SOIL FERTILITY MANAGEMENT AND AGRICULTURAL PRODUCTIVITY IN EASTERN KENYA
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Introduction
Eastern Province has an area of 160,405 sq. km, being the second largest province in the country. The province covers a wide range of agro-ecological zones, from mountainous and medium zones to low semi-arid and arid zones. The high and medium potential areas cover about 30% (with 700 to 2000 mm annual rainfall), while the remaining 70% is arid and semi arid land (with 200 to 700 mm annual rainfall). The soils are equally as diverse as AEZs, both of which dictate a wide range of crop and livestock production activities in the province. Administratively the province has 25 districts with an estimated population of about 6 million people while the number of farm families is estimated to be 950,000. Due to rapidly increasing population, the pressure on land, both in high potential and ASAL areas has contributed to extensive subdivision of land at times to uneconomical farm holdings. The poverty index in the province stands at 52%

Soil fertility: Quality of the soil that enable it to supply plant nutrients in available forms, adequate amounts & balanced proportions necessary for plant growth when other factors are favourable. Management aims at maintaining or improving the fertility of any particular soil (Mugendi D.N., et al 2006).

Soil productivity: Describes the ability of the soil to support crops when cultivated correctly. Productivity of any soil is determined by its fertility status. A highly fertile soil will be highly productive whereas soil with low fertility will equally be poorly productive. Any activities or measure that aim at maintaining or improving soil fertility will also go along way in ensuring that the land remains productive. It is therefore paramount that soil fertility should be properly maintained and even continually improved in order to maintain or improve agricultural productivity. This will ensure food security both at household, community and national level (Mugendi D.N., et al 2006).

There are many measures that have been employed by farmers in Eastern Kenya to maintain soil fertility status of their soils. These include among others, shifting cultivation, use of inorganic amendments, application of farm yard and compost manures, use of nitrogen-fixing and incorporation of crop residues, conservation agriculture and soil conservation measures.

Prevailing methods of maintaining soil fertility

1. Shifting cultivation.
This involves cultivation of a piece of fallow land by clearing and burning the trash. The land is cultivated for 2 to 3 years and then left fallow for 2 to 10years. This method is outdated in many areas due to population pressure but is still maintained in the semi-arid areas of Eastern Kenya particularly in Tharaka, Mbere, and great parts of Machakos and Kitui districts. During the first year, the land is highly productive but yields fall subsequently since no fertility measures are put in place. The farmer then moves to anew locality leaving the land to regenerate. This method is still
applicable in places land is in plenty and undemarcated. However, as the population pressure increases the practice has no future even in the marginal areas.

2. Use of inorganic soil amendments

Judicious application of inorganic fertilizers is recognized as an indispensable means of overcoming soil fertility decline not only in Eastern Kenya but in the entire east African region. Inorganic nutrient sources are essential inputs used for maintaining and/or increasing the soil fertility levels in intensive agricultural systems. They primarily supply the crop with essential nutrients or facilitate uptake of a particular nutrient. In most soils of eastern Kenya, nitrogen and phosphorus have to be applied regularly to compensate for the amounts exported from the soil by harvested crop products. Other losses of N and K include leaching.

In the sub-humid parts of eastern Kenya, the rates of inorganic fertilizers used are estimated to be between 15-20 kg N ha\(^{-1}\). The main sources of inorganic nutrients include CAN, DAP, 23.23.0, 20.20.0, 17.17.17. The main consumers of these fertilizer materials are cash crop enterprises such as coffee, tea and horticulture. The current price of DAP and 20:20:0 is approximately Kshs. 2,800 and 2,200 respectively.

In the semi-arid parts of eastern Kenya, inorganic fertilizers are rarely used or used in fairly small quantities by the resource poor farmers (18%). This is attributed to the high cost as well as unavailability of these fertilizers in these areas. Further, many small holders have the perception that the use of inorganic fertilizers has an impoverishing effect on the soil. Continuous use of inorganic fertilizers especially those with high acidity like DAP and Urea without using organic materials and/or liming, has been found to result in decreased land productivity. This is due to increased soil acidity which leads to fixation of P and Al toxicity. Hence corrective measures must be continually put in place to maintain productivity.

3. Farm Yard Manures

Farm yard manure (FYM) is an organic by-product derived from either purely animal droppings or mixed with plant residues. In eastern Kenya, FYM is widely used across different farming systems as a source of nutrient and general soil fertility improvement. In the sub-humid parts of eastern Kenya, application rates of 4-10 tons' ha\(^{-1}\) are common. In the semi-arid parts of eastern Kenya, more than 80% of the farmers use FYM but the usage is restricted to small plots near the homestead due to transportation constraints. Though these areas produce sizeable quantities of FYM due to large livestock population, much of it is sold to farmers in the sub-humid areas (Mugendi D.N., et al 2006). Despite the importance of FYM as a source of nutrients and in improving soil properties, its usefulness in eastern Kenya is limited due to the variable composition and the large quantities needed to provide adequate plant nutrients. Further its nutrients composition remains very variable due to the materials used for feeding and animal beddings. The poor handling and storage also contribute to the low quality of FYM in most farms. The general concentrations of main nutrients in FYM reported in eastern Kenya is 0.42%N, 0.17%P and 0.88%K. FYM and compost manure on their own cannot supplying all the needed nutrients. Hence an addition of some inorganic fertilizers is necessary to supply the necessary nutrients. Despite the shortcomings and deficiencies in compost and FYM as a source of crop nutrients, they will remain key source for soil fertility management in both the wet and drier parts of eastern Kenya.
Figures 1 and 2 show results obtained when manure, fertilizer and other fertility practices are applied to maize crops in different parts of eastern Kenya.

Other technologies used in the province especially by small scale farmers include green and compost manure. Composting is done by small scale farmers where other types of manure are either not available or expensive for the farmers. The application of compost manure in kitchen gardening is of great importance in many households in the province. This year, 1200 groups comprising 15,000 farmers were trained on kitchen gardening. Kitchen gardening involves intensive production of vegetables,
herbs and some fruits. These are cheap and accessible sources of micronutrients, whose intake in diets contributes greatly to food and nutrition security. The role of 4K clubs in the promotion and use of compost manure cannot be underestimated. School gardens, operated by the 4K clubs have continuously been used as demonstration sites for compost making. This year, 405 crop projects covering 105 acres have so far been put under crop production in primary schools under compost manure (PDA Eastern Reports, 2007).

4. N2-Fixing Legumes and Plant Residues
Legumes form an integral part of the farming systems of eastern Kenya. The grain legumes that are grown include dry bean (Phaseolus vulgaris), cow peas (Vigna ungiiculata), pigeon peas (Cajanas cajan), and dolichos (Dolichos lablab). These legumes have the potential to fix N\textsubscript{2} through biological nitrogen fixation in environments where they grow. Some legumes are more efficient than others in their ability to fix N\textsubscript{2}. In eastern Kenya, cowpeas have been reported to fix between 73-80kg N ha\textsuperscript{-1}, pigeon peas between 65-85 kg N ha\textsuperscript{-1} while dry beans inoculated or uninoculated have in most cases failed to fix any N\textsubscript{2}. However, the effectiveness of a legume to enhance soil nitrogen is only realized if the residues are returned into the soil. In situations where most of the nitrogen is carried away in the grain as crop harvest i.e. the legume has a high Nitrogen and harvest index, such legumes do not enhance the soil nitrogen in the immediate environments where they are grown. In Eastern Kenya several use of crop residues as a method of soil fertility enhancement occurs mainly in the semi-arid areas where trash lines used against soil erosion are left to decompose in the farms.

5. Organic and Inorganic Nutrient Combinations
Fertilizer used effectively is essential to attain sustainable agricultural growth. Technologies that use organic resources are also essential, more appropriate and feasible especially among the resource poor farmers who represent a greater number in Eastern Kenya. Traditional organic materials such as crop residues and animal manure however cannot themselves reverse soil fertility decline because they are not available sufficiently large quantities. In most farms low nutrient content and high labour demand in the processing and application also limit their use. The technologies that combine mineral fertilizers with organic nutrients sources are a better option in Eastern Kenya where the levels of mineral fertilizer used is relatively low. This is useful in,
- Increasing fertilizer use efficiency
- Reducing risks of acidification
- Providing a more balanced support of nutrients
- Providing additional physical, chemical and biological benefits by the organic materials and prevention of nutrient deficiencies

6. Conservation Agriculture (CA)
Conservation Agriculture is a package of many soil fertility management practices. It aims to produce high crop yields while reducing production costs, maintaining the soil fertility and conserving water. It is a way to achieve sustainable agriculture and improve livelihoods. It has three basic principles
a) Disturb the soil as little as possible
b) Keep the soil covered as much as possible
c) Mix and rotate crops
In Conservation Agriculture, crop residues are left on the field, mulch and special cover crops protect the soil from erosion and limit weed growth throughout the year. Planting of the right mix of crops in the same field and rotating of the crops from season to season are part of the CA package.

Conservation Agriculture retains water in the soil, keeps the soil temperature even and protects the land from severe erosion. This technology is quite new in the province and at infancy/demonstrative stage. It has however been found to give increased Agricultural Productivity in other areas in Kenya and is therefore expected to yield good results in Eastern Kenya. Experimental sites have been established in all the districts in the province spearheaded by Siakago and Machakos Agricultural Technology Development Centres (ATDC).

7. Soil Conservation methods/measures

Unprotected soil is exposed and liable to erosion by several agents like water and wind. Any loss of the top most part of the soil has got negative impacts on the fertility of the soil and thus its production capability. Several measures are being practiced in order to maintain fertility thus enhancing productivity. These methods include,

   a) Agronomical Methods

Strip Cropping
Strip cropping is the farming of the sloping land in alternate, contoured strips of inter-tilled row crops and close growing grasses (or other crops ground cover crops) aligned at right angles to the direction of natural flow of runoff. The close-growing strips slow down runoff and filter out soil washed from the land in the inter-tilled row. This control of runoff also allows increased opportunity for infiltration of the runoff and thus increased moisture in the soil. This practice requires a lot of land and it is only practiced in the low-lying areas where population pressure is not high.

Trash lines
Trash lines made by laying crop residues or trash in lines along the contour as shown in Fig. 4 They slow down runoff and trap eroded soil eventually forming terraces. This is practiced where and when crop residues are available.

Grass Barrier Strips
The barrier strips are planted along the contours. They are planted with fodder grass such as Napier or are left with natural grass as shown in fig.5. This practice is common in the hilly areas even on the slopes as steep as 35%.

Agro-forestry
Agro-forestry is practiced a lot by the farmers especially those on high and medium potential areas.
**Contour Farming.**
This involves aligning plant rows and tillage lines at right angles to the normal flow of runoff. It creates detention storage within the soil surface horizon and slows down the rate of runoff, thus giving the water the time to infiltrate into the soil.

**b) Mechanical Protection Works**

**Terraces**
Fanya Juu terraces shown in Fig.6 have an origin in the province. A Fanya Juu terrace is constructed by digging a trench and throwing the soil uphill to form an embankment. They are either retention or graded channels so as to retain or drain excess water. Soil and rainwater are conserved within the bunds and the bunds are usually established with planted fodder grasses.

**Check Dams.**
They are structures built across a gully or a small stream. They are meant to check and control the growth of a gully and help in its healing. They are used to trap water and either stores it for future use or allows it to infiltrate into the soil slowly without causing any major damage to the land and at the same time trap any soil that is being carried by the flowing water. There are various types of check dams depending on the material used. The following are found in the district,

(a) Gabions – Basically made of wire mesh boxes filled with stones.
(b) Sisal embankments – Sisal has proved to be a very effective form of embankment. When planted across a gully, it is able to grow well and hold the soil and reduce the erosive power of the flowing water.
(c) Stone Walls – Stonewalls have been constructed across gullies and streams to store the water that is flowing and also trap any soil that may be flowing along with the water. The walls are made where stone is locally available. Fig. 7 shows bench terraces and stone terraces respectively.
(d) Trash walls – Trash has also been used to create a wall for trapping the soil and reducing the velocity of flow of the water. The most common materials are tree branches, sorghum trash, maize stalks, etc.

8. The National Accelerated Agricultural Inputs Access Program – NAAIAP

The project has been established in the whole country to address declining agricultural productivity due to depletion of soil nutrients especially among the poor farmers. The primary objective of the project is to improve input access and affordability of the key inputs for millions of small scale farmers, particularly those living below the absolute poverty line so that they can get out of the vicious cycle of poverty and participate in agriculture as a business enterprise. It covers 8 districts (Meru North, Meru Central, Meru South, Tharaka, Embu, Machakos, Makuени, and Mwingi) in Eastern province with 2 divisions in each district as pilot areas. 1000 farmers have been selected per district and each farmer is getting Kshs. 6,000. The total funding for the province is about Kshs. 50 million this year. There are 7 main components,

- Inputs Supply and Utilization,
- Marketing,
The program will involve several stakeholders, NGOs, MFIs, Development partners and institutions among them the Provincial Administration, District Social Development Officers, Stakeholder For a, SACRED Africa, AGMARK, KACE, Rockefeller Foundation, STAK, KEPHIS, NCPB, etc.

Conclusion

Reports indicate that the average yield of maize and beans was 62% and 77% higher respectively in high potential areas where soil conservation was done. In the semi arid areas the yield realized was 47 & 67 % higher for maize and beans respectively (Soil and Water Conservation Manual, Ministry of Agriculture). It is necessary to maintain soil fertility for continued crop production and livelihood sustenance. This cannot be achieved by a single ministry but it takes the effort of all stakeholders to continuously educate our farmers. This would enable them to move from being receivers of famine relief to contributors of sustainable development.

The inter-relationship between different factors that are responsible for low soil fertility in eastern Kenya can be summarised as follows:

REFERENCES

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