#7708 ENHANCING THE USE OF APPROPRIATE FERTILIZERS FOR IMPROVING RICE AND MAIZE PRODUCTION IN TANZANIA

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ABSTRACT

In years 2017 to 2019, site specific fertilizer trials were conducted in Tanzania to enhance the precision in using appropriate fertilizer in rice and maize production. Two new fertilizers namely: NPS (19- 38-0+7S) and NPSZn (12- 45-0+5S+1Zn) were tested in comparison with DAP, the commonly used fertilizer by farmers. Control treatment was also added to assess crop yields under farmers practices. The trial design was randomized complete block designed. Treatments were replicated 4 to 16 times in each village depending on soil variations and willingness of farmers to set trial. The amount applied for NPS and NPSZn fertilizers were based on the recommended rates of P for rice and maize in the studied Agricultural Zones. Nitrogen fertilizer was applied in 2 splits as urea in all treatment except control. The amount of urea applied was adjusted to take into consideration the N contained in each fertilizer. Results indicates that there is a significant variation ($P<0.05$) of soil fertility status and crop yields among agro-ecological zones. All study sites are characterized by low levels of N and OC for maize and rice production. Most of the study areas have medium to low levels of P, K, Zn, Mg, Ca, and S. In Southern highlands zones, application of NPSZn and NPS gave significantly higher rice grain yields up to 8.39 t ha^{-1} as compared to DAP fertilizer (6.84 t ha^{-1}). For the other 7 zones, fertilizers tested (DAP, NPSZn, NPS) had comparable effectiveness in improving rice and maize grain yields. The tested fertilizers increased up to 3 times more grain yields than control practices. Economically, NPSZn and NPS fertilizers gave more profit in maize and rice production than DAP and farmer's practices. It is recommended that, fertilizers NP+S and NP+SZn be adopted by farmers in the study areas instead of DAP. Further research is needed to determine appropriate S, K, Zn, Mg, and Ca nutrients rates which can be used to formulate balanced fertilizer recommendations for improving maize and rice production in Tanzania.

INTRODUCTION

Maize and rice are important staple food in Tanzania. Maize ranks the first staple food followed by rice. These crops are also used to generate income when there is surplus. Most soils under maize and rice production in the country are characterized by low soil fertility. Nitrogen (N) and phosphorus (P) are the major limiting nutrients. For this reason, nutrient management efforts have been concentrating on these two nutrients. The available fertilizer recommendations for most crops by Samki & Harrop (1984), Mowo et al. (1993) and Marandu et al. (2016) do not cover micronutrients because of insufficient information on micronutrient status of the soils as well as response of crops to micronutrients. However, some studies have indicated deficiencies of micronutrients particularly Zn, Cu and S in some parts of Tanzania (Amur and Semu 2006; Massawe and Amur, 2012; Kamasho and Singh 2012; Mhoro et al., 2015; Senkoro et al., 2017)). Fertilizer blends which contain macro nutrients in combination with secondary and/or micronutrients for rice and maize production are currently very few in Tanzania. Among major reasons include inadequate information on soil fertility status of most

maize and rice producing areas, and few scattered experiments, which did not generate adequate information that can be used to develop fertilizer formulations for entire country. Most of the established recommendations are also blankets recommendation. They did not consider the variations in soil fertility across farmers' fields. Site specific soil fertility assessment is therefore important to formulate appropriate fertilizer blends and increase precision and efficiency in fertilizer use by farmers.

The main Objective of this study was to generate information which will be used to formulate appropriate fertilizer blends for improving rice and maize production in Tanzania. The specific objectives were to: i) assess current soil fertility status in selected major rice and maize growing areas in Tanzania, ii) determine the limiting nutrients which contribute to low rice and maize production, iii) assess the effects of OCP blended fertilisers namely NPS and NPSZn to maize and rice yields iii) determine the economic returns of using OCP blended fertilisers on maize and rice production.

MATERIALS AND METHODS

In years 2017 to 2019, soil fertility assessment was conducted in 769 farmers' field in the Southern Highland Zone (SHZ), Western Zone (WZ), Lake Zone (LZ), Northern Zone (NZ), Eastern Zone (EZ) and Central Zone (Figure 1). The sites were purposively selected to evaluate performance of (NPS (19-38-0+7S) and NPSZn (12-45-0+5S+1Zn) on rice and maize yields. Sites selection was based on the production potential for both crops, climatic conditions, fertilizers use and accessibility. In each selected field, a geo-referenced composite sample of topsoils (0 – 20 cm) and sub soil (20 – 40 cm) were collected and brought to laboratory for analysis. Soil samples were air dried and sieved through a 2 mm sieve ready for laboratory analysis.

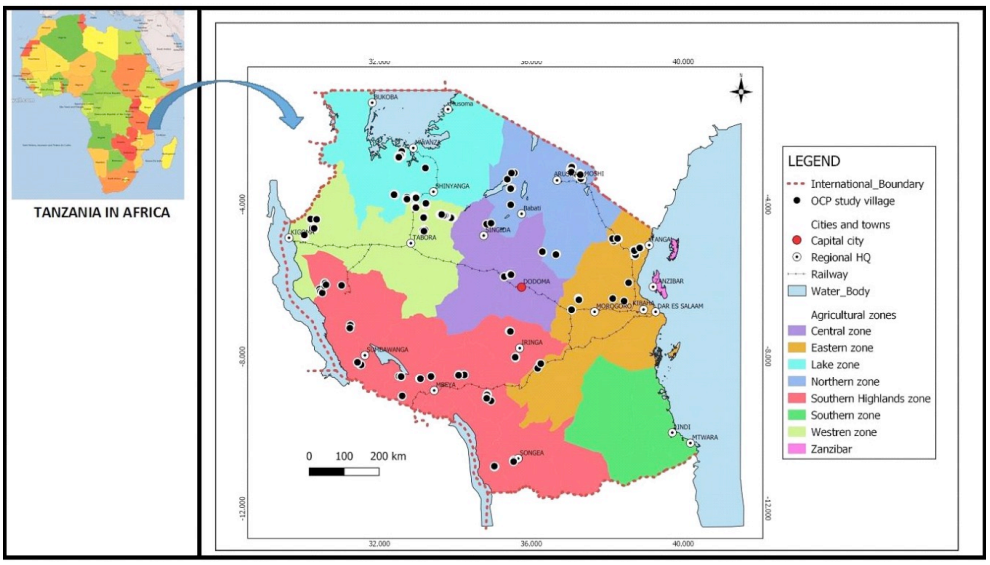

Figure 1. Location of the study villages in Tanzania where site specific OCP fertilizer trials were conducted.

Nutrient availability was determined using mid-infrared (MIR) spectral analysis following validation using data from wet chemistry analysis which were 10% of the total samples (Shepherd and Walsh, 2007; Terhoeven-Urselmans et al. 2010; and Towett et al.

2015). Soil pH was determined with a 1:2.5 soil: water slurry. The Mehlich 3 extraction was used for available P, exchangeable bases and available micronutrients (Mehlich 1984).

Soils at the study areas are characterized by low levels of N and OC for maize and rice production. Most of the study areas have medium to low levels of P, K, Zn, Mg, Ca, and S ((Landon 1991; Horneck et al. 2011; Howeler 2002).

The experimental design was randomized complete block designed with 4 treatments replicated 4 to 16 times in one village depending on soil variations. Treatments tested were: (1) absolute control (2) NP at recommended rates for maize and rice, (3) NPS (19-38-0+7S) and (4) NPSZn (12-45-0+5S+1Zn). The amount applied for NPS and NPSZn fertilizers were based on recommended rate of P for rice and maize (Senkoro et. al., 2017). Nitrogen fertilizer was applied in 2 splits as urea in all treatments except control. The amount of urea applied was adjusted to take into consideration the N contained in each fertilizer. The amount of fertilizer nutrient rates applied are as indicated in Table 1. Maize and rice grain yield data were subjected to Analysis of Variance using Statistix statistical programme and where significant difference existed, means were separated using Duncan's New Multiple Range Test. The profitability of maize and rice production in the study areas from each of the four fertilizer types was estimated through a partial budget analysis, and Value-Cost Ratio (VCR).

Table 1. Nutrients from NPSZn and NPS fertilizers applied to rice and maize in the studied zones.

Agricultural Zone	Rice				Maize			
	N*	P*	S	Zn	N	P	S	Zn
Nutrients applied (kg ha^{-1}) from NPSZn (12-45-0+5S+1Zn)								
Eastern Zone	150	20	5.0	1	65	40	10	2
Northern Zone	100	20	5.0	1	74	20	5	1
Southern Highland Zones	116	40	10.0	2	60	20	5	1
Western Zone	66	23	8.1	1.2	43	25	6.3	1.3
Lake Zone	80	31	7.8	1.6	53	30	7.5	1.5
Nutrients applied (kg ha^{-1}) from NPS (19-38-0+7S)								
Eastern Zone	150	20	7	0	65	40	14	0
Northern Zone	100	20	7	0	74	20	7	0
Southern Highland Zones	116	40	14	0	60	20	7	0
Western Zone	66	23	8.1	0	43	25	8.8	0
Lake Zone	80	31	10.9	0	53	30	10.5	0

*Fertilizer recommendations for the Zones

RESULTS AND DISCUSSION

The results indicate that most smallholder famers (52 – 95%) in Central, Western, Eastern, Northern and Lake Zones do not use fertilizers in maize and rice production; 70% of farmers in Southern Highland Zone use fertilizers. There is a significant variation ($P<0.05$) of soil fertility status and crop yields among agro-ecological zones indicating that site specific fertilizer recommendation is important to increase fertilizer use efficiency and crop yield. All study sites are characterized by low levels of N and OC for maize and rice production. Most of the study areas have medium to low levels of P, K, Zn, Mg, Ca, and S. In Southern highlands zones, application of NPSZn and NPS gave significantly higher rice grain yields up to 8.39 t ha^{-1} as compared to DAP fertilizer (6.84 t ha^{-1}). For the other 7 zones, fertilizers tested (DAP, NPSZn, NPS) had comparable effectiveness in improving rice and maize grain yields (Table

2). The tested fertilizers increased up to 3 times more grain yields than control practices (Table 2).

Economically, NPSZn and NPS fertilizers gave more profit in maize and rice production than DAP and farmer's practices. Rice yield from NPSZn fertilizer in Nzega district in the lake Zone had the highest net benefit of TZS. 7,370,597 equivalents to US $ 3,258.40.

Table 2. Rice response to tested fertilizers in the studied Agricultural Zones in Tanzania.

Crop and Zone	Grain yield per fertilizer type (t ha^{-1})				Level of significance	CV (%)
	Control	NPS	NPSZ	DAP		
Rice						
Lake Zone	2.26b	5.35a	5.29a	5.72a	***	32.0
Western Zone	4.54b	8.81a	9.76a	8.29a	***	32.1
Southern Highland Zone 1	3.55c	7.82a	8.39a	6.35b	***	25.0
Southern Highland Zone 2	5.37d	6.32c	7.56a	6.84b	***	14.0
Northern Zone	5.1	5.1	6.4	5.9	ns	31.8
Eastern Zone	3.6	4.5	4.8	4.8	ns	18.3
Maize						
Lake Zone	1.83	4.24	4.27	3.62	ns	55.0
Western zone	3.42	5.21	5.83	5.99	ns	78.0
Southern highlands1	3.36b	6.55a	6.69a	6.46a	***	39.0
Southern highlands2	1.60	3.61	3.95	3.26	ns	42.0
Northern Zone	2.057b	3.173b	3.745b	3.7b	**	21.6
Eastern Zone	1.15	1.73	1.99	1.91	ns	26.7

Numbers within the same row bearing the same letter are not significantly different using Duncan New Multiple Range Test (DNMRT)

CONCLUSIONS AND RECOMMENDATIONS

There is significant variation of soil fertility status among sites in areas under rice and maize production in Tanzania emphasizing that more assessment is needed to establish site specific nutrient recommendations. Due to nutrient mining, application of N and P alone will not lead to sustainable production. It is recommended that, fertilizers NP+S and NP+SZn be adopted by farmers in the study areas instead of DAP. Further research is needed to determine appropriate S, K, Zn, Mg, and Ca nutrients rates which can be used to formulate balanced fertilizer recommendations for improving maize and rice production in Tanzania.

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