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Research Application Summary

Soil properties and maize yields under tied ridging, fertilizer micro-dosing and different cropping systems in semi-arid regions of Kenya

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Abstract

In semi-arid parts of Kenya, the major threat to food security is declining soil fertility, inadequate and un-reliable rainfall. In order to minimize these challenges, there is need to adopt soil management practices that cope with low rainfall in semi-arid areas. A field experiment was carried out in four seasons at Katumani in Machakos County. The main objective of the study was to determine the effect of tied ridging, fertilizer micro-dosing and cropping systems on soil properties (soil pH and soil organic carbon) and maize yields. The experiment was a 2x4x2 factorial laid in a randomized complete block design (RCBD). The treatments were tied ridging, flat bed planting, farm yard manure 0t/ha, farm yard manure 5 t/ha, 20 kg nitrogen/ha, farm yard manure 5 t/ha + 20 kg N/ha, maize monocrop and maize-cowpea intercrop. The results revealed that the interactions between tied ridging x fertilizer micro-dosing x cropping systems had a significant ($P < 0.05$) effect on soil organic carbon, soil pH and maize yields. The findings suggest that it is important to integrate different soil management practices in order to maximize maize yields. The effectiveness of tied ridges is affected by the seasonal rain fall variations and that success is more feasible when the rainfall amount is low.

Key words: Cropping systems, fertilizer micro-dosing, flat bed planting, Kenya, tied ridging

Résumé

Dans les régions semi-arides du Kenya, la principale menace pour la sécurité alimentaire est la baisse de la fertilité des sols, des précipitations inadéquates et peu fiables. Afin de minimiser ces défis, il est nécessaire d'adopter des pratiques de gestion des sols qui font face aux faibles précipitations dans les zones semi-arides. Une expérience sur le terrain a été menée en quatre saisons à Katumani dans le comté de Machakos. Le principal objectif de l'étude était de déterminer l'effet du billonnage lié, du microdosage d'engrais et des systèmes de culture sur les propriétés du sol (pH et carbone organique du sol) et les rendements de maïs. L'expérience était une factorielle 2x4x2 posée dans un plan de bloc complet randomisé (RCBD). Les traitements portaient sur le billonnage lié, la plantation à plat, le fumier de cour de ferme 0 t / ha, le fumier de cour de ferme 5 t / ha, 20 kg d'azote / ha, le fumier de cour de ferme 5 t / ha + 20 kg N / ha, le maïs monoculture et le maïs avec le niébé intercalé. Les résultats ont révélé que les interactions entre le billonnage lié x le microdosage d'engrais x les

systèmes de culture avaient un effet significatif (P <0,05) sur le carbone organique du sol, le pH du sol et les rendements de maïs. Les résultats suggèrent qu'il est important d'intégrer différentes pratiques de gestion des sols afin de maximiser les rendements du maïs. L'efficacité des crêtes liées est affectée par les variations saisonnières des précipitations et ce succès est plus réalisable lorsque la quantité de pluie est faible.

Mots clés : Systèmes de culture, micro-dosage d'engrais, plantation à plat, Kenya, billonnage lié

Background

In semi-arid areas, food shortage is a common problem amongst small scale farmers. This shortage is caused by low crop yields due to inadequate soil moisture for plant growth and declining soil fertility (Baron *et al*. (2005). In these areas, the effect of erratic rainfall on crop yield is important and therefore, efficient rain water management is important (Haibu *et al*., 2006). Soil erosion is the major cause of nutrient loss mostly where agronomic inputs are low and under scarce vegetation cover (Powlson *et al*., 2010). Soil erosion has a direct negative effect on land productivity since it leads to loss of soil, water and nutrients (Stolte *et al*., 2009). Nutrient loss and water deficit especially at the root zone are important factors limiting crop production (Bossio *et al*., 2010). Increased soil storage at the root zone (in situ water conservation) reduces run-off as well as soil loss (Ngigi *et al*., 2006). Since there is a strong relationship between soil and water conservation hence, it is important to address the two concurrently.

Rainfall in semi-arid areas is inadequate and un-predictable. In addition, soil impoverishment in these regions is associated with poor farming practices coupled with low application of fertilizers. The soils in semi-arid areas are characterized by low water holding capacity and low organic matter content (Mora - Vallejo *et al*., 2008). The average maize yield by the farmers in the study area is less than 0.5 t/ha. This is only 1/3 of the potential (NEMA, 2013). Therefore, integrating tied ridges, fertilizer micro-dosing and cropping systems could be a viable solution to effective sustainable crop production. This study was carried out to determine the effect of tied ridges, fertilizer micro-dosing and cropping systems on soil properties (soil organic carbon and pH) and maize yield in semi-arid Eastern Kenya.

Study site description; The experiment was carried out in Machakos County which is located in the Eastern part of Kenya. The County is dominated by agro - climate zones IV and V (Karuma *et al*., 2014) with an altitude of 400 to 2100 meters above the sea level (Claessens *et al*., 2012). The climate in Machakos County is characterized as semi - arid with bimodal rainfall pattern, giving two unique rainy and dry seasons. The mean annual rainfall ranges between 500 - 900 mm; with a high inter - seasonal rainfall variation and the co-efficient of variation is 28% ((Mora - Vallejo *et al*., 2008). The mean annual temperatures range from a mean minimum of 15oC to a mean maximum of 25oC (Muhammed *et al*., 2010). In Machakos County, majority of the soils reflect largely metamorphic parent rock and rainfall patterns which play a key role in their formation. The dominant soils are Alfisols, Ultisols, Oxisols and Lithic soils (FAO, 1970) with low fertility and are highly susceptible to erosion. In addition, less than 20% of the soils are well drained. The soil pH was determined by following the procedure outlined by Okalebo *et al*. (2002) while for the organic carbon, modified Walkley and Black oxidation procedure described by Ryan *et al*., (2001).

Results

The soil pH, organic carbon and maize yields varied significantly ($P < 0.001$) between the treatments. Overall, the highest numerical pH value was observed from treatment combination between farm yard manure 5 t/ha with maize mono crop (6.32). This was followed by farm yard manure 5 t/ha with maize mono crop (6.31). In relation to soil organic carbon, the highest mean was given by farmyard manure 5 t/ha +20 kgN/ha with maize monocrop (1.04%); followed by farm yard manure 5 t/ha with maize-cowpea intercrop (1.03%) (Table 1).

During the short rains 2015, treatment combination between maize cowpea intercrop with farmyard manure at 5 t/ha under flat bed registered numerically higher means for grain yield (3.59 t/ha), stover yield (3.13 t/ha) and dry biomass (7.73 t/ha) (Table 2). However during the long rains 2016, treatment combination between maize monocrop with an addition of 20 kgN/ha under tied ridges gave numerically higher mean for grain yield (0.67 t/ha) and dry biomass (2.81 t/ha) while maize monocrop with farmyard manure under tied ridges had the highest mean for stover yield (0.26 t/ha). Maize monocrop with farmyard manure 5 t/ha + 20 kgN/ha under tied ridging registered the highest mean for harvest index (0.26) (Table 2).

Discussion

Application of farmyard manure to the soil leads to absorption or binding of hydrogen ions in the humic forms which increases soil acidity. Farmyard manure also increases chemical activities in the soil which in turn increases soil acidity. In addition, during decomposition of the farmyard manure, several organic oxides are released and synthesized. The carbon (iv) oxide produced during decomposition dissolves in water to form hydrocarbonic acid making soil more acidic (Ashiono *et al*., 2006). This explains why application of farmyard manure increased soil acidity.

The increased soil organic carbon in treatments with farmyard manure could be attributed to improved nutrient availability for the soil micro-organisms increasing their activity. This resulted to increased mineralization and therefore higher soil organic carbon (Antil *et al*., 2001). The increased yields during short rains 2015 could be as a result of high rainfall which was above average (574 mm) as compared to the amount received during the long rains 2016 (96 mm). This increased the soil moisture thus, enhancing growth. Higher moisture status increases root profile ration and enhances availability of nutrients to crop roots improving yields (Sarkar, 2005).The increased yields in treatments with maize cow pea intercrop was as a result of benefits of intercropping in improving yields. This is because environmental resources like water, light and nutrients are more effectively used as compared to monocropping (Tadesse *et al*., 2012).

Conclusion

The optimum pH value for growing maize ranges from 6 – 7.2. Therefore, it may be concluded that, application of farm yard manure (5 t/ha) with maize cowpea intercrop resulted in optimum pH value for maize growth. Also, application of FYM at 5 t/ha + 20 kgN/ha increased the amount of organic carbon in the soil more than the control. In maize production, soil moisture and nutrients are important aspects to be addressed since they significantly affected yields. In addition, effectiveness of tied ridging was feasible during the long rains when the amount of rainfall received was very low. This means that the effectiveness of soil management technologies in semi-arid areas is also

determined by seasonal rainfall variations.

Table I. Effect of fertilizer micro-dosing and cropping systems on soil organic carbon and pH

Treatments	Initial organic carbon (%)	Final organic carbon (%)	Change in organic carbon (%)	Initial soil PHwater	Final soil PHwater	Change in soil PHwater
Farm yard manure 0t/ha x maize mono crop	0.67	0.91bc	0.37	6.54	5.96cd	-0.58cd
Farm yard manure 0t/ha x maize cow pea intercrop	0.67	0.88c	0.35	6.54	6.06c	-0.48bc
Farm yard manure5t/ha x maize mono crop	0.67	1.00ab	0.45	6.54	6.31a	-0.23a
Farm yard manure 5t/ha x maize cow pea intercrop	0.67	1.03ab	0.47	6.54	6.32a	-0.22a
20kg nitrogen/ha x maize mono crop	0.67	0.84c	0.21	6.54	5.78e	-0.76e
20kg nitrogen/ha x maize cow pea intercrop	0.67	0.92bc	0.26	6.54	5.84de	-0.70de
Farm yard manure 5t/ha +20kg nitrogen/ha x maize mono crop	0.67	1.04a	0.37	6.54	6.10bc	-0.44bc
Farm yard manure 5t/ha +20kg nitrogen/ha x maize cow pea intercrop	0.67	1.02ab	0.32	6.54	6.12a	-0.42b
P value		0.005	0.092		< 0.001	< 0.001
s.e.d		0.0603	0.0906		0.0712	0.0712

*Means with the same letter in each column are not significantly different at $P < 0.05$

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