Assessment of Nutrient Imbalances Limiting Maize (*Zea mays*) Production in western Kenya

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Background

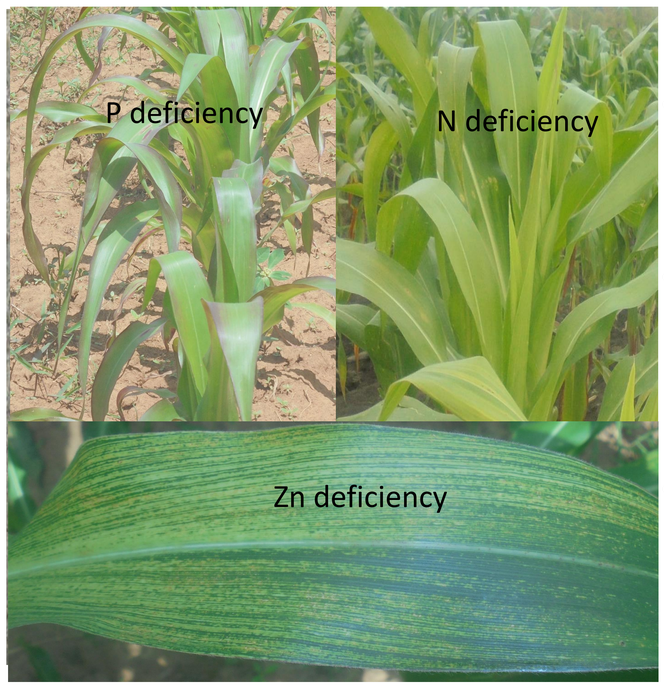

Plate1: Macro-and micro nutrient visual deficiencies in maize

- Poor responsiveness of soil to fertilizer contributes to maize yield gaps in Kenya.
- Nutrient imbalances (deficiencies and/or luxury consumption) are speculated to be major causes of poor responsiveness.
- Compositional Nutrient Diagnosis (CND) can identify nutrient deficiencies in maize grown in poor responsive soils and leads to corrective measures.

Objectives

Determine the extent of poor responsiveness in western Kenya soils and identify nutrient deficiencies limiting optimal maize grain production

Methodology

Plate 2: Field trial establishment and maize ear leaf sampling for nutrient diagnoses

- Multi-locational study (Long rainy season, 2014).
- Location: Bungoma & Busia counties of western Kenya (22 sites per county).
- Treatments: With & Without N, P & K fertilizer applied at 100 kg N ha^{-1}, 30 kg P ha^{-1} & 60 kg K ha^{-1}.
- Value cost ratio (VCR) of <2 is economically defining poor responsive soils (Kelly, 2005).
- CND approach determines nutrient imbalances (Nelson and Anderson,1977, Khiari et. al., 2001).

Results

Occurrence of poor soil responsiveness in western Kenya

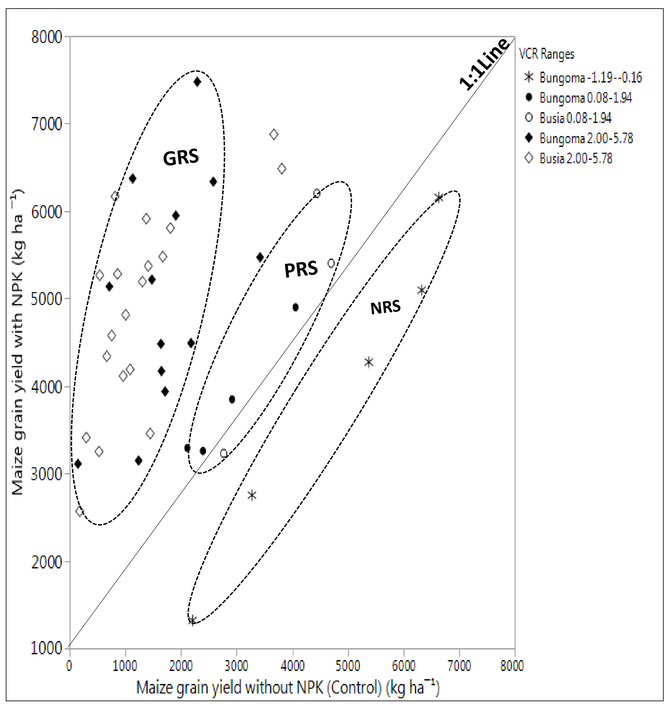

Fig1: Maize grain yield with versus without fertilizer and economic return classification

- GRS: Good responsive soil (VCR>2)
  - 73% of 44 sites
  - Mean VCR
    : Bungoma (3.59)
    : Busia (3.89)
- PRS: Poor (Marginal) responsive soil (VCR(0.1 -1.9)
  - 16% of 44 sites
  - Mean VCR
    : Bungoma (1.03)
    : Busia (1.05)
- NRS: Negative responsive soil (VCR<0)
  - 11% of 44 sites
  - Mean VCR:
    : Bungoma (-0.91)

Application of CND approach

CND allowed to determine:

(i) Yield cutoff of 4.10 t ha^{-1} separating high from low yield subpopulations.

(ii) Critical nutrient index (CND r^2) of 10.3 for defining nutritional balances.

(iii) CND nutrient sufficiency ranges to identify nutrient deficiencies.

Maize nutrient balance as defined by yield cutoff and CND r^2

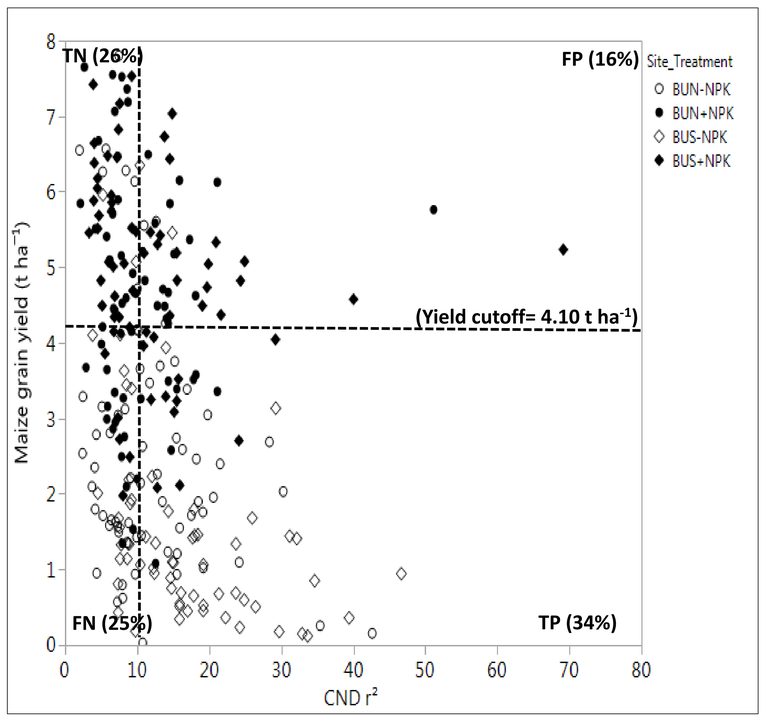

Fig 2: Maize grain yield versus CND r ^{2} quadrant partitioning of nutrient response at plot level

- True Negative (TN) = Balanced nutrition (CND r^2 ≤ 10) & high yield (≥ 4.10 t ha^{-1}).
- False Negative (FN) = Balanced nutrition (CND r^2 ≤ 10) & low yield (≤ 4.10 t ha^{-1}).
- False positive (FP) = Imbalanced nutrition (CND r^2 ≥ 10) & high yield (≥ 4.10 t ha^{-1}).
- True positive (TP) = Imbalanced nutrition (CND r^2 ≥ 10) & low yield (≤ 4.10 t ha^{-1}).

Nutrient sufficiency ranges for maize grown in western Kenya

Table 1: Comparison between CND and reference sufficiency ranges

	CND		‡REFERENCE	
	Lower	Upper	Lower	Upper
Macronutrient (%)				
N	2.59	3.25	2.60	3.10
P	0.27	0.33	0.25	0.40
K	2.70	3.38	2.10	2.60
S	0.19	0.24	0.16	0.22
Ca	**0.58**	**0.73**	0.21	0.50
Mg	0.22	0.27	0.21	0.25
Micronutrient (mg kg^{-1})				
B	8.26	10.36	6.00	25.00
Cu	8.37	10.50	6.00	20.00
Zn	**16.63**	**20.86**	28.00	51.00
Mn	76.60	96.09	20.00	150.00

‡ reference source: Reuters and Robinson, 1997

- CND sufficiency ranges for most of the nutrients are within the published ranges.
- Exceptionally, Ca and Zn ranges are above and below the reference sufficiency boundaries respectively.

Nutrient deficiencies for maize grown in poor responsive soils

Table 2: Frequency of nutrient deficiencies at plot level

Site	TRT	#Plots	Frequency Interval (%)					
			100-90	89-80	79-70	69-60	59-50	49-40
Bungoma	Control	26	**N, P**	B, Ca, Cu, Mn, Zn	Mg	K	S	
	NPK	8	**Zn, Ca**	P, K, Mg, B	N	Cu, Mn		S
Busia	Control	40	**N**	Cu, Zn	P	Ca, Mn	B, Mg	K, S
	NPK	10	**Cu, Zn**	N	S	P, Mg	Ca, B, Mn	K
Overall	Total	84	N	Cu, Zn	P, Ca, B, Mn	Mg	K, S	

Conclusion

- ❑ 16% of the study sites displayed poor soil responsiveness.
- ❑ CND is a viable tool to determine local nutrient sufficiency ranges.
- ❑ N and P primarily limit maize grain production in poor responsive soils.
- ❑ Application of NPK fertilizer induce Zn & Ca deficiencies in Bungoma while Cu & Zn become more prevalent in Busia.

Acknowledgements

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