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DETERMINATION OF FARMER'S CHOICE OF FERTILIZER APPLICATION RATE AND ITS EFFECT ON THE GREENHOUSE TECHNOLOGY PERFORMANCE IN GUSII HIGHLANDS, KENYA

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ABSTRACT

The study aimed at determination of farmer's choice of fertilizer application rate and its effect on the greenhouse technology performance and come up with recommendations for improvement based on the findings in Kisii and Nyamira Counties in Kenya. The research design employed in the study was a survey research design. A purposive and multi-stage sampling technique was used to sample 276 respondents guided by target population of 1,000 and the concentration of farmers practicing the technology in the study area. Questionnaires and key informant interviews were used to collect data. Data was then computer analysed and interpreted using Microsoft excel and Statistical Package for Social Sciences (SPSS) linear regression programme. The major finding of the study was/is that greenhouse tomato production in small scale farms in Kisii and Nyamira Counties is low ranging between 2,484.67kg and 6,558.50kg compared to the potential of 7,500kg and a negative mean deviation of -3609.76kg. The study found out that fertilizer application rate had a significant effect on performance of technology by 65.41kg (t= 7.450 and p= 0.000) indicating a direct and positive relationship with the highest application rate 31.47 kg corresponding to highest performance 6558.50 kg. The conclusion drawn is that there is need to invest in fertilizer and other inputs and apply recommended rates to fully exploit its potential. There is need to address other identified constraints facing farmers investing in the technology in specific areas of extension provision, structural design, inputs supply and policy. The study findings informed the recommendations on the future of greenhouse technology in the study area and other areas with similar physical and socio-economic environment to enhance uptake, adoption and ensure farmers benefits from in the greenhouse technology investment.

Keywords: Fertilizer application, greenhouse, tomatoes, performance, technology.

INTRODUCTION

Underuse of agricultural inputs still stands in the way of achieving the vision of food security in Africa (Comprehensive Africa Agriculture Development Programme (CAADP) and Alliance for a Green Revolution in Africa (AGRA), 2012). Poor technological performance can be attributed to not only limited use of inorganic and organic fertilizers but also certified seeds. It is also manifest in limited adoption of a technology (Claude and Bart, 2005). Productivity of a technology depends on climate and efficient and effective use of the factors of production; fertilizers, certified seeds, irrigation, and capital equipment, land, labour and farmers' skills. Access to credit boosts productivity by enabling farmers to purchase agricultural inputs and by allowing them to manage shocks without selling their assets (Comprehensive Africa Agriculture Development Programme CAADP and Alliance for a Green Revolution in Africa (AGRA), 2012), improving local financial markets efficiency of (purchased) input use and promotes diversification and non-agricultural investment (Klaus and John, 2001). The incentives to innovate and adopt better technologies, as well as to invest in agriculture, depend on the overall policy environment, including macro-economic and sectarian policies and regulations. Diminished incentives for farmers to invest and expand production are

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significantly related to protection of non-agricultural sectors leading to poor agricultural productivity (Food and Agriculture Organization FAO and Overseas Economic Commission for Development (OECD), 2012). Improving incentives has been used by various African governments to encourage more farmers use inputs, e.g. Malawi reintroduced National Seed and Fertilizer Subsidy Programme in 2005/07. Zambia invested in input and price subsidy to encourage maize production (CAADP (Comprehensive Africa Agriculture Development Programme and Alliance for a Green Revolution in Africa AGRA, 2012). The National Accelerated Agricultural Input Access Programme (NAAIAP) was reintroduced in Nyamira County to encourage farmers to use the right quantity of fertilizer and seed in maize production (District Agriculture Officer (DAO) Annual Report, 2012). Policy-induced failures and the lack of enabling institutions constrain the productivity of small family farms, e.g. poor policies and institutions that grant smallholders limited control over resources on which their productive activities and livelihoods depend. Poorly defined property rights limit their access to credit and insurance markets (Food and Agriculture Organization (FAO) and Overseas Economic Commission for Development (OECD), 2012). The impact of specific agricultural support policies on farm productivity depends on how and why it is delivered. From the examples given above, the programmes proved to be expensive. During implementation of the programmes, vested interests were noted. Without proper targeting these programmes might not reduce poverty and strengthen food security (CAADP and AGRA, 2012). Commodity-based support has the largest impact on production if support is targeted to a specific input. This can encourage an input mix that will not necessarily be economically or environmentally sustainable (FAO and OECD, 2012*).* Solutions to agricultural productivity lie in viewing the drivers of agricultural productivity holistically (CAADP and AGRA, 2012).The global demand and consumption of food is increasing in the near future (Jelle, 2003), with global population projected to shoot, much of this increases is being experienced in developing countries. Africa's population is projected to double to two billion people by 2050, and globally food production will need to double in order to meet the needs of increasingly urban population (Lamboll *et al.,* 2011), this calls for increased agricultural productivity. Although agriculture is the backbone of most if not all African countries, it is faced by a number of challenges among them, climate change, high food demands precipitated by increased population which again constraints availability of inputs such as land. The global food needs will is projected to be met by new and effective technologies which can improve continuously the productivity, profitability, sustainability of major farming systems. One such technology is the greenhouse technology used in production of majorly high value horticultural crops.

There are many types of greenhouses; whose classification bases include differences in frame structure designs, frame materials and covering materials used (Liu *et al.*, 2005) or classification based on skeletal structure, type of construction material and use/purpose of production (National Agriculture and Livestock Extension Programme, (NALEP, 2011). According to Liu *et al.* (2005) frame structures are; A-frame, tunnel and saw-teeth, while frame materials used include; metal pipes, timber, bamboo and concrete, covering materials used are plastic-house (poly film greenhouse), fibre glass or glasshouses. Simple tunnel type of greenhouses are most common, generally used without any elaborate environmental control equipment and covering material used is cladding material that is UV stabilized polyethylene film. Simple tunnel type greenhouses are generally used without any elaborate environmental control equipment mostly using ultra violet stabilized polyethylene film as cladding material. Greenhouse technology was introduced in Kisii and Nyamira Counties as recent as five years ago with the aim of improving agricultural productivity and increasing income, and overcome the numerous challenges facing agricultural production (The Organic Farmer, 2011, DAO, Nyamira North Annual Report, 2012). Among the crops that can be successfully grown in a greenhouse are; tomatoes, cucumber, onions, black nightshade, brinjals, butternut, cabbages, capsicums, herbs/spices, water melon, cowpeas, strawberry, flowers to mention but a few (NALEP, 2011). To obtain optimum returns from greenhouse investment farmers are advised to grow mostly high value crops and preferably planting of F_1 seeds/varieties which have other added advantages. However tomato is the most widely grown greenhouse crop in the counties due to its competitive and comparative advantages. The other crops are only grown as part of crop rotation plan for disease control and pest management though their economic performance may be lower compared to tomatoes.

METHODOLOGY

Study Area description: The study area consists of high potential agricultural area of Kisii and Nyamira Counties MoA (2009) in Kenya. It covers a total area of 2,334.2 Km^2 out of which approximately 80% isarable land. The counties lay between longitudes 340 581E and 350 051E and latitudes 00.351S and 00.883S. This area falls squarely under AEZs LH1, LH2, UM1, LM1 and LM2. The altitude range is between 1700-1800M ASL. The two counties border Kericho, Bomet, Narok, Homabay, and Migori counties. The soil types are generally clay loam in most parts of the study area. The counties have two rain seasons; long rains from February to June and short rains from August to December with dry spells in January and July. The two seasons sometimes overlap leading to continuous cropping. The rainfall ranges from 1,200-2,500 mm per annum. The mean temperature ranges are 20-27^oC (maximum) and 15-18^oC (minimum). Administratively Kisii and Nyamira counties are divided into fourteen (14) districts/sub counties carved out in 2009 namely; Gucha, Gucha south, Kisii central, Kisii south, Marani, Masaba south, Nyamache, Sameta, Borabu, Masaba North, Nyamira, Nyamira North , and Manga with a total of thirteen (13)constituencies. These are further subdivided into smaller administrative units as follows; 274 sub locations, 149 locations, 65 wards, and 35 divisions. The total population for the area is approximated at 1,865,149 persons with 193,165 farm families and a household having an average of 6 persons (National Housing and Population Census, 2009). In terms of extension services there are 149 extension units and with average staff: farmer ratio of 1:2,500. The average farm size is 0.5-1.5 Ha. With the highest having over 100 Acres (in Borabu) while the lowest is having 0.25 acres in other sub counties. The major economic activity is agricultural production for food and income. The major crops grown include cash crops such as tea, coffee, bananas, industrial and chewing cane and pyrethrum. Food crops are maize, beans, bananas, sweet potatoes cassava, sorghum millet and various fruits and horticultural crops like tomatoes, kales, and indigenous vegetables for both local and export market. Livestock production is dominated by dairy and local poultry. Agriculture employs an estimated 80% of the population either directly or indirectly. The estimated rural poverty is 30% with some areas having as high as 61% according to Kisii and Nyamira counties profiles (MoA, 2012).

Sampling and data collection procedures: The target population of the study was the entire small scale greenhouse farmers in Kisii and Nyamira counties estimated to be approximately one thousand (1,000) and who are members belonging to eighty eight (88) groups and institutions and one hundred and twenty one (121) as individual farmers. All together they own a total of two hundred and nine (209) greenhouse units in the study area. The study sample size used was two hundred seventy six (276) as dictated by factors such as: research cost, size the area covered, time, transport and human resources among others. This was as derived from the Morgan table (Krejcie and Morgan, 1970) based on probability proportional to size sampling from practicing greenhouse farmer groups, individual greenhouse farmers, input suppliers and extension staff. The study used a purposive and multi-stage sampling technique to select farmers that participated in the study (Mugenda, 1999). The choice of this technique was guided by the concentration of individual farmers and farmer groups undertaking greenhouse farming and their spread in the study area sub sampled. This was aimed at minimizing errors and provided opportunities to check some of the more likely sources of bias or random error (Dooley, 2001). First stage was the sub-counties where greenhouse farming is undertaken. The second stage was the division/ ward and the third stage was the groups undertaking the farming and the agro-dealers. Selection of individual farmers, group members, stockists, and extension staff was undertaken randomly. The main data collection instruments were key informant interview checklist and questionnaires schedules. Key informant interviews using focused group discussions were conducted for agro-dealers and extension staffs at the district and division/ward office. The researcher used interview checklist with open ended questions for cross checking responses given on technology performance related issues by various groups. Questionnaires administered by enumerators were used to collect data from farmers at farm level on greenhouse technology performance. Data on education level and experience, production levels and technological skills, farm input types and use, and challenges facing the target groups was collected. The research instrument content was shared with the supervisors for their necessary input and approval before embarking on field data collection and then pretested in a pilot study for validity then finally used. The respondents were informed of the purpose of the interview and the need to respond truthfully. This was to ensure that the data collected by the enumerator is reliable. Data were analyzed and interpreted using Microsoft excel, and Statistical Package for Social Sciences linear regression analysis programmes. Findings were further critically analyzed, interpreted and are presented in descriptive statistics and by use of diagraphs e.g. tables, pie charts and bar graphs. The research findings on the fertilizer application rates and its effect on greenhouse technology performance informed the recommendations and way forward on the future of greenhouse technology in the study area and beyond.

RESULTS AND DISCUSSIONS

Distribution of respondents according to their gender and age: The sample population of 198 greenhouse farmers distribution by gender comprised 62% (122 males) and 38% (76 females) while according to age distribution was 71% (142 adults) and 29% (56 youths). Further analysis of results indicate that for both age groups female farmers were less than males i.e. 27% (female adults) and 11% (female youths). The results of the findings are presented in Table 1 below;

Table 1. Distribution of greenhouse farmers by gender and age as % of sample population

Gender	Frequency	Sub total	Percentage	Sub total
Male Adult	87		44	
Female Adult	55	142	27	71
Male Youth	35		18	
Female Youth	21	56	11	29
Total	**198**		**100**	

The challenge of youth unemployment is still present in rural Kenya, despite the fact that agriculture supports about 75% of Kenya's population. This is because Kenya's farming population is aging (averaging 60 years), implying that agriculture is not a core attraction for the youth (UNDP, 2011).The study findings on gender and age indicate that the uptake of greenhouse technology by youths is on the raise with 29% of sample population being youths. This confirms the notion of quick wins that youths prefer modern farming technologies, with higher returns per unit area and regular income such as greenhouse farming technology.

Fertilizer application rate effect on the performance: The study findings on amount of fertilizer applied and the resultant technology performance indicate a significant effect by 65.41kg of performance, (t- value of 7.450and significance level 0.000) that is a direct and positive relationship. The highest fertilizer application rate 31.47kg corresponding to highest performance 6558.50 kg with some variations which can be attributed to others factors that affect production. The study area had a fertilizer application rate mean of 21.94 kg and with a performance mean of 3890.24 kg. The lowest application rate 13.40 kg does not correspond to lowest performance 2484.67 kg but instead corresponds to performance 2571.47 kg. Other variations are the second highest application rate 28.42 kg does not correspond to the second highest performance 5352.47 kg instead corresponds to performance third highest 3436.98 kg. Hence solutions to agricultural productivity lie in viewing the drivers of agricultural productivity holistically (CAADP and AGRA, 2012).Poor technological performance can be attributed to not only limited use of inorganic and organic fertilizers but also certified seeds (Table 2).

Counties fertilizer applied and effect on the performance

Kisii county fertilizer applied and effect on theperformance: Kisii County had a fertilizer application rate mean of 22.07 kg and performance mean of4241.78 kg. Sub counties fertilizer application rate mean and performance results were as follows starting with highest to lowest; Masaba south 31.47 kg and 6558.50 kg, Kenyenya27.93 kg and 5352.47 kg, Kisii Central15.47 kg and 2484.67 kg finally Gucha13.40 kg and 2571.47 kg. The study findings are as presented in summary in table 3 showed below.

Nyamira county fertilizer applied and effect on the performance: Nyamira County had fertilizer application rate mean of 21.70 kg and a performance mean of3187.18kg. Nyamira North Sub County had a mean fertilizer application rate of 28.42 kg and a performance of 3436.98 kg. Manga had a corresponding lower fertilizer applicationrate of 14.97 kg and a performance of2937.37 kg. The study findings are as presented in summary Table 4.

Table 2. Effect of amount of fertilizer applied on the performance.

Sub county	Fertilizer applied (kg)	Mean Performance (Kg)
Nyamira North	28.42	3436.98
Kisii Central	15.47	2484.67
Gucha	13.40	2571.47
Manga	14.97	2937.37
Masaba South	31.47	6558.50
Kenyenya	27.93	5352.47

Table 3. Kisii county fertilizer application rate and effect on the performance.

Sub county	Fertilizer applied (kg)	Mean Performance (Kg)
Kisii Central	15.47	2484.67
Gucha	13.40	2571.47
Masaba South	31.47	6558.50
Kenyenya	27.93	5352.47
Combined	22.07	4241.78

Table 4. Nyamira county fertilizer applied and effect on the performance.

Sub county	Fertilizer applied (kg)	Mean performance (Kg)
Manga	14.97	2937.37
Nyamira north	28.42	3436.98
Combined	21.70	3187.18

Table 5. County comparison fertilizer application rates and effect on the performance

County	Fertilizer application rate mean (kg)	Mean performance (Kg)
Kisii	22.07	4241.78
Nyamira	21.70	3187.18
combined	21.94	3890.24

Counties comparison of fertilizer application rate and effect onthe performance: The study area had a fertilizer application rate mean of 21.94 kg and with a performance mean of 3890.24 kg. While Kisii had a higherfertilizer application rate mean of 22.07 kg and a corresponding higher performance mean of 4241.78kg. Nyamira had a lower fertilizer application rate mean of 21.70 kg and a corresponding lower performance mean of 3187.18kg. The study findings are as presented in summary Table 5.

The effect of fertilizer application rate on the performance: The research hypotheses that guided the study are null hypothesis and alternative directional hypothesis based on a sound rationale from theory, professional experience and variables that are in consistent with objective and research question. The following null hypothesis was tested at 5% level of significance in the study:Ho_2 There is no relationship between fertilizer application rate and technology performance.H_2There is relationship between fertilizer application rate and technology performance.Regression analysis is used in statistics to measure average relationship between two or more variables. Since this research was testing relationship of more than two variables, what was applied is

multiple regression method in linear form. The independent variable being the technology performance whereas the regressor variable was fertilizer application rate. Coefficient is 0.297is significantly different from 0 with a βvalue0.000 < 0.05 is less than 0.05 hence rejected null hypothesis and alternative accepted.

CONCLUSION AND RECOMMENDATIONS

Conclusions: Based on the data analysed and results presented, the following conclusions can be drawn; Greenhouse technology performance in small scale farms in Kisii and Nyamira Counties is in general lower than the potential of 7,500 kg and above. Performance ranged from 2,484.67 kg to 6,558.50 kg and with a performance mean of 3,890.24 kg and a negative mean deviation of -3609.76 kg.The study findings on amount of fertilizer applied had a significant effect by 65.41kg of performance, (t- = 7.450 and p= 0.000) that is positive with the highest application rate 31.47 kg corresponding to highest performance 6558.50 kg with some variations which can be attributed to others factors that affect production.The conclusion drawn is that there is need to invest in fertilizer and other inputs and apply recommended rates to fully exploit its potential.

RECOMMENDATIONS

From the study findings following recommendations are made to improve greenhouse technology performance in small scale farms in Kisii and Nyamira Counties and other areas with similar physical and socio-economic environmental conditions. The recommendations have cross cutting implications on extension, policy and research. Greenhouse technology is capital intensive venture and requires high level of management from farmers for corresponding results in terms of crop yield and quality. Since performance results are low and according to logic model and on the expected logical relationships between the inputs, outputs, outcomes, impact all contribute to the current situation. Ministry of agriculture and all concerned authorities involved in technology development and dissemination need carry out a SWOT analysis and address gaps that are likely to emerge. There is need to develop standard extension package for use by all stakeholders promoting greenhouse technology and to build capacity among extension staff to pass quality information to greenhouse farmers on all aspects of management. To improve farmer coverage there is need to employ more extension staff and improve their mobility. Policy on importation and taxation of imported greenhouse materials and other inputs such as seeds, fertilizers and pesticides need to be reviewed to cut down initial investment costs.

Suggestion for further research: Other factors affecting greenhouse technology performance that were not covered in this study such as water and irrigation, soil sampling and analysis structural design among others need to addressed since solutions to agricultural productivity lie in viewing the drivers of agricultural productivity holistically. Kisii central sub county performance results and extension visits were lowest in the study area despite the fact it has a comparative and competitive advantage over the rest in terms of proximity to market, credit institutions, and inputs suppliers, good infrastructure as well as agriculture extension staff coverage (in term of numbers). Effectiveness of extension services in Kisii central sub county and therefore need to be evaluated.

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