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# Economic Analysis of Use of Non-Conventional Fertilizers in Maize and Bean Production in Vihiga County, Kenya

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**Abstract:** The majority of smallholder maize farmers in the study area depend on farming whose returns are very low. This, together with low soil fertility and the inability of farmers to purchase chemical fertilizers, has resulted in the undertaking of research on non-conventional fertilizers, mainly organic fertilizers, by researchers in research institutions, universities, and NGOs. Researchers have registered high yield responses to the use of non-conventional fertilizers in demonstration farms and extension agents have been tasked with promoting the use of the fertilizers. Studies have shown that emphasis was put on informing farmers of the ability of the fertilizers to improve yields. Despite the high yields in research settings, smallholder farmers have continued to witness low crop yields. This begs the question, why was this the case? The purpose of this study was to analyze the promoted non-conventional fertilizers with the aim of determining whether there were significant profitability differences between their use and the use of inorganic fertilizers among smallholder farmers. The objective of this study was to carry out a comparative profitability analysis of the commonly used fertilizers, namely: inorganic fertilizers, farmyard, compost, agroforestry, and *Thithonia difersifolia* promoted in the study area. Stratified random sampling was used to select 150 respondents from Vihiga County, Kenya. Farmers were stratified into five strata based on the type of fertilizer that the farmers used, and at least 30 farmers were selected from each strata. Primary data was collected using questionnaires and the data collected was analyzed using net present value and gross margins. The results of the evaluation of the technologies on food production indicated that there were significant profitability differences at a 5% level between the use of non-conventional fertilizers and that of inorganic fertilizers. The study recommended that farmers be educated on the economics of the use of non-conventional fertilizers in order to enable them to select the most economically efficient technology. An economic analysis should also be done to determine the profitability of the use of non-conventional fertilizers on high-value crops such as vegetables and fruits. Maize/bean intercrop formed the basis of profitability analyses in this study because most farmers used them on the maize/ bean intercrop. Net present value profitability analysis should also be done on the use of organic materials on perennial crops such as fruits.

**Keywords:** Economic, Non-Conventional, Fertilizers, Maize, Bean, Production

## 1. Introduction

Farmers conventionally use chemical fertilizers. Continued use of chemical fertilizers result in loss of organic matter and living organisms that help to build quality soil [16]. The continued loss of plant nutrients through crop harvest removals, leaching and soil erosion and the inability of most farmers to replace the lost plant nutrients has diverted research and extension efforts to soil fertility technologies. Small scale farmers in Kenya often apply suboptimal levels of fertilizers making it hard for farmers to achieve potential yields of hybrid crop varieties [17, 21, 20]. A research in Kakamega, showed that low levels of fertilizer usage resulted in producers making losses in using external input [18]. In addition, Diwani et al. [4] and Jindo et al. [11] reports low levels of fertilizer usage resulted in producers making losses in using external input in western region. The study proposed use of alternative soil fertility technologies other than the

unaffordable chemical fertilizers.

Hazra [9] and Fang et al. [8] proposed that organic fertilizer use in soil fertility management be promoted for being environmentally friendly and more cost effective than chemical fertilizers. Organic materials are applied in large amounts of up to 5.5 tons/ha [14, 6]. Organic fertilizers have residual effects in soil and use of recommended levels result in as good crop yields as chemical fertilizers [3, 15].

According to a 2013 report published by Agrarian Green Revolution for Agriculture (AGRA), an average of 32kg of chemical fertilizer is applied per hectare in Kenya. This is against the recommended 50 kg per hectare. The suboptimal use of chemical fertilizers is due to high fertilizer prices arising from weak or underdeveloped fertilizer markets and high transaction costs making fertilizers sell at prices beyond reach of majority of small-scale and subsistence farmers [5]. To enable smallholder farmers participate in agriculture, it was recommended that use a combination of organic and inorganic fertilizers be promoted. One of the big four agenda for the Jubilee Government (2017 to 2022) in Kenya was to achieve 100% National Food Security through the Ministry of Agriculture, Livestock, Fisheries and Irrigation. According to the Ministry of Agriculture, Livestock, Fisheries and Irrigation (2016), Kenya in 2016 received 104,000 tonne consignment of Government subsidized imported chemical fertilizer that was delivered to National Cereals and Produce Board (NCPB) stores countrywide and was distributed to farmers. Fertilizers were made available to all counties where farming was extensively practiced. Despite this, fertilizer are still out of reach of most smallholder farmers due to high prices and transaction costs.

Non-conventional fertilizers in this study refer to organic materials from plant and animal sources or mined rock minerals used to fortify organic materials. They include rock phosphate, an organic fertilizer that has for a long time been used in many parts of western Kenya under experimental conditions, agroforestry, compost manure, farm yard and *Tithonia diversofolia*. Organic fertilizers are often applied by broadcasting and hoeing or raking it into top soil. Some are added in small amounts to planting holes or rows as seeds are planted. This study evaluated four organic materials namely; agroforestry, compost manure, farm yard and *Tithonia diversofolia*. Organic materials that were fortified with rock phosphate were also evaluated in this study. In a study on the use of organic matter technologies in a combination with crops [22] it was shown that organic materials had lots of benefits to soil, to the environment and thus to farmers. According to Sharma & Singhvi, Africa's agricultural problems include exclusive use of chemical fertilizers [19]. Animal manure and plant materials however are bulky and unable to bring sufficient yield increases due to their low nutrient content, difficulties in preparation, lack of constant supply due to low livestock numbers and high labor needs for collection, storage, transportation and application in fields [7, 10]. Organic materials contain from 1- 4% Nitrogen-N (10-40g N/kg) on a dry weight basis, while inorganic fertilizers contain from 20-46% N (200-460 g N/kg) [13]. To haul 100 kg N needed for a 4 ton/ha maize crop, it takes 0.217 tons urea or 20 tons of leaf biomas [10]. Organic inputs are poor in Phosphorus (P) due to their low P concentration [2].

In promotion of non-conventional fertilizer technologies, research and extension activities have not emphasized on economics of use of the technologies. Researchers' interests have been on input and output interactions whereas extension agents have been interested in demonstrating how to use of the technologies and in encouraging farmers to adopt them in order to improve yields and realize research potential of technologies. Despite good and technically feasible results obtained under research conditions, crop yields remained low in farmers' fields. Most researchers continued to view technologies in terms of mandates of improving yield and economic analysis has not been part of it. For making rational choices of existing promoted soil fertility technologies it was important to undertake an economic evaluation of the promoted technologies in the study area. This study did an economic analysis of the commonly promoted non-conventional fertilizer technologies used on maize and bean production in Vihiga County of western Kenya. Performance of chemical fertilizers was also compared with that of non-conventional fertilizers. The study hypothesized that there were no significant profitability differences between the use of the selected non-conventional fertilizers and between non-conventional fertilizers and chemical fertilizers used in maize bean intercrop in the study area.

There are many sources of organic materials but only four of the commonly used technologies were considered in this comparative profitability analysis study. Among the agroforestry shrubs only two: *Crotalaria* and *Tephrosia* (with known nitrogen-fixing capabilities) were chosen. Other agroforestry plants in use were not analyzed. Soil fertility promoting technologies in the study were evaluated in terms of yield responses to use of the soil fertility technologies, cost of variable factors of production and economic analyses of the use of the promoted technologies. The economic analyses involved GMA, NPV and VCR. ANOVA was used to make comparative GMA. GM is an appropriate measure of profitability to adopt when comparing enterprises for short-run and for annual planning decisions [12]. It is used to select technologies that place similar demands upon limiting resources in production. Year-to-year technology decisions do not affect fixed costs. Return over variable costs is an appropriate profit indicator.

Vihiga County is made up of 6 divisions, 24 locations and 110 sub-locations covering three (Emuhaya, Luanda and Sabatia) out of six (Hamisi, Sabatia, Vihiga, Emuhaya, Tiriki, and Luanda) divisions that represented the two main AEZs of Vihiga County which are the major AEZs of Vihiga County. Vihiga was chosen since many research institutions were involved in promotion of organic fertilizers in the area. Vihiga County is characterized by undulating Hills and valleys with vast network of streams and brooks that serve rivers Esalwa & Yala. Vihiga's bimodal, reliable, adequate and well distributed rainfall of 1800-2200mm per annum

peaks in April and June for long rains and September and November for short rains. The County's warm and humid climate supports growing of most crops. However, the soils are of low fertility, limited water-holding capacity and are prone to erosion due to their sandy texture, high land use intensity and heavy rainstorms.

# 2. Research Methodology

This section presents sampling procedure, the sample frame, sample size, types and sources of data collected, data collection tools and data collection exercise as well data analysis tools.

### *2.1. Sampling Procedure*

The population was divided into three sampling units represented by three divisions (Emuhaya, Luanda and Sabatia) of Vihiga County based on agro-ecological zonation and prevalence of organic matter technologies under consideration. To reduce selection bias, random sampling of respondents was done Acharya et al. [1] through use of assigned random numbers.

### *2.2. Sample Frame*

The target population sampled was the set of resource poor farmers who used organic matter technologies that this study recognized as important in subsistence food (maize and bean) production in Vihiga County.

### *2.3. Sample Size*

The exact number of farmers chosen in each location depended on prevalence of the technologies the study focused on in the location. However, at least two farms were selected from each of the 20 sub-location. Data was collected from a total of 150 households. A household was the enumeration unit and was defined as decision-making unit at farm level. Use level of non-conventional fertilizers was found to be highly variable; farmers using amounts ranging from less than a gunny bag /ha to several bags/ha.

### *2.4. Data Collection Exercise*

Ten trained agriculture staff familiar with the local language/ customs served as enumerators and orally administered questionnaires during data collection exercise. Questionnaires were first pre-tested with a random sample of 15 resource poor farmers in Sabatia. Corrections and adoption of the questionnaires to the field situation was made before actual data collection was carried out.

### *2.5. Types and Sources of Data Collected*

Primary data was collected through administration of structured questionnaires. Information collected included those on maize bean intercrop enterprise on the farm, level of incomes and outputs, yield responses to soil fertility technologies under review, inputs and output prices, farmers' use levels of selected organic fertilizer. To get information on estimates of family income, respondents were interviewed on returns from a range of farm enterprises, and incomes from non-farm sources such as salaried employment, business and remittances. Operational costs considered included costs such as those of planting, collecting, preparing, carrying and application of organic materials, cost of crop protection, harvesting, handling and marketing of the produce and costs of labor which reflected the opportunity cost of own/household labor. Information on use levels of fortified or unfortified organic materials and associated crop yields were obtained from some selected farmers using the selected technologies in maize and bean production. The input and output prices were obtained from agriculture market survey data. The data collected from interviewed farmers was also complemented with data available in Kenya Agricultural Research Livestock Organisation (KALRO) Kakamega.

### *2.6. Data Analysis*

The Gross Margin analysis and Value to Cost ratios were used as proxies in the profitability analysis of the analyzed soil fertility technologies. The benefit associated with adoption of the promoted soil fertility technologies was mainly based on maize and bean intercrop yields. The farm gate price of maize was Kshs. 1800/ 90kg bag or 40/ 2kg tin while the price of beans was Kshs. 3600/90kg bag or Kshs. 80/ 2kg tin.

# 3. Results and Discussions

Comparative Profitability Analysis of Soil Fertility Technologies

The Gross Margin (GM) and Value to Cost Ratios (VCR) were carried out and used as proxies for profitability of use of selected soil fertility technologies on maize and bean intercrop farming. The results of the analyses are provided in the Table 1 below.

The GMA indicated that use of inorganic Fertilizers had the highest land, labor and capital productivity meaning use of inorganic fertilizers was more rewarding than use of organic materials in the study area. Farmers however used suboptimal levels as they could not afford to acquire optimal levels of inorganic fertilizers. Non-conventional fertilizers were the best alternative to inorganic fertilizer. Farmers used organic materials mainly *Tithonia* and farmyard but in suboptimal levels. The VCR of using agroforestry as a technology was the highest among the organic matter technologies reviewed in this study. Use of agroforestry shrubs (*Crotalaria* and *Tephrosia* species) on maize and bean production gave a profitability that was comparable to that of use of inorganic materials. Although *Tithonia* had high output thus high total revenue, the GM and VCR was lowered by the high labor demands of using it. Tithonia is bulky and hauling required amounts call for high labor costs. Farmyard and compost manures fortified with Rock Phosphate or inorganic fertilizers had low crop

yields and high labor costs lowering net returns to their use.

Land, labor and capital productivity of using unfortified Tithonia and production without fertilizers was negative. Apart from using unfortified *Tithonia diversifolia* farmers made positive returns to using all the analyzed soil fertility management technologies on maize bean production. From the results use of agroforestry as a soil management technology was the most profitable of all the organic fertilizer efficient use of land when other benefits of agroforestry are taken into account.

To test the null hypothesis that there were no significant profitability differences arising from the use of organic materials on maize and bean production, a single factor ANOVA was carried out. The results showed significant profitability differences between the organic materials at 95% confidence level. Agricultural extension agents thus need to educate farmer so that they can consider profitability differences in choice of technologies to adopt. To promote agroforestry it was noted that farmers needed to be supplied with agroforestry shrubs seeds as they were nor readily available.

***Table 1.*** *Results of Economic Evaluation of Organic Matter Technologies.*

| Soil Fertility Management Technology | Gross Margin KShs / ha | Labor Productivity KShs /KSh | Capital Productivity Kshs /Ksh. | Value to Cost Ratio | Rank Based on Productivity |
|---|---|---|---|---|---|
| Inorganic Fertilizer | 12777.65 | 0.426 | 0.259 | 1.26:1 | 1 |
| Fortified Crotalaria | 11626.40 | 0.411 | 0.269 | 1.27:1 | 2 |
| Fortified Tephrosia | 5498.35 | 0.197 | 0.129 | 1.13:1 | 3 |
| Fortified Tithonia | 3682.40 | 0.119 | 0.0797 | 1.08:1 | 4 |
| Fortified Compost | 2408.20 | 0.0805 | 0.0545 | 1.05:1 | 5 |
| Fortified Farmyard | 1530.70 | 0.0529 | 0.0356 | 1.036:1 | 6 |
| Unfortified Tithonia | -0.6039.45 | -0.179 | -0.134 | 0.87:1 | 7 |
| Production without Fertilizer (control) | -11719.20 | -0.440 | -0.330 | 0.61:1 | 8 |

Source Analysis of Data from Farm Survey in this Study, 2015

Farmers also needed more education on how to propagate and manage the agroforestry plants and use them for soil fertility improvement.

# 4. Conclusions and Recommendations

### *4.1. Conclusions*

Results of the study indicated a significant profitability difference at 95% confidence level in using the evaluated organic matter technologies on maize and bean production. The average use levels of FYM were found to be significantly below those recommended by researchers at 99% confidence level. The null hypothesis postulated in the study was thus rejected.

### *4.2. Recommendations*

A study should be undertaken to evaluate the profitability of use of organic materials on production of high value crops such as fruits and vegetables in high demand and have quick attractive returns. There is also growing market for the crops in western Kenya towns such as Edoret, Kitale, Kisumu, Kakamega and Kapsabet due to the high population growth. Availability of Rock Phosphate in retail shops should be enhanced as organic materials fortified with Rock Phosphate improved profitability and is a cheaper source of Phosphorus (P) than chemical P fertilizer sources.

# Competing Interests

The authors have declared that no competing interests exist.

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