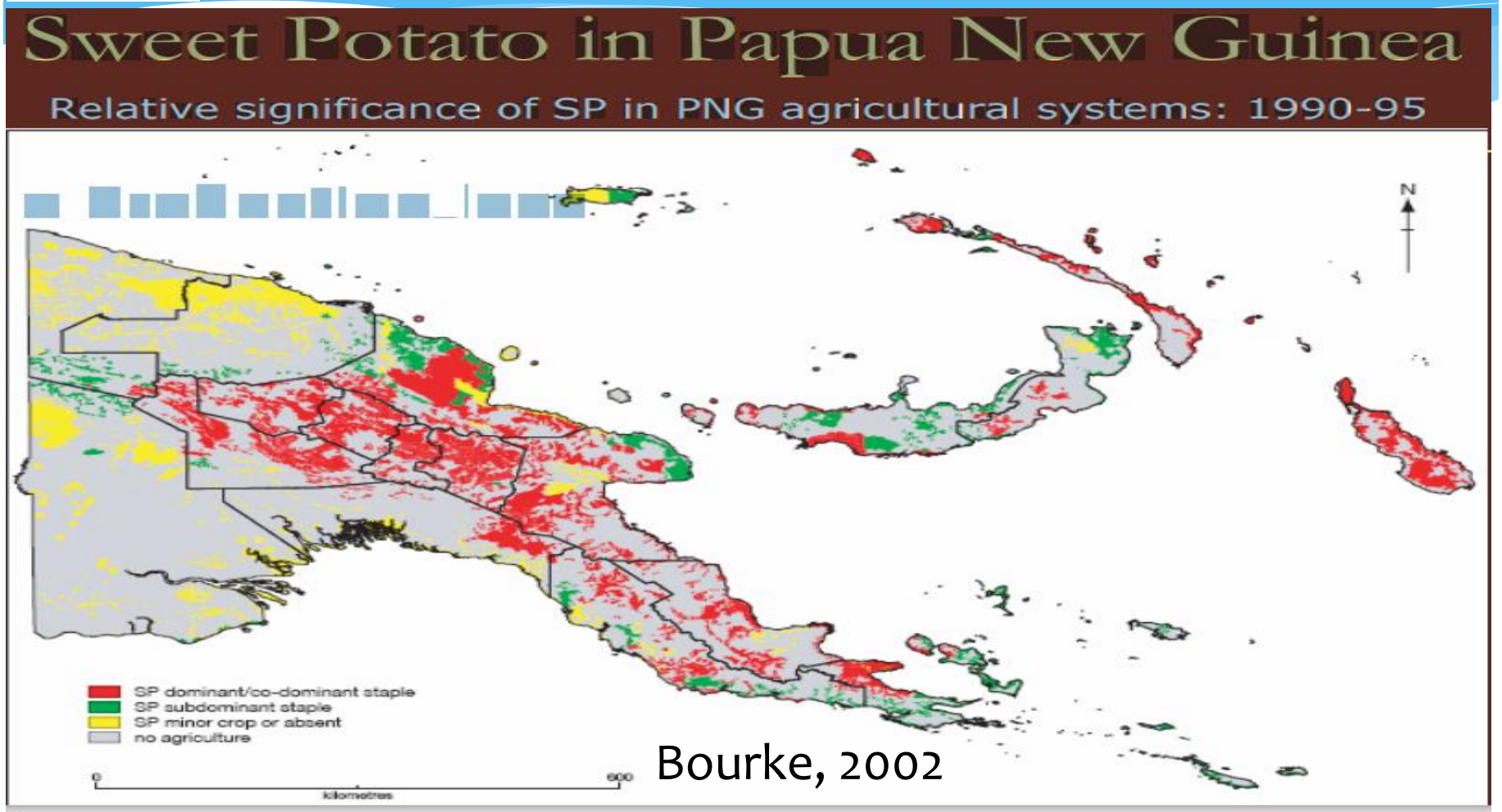
BACKGROUND

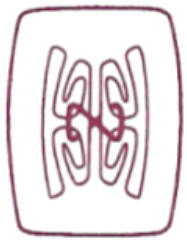
* Sweet potato (*Ipomoea batatas*, Lam.) is the only staple crop grown in the highlands of PNG (3.5-5 million people, 82% of rural and 44% urban).
* Seventh most important crop in the world after rice, wheat, maize, potato, barley, and cassava sustaining millions of lives (ASHS, 2007; Clark *et al*., 2012; Peter and Michael, 2023).

- Approximately 2-3 mill. tons are produced annually, and 25-50 000 tons of these are sold (Bourke, 2002).
- About 28000-58000 tons are sold from the highlands annually (Bourke and Ramakrishna, 2009), K84-K174 million/year (MTDP 2023-2027). Lowland yield is 75% (Bourke and Valassak, 2004).
- Is a subsistence crop with input mainly from family units, contributing to national food and nutrient security (household nutrient improvement, poverty reduction and economical resilience).
- As at the moment, sustainable production of the crop under climate change is not well understood in PNG.

Importance – PNG



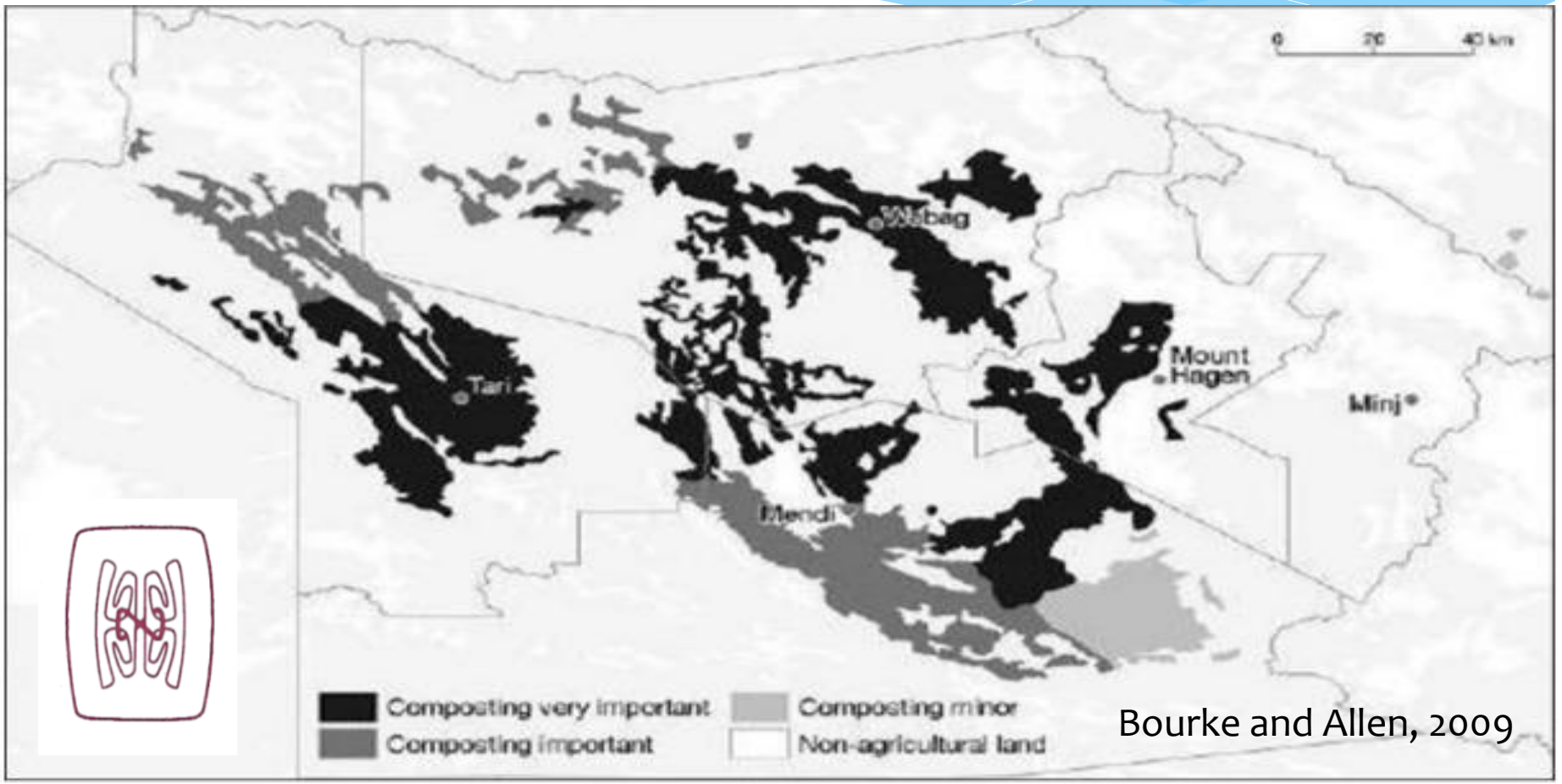
Bourke, 2002



COMPOSTED MOUNDS

* Is a technique that was developed by a farmer in Enga Province after introduction to New Guinea (Ballard, 2005).
* The technique improves soil parameters and raises crops above water table (Taraken and Ratsch , 2005; Wood, 1984).
* It generates heat to enhance tuberisation (Bowers, 1968), reduce soil-borne diseases, minimize soil erosion, enhance land use, and allow crop diversification and multiple harvesting.
* **Most importantly, it reduces fallow period whilst protecting the soil health and nutrients security.**

MAP OF WESTERN CENTRAL HIGHLANDS SHOWING THE PRACTISE



Bourke and Allen, 2009

SUSTAINABLE FOOD PRODUCTION GOALS

* The study serves UN SDG (SDG2) 'zero hunger' (Blesh *et al*., 2019) to improve food production, and,
* FAO climate smart agriculture for sustainable production to overcome food and environmental issues (Mosier *et al*., 2021).
* OM use is environment friendly and is sustainable compared to chemical fertilizers that are expensive and availability is a problem to small farmers.

RECENT RESEARCHES

* Bourke *et al*. (2005) conducted 30 agronomic trials in the highlands on volcanic ash soil (Andepts) to evaluate yield. In all the studies, yield was high and increased above-ground biomass.
* Wood (1984) measured high K content in tubers.
* Michael (2020) estimated low soil K in a planted pot trial, suggesting that high yield is in response to increase uptake of potash.

* A survey in 2005 showed a decline in soil fertility (P, K, and S) was threatening production and there is need to understand the limitations of trace elements (Taraken *et al*., 2010).
* Summarily, studies from 1977 to 2009 do not clearly show the types of OM used and the changes in soil properties measured (Bourke *et al*., 2002).

OBJECTIVES

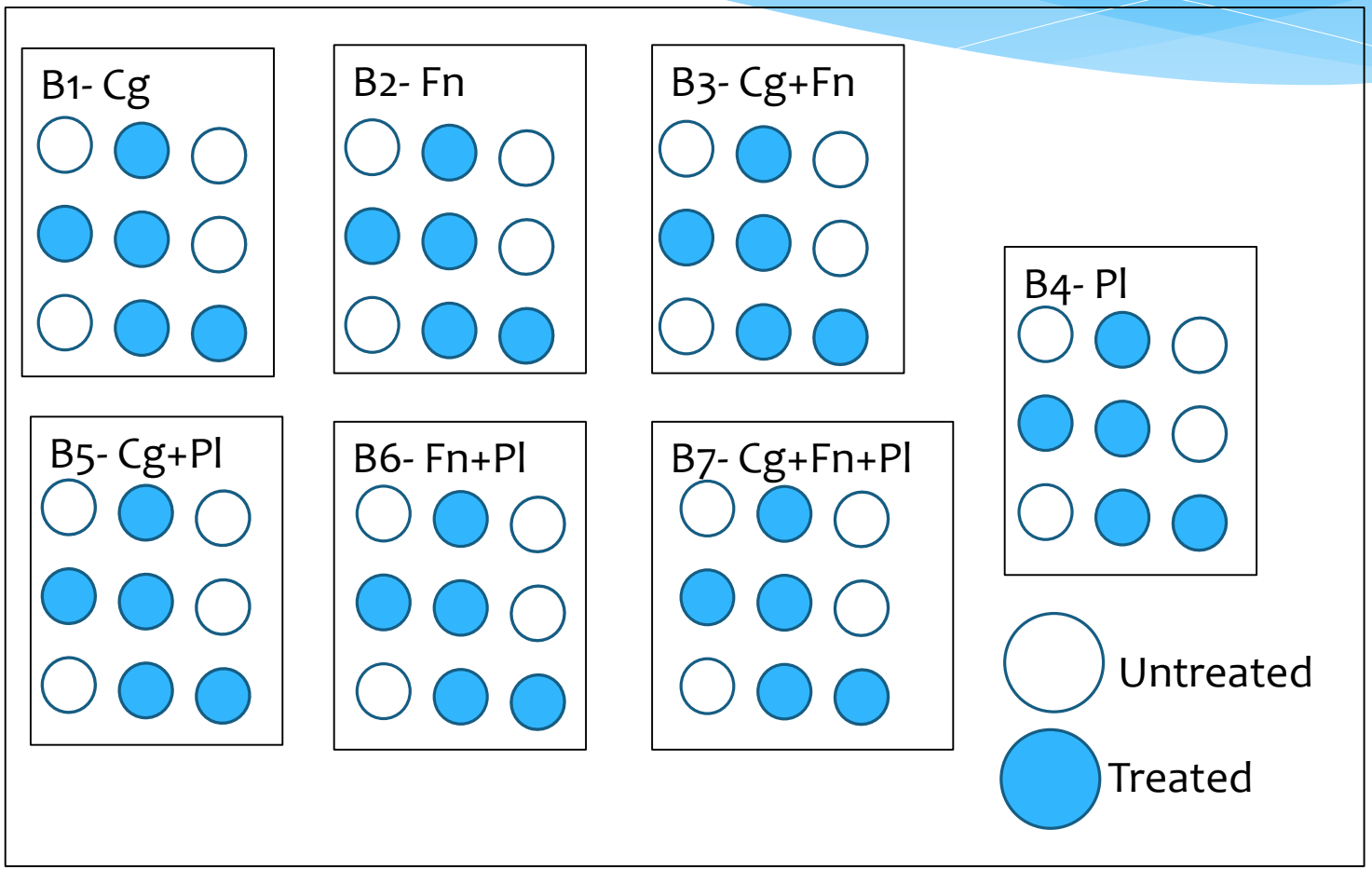
- To understand the roles of organic matter in composted mounds (soil health and nutrients security),
- To understand the importance of use of different sources of organic matter in composted mounds,
- To establish the use of organic matter in composted mounds is a sustainable practice and is environment friendly compared to inorganic fertilizer uses in sweet potato production (...technically...).

METHODOLOGY

Treatments

- Control – soil only,
- Cogon (Cn),
- Fern (Fn),
- Cn + Fn,
- Planted (Pl),
- Cn+Pl,
- Fn+Pl,
- Cn+Fn+Pl,
- All the treatments were replicated 4 times and setup in a randomised complete block design (RCBD).

Arrangement of treatments



Measurements - Physical parameters

* Bulk density - Core cut,
* WHC - flooding filtration,
* Total porosity.

Measurements - Chemical parameters

* TN (Kjeldahl, 1883),
* Available NO3-N by transnitration of salicylic acid method (John,1990),
* Macro & micro nutrient by Melich 3 (1984), ICP-OES,
* Plant samples nutrients by wet ashing, HNO3/H2O2, ICP-OES (Emmanuel *et al*., 2019),
* P by Olsen method (1954),
* pH and electrical conductivity ,CEC and BS%.

All as per Raymen and Lyons (2010).

Soil nutrients analysed

* A total of 13 elements:
  - Macronutrients: N, P,K (primary) & Ca ,Mg, & S (secondary).
  - Only N,P,K & Mg are presented.
  - Micronutrients: Na,Fe, B, Mn, Zn, Cu, & Al. Only B, Zn, Mn & Fe are presented.

STATISTICAL ANALYSIS

- Data from three replicates ($n=3$) were used.
- The data from the three replicates were pooled and the average were kept as the final data.
- The replicate data were used for basic statistical analysis using the statistical software JMPIN, AS Institute Inc., SAS Campus Drive, Cary, NC, USA 27513.
- Standard error of the mean was used to determine the difference between the treatment means and ANOVA at $p<0.05$ was used to compare the significant difference (variance) across the means.


(a)


(b)

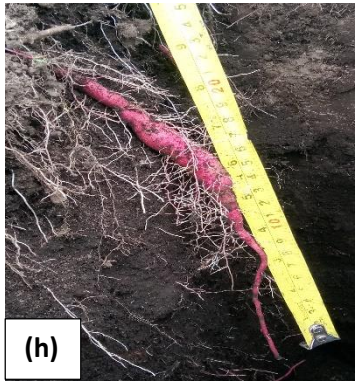

(c)


(d)


(e)


(f)


(g)


(h)


(i)


(j)


(k)

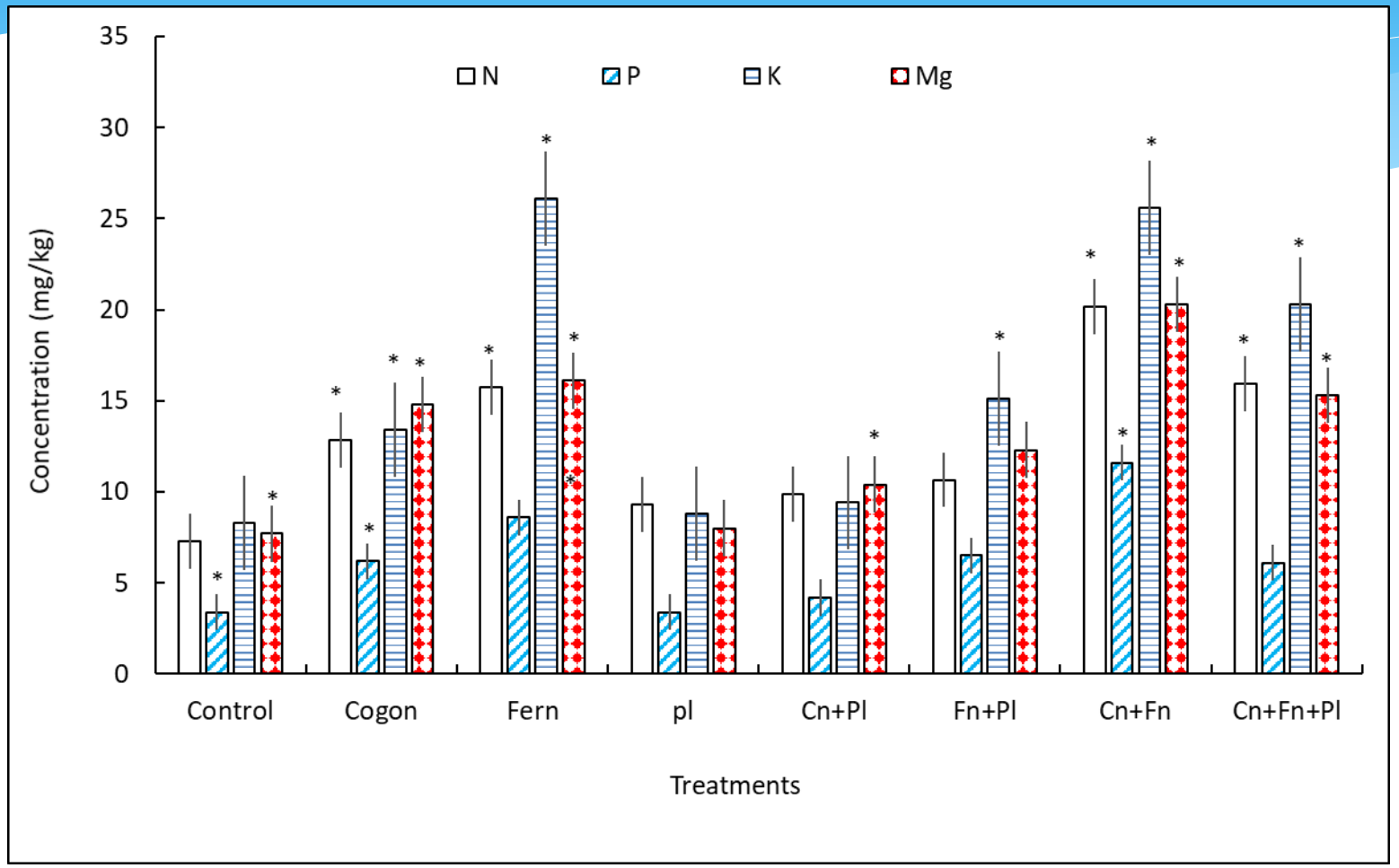
RESULTS AND DISCUSSION

Effects on SOM, WHC, pH and EC

Treatments	Soil parameters			
	SOM (%)	WHC (%)	pH	EC (mS m^{-1})
Control	30.23	51.80	5.45	0.65
Cn	40.25	76.80	6.52	0.68
Fn	35.38	70.50	5.61	0.57
Cn+Fn	36.31	60.25	5.82	0.72
Pl	25.64	50.40	5.54	0.35
Cn+Pl	35.33	53.8	5.66	0.45
Fn+Pl	33.71	52.8	5.75	0.43
Cn+Fn+Pl	36.45	54.8	5.65	0.46

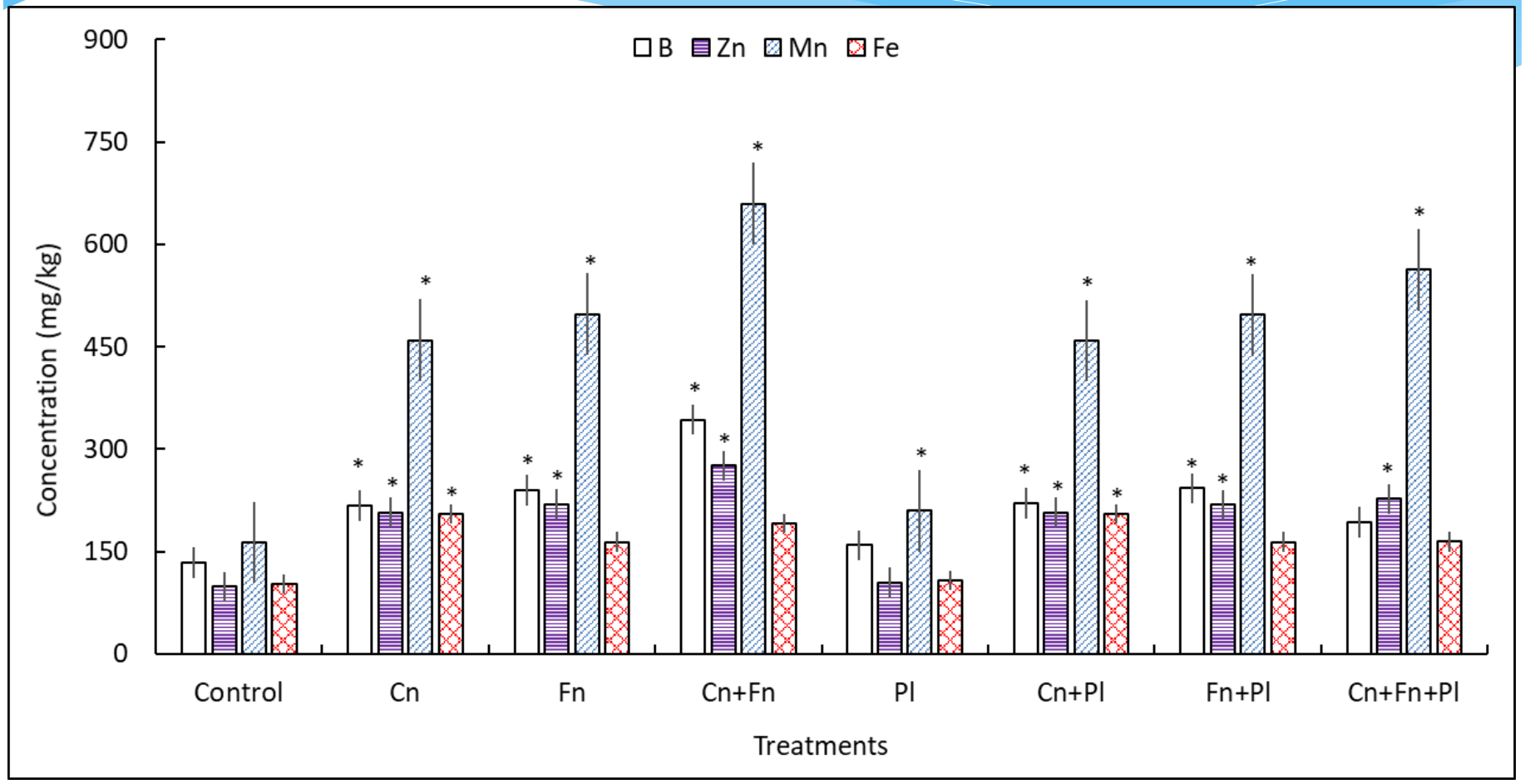
- OM increased SOM and WHC but planting decreased them.
- OM increased pH but EC was fairly the same.
- EC was lower in the planted soil, indicating nutrient use by plants.

Effects on macro-nutrients



The values are mean ± se and an asterisk indicates significant difference between a treatment and the control.

Effects on micro-nutrients



The values are mean ± se and an asterisk indicates significant difference between a treatment and the control.

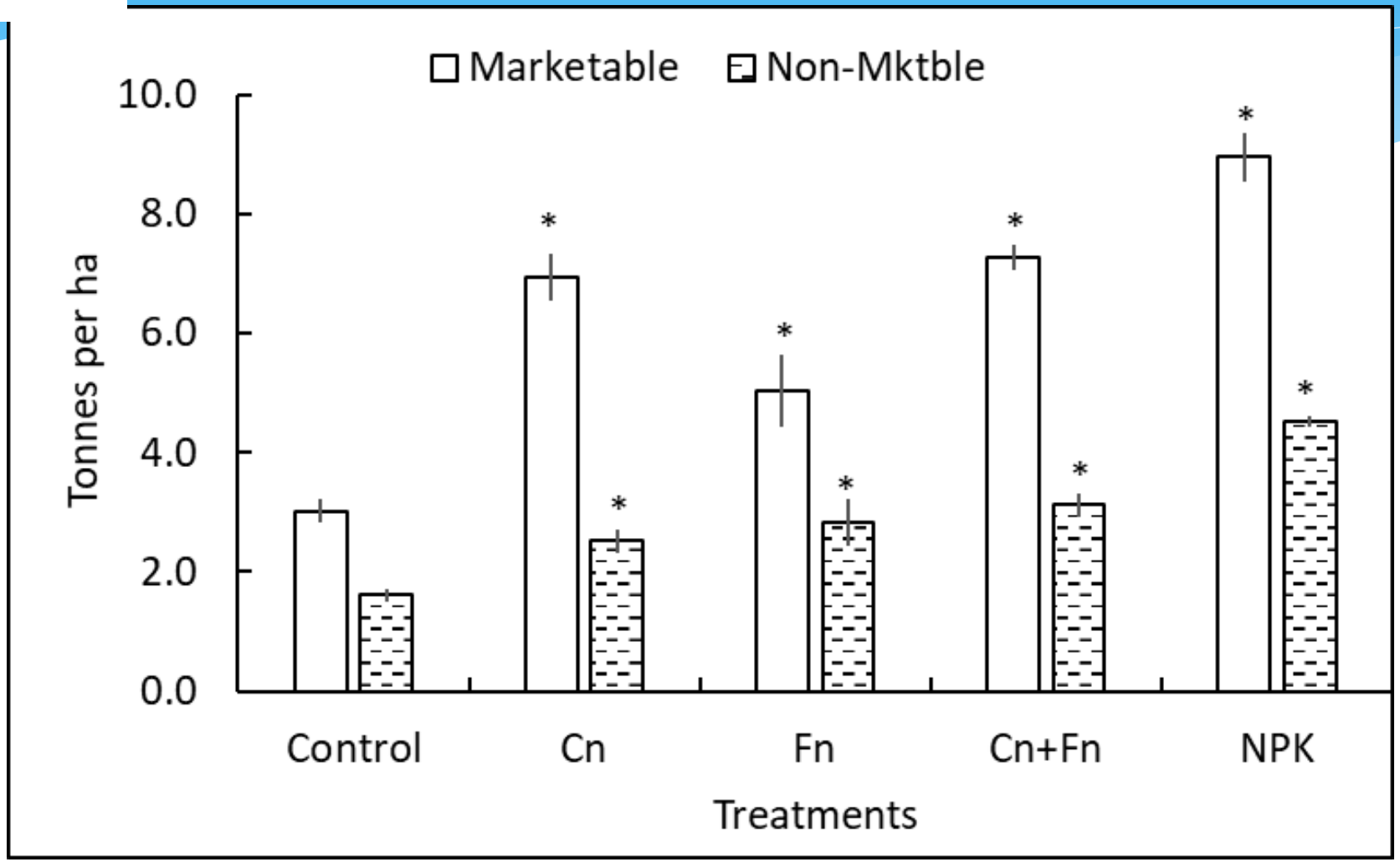
Tissue concentrations of macro-nutrients

Treatments	Nutrient concentrations in vines and tubers (mg kg^{-1})							
	Vine				Tuber			
	N	P	K	Mg	N	P	K	Mg
Planted	2.21±0.2	7.91±2.1	27.50±3.2	34.65±3.6	0.74±0.0	15.16±0.1	19.03±1.3	6.00±0.1
Cn+Pl	0.96±0.1	1.54±0.3	25.54±0.1	34.47±2.5	0.66±0.1	8.73±1.3	15.19±1.4	7.54±2.6
Fn+Pl	0.84±0.0	1.72±0.2	29.91±0.0	47.07±1.3	0.70±0.0	8.86±3.5	16.55±2.4	7.30±2.9
Cn+Fn+Pl	0.84±0.0	1.68±1.8	26.03±0.0	30.88±2.7	0.55±0.0	10.72±3.1	23.05±2.6	7.54±1.5

The values are mean ± standard error (S.E).

- In the vines, N<P<K<Mg.
- In the tubers, N<Mg<P<K.
- The data show lesser N and P content in the biomass compared to K, indicating a higher K-plant interaction.
- Mg was more in the vines than in the tubers, indicating its roles in chlorophyll.

YIELDS



The values are mean ± se and an asterisk indicates significant difference between a treatment and the control.

CONCLUSIONS

- Organic matter addition improved:
  - SOM, WHC, pH and EC (key soil parameters).
  - N, P, K and Mg (primary macronutrients)
  - B, N, Mn and Fe (secondary macronutrients)

  - N and P are widely used and tissue accumulation is high for K.
  - Mg accumulates in vines than in tubers.
  - Composting produces the same yield as commercial fertilizer, the yield ranging from 7-8 tonnes per ha.

ACKNOLODGEMENT

This study was co-funded by the PNGSTS research grant to Professor (Assoc.) Patrick S. Michael and PNGUoT research grants to Topas Peter. We are grateful to PNGSTS and PNGUoT for making available the funds supporting the project Soil to Nutrition-The importance of use of organic matter in composted sweet potato mounds in PNG.

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