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Improving Fertilizer Use Efficiency in Cassava Production Systems of West Africa

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Introduction

- *Manihot esculenta*, Crantz
- Important crop: staple food in SSA, raw material in food, feed, beverage, starch, biofuel industries
- Low productivity in West Africa :
  average yield <10 Mg ha^{-1} fresh storage roots (equals <4 Mg DM) against a potential of 60 Mg ha^{-1} (equals 25 Mg DM ha^{-1})
- Causes: declining soil fertility, low fertilizer use and lack of fertilizer recommendations for cassava production systems
- ➔ Low fertilizer use efficiency

Introduction

- Improving fertilizer use efficiency → Improving nutrient uptake efficiency and nutrient utilization Efficiency
- Nutrient uptake efficiency = actual nutrient uptake / total nutrient supply
- Total nutrient supply = indigenous nutrient supply by the soil (IS) + amount of nutrient applied
- Nutrient utilization efficiency = nutrient physiological use efficiency (PhE) = nutrient internal use efficiency = root DM yield / total nutrient uptake
- Maximization of NPK uptake efficiencies: Balanced nutrition

→QUEFTS model (Quantitative Evaluation of the Fertility of Tropical Soils)

Introduction

Objectives:

- Increase cassava productivity by improving fertilizer use efficiency using QUEFTS model
    - Conducted a fertilizer trial to calibrate QUEFTS model for cassava
    - Assessed indigenous soil nutrients supplies to identify the most limiting nutrients to cassava yields
    - Assessed optimum nutrient uptake requirements for balanced nutrition

Material and Methods

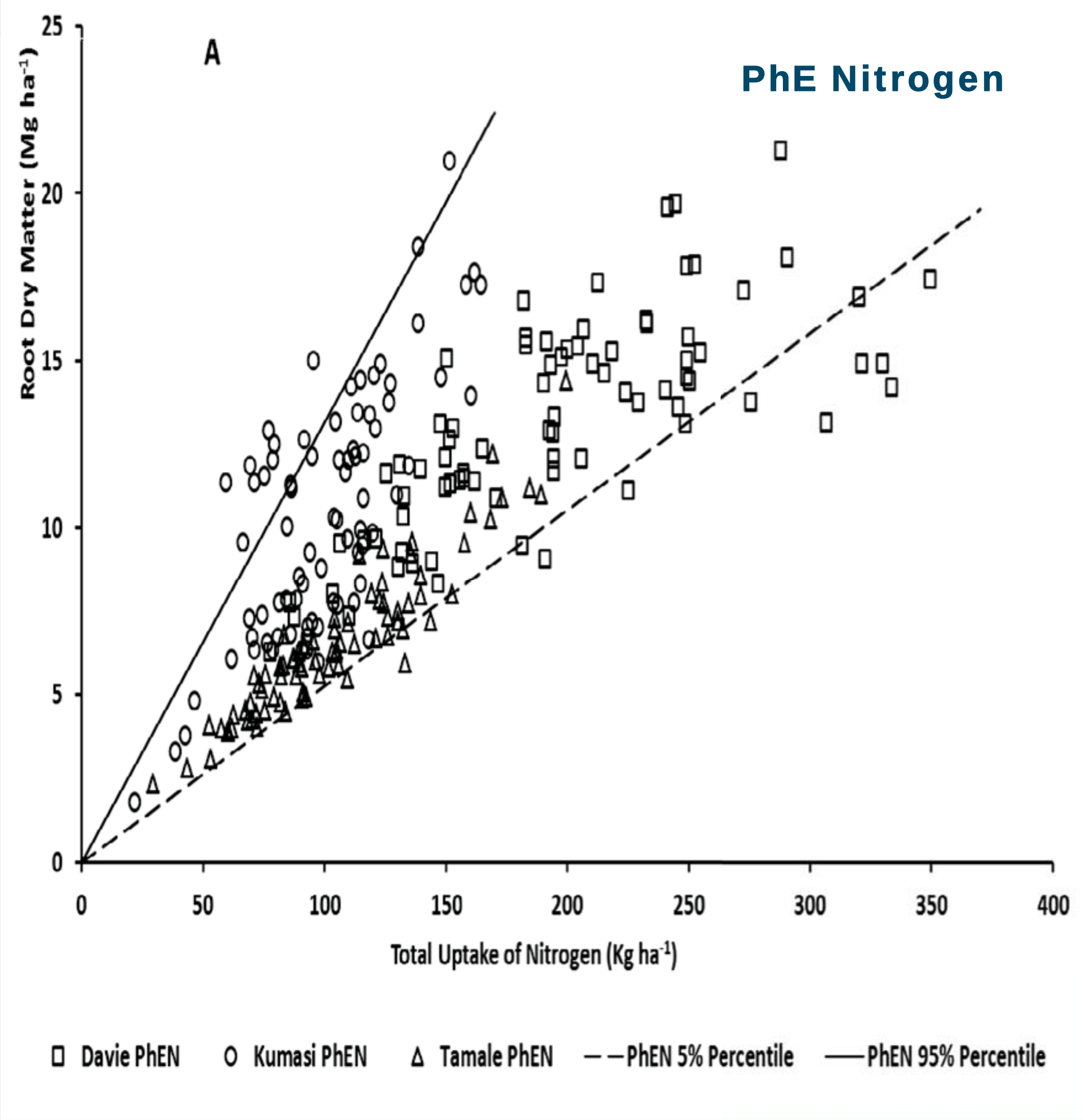
- Fertilizer trial
  - 10 NPK rates (0-0-0, 0-40-130, 40-40-130, 80-0-130, 80-20-130, 80-40-0, 80-40-65, 80-40-130, 40-20-65, 100-50-170 kg ha^{-1})
  - Two improved cultivars: Gbazekute and Afisiafi
  - Three soil types: Ferralsols (Davié, Togo), Acrisols (Kumasi, Ghana), Gleyi-ferric Lixisol (Tamale, Ghana)
- QUEFTS model (Quantitative Evaluation of the Fertility of Tropical Soils, Janssen and al., 1990): Yield prediction and optimum NPK rates recommendations
  - Boundary lines of physiological use efficiency (PhE):
    - Max accumulation: 5% percentile
    - Max dilution: 95% percentile

Results and Discussion

Physiological Use Efficiency of Nitrogen (PhE N)

PhEN accumulation = 53 kg DM kg^{-1} N
PhEN dilution = 132 kg DM kg^{-1} N

Wolf (1984) and Nijhof (1987):
PhE N: 35-145 kg DM kg^{-1} N



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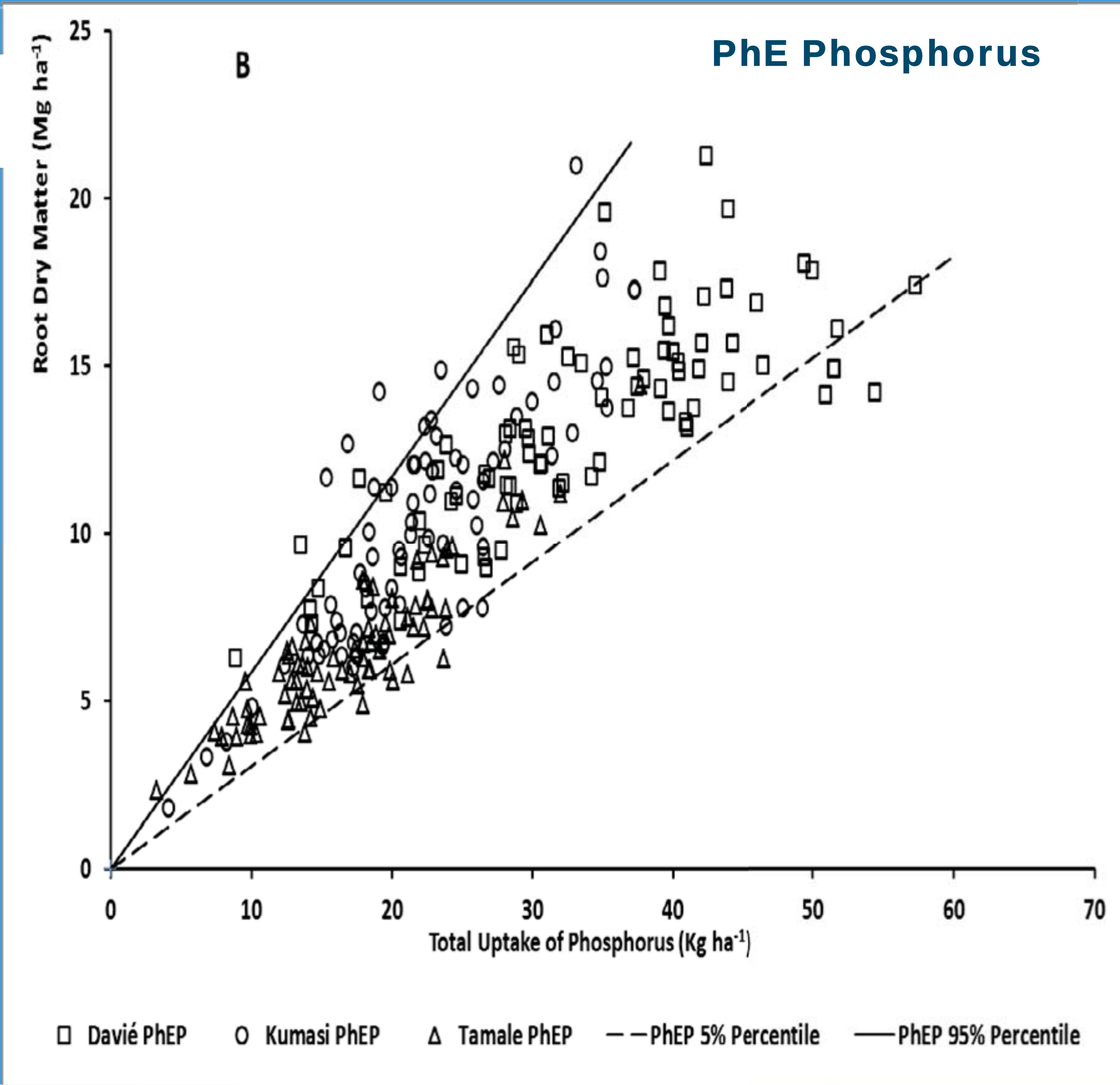
Physiological Use Efficiency of Phosphorus (PhE P)

PhEP accumulation = 305 kg DM kg^{-1} P
PhEP dilution = 585 kg DM kg^{-1} P

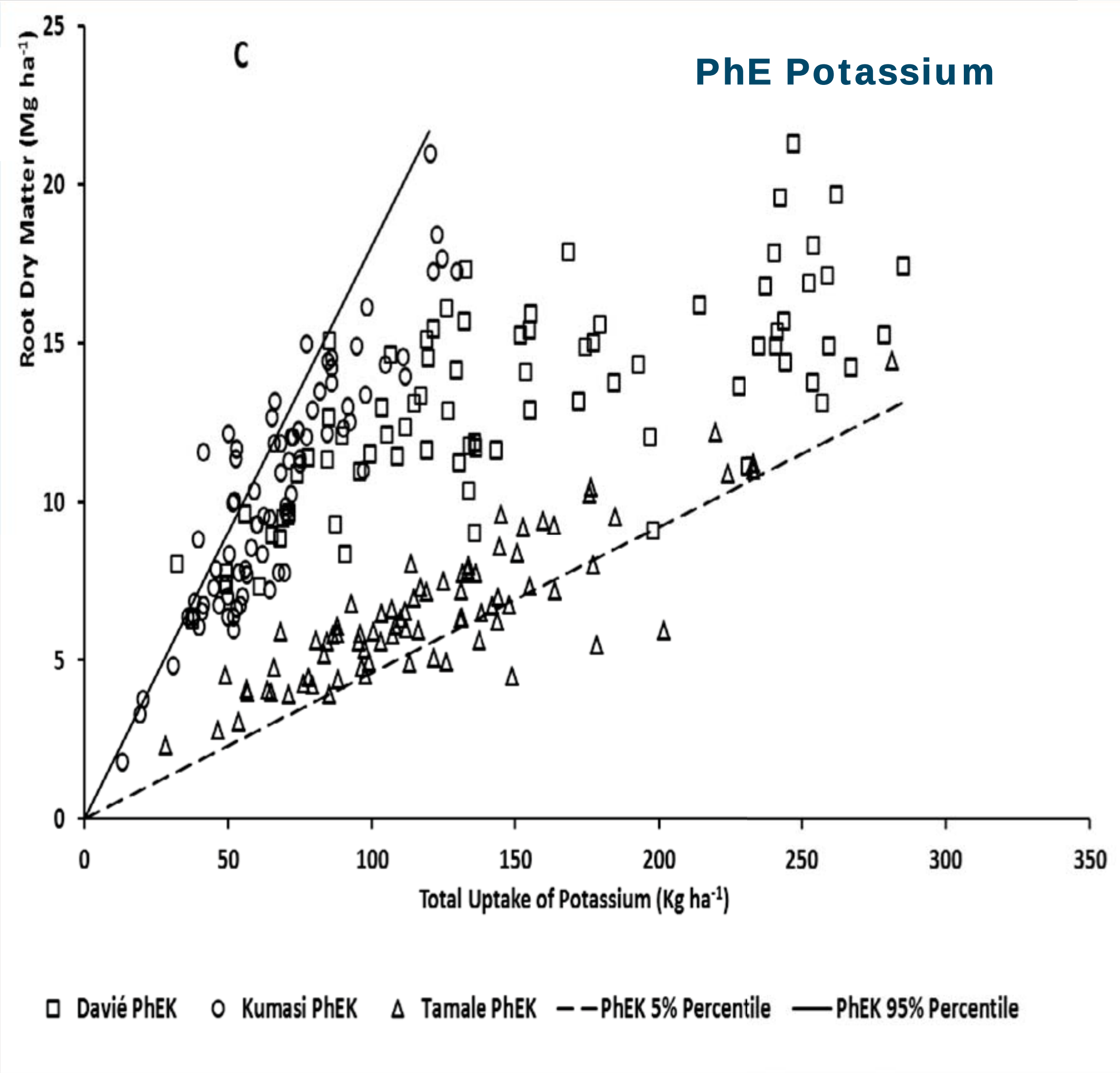
Wolf (1984) and Nijhof (1987):
PhE P: 125-590 kg DM kg^{-1} P



Physiological Use Efficiency of Potassium (PhE K)

PhEK accumulation = 46 kg DM kg^{-1} K
PhEK dilution = 181 kg DM kg^{-1} K

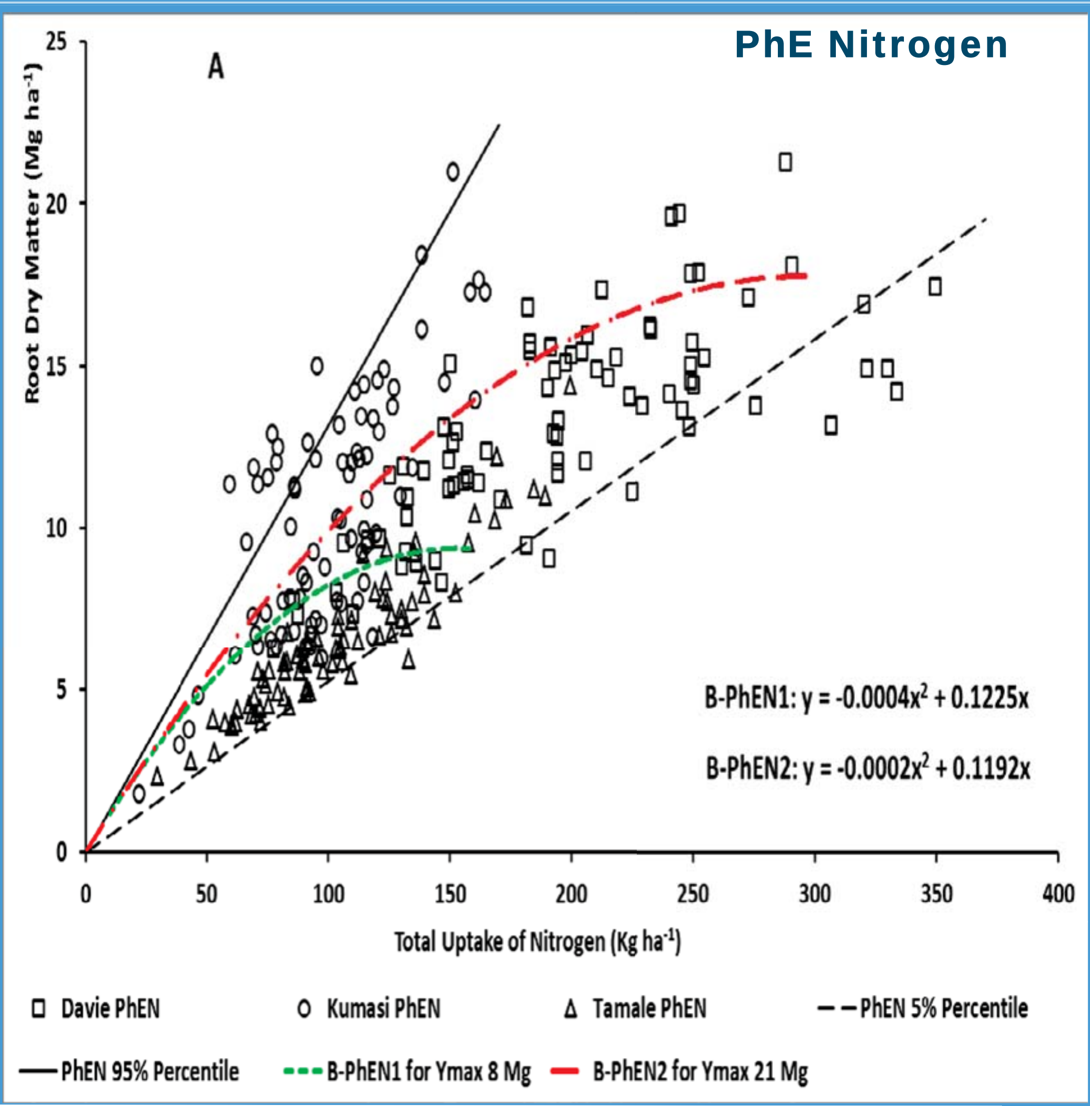
Wolf (1984) and Nijhof (1987):
PhE K: 30-135 kg DM kg^{-1} K



Physiological Use Efficiency for balanced nutrition of N

Balanced PhEN: $y = -ax^2 + bx$
Max slope = 89 kg DM kg^{-1} N

Balanced PhE increase linearly up to 68.8 – 77.8% Ymax



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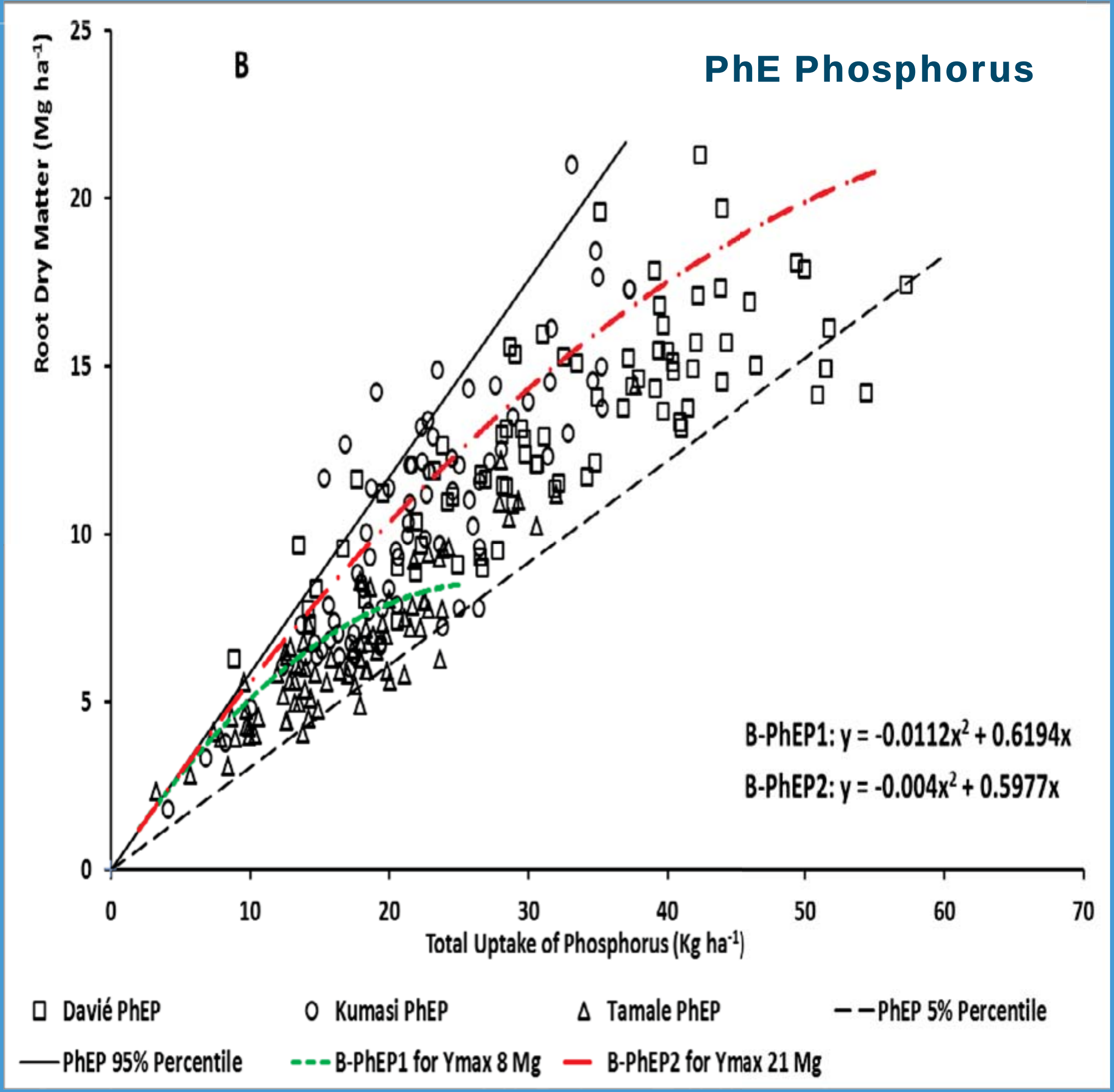
Physiological Use Efficiency and balanced nutrition of P

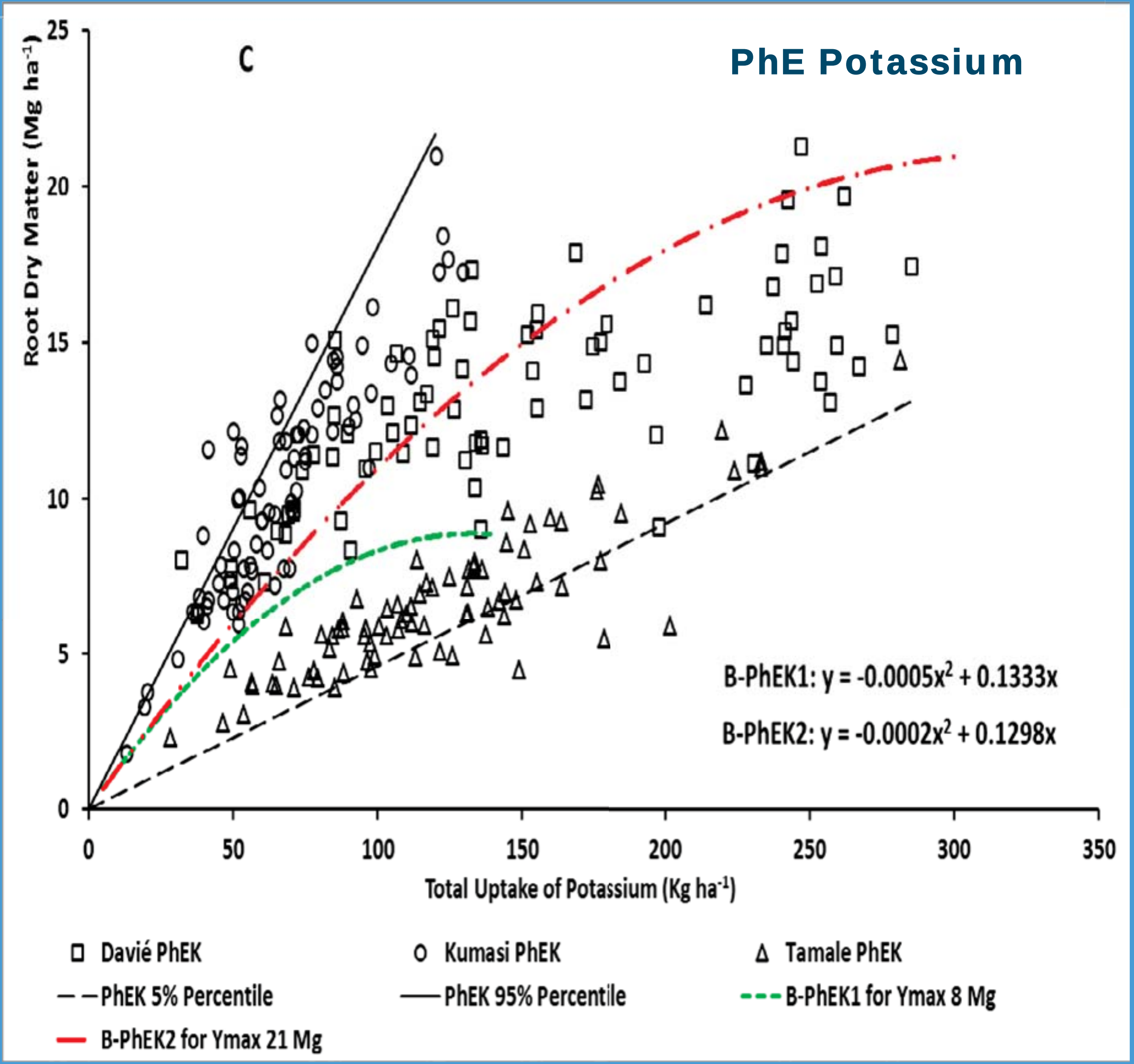
Balanced PhEP: $y = -ax^2 + bx$
Max slope = 449 kg DM kg^{-1} P

Balanced PhE increase linearly up to 68.8 – 77.8% Ymax



Physiological Use Efficiency for balanced nutrition of K

Balanced PhEK: $y = -ax^2 + bx$
Max slope = 97 kg DM kg^{-1} K



Balanced PhE increase linearly up to 68.8 – 77.8% Ymax

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Optimum NPK uptake requirement and ratio

PhE for Balanced Nutrition:

89 kg DM kg^{-1} N
449 kg DM kg^{-1} P
97 kg DM kg^{-1} K

Optimum NPK uptake requirement:

11.3 kg N – 2.2 kg P – 10.3 kg K Mg^{-1} Storage Root Dry Matter

Howeler (2002): 14.1 kg N – 1.8 kg P – 10.5 kg K Mg-1 Root DM

Optimum NPK uptake ratio:

NPK: 5.1 – 1.0 – 4.7

$N\text{-}P_2O_5\text{-}K_2O$: 2.2 – 1.0 – 2.5

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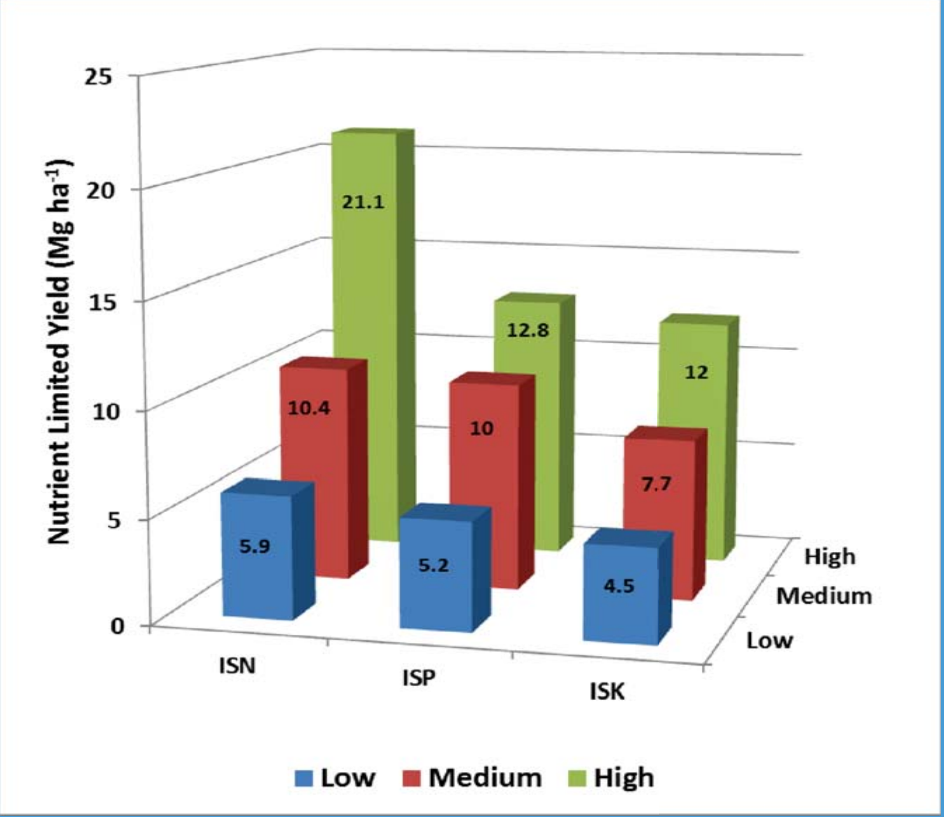
Soil fertility classes and nutrient limited yields

Variables	Units	Mean	Min	Max
Low ISN	kg N ha^{-1}	66.5	53.0	79.9
Medium ISN	kg N ha^{-1}	117.0	79.9	154.0
High ISN	kg N ha^{-1}	237.1	154.0	320.1
Low ISP	kg P ha^{-1}	11.6	4.1	19.0
Medium ISP	kg P ha^{-1}	22.4	19.0	25.7
High ISP	kg P ha^{-1}	28.6	25.7	31.5
Low ISK	kg K ha^{-1}	46.4	32.0	60.8
Medium ISK	kg K ha^{-1}	79.3	60.8	97.7
High ISK	kg K ha^{-1}	124.1	97.7	150.5



Low soil N, P and K supplies limit cassava yields
K is the most limiting nutrient, especially if ISK < 60.8 kg K ha^{-1}
P and N can be more limiting when ISK > 60.8 kg K ha^{-1}
Initial assessment of ISN, ISP and ISK is important prior fertilizer application

Conclusion

- This study:
  - Calibrated QUEFTS for cassava production under West Africa conditions
  - Formulated NPK uptake requirements for maximum efficiency at balanced nutrition
  - Showed that the low supply of NPK can limit cassava yield. But K is the primary yield limiting nutrient to cassava in the region.

These are indicative to derive fertilizer recommendations for maximum efficiency in West Africa.

However, good crop and nutrients management practices are required to achieve this goal.

Conclusion

- Current PhD study to assess budget and enhance K management in cassava based farming systems of West Africa

End of presentation

Thank you for your attention