Original Research Article

FARMERS' RESPONSE TO ORGANIC AND INORGANIC FERTILIZER UTILIZATION ON MAIZE CROPPING SYSTEMS IN KISII COUNTY, KENYA

Abstract

Decline in soil fertility has been identified as a major factor hindering maize productivity globally; the majority of these soils are deficient in nitrogen, phosphorous and organic matters. Low maize productivity in Kenya is attributed to decline in soil fertility. Improving soil fertility is necessary to achieve sustainable maize productivity among small-scaled farmers. However, farmers' response toward the application of fertilizers is not enough. This study sought to determine farmers' response towards the usage of organic and inorganic fertilizer in maize cropping systems among the maize producers. A simple random sampling technique was employed to achieve a sample size of 246 respondents from accessible household population of 10,800 maize farmers. A structured questionnaire was used to collect data, which was then subjected to Microsoft Excel and Statistical Package for Social Sciences (SPSS) software (Version 20) for analysis. The findings indicated that, the mean age of the farming population was 42 years with an average farming experience of 18 years. Majority of the farmers had secondary education as their highest level of education. The findings revealed that 90.2% of the farmers use di-ammonium phosphate (DAP) fertilizer; the findings further indicated that there was prolonged single use of DAP fertilizer in the same piece of land for a period of 6-10 years continuously. 84.1% of farmers applied inorganic fertilizer while, 58.9% used manure or manure and inorganic fertilizer. In terms of soil analysis and replenishment, the findings revealed that there was poor response towards soil testing and lime application. A further 94.7% of the farmers indicated they had never carried out soil testing in their farm while 92.3% of the farmers had not applied lime to normalize soil pH. Farmers in Kisii County need seek for soil testing services as a guide to determine which fertilizer to be applied and use of lime if it is needed be as well as use of organic manure to improve soil properties and also make use of zero-tillage method of cultivation to allow soil nutrients built up. These recommendations will lead to an increase in production of maize to an optimal level in Kenya.

Key words: *Maize productivity; Soil fertility; Organic manure; Inorganic fertilizer; Soil pH*

Background of the Study

Soil fertility decline has been identified as a major factor hindering maize productivity globally and the majority of the soils in the region are deficient in nitrogen, phosphorus and organic matters. Nitrogen is an integral component for many elements and enzymes necessary for plant to carry out its physiological processes (Ali *et al.*, 2011), Nitrogen therefore plays a significant role in improving soil fertility and increasing crop productivity (Habtegebrial *et al.* 2007).

According to Ogola *et al.* (2002), nitrogen application to the soil contributes to increased grain yield up to between 43% to 68% and biomass of 25% to 42% in maize cropping systems. There is also a positive interaction between the organic manures and urea as nitrogen source (Yang *et al.* 2007). Synergistic effects of N with organic fertilizers (Animal residue or FYM) accumulate more soil total N (Huang *et al.* 2007 & Zada *et al.* 2000), but sole effects of FYM result in increased yield of maize (Anatoliy & Thelen, 2007), studies have shown that, 44% of organic matter in the soils improves soil porosity to about 25% and water holding capacity 16 times (Gangwar *et al.* 2006). Agricultural scientists are engaged to establish agricultural systems with lower production cost and conserving the natural resources. Therefore, recent interest in the manuring has re-emerged because of escalated prices of fertilizer and importance of farm yard manure, green manure and poultry manure in maintaining long term soil productivity besides meeting timely nutrient requirements (Ali *et al*. 2011).

The problem of soil fertility decline is widespread in Sub-Saharan Africa, largely as a consequence of continued cultivation of crops with low levels of nutrient inputs (Zingore, 2011). To counter growing maize shortage, there are renewed efforts to support the predominantly subsistence farmers to intensify crop production mainly by increasing the utilization of fertilizers by introducing improved crop varieties. Soil fertility varies considerably at the farm and landscape levels in many small-scaled maize farming systems in Africa, leading to variable crop productivity and crop response to additions of inorganic and organic nutrient (Zingore *et al*., 2007).

Generally low maize productivity among the small-scaled maize farmers in Kenya is attributed to decline in soil fertility (Mugwe *et al*., 2008). Improving soil fertility is important to achieve sustainable maize productivity; however farmers' response toward the utilization of organic and inorganic fertilizers is apparently poor. According to Okalebo *et al.*(2006), the application of inorganic fertilizer and manure are some of the scientific recommendations that might improve soil fertility. But, some farmers lack technical know-how as to which kinds and rates of fertilizers are suitable (Hopkins *et al*., 2008).

The application of inorganic fertilizer is one of the quickest and easiest ways of increasing maize productivity per unit area. However, the problem with inorganic fertilizer nutrient supplementation is that it leads to pollution of ground water and does not improve soil structure (Khaliq *et al*., 2004). Moreover, required chemical fertilizers are not readily available to farmers at the right time and the prices are very high (Khan *et al*., 2005). Many crop species respond well to the application of organic manure than inorganic fertilizers, these crops can sustain yield under continuous cropping on various textured soils (Maynard, 1991).

Crop husbandry measures necessary to achieve the maximum possible maize productivity should be adhered to without compromising the land's productive sustainability. Conversely, misusage of fertilizer by most farmers has caused high soil acidity as several studies have shown that, prolonged single use of di-ammonium phosphate (DAP) fertilizer for instance, is partly responsible for the high acidity in the soil, which is highly practiced in the region. The study was therefore conducted to determine farmers' response to application of organic and inorganic fertilizers in maize production in the region of Kenya.

METHODOLOGY

The study Area

Kisii County was chosen as the study area because of its potential to agricultural activity. It lies between a latitude of 0 30‘ and 1 0‘ South and longitude 34 38‘ and 35 0‘ East. The County covers an area of 1,317 km^2 with a total population of 1,152,282 and 245,029 households. The county exhibits a highland equatorial climate resulting into a bimodal rainfall pattern with average annual rainfall of 1,500 mm with the long rains between March and June while the short rains are received from September to November. The months of July and January are relatively dry with maximum temperatures ranging between 21– 30°C and minimum temperatures ranging between 15– 20°C. The region has a great diversity of 20 different types of soils, although nitosols (49%) and pheozomes (13%) are the most common, occurring in all the districts. Others include vertisols (2%), planosols (8%), solonetz (0.8%), gleysols (2%) and greyzems (4%) constituting 16.8% of the total soil that are poorly drained and thus require specific agronomic management practices in order to ensure high crop productivity. The high and reliable rainfall coupled with moderate temperatures is suitable for growing maize and other crops such as beans, bananas, tea, coffee and pyrethrum as well as dairy farming.

Sampling and Data Collection Procedures:

The target populations for the study were maize farmers. Simple random sampling was used to select the sample for the study from the accessible household population of 10,800 maize farmers. Fisher formula was used to derive a representative sample size of 246 respondents

(Mugenda & Mugenda, 1999). A questionnaire with open and closed ended question was administered to the farmers at the farm level to collect data concerning farming and other important information. Analysis was done with aid of Statistical Package for Social Sciences (SPSS) software version 20 and Microsoft excel.

RESULTS AND DISCUSSIONS

Distribution of Farmers according to their Age Bracket and Level of Education

Majority of the farming population in Kisii County are of age bracket of 36-55 years which is translated to 48.0 % followed by youth age of 18 -35 years translated to 30.0 % (Table 1). The age of the respondents was used as a proxy for farming experience; the finding indicated that, the average age of farming population was 42 years. The findings are in a good agreement with Mironga, (2005), (though slightly lower) that, the average age of Kisii farmers was 40.5 years. The age was therefore included to evaluate the effect of age on soil management. It is believed that, younger farmers can be more active for carrying out their farming operations than the older farmers. It is possible that older farmers may be traditional and conservative to change, and thus show less willingness to adopt new farming technology aimed at increasing maize yield and soil fertility improvement.

The respondents were of diverse levels of education ranging from illiterate to educated farmers. The findings indicated that illiterate group was 4.9%, farmers with primary education being 25.6%, secondary level were 32.1%, middle level college were 22.0% and those with University education were 15.4 %. The result indicated that majority of the farmers in Kisii County had secondary education as their highest level of education. The level of education plays a major role in farmers' decision making especially in the improvement of soil fertility through proper utilization of organic and inorganic fertilizers and also the adoption of improved maize production technologies. The number of years when a person spent in formal education is one of the most important determinants to increased farmers knowledge. Educated farmers usually have a better opportunity to access information on new technologies and are generally able to assimilate, to process and to use this information to manage their soils for better production (Table 2).

Table 1: Age of the respondents

Age bracket of the respondents	Frequency	Percent (%)
18-35	74	30.0
36-55	118	48.0
56-69	46	18.7
70 and above	8	3.3
Total	246	100.0

Table 2: Educational levels of the respondents

Level of education	Frequency	Percent (%)
Illiterate	12	4.9
Primary	63	25.6
Secondary	79	32.1
Middle level college	54	22.0
University	38	15.4
Total	246	100.0

Farmers' response towards organic and inorganic fertilizer applications

About 84.1% of the farmers indicated that, they used inorganic fertilizer to improve maize productivity and soil fertility as well, whereas 13.8% of the farmers indicated that they did not use inorganic fertilizers. On the other hand, about 58.9% of farmers indicated that they use manure (Animal manure and FYM) while 38.2% that they did not use manure in their farm. This is a clear evident that there is imbalance between organic and inorganic fertilizers application in the region. Studies have shown that inorganic fertilizer utilization is one of the quickest and easiest ways of increasing maize yields per unit area. However, the problem with nutrient supplementation of inorganic fertilizers has no significant improvement to soil structure (Khaliq *et al*., 2004). According to Khan *et al*. (2005), inorganic fertilizers are not readily accessible to all farmers due to its escalating costs. This study concur with Kamoni, (2009) that, continuous application of DAP fertilizer for a long period of time results to lowering soil pH. From the findings, it's evident that 90.2% of Kisii County farmers use DAP fertilizer for a period between 6 to 10 years consecutively, which is indicated that most soils in the region have accumulated acidity (Table 3).

Utilization of organic fertilizer in Kisii County is fairly good. The percentage ratio of farmers who use manure to that who do not use is 3:2 in Table 3. Increased application of organic manure improves soil organic matter as many studies in Sub Saharan Africa (SSA) which have reported on the positive interaction of applying organic manure and maintaining soil fertility (Mtambanengwe & Mapfumo, 2005; Zingore *et al*., 2008). Previous studies have shown that application of organic manure significantly impact the physical, biological and chemical properties of the soils better, which are mostly due to an increased soil organic matter resulting from manure application (Shirani *et al*., 2002; Bakayoko *et al*., 2009; Liang *et al*., 2011).

Organic manure therefore is an excellent source of major plant nutrients such as nitrogen (N), phosphorus (P) and potassium (K) and also provides many of the secondary nutrients required by the plants. The effect of manure application on soil physical properties include increased infiltration (Risse *et al*., 2006), water holding capacity (Rasoulzadeh & Yaghoubi, 2010; Liang *et al*., 2011; Salahin *et al*., 2011) and reduced compaction and erosion (Salahin *et al*., 2011). These findings are divergent from Makokha *et al*. (2001) in the points of view that manure is the most widely used organic fertilizer by approximately 80% of households in Central Highland of Kenya.

Table 3: Use of organic and inorganic fertilizers

	Use of inorganic fertilizer		Use of manure		Use of DAP	
Responses	Frequency	%	Frequency	%	Frequency	%
No	34	13.8	94	38.2	16	6.5
Yes	207	84. 1	145	58.9	222	90.2
No response	5	2.1	7	2.9	8	3.3
Total	246	100.0	246	100.0	246	100.0

Response towards soil testing and lime applications

Soil analysis and lime application was generally poor in the region. Majority of the farmers represented by 94.7% indicated that they did not carry out soil analysis to check the status of the soil property. In addition, they claimed that, the process of soil analysis is tedious and too costly and the distance to the nearest soil testing research station is far and expensive, while only 4.9% of the farmers carried soil sampling. About 92.3% had never used lime for the reasons that, they had never heard about the lime and its importance, whereas 7.3% of the farmers applied lime (Table 4).

Soil testing is a valuable tool for determining the inputs required for efficient and economic production. A proper soil test ensures the application of enough and right fertilizer to meet the requirements of the crop, and taking advantage of the nutrients already present in the soil. It also allows the farmers to determine lime application. Soil testing is also a requirement for farms to complete a nutrient management plan. The application of lime tends to raise the soil pH by displacement of H^{+}, $Fe^{2+,}$ Al^{3+}, Mn^{4+} and Cu^{2+} ions from soil adsorption site (Onwonga *et al.*, 2010). More than increasing soil pH, it also supplies significant amounts of Ca and Mg, depending on the type of lime. Indirect effects of lime include increased availability of P, Mo and B, and more favorable conditions for microbial mediated reactions such as nitrogen fixation and nitrification, and in some cases soil structures are also improved (Crawford *et al.*, 2008). Increase in soil pH and reduction of soil exchangeable acidity following application of manure and lime either sole or combined can be attributed to the release of organic acids which in turn may have suppressed aluminum (Al) content in the soil through chelation (Okwuagwu *et al.*, 2003 & Onwonga *et al.*, 2008). The presence of Al contents in the soils reduces soil pH, leading to soil acidity. Moreover, when lime is applied in these soils, reaction with water leads to the production of OH^{-} ions and Ca^{2+} ions which displace H^{+} and Al^{3+} ions (which are responsible for low soil pH) from soil adsorption sites resulting in an increase in soil pH (Kisinyo *et al.*, 2012).

Table 4: Farmers' response towards soil testing and lime applications

Responses	Carrying out Soil testing Frequency	Percent (%)	Use of Lime Frequency	Percent (%)
No	233	94.7	227	92.3
Yes	12	4.9	18	7.3
No response	1	0.4	1	0.4
Total	246	100.0	246	100.0

Maize crop rotation and intercropping in the Kisii County

The response towards crop rotation and maize intercropping was good. The finding indicated that, about 78.9% of the farmers rotate their crop whereas 20.7% did not do crop rotation. On the other hand, about 95.1% of the farmers were intercropping maize with leguminous plants such as beans, soybean and groundnuts and other root crops such as, sweet potato, irish potato and cassava whereas, 4.9% of the farmers did not intercrop maize with any other crops (Table 5).

According to Giller *et al*. (1997), various legume-based technologies such as rotations of cereal crops with grain legumes has been advocated as viable option for providing supplementary N to cereal crops through biological N fixation. Moreover, the yield of maize following groundnut is greater than continuously fertilized maize, but soybean has no effect on maize productivity Groundnuts can double the yields of maize crop in the subsequent season without fertilizer application but gave more additional grain yield of maize when fertilizer are used on the maize cropping.

Intercropping maize with grain legumes offers opportunities to improve overall productivity of both crops, and ensures the legume's benefit from fertilizer targeted to maize. Intercrops can result in increased grain output over maize alone, both with and without fertilizers (Snapp & Silim, 2002).

Studies have shown that, a meta-analysis of fertilizer response under agro-forestry in small-scaled farming systems gave better maize yield response than legume trees and green manures. However, maize yield response to fertilizer application in the tree legumes systems is significantly higher than in green manures, natural fallows, and unfertilized maize (Sileshi *et al*., (2008). Strategically targeting fertilizer use to variable soil fertility conditions, combined with recycling crop residues, manure application, and various legume-based technologies is necessary for viable fertilizer use in small-scaled farming systems in SSA (Giller *et al*., 2006).

Table 5: Crop rotation and maize-intercropping in maize producers.

	Crop rotation		Maize intercropping	
Response	Frequency	Percent (%)	Frequency	Percent (%)
No	51	20.7	12	4.9
Yes	194	78.9	234	95.1
No response	1	0.4	-	-
Total	246	100	246	100

CONCLUSION AND RECOMMENDATIONS

Continuous application of DAP fertilizer for a long period of time may result to lowering soil pH inhibiting uptake of some nutrients in maize crop. The application of organic nutrient resources, such as compost and animal manures plays an important role in replenishing soil fertility and improving other soil characteristics. Similarly application of lime, crop rotation and intercropping maize with leguminous cereal crops such as groundnut, beans and soybeans increases maize yields and soil fertility as well. It is recommended that farmers should seek alternative fertilizer for basal application of NPK to substitute with DAP application in the region, use lime and organic manure to improve soil properties and also make use of zero tillage method of cultivation to allow soil nutrients built up.

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