VARIABILITY IN YIELD RESPONSE OF MAIZE TO N, P AND K FERTILIZATION TOWARDS SITE-SPECIFIC NUTRIENT RECOMMENDATIONS IN TWO MAIZE BELTS IN TOGO
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ABSTRACT

Savannah and central regions are the major maize production zones in Togo, but with maize grain yields at a threshold of only 1.3 Mg ha^{-1}. We use a participatory approach to assess the importance of the major three macro elements (N, P and K) for maize cropping in the two regions to further allow for site-specific and scalable fertilizer recommendations. Thirty farmers' fields served as pilot sites, allocated within the two regions to account for spatial variability in soil inherent fertility and weather conditions. Five fertilization schemes were applied to maize crop at each site as a replicate plot of 10 m x 10 m (100 m^2). The fertilization schemes were derived from a nutrient omission-based approach and consisted of the following treatments: T1, control, no fertilizer application; T2, full NPK fertilization at 120 kg N ha^{-1}, 60 kg P ha^{-1} and 70 kg K ha^{-1} ($N_{120}P_{60}K_{70}$); T3 ($N_0P_{60}K_{70}$); T4 ($N_{120}P_0K_{70}$); T5 ($N_{120}P_{60}K_0$). Fertilizer P and K rates were applied two weeks after maize planting together with half of N fertilizer rate, and the remaining half of N was applied 40 to 45 days after planting. Maize grain yields were determined by harvesting a sub-plot of 16 m^2 delimited at the center of each plot of 100 m^2. Mean yield data in the Savannah Region ranged from 0.56 to 4.57 and 0.32 to 3.02 Mg ha^{-1} for the Tandjouare and Tone districts, respectively. In the Central Region, mean grain yields were between 1.60 and 3.70 and 1.05 and 3.46 Mg ha^{-1} for the Tchaoudjo and Sotouboua districts, respectively. The fertilization treatment-based ranking of the yield data clearly indicated that all the three macro nutrients (N, P and K) are needed for maize production in the two regions with a priority-based ranking being N > P > K. However, the data set showed significant variability in yields within and across region, indicating that site-specific fertilizer recommendation is needed at a district-scale to maximize nutrient use efficiency and to realistically fulfill crop nutrient need.

Keywords: Maize cropping, mineral fertilizer, site-specific fertilizer recommendation, nutrient use efficiency, Togo

INTRODUCTION

Improving agricultural productions has become a growing concern in Togo because the sector is the primary engine of the country's economy with a contribution of over 40% to the GDP and more than 20% to the export gains (DSID, 2015). Furthermore, agriculture employs over 65% of the active population with 3.6 million ha of arable land representing 60% of the country's total area. Maize is the number one cereal food crop and produces 68% of the agriculture-based contribution to the country's GDP (FAO, 2021; DSID, 2015;). Food security is termed as maize grain availability (Detchinli, 2017) called ***Queen Grain***. Moreover, maize cropping occupies 700,000 hectares, which represents 40% of the total food crop area with a yearly grain production of typically 900,000 t (DSID, 2022), most of which comes from the

Savannah and Central regions known as the country's maize belts. Nevertheless, maize grain yield in the country is typically in a threshold of 1.3 t ha^{-1}, which is very low compared to the potential yields of 5 to 6 t ha^{-1} for the major used varieties (ITRA 2007).The low maize yield primarily results from the use of pan-territorial and very aged (1980's) fertilizer recommendations (Sanou et al. 2017which can also lead to environmental pollution (Ezui, 2010). Other problems faced by maize cropping include the complexity of the country's agro ecology and land degradation. Relatively recent exploratory studies (IFDC, 2012) showed noticeable variability in maize grain yield response to major nutrients across the different regions of the country. This indicates that maize production improvement in the country requires that fertilizer recommendations be updated on a site-specific basis. In other words, the production system should operate on a precision nutrient management basis with practices that are technically, socially, and economically justified and sustainable.

The objective of this study was to assess variability in yield response of maize to macro elements N, P and K fertilization in two maize belts in Togo. The aim was to determine the need level of each of the three elements (N, P and K) in maize production and asses the priority order of the need to further catalyze the development of precision site-specific nutrient management recommendations for maize cropping.

MATERIAL AND METHODS

Study sites

The study was conducted in two regions known as maze belts of the country including the Savannah region and the Central region (Fig. 1). The soils of the Savannah region are ferruginous tropical soils with organic matter content, $pH_{(H2O)}$ and sum of exchangeable bases ranging from 0.43 to 1.72%, 5.8 to 6 and 7 to 20 meq, respectively. The climate has a monomodal rainfall regime with an mean of 1200/yr and provides one maize crop typically from June to September. The Central region has clayed-vertisols with organic matter content and $pH_{(H2O)}$ between 0.55 and 2.08% and 5.4 and 8.0, respectively, and a monomodal rainfall regime climate with an average of 1200/yr and provides one maize typically from June to September.

Participatory nature and design of the study

In each of the two regions, fifteen (15) farmers were selected in two districts (Fig. 1) to host the experiment as a replicate. Farmers were strategically selected for capacity building and high technology adoption potential purposes and for serving as pilot sites for the region. At each pilot site, five plots of 10 m x 10 m (100 m^2) each were laid out and the following five fertilization treatments were applied on the basis of the principle of omission trials: T1: control, no fertilization; T2, N omitted from the full NPK (PK); T3: P omitted from the full NPK (NK); T4: K omitted from the full NPK (NP); T5: full NPK (120 kg N ha^{-1}, 60 kg P ha^{-1} and 70 kg K ha^{-1}).

Soil and crop management

At each site, Ikenne, the most used maize variety in the regions was planted at the scheme of 0.8 m x 0.4 m and thinned to 2 plants/hill making it to a potential population density of 62,500 plants/ha. Maize crop was manually weeded three times and treated as needed to EMACOT 50 MG to fight army worms. Fertilizer application consisted of the application in point-placed mode of $N_{120}P_{60}K_{70}$ kg ha^{-1}, with half of the N rate (60 kg N ha^{-1}) and full rates of P and K applied approximately 15 to 21 days after maize planting and the remaining half of N applied 40 to 45 days after maize planting. Fertilizers N was applied as urea (46% N), and P

and K were applied as triple superphosphate (TSP 46% P2O5) and potassium chloride (KCl 60% K2O), respectively.

Data collection and analysis

Mean maize grain yield for each fertilization treatment in each district was measured by harvesting an area of 16 m2 (3.2 m x 5 m) in the middle of the 100 m^2 treatment plot. Harvested maize grain was sun-dried at about approximately 14% moisture content. The yield data set was subjected to analysis of variance (ANOVA) using the GENSTAT software version12.0 and mean yield values were discriminated with the Duncan test at a p value of 0.05.

RESULTS AND DISCUSSION

Mean maize grain yield data are presented in Table 1. For the Savannah region, the data set indicated that yield trends as linked to fertilization treatments are in general identical in the two districts of the region. The fertilization treatment-based ranking of the data clearly indicated that all the three macro nutrients (N, P and K) are needed for maize production in the two districts with the ranking of their importance being N > P > K. However, the data showed that fertilization treatment-based grain yields were constantly higher in the Tandjouare district than those in the Tone district (Tables 1). This indicates that site specific nutrient management is required in the region at the district-scale to realistically fulfill crop nutrient need thereby maximizing nutrient use efficiency.

In the Central region, the yield trends as linked to fertilization treatments are similar in the two districts except in Tchaoudjo where mean yield under T1 (control) was numerically higher than that under T2=PK (Table 1). This change in the yield general trend in Tchaoudjo presumably resulted from cropping history (use of cow dung two years prior to the experiment) at two pilot sites. Like the Savanah Region, the fertilization treatment-based ranking of the data (Table 1) indicated that all the three macro nutrients (N, P and K) are needed for maize production in the two districts with the ranking of their importance being N > P > K. Unlike the Savannah Region, the data set showed that fertilization treatment based mean grain yields were reasonably similar for the two districts of the Central Region. This suggests that recommended fertilization schemes towards maximizing nutrient use efficiency to enhance maize production may reasonably apply for the two districts of the region.

On a regional basis, although the yield trends were similar with respect to fertilization treatment and the ranking of the importance of the three nutrients was N > P > K, mean maize grain yields were higher in the Central region as compared to those in the Savannah region. This further highlights the variability in yield response to nutrient across regions. Results of this study corroborate those of IFDC (2012) and Mawussi et al. (2015) in terms of both yield trends and nutrients' importance in the Plateau, Central and Savannah regions of Togo. However, results from several studies in the Maritime region (Sika, 2022; Tagba, 2022, William, 2021) agree with our results in terms of yield variability in response to N, P and K, but are against our results in terms of nutrients' importance because their ranking was N > K > P.

Table 1. Mean maize grain yield (Mg ha^{-1}) under fertilization treatment at district and regional scales.

Region	District	Fertilization Treatment					LSD
		T1=control	T2=PK	T3=NK	T4=NP	T5=NPK	
Savannah	**Tandjouaré**	0.56**c**	0.83**c**	3.18**b**	3.44**b**	4.57**a**	**0.6282**
	Tone	0.32**b**	0.52**b**	1.06**b**	2.39**a**	3.02**a**	**0.785**
Regional Mean		**0.44**	**0.68**	**2.12**	**2.91**	**3.80**	
Central	**Tchaoudjo**	1.55**c**	1.32**c**	2.34**b**	3.34**a**	3.73**a**	**0.5964**
	Sotouboua	1.05**c**	1.09**c**	1.33**c**	2.83**b**	3.46**a**	**0.5056**
Regional Mean		**1.30**	**1.20**	**1.83**	**3.08**	**3.59**	

CONCLUSION

Maize cropping in the Savannah and Central regions of Togo would not be an option without fertilizers N, P and K application. The gradient of the variability in yield response which prioritize fertilizer need was N > P > K. District-specific based nutrient recommendations may be required in the Savannah Region, but a region-based recommendation could be relevant for the Central Region. Findings from this study together with other information could be integrated with relevant decision support tools to develop nutrient recommendation schemes that are both agronomically and economically suitable in the regions.

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