Research Application Summary

Response of maize and soybean crops to inorganic fertilisers in Western Kenya

Mongare, P.O.[1], Okalebo, J.R.[1], Othieno, C.O.[1], Ochuodho J.O.[1], Kipkoech, A.K.[1] & Nekesa, A.O.[1]
[1]Moi University, Chepkoilel University College, P. O. Box 1125, Eldoret, Kenya
Corresponding author: perismongare@yahoo.com

Abstract

Fertiliser performance trials involving three Farmer Associations (FAs) were set-up starting 2011 long rains to assess the output potential of five commercially available fertilisers, namely Calcium Ammonium Nitrate-CAN, Triple Super Phosphate-TSP, Diammonium Phosphate-DAP, Sympal and Canpal. The soybean inoculated with biofix and planted with maize in a MBILI system were used as test crops. All fertilisers were applied at the same rate of 125 kg per ha. Farmers were invited to experimental fields during all crop establishment stages in order help in selection of high yielding fertilisers to be offered under a collective fertiliser purchase program by the FAs. Initial soil characterisation was done to determine the nutrient levels of the soil before the treatments were applied and thereafter, soil was sampled for measuring nitrate contents after every 4 weeks. Results showed that soils were heterogeneous with different soil fertility gradients with all the experimental sites being phosphorus (P) and nitrogen (N) deficient. Crops responded to P fertilisers in Bungoma and to N in Teso. Maize and soybean grain yield was not significantly ($p<0.05$) different among all the fertiliser types at all sites. It is important to assess soil nutrients before application of any fertiliser in order to get optimal results by only applying the deficient nutrients.

Key words: Inorganic fertilisers, maize, Soil pH, phosphorus, soyabean, yields

Résumé

Les essais de performance des engrais impliquant trois associations d'agriculteurs ont été mis en place à partir de longues pluies de 2011 pour évaluer le potentiel de production de cinq engrais disponibles dans le commerce, à savoir le Nitrate d'Ammonium- Calcium CAN, le Triple Super Phosphate-TSP, le phosphate de diammonium-DAP, le Sympal et le Canpal . Le soja inoculé avec le biofix et le soja planté avec du maïs dans un système de MBILI ont été utilisés comme cultures d'essai. Tous les engrais ont été appliqués à la même proportion de 125 kg par ha. Les agriculteurs ont été invités dans des champs d'expérimentation durant toutes les étapes de l'implantation des cultures afin d'aider dans la sélection des engrais de haut rendement qui seront offerts dans un programme collectif d'achat des engrais par les associations d'agriculteurs. La caractérisation initiale des sols a été effectuée afin de déterminer les niveaux d'éléments nutritifs du sol avant que les traitements aient été appliqués et par la suite, le sol a été échantillonné pour mesurer des teneurs en nitrates après toutes les 4 semaines. Les résultats ont montré que les sols étaient hétérogènes avec différents gradients de fertilité des sols et avec tous les sites expérimentaux étant déficients en phosphore (P) et en azote (N). Les cultures ont répondu aux engrais phosphatés à Bungoma et de aux engrais azotés à Teso. Le rendement en grains de maïs et de soja n'a pas été significativement (p <0,05) différent parmi tous les types d'engrais dans tous les sites. Il est important d'évaluer les nutriments du sol avant l'application d'un engrais afin d'obtenir des résultats optimaux en appliquant seulement des éléments nutritifs déficients.

Mots clés: Engrais inorganiques, maïs, pH du sol, phosphore, soja, rendements

Background

Crop productivity in most of sub-Saharan Africa is on the decline as soils increasingly become depleted of nutrients. In Western Kenya, soils are considered inherently deficient in important macronutrients especially, Phosphorus (P) and Nitrogen (N) and the use of fertilisers to replenish fertility and increase crop yields is indispensable in improving food security. In western Kenya, many attempts to raise yields have been made by researchers and who have developed various soil fertility replenishment technologies. Use of fertilisers is one of the technologies set for out-scaling in the Community Action Research Project (CARP) funded by The Regional Universities Forum (RUFORUM). Uniform field trials were set up with Farmer Associations (FA's) to determine which available fertiliser performs best on the maize and soybean system. Results of this study will help direct selection of fertiliser brands to be promoted under collective purchasing by participating farmer groups.

Literature Summary

Low soil fertility, limited availability of resources to farmers, nutrient mining, and drought are the main causes for low agricultural productivity in sub-Saharan Africa (McClann, 2005). Substantial efforts however have been made in western Kenya to develop technologies for replenishing soil fertility of degraded soils in attempts to raise crop yields (Okalebo *et al.*, 2006). The strategies developed have varying characteristics that demand different resource and skill threshold in order for farmers to reap the benefits embodied in the technologies. Tittonell *et al*. (2005a) observed on smallholder farms in Western Kenya that soil fertility indicators and nutrient concentrations varied quite consistently between different land quality classes. Indeed, in this region, soil fertility differences are evident even among neighboring households. Although regional and national estimates of nutrient balances are negative for all major nutrients in the region, large differences in nutrient balances can be observed between fields within a farm. This leads to some fields showing positive balances, resulting in substantial differences in soil fertility status between those fields (Smaling *et al*. 2002).

Formulating fertilisers differently is important to meet the diverse needs of farming households resulting from the specific fertiliser needs at household level. The focus of soil fertility now concentrates on fertiliser combinations that will effectively arrest the on going soil fertility decline in sub-Saharan Africa with long term effects (Vanlauwe *et al.,* 2001).

Study Description

Initial soil sampling was carried out before applying the treatments to characterise the soils in the study sites. Other than soil for testing nitrate (NO_3-N and ammonium (NH_4-N) that was taken from five depths of 15 cm each up to a depth of 75 cm, soil was scooped (from 12 points per plot) within a depth of 0-15 cm and 15-30 cm, using a zigzag method of sampling. A quartering system was used to get a composite sample across each plot. The soil samples obtained were air-dried and sieved to pass through 2 mm and 0.25 mm screens and a sample of 500g picked for laboratory analysis. Soil pH, carbon, nitrogen and available P contents of soils was determined as recommended by Okalebo *et al.* (2002). Five fertilisers; CAN (26% N) that provides nitrogen (N) alone at the rate of 33 kg/ha, TSP (46% P_2O_5) that provides phosphorus (P) alone at the rate of 25 kg/ha, DAP (18% N, 20% P) that provides both N and P at the rates of 22 kg N and 11 kg P per ha, SYMPAL +KS (23% P_2O_5, 16% K_2O (potassium), 4% sulfur (S) and 1% MgO (magnesium) provides 13 kg P, 18 kg K, 5 kg S and 1 kg Mg per ha) and CANPAL (13% N, 12% P_2O_5, 8% K_2O, similar to 10-10-10) were compared to one another at the rate of one 50-kg bag per acre (125 kg per ha). The treatments were applied in plots measuring 3 m x 6.5 m to give experimental units of 19.5 m^2. One metre wide pathways were separated the plots. Six plots were planted with IR maize (IR maize) in the back half of the plot and six sub-plots were planted with inoculated soybean (SB 19). Maize was planted at a density of 75 cm between rows and 30cm between plants within the rows. These resulted to 4 maize rows per sub- plot. Soybeans were planted in the front half of the trial. First, the soybeans were inoculated with biofix; a mycorryhizal inoculant to stimulate nodulation and hence biological nitrogen fixation (BNF) as described on the BIOFIX package. The soybeans were planted at a spacing of 50cm between rows and 10cm between plants within the row. Crop yields were taken at harvesting and data were subjected to SAS program.

Research Application

The initial soil nutrient analysis shows that all the experimental sites are phosphorus (P) and nitrogen (N) deficient (Table 1). The soil Ph at Vihiga ranged from 4.8-6.8 and Bungoma 4.7-8.2 while in Teso and Busia, the Ph was 4.8-7.6 and 5-7 respectively. The soil Ph at Vihiga is lower than 5.5 that is considered optimum for most of the crops, and thus, it requires correction perhaps through liming and organic manures. Apparently, all soils in the study area require N additions. This is seen in Table 1.

Results in Figures 1 and 2 shows that maize and soybean grain yield was not significantly different ($p<0.05$) among all the fertiliser types at all sites. CAN, Canpal and DAP yielded higher maize grain and stover in Teso than in Bungoma because of the nitrogen provided by the fertlisers. Sympal, Canpal and the control have no starter nitrogen needed for the Teso soils. Teso soils are sandy and nitrogen is leached easily making them very deficient in nitrogen (Table 1). Bungoma soil had high nitrogen (0.3-0.9) leading to the control treatment giving the highest yield in maize grain. Bungoma soils were deficient in phoshporus (P) 0.8-4.7 thus <10 (crop response to P fertlilisers) whereas Teso soil were at 2.5 to 16.4. This led toBungoma soil responding to TSP and having higher maize grain and stover yield than Teso. Soybean grain and haulm yield were higher in Bungoma than Teso because of the high Nitrogen in Bungoma (Table 1). This was regardless of the fertiliser added. There was higher yield in both stover and haulm in Teso than in Bungoma consistently due to the added Nitrogen from the fertlisers.

The integrated approaches using organic materials and/or incorporation of legumes into the system would be much more

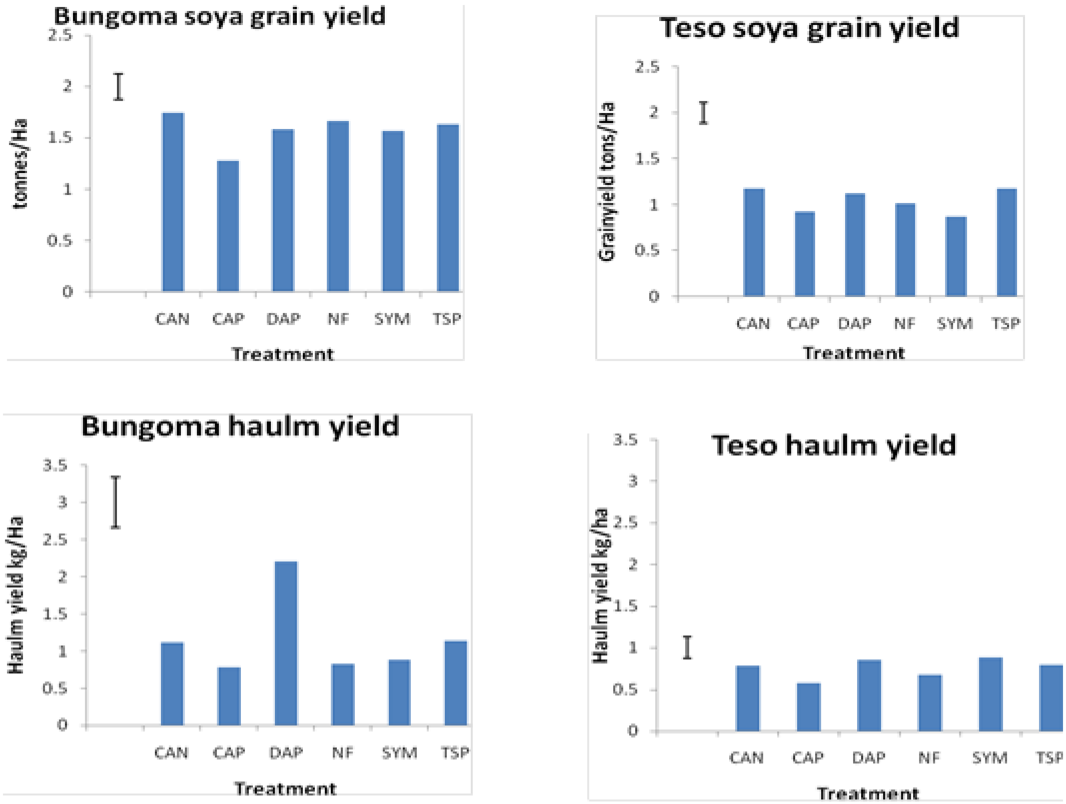

Figure 1. Response of soybean grain and haulm yield to different fertilizer formulations.

Table 1. Soil nutrient analysis in three study counties of western Kenya.

	Teso	Bungoma	Vihiga	Rating
Nitrogen	0.02-0.1	0.3-0.9	0.1-0.2	<0.02 (Very low), 0.05-0.12 (low), 0.12-2.5 (moderate), >0.25 (high)
Phosphorus (ppm P)	2.5-16.4	0.8-4.7	3.1-20.0	<10 (Crop response to P fertilizers)
Carbon	0.03-0.1	0.02-0.1	0.05-0.2	<0.5 (Very low), 0.5-1.5 (low), 1.5-3.0 (moderate), >3.0 (high)
pH	4.8-7.6	4.7-8.2	4.8-6.8	<4.5 (extremely acidic), 4.5-5.0 (strongly acidic), 5.0-6.0 (moderately acidic), 6.0-6.5 (slightly acidic), 6.5-7.0 (near neutral)

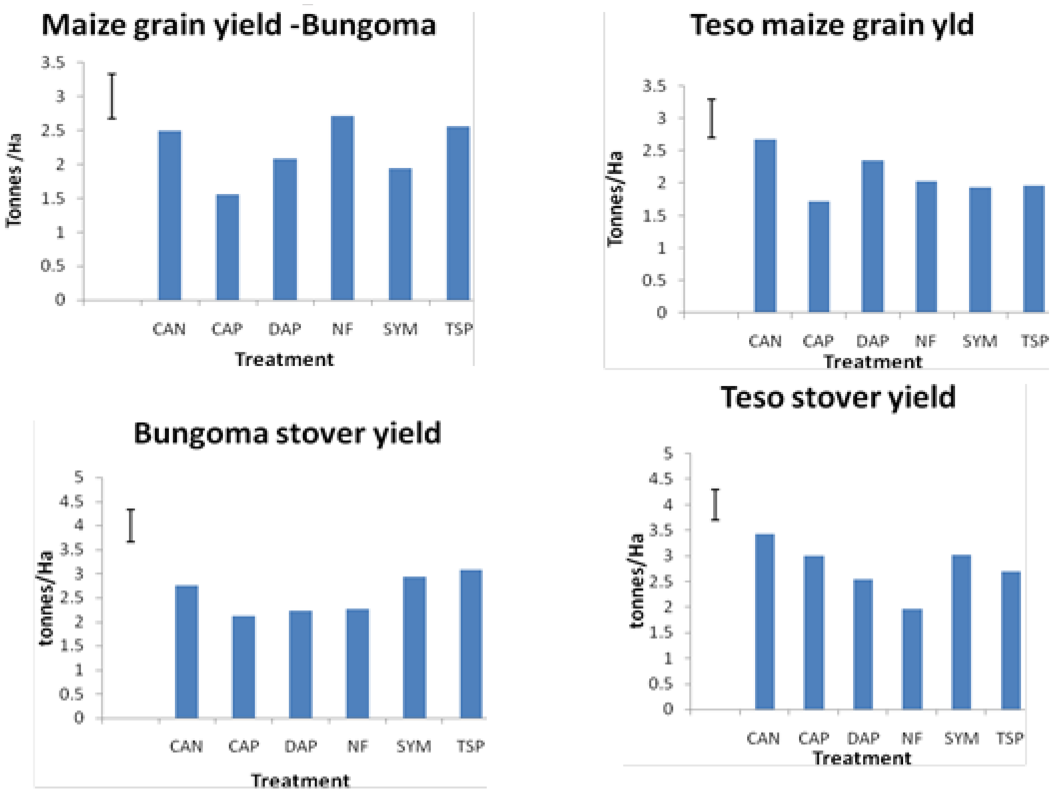

Figure 2. Response of maize grain and stover yield to different fertilizer formulations.

economical. However, these observations are only preliminary and thus justify setting up of field experiments to prove them. Although statistical analyses yielded no significant differences ($p<0.05$) among all the fertiliser types at all sites, crops responded better to TSP in Bungoma whereas the nitrogen fertililsers (CAN,CANPAL, DAP) performed best in Teso county.

Acknowledgement

This study was funded by the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM).

References

M cCann, J.C. 2005. Maize and Grace. Africa's Encounter with a New World Crop 1500–2000. Harvard University Press, Cambridge.

Okalebo, J.R., C.O. Othieno, P.L., Woomer, N.K. Karanja, J.R.M. Semoka, M.A. Bekunda, D.N. Mugendi, R.M. Muasya, A. Bationo, and E.J. Mukwana. 2006. Available Technologies to Replenish Soil Fertility in East Africa. *Nutrient Cycling in Agroecosystems* 76: 153-170.

Smaling E.M.A., Stoorvel J.J. and de Jager A. 2002. Decision making on intregrated nutrient management through the eyes of the scientist, the land-user and the policy maker.In: Vanlauwe B., Diels J., Sanginga N. and Merckx R. (Eds.). Intergrated sub-Saharan Africa: From Concept to Practise.CABI, Walling, UK. pp. 265-284.

Tittonel P., Vanlauwe B., Leffer P.A., Rowe, E. and Giller K.E. 2005. Exploring diversity in soil fertility management of smallholder farms in Western Kenya. Heterogeneity at the region and farm scale. Agriculture Ecosystem Environment.In Press.

Vanlauwe, B., Wendt, J. and Diels, J. 2001. Combining organic matter and fertiliser for the maintenance and improvement of soil fertility. In: Tian, G., Ishida, F. and Keatige, J.D.H (Eds.). Sustaining soil fertility in West Africa. American Society of Agronomy Special Bulletin, Madison, Wisconsin, USA.