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Research Application Summary

Is there potential for integrated soil fertility management use in Machakos County, Kenya?

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Abstract

Chronic food insecurity in Machakos and other semi arid areas in Kenya could be attributed to climate variability but mainly to soil nutrient decline. A lot of resources have been directed to smallholder farmers in drylands in the past but crop yields have remained low compared to surrounding on-station and commercial farms. Studies have credited these to use of blanket recommendations that disregards diverse adaptive power and agricultural systems of individual household, hence need for a farm specific approach such as Integrated Soil Fertility Management approach (ISFM). Despite ISFM's novelty, few studies have been conducted to establish causes for its low usage. As such, a study was conducted in Mwania watershed in the Machakos County in 2015 to establish ISFM potential use by assessing the awareness and extent of ISFM use such as *in-situ* water structures, improved seed variety and micro dosing of fertilizers. A well delineted watershed of 5-10 km^2 with 175 sampled (Households) was used in the study. Data were collected through a participatory survey, key informant interviews and focus group discussions. Results revealed that 85%, of the respondents were aware of improved seed varieties. *In situ* water harvesting and micro dosing were reported by 90 and 80% respectively. However, low adoption was majorly attributed to climate variability (89.7%), followed by high initial cost (80.6%) while small land holdings and intensive labor force were reported by 42.3% and 24.6% of the respondents, respectively. There is huge potential of ISFM usage, if only initial cost and labor demand were addressed adequately.

Key words: Awareness, ISFM, Mwania Watershed

Resume

L'insécurité alimentaire chronique à Machakos et dans d'autres régions semi-arides du Kenya pourrait être attribuée à la variabilité climatique mais principalement au déclin des éléments nutritifs du sol. Dans le passé, de nombreuses ressources ont été dirigées vers les petits exploitants des zones arides, mais les rendements des cultures sont restés faibles par rapport aux exploitations agricoles et commerciales environnantes. Des études les ont crédités à l'utilisation de recommandations générales qui ne tiennent pas compte de la diversité de la puissance adaptative et des systèmes agricoles des ménages individuels, d'où la nécessité d'une approche spécifique à la ferme telle que l'approche de gestion intégrée de la fertilité des sols (GIFS). Malgré la nouveauté du GIFS, peu d'études ont été menées pour établir les causes de sa faible utilisation. En tant que tel, une étude a été menée dans le bassin versant de Mwania dans le comté de Machakos en 2015 pour établir l'utilisation potentielle de GIFS en évaluant la sensibilisation et l'étendue de l'utilisation du GIFS, telles que les structures d'eau in situ, l'amélioration de la variété des semences et le microdosage des engrais. Un bassin versant bien délimité de 5 à 10 km2 avec 175 échantillons (ménages) a été utilisé dans l'étude. Les données ont été recueillies par le biais d'une enquête participative, d'entretiens avec des informateurs clés et de discussions de groupe. Les résultats des ménages ont révélé que 85% des répondants étaient au courant des variétés de semences améliorées. Des prélèvements d'eau in situ et des microdosages ont été signalés respectivement à 90 et 80%. Cependant, une faible adoption a été principalement attribuée à la variabilité climatique (89,7%), suivie d'un coût initial élevé (80,6%), tandis que de petites propriétés foncières et une main-d'œuvre intensive ont été signalées par 42,3% et 24,6% des répondants, respectivement. Il existe un énorme potentiel d'utilisation du GIFS, si seuls les coûts initiaux et la demande de main-d'œuvre étaient traités de manière adéquate.

Mots clés: sensibilisation, GIFS, bassin versant de Mwania

Introduction

The agriculture sector in Kenya directly contributes 26% of the gross domestic product (GDP) and directly or indirectly employs 75% of the country's work force (ERA, 2015). However, Kenya is among the sub-Saharan countries whose agricultural development lags behind her population growth (GoK, 2013). Agricultural growth is constrained by among other factors the declining per capita land resource, limited appropriate technological options, inadequate transfer of appropriate technologies and piecemeal adoption of production technologies (ICARDA, 2012). Various studies on smallholder farms across the country have reported a yield decline from 2 t ha^{-1} to 0.5t ha^{-1} per year in the recent past. Furthermore, shortfalls in yields, particularly in Machakos are attributed partly to drought, but mainly to declining soil fertility. Whilst most of the soil in Kenya is heavily depleted of nitrogen (N), phosphorus (P), and is extremely low in organic matter, the situation is worse in the arid and semi arid areas (ASALs), which occupy over 80% of the total Kenyan landmass, and is home to nearly 12 million people. In Machakos county, for instance very low levels of Nitrogen (< 0.1 %), phosphorous (< 11 Mg/Kg), organic matter (0.6-1.25%), respectively, have been reported across most of the farms. Consequently, a yield gap of over 3t ha^{-1} in various parts of the country. This has contributed significantly to inherent food insecurity, widespread poverty, a recurrent need for emergency food supply and an increasing dependence on food imports. Kenya imports on average 350, 000 tons of maize per year to meet its domestic demand and the situation is bound to worsen with the expected change in climate (Jaetzold *et al.,* 2006).

Adequate and better technologies that can reverse this situation and spur production exist and are readily available. However, their professional use has not been transferred satisfactorily to field practice and some are not only prohibitively expensive, but also labor intensive for smallscale farmers. For instance, combinations of inorganic fertilizer and animal manure is not only cost prohibitive, but low quantity and quality (Bationo and Waswa, 2011). These factors are not only largely influenced by household characteristics such as household head: education, gender, age, but also attributes related to the institutional framework like market infrastructure and extension services. For example, farmers' who attempt to adopt proven technologies such as integrated soil fertility management (ISFM) practices they do so in piecemeal and hence do not realize their full benefits. For instance, although smallholder farmers across the country adopt new crop varieties, a majority of them consistently ignores extension recommendations on improved soil and water management technologies. As a result, many farmers only achieve a small portion of the potential productivity gains possible from adoption of new crop varieties. Similarly, about 80% of farmers in semi arid areas like Machakos still do not use fertilizer, and among the users, 50% apply less than the stipulated rate (Ariga *et al.,* 2008). However, numerous findings have reported that integrated soil fertility management (ISFM) approach can cheaply and sustainable reverse this situation (ICARDA, 2012). Furthermore, ISFM is undeniably known and widely regarded as a strategy that can help low resource farmers to improve agricultural productivity, increase income, conserve the environment and increase the resilience of their agricultural system (Vanlauwe *et al.,* 2011).

ISFM is the adoption of a systematic conscious participatory and broad knowledge, intensive holistic approach to research on soil fertility that embraces the full range of driving factors and consequences such as biological, physical, chemical, economical, social and political aspect of soil fertility degradation. The approach advocates for careful management of soil fertility aspects, optimize production potential through incorporation of a wide range of adoptable soil management principles, practices and options for productive and sustainable agricultural systems. It entails the development of nutrient management technologies for adequate supply and feasible share of organic and inorganic inputs that meet the farmer's production goals and circumstances. The approach includes other important aspects of the soil complex; soil life, structure and organic matter content. The approach integrates the roles of soil and water conservation, land preparation and tillage; organic and inorganic nutrient sources; nutrient adding and saving practices; pest and disease; livestock; rotation and inter-cropping; multipurpose role legumes and integrating different research methods and knowledge system. The approach also includes a social and economic dimension (Vanlauwe *et al.,* 2011). In a nutshell, the aim of ISFM is to improve soil moisture holding capacity, maximize synergistic interactions between fertilizers, organic refuse and improved seed variety (Iqbal *et al.,* 2012). ISFM technologies include in-situ water harvesting technologies such as tied ridges, terraces, pits, contour bands and water pans; improved maize varieties; integrated nutrient management practices such as chemical fertilizers, compost and agro-forestry. However, the awareness and extent of the uptake of these technologies in the Mwania watershed are not well articulated and hence the study. This study aimed to establish wether there is potential for ISFM use and make farm specific recommendations with communal execution. This study is important not only towards enriching the body of knowledge and researchers but also for policy makers towards improving food security.

Materials and methods

Description of the Study area

Mwania watershed watershed lies between 37.25 to 37.29 E longitudes and latitude 1.55 to 1.58 S and is located in the semi-arid and arid lands (ASALs) of Eastern Kenya covering a total land area of 889.9ha. The climate and population density of the watershed generally follows that of Machakos County, which is cooler semiarid climate. The main three cropping systems in the watershed namely; inter cropping (86.9%), Mono-cropping (50.9%) and multiple cropping (4.6%) are constrained by low soil moisture as a result of erratic and unpredictable rainfall a typical characteristic of agro-ecological zone (AEZ) IV (Jaetzold *et al.,* 2006). The study area experiences bimodal rainfall divided into long and short rains that run from March – May and October- December respectively. Total rainfall amounts range from 300-1300 mm. Mean minimum and maximum temperature are 12 and 27o, respectively, with generally high evapo-transpiration rates > 8.2mm day^{-1}.

Some of the most conspicuous agro-ecological and biophysical characteristics of the study area include undulating topography and inherent low soil fertility. Most of the rivers in study area are seasonal and thus cannot supply adequate water when most needed. Groundwater resources are also not abundant and, in many places, the water produced is saline. Although on the average, there is a crop failure in two out of every five seasons, the main cropping systems were mixed crop livestock systems. The main traditional value chains cops were maize, sorghum, and legumes with good market access opportunities.

There are two soil types in the study area: (i) Cambisol (264 ha) and (ii) Acrisol (636 ha). The latter is derived from granite parent material, with rhodic Paleustalfs and ultic Haplustalfs. These are predominantly dusky, dark reddish brown to dark red and dark brown (IUSS Working Group WRB, 2015; Soil Survey Staff, 1975).

Survey. The major primary data were collected through formal surveys. In the formal survey, data were collected from 175 sampled Households picked in a two-stage random sampling of a total of 409 Households who were registered members of the watershed WRUA. In this survey, a structured interview questionnaire was used. The questionnaire was developed in a participatory manner and pre-tested before conducting the actual formal surveys. The types of information soought in the HH questionnaire included general information, production constraints, technologies used and social capital. Data were entered in Microsoft ACCESS & EXCEL and imported into SPSS for analysis.

Results and discussion

Landholding and use

The watershed covers 899.9 hactares with different land use. The majority of land in the study area is owned by men (87.4%) with women owning the remaining 12.6 %. This pattern influences the type of agricultural productivity enhancing practices in use. The mean farm size cultivated was 1.46 ha with a standard deviation of 1.566, ranging from less than one acre to 9.6 ha. The mean land holding left fallow was 1.46 ha with a standard deviation of 2.044 ha and a range of less than one ha to 13.2 hectares. However, the most frequent landholding left fallow was 0.8 ha. There was very little land left fallow probably due to the increasing population pressure. Since the land holdings in this watershed are small and mainly used for cultivation, any efforts to improve livelihoods should be targeted to those Households owning two hectares or less.

Crop production constraints

A number of constraints affecting maize production in the study area were identified and ranked. The three high ranking constraints were high climate variability (90%), high cost of inputs (81%) and low availability of water for production (73%) (Figure 1). Other maize production constraints in order of importance included pests and diseases (50%), poor access to inputs (46%), small land holdings (42%), low soil fertility (39%), limited labor force (24%) and limited improved crop varieties (24%). For that own land, majority Households(83.4 %) cultivated less than five acres while 48.6% left less than five acres of their farmland fallow. Of the rented land, 5.7% Householdsrented five acres or less. About 4.0% of the Households cultivated rented land while 1.7% Householdsrented and left it fallow.

Use of agricultural technologies

In attempting to understand the status of knowledge of agricultural technologies in Mwania watershed, about 50 technologies were identified. Some of these technologies included soil and water management technologies such as tied ridges, terraces / trenches, water harvesting, irrigation, and mulching. Others were soil fertility management technologies like use of animal manure, compost, cover crops, crop rotation, intercropping, chemical fertilizer, and Rhizobia inoculation. The last category involved crop management practices such as row planting, seed priming, row spacing, pesticides, and herbicides, local (Kinyanya) and improved maize varieties such as Duma 43, 511, Pioneer, DK, DH01 & 04, PH4, Pannar, Kat, KDV1-6, and KCB.

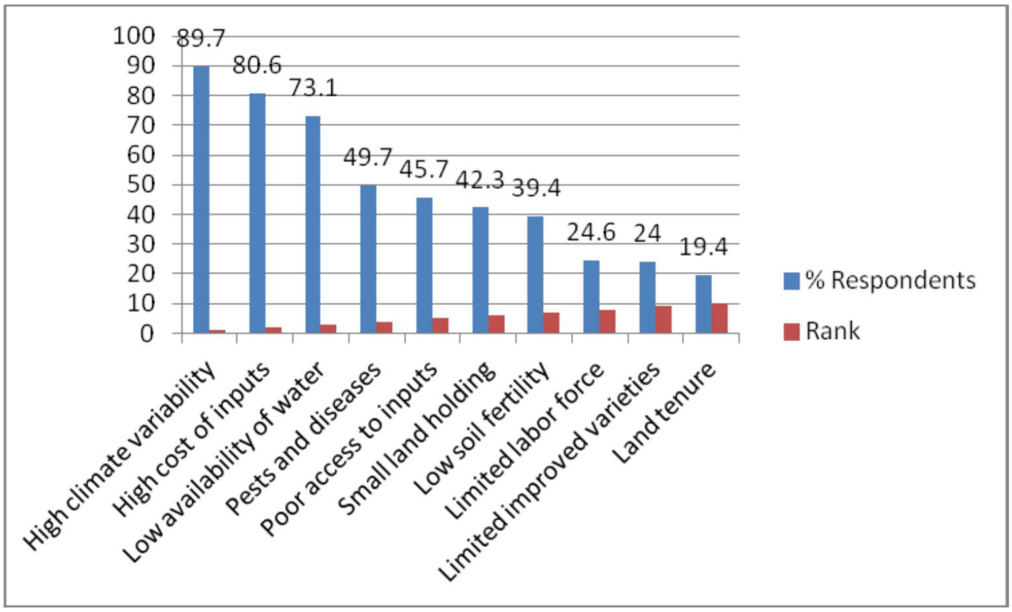

Figure 1. Maize production Constraints

Households as reflected in Figure 2, some households had knowledge about some technologies, while others did not have any knowledge about other technologies. For instance, very few households hardly knew anything about early planting. However, many had some knowledge of soil and water, and soil fertility management technologies. Particularly, 73 % had knowledge of improved varieties; up to 90% knew about water harvesting technologies. Knowledge on manure/composting and chemical fertilizer was reported by 91% and 79%, respectively.

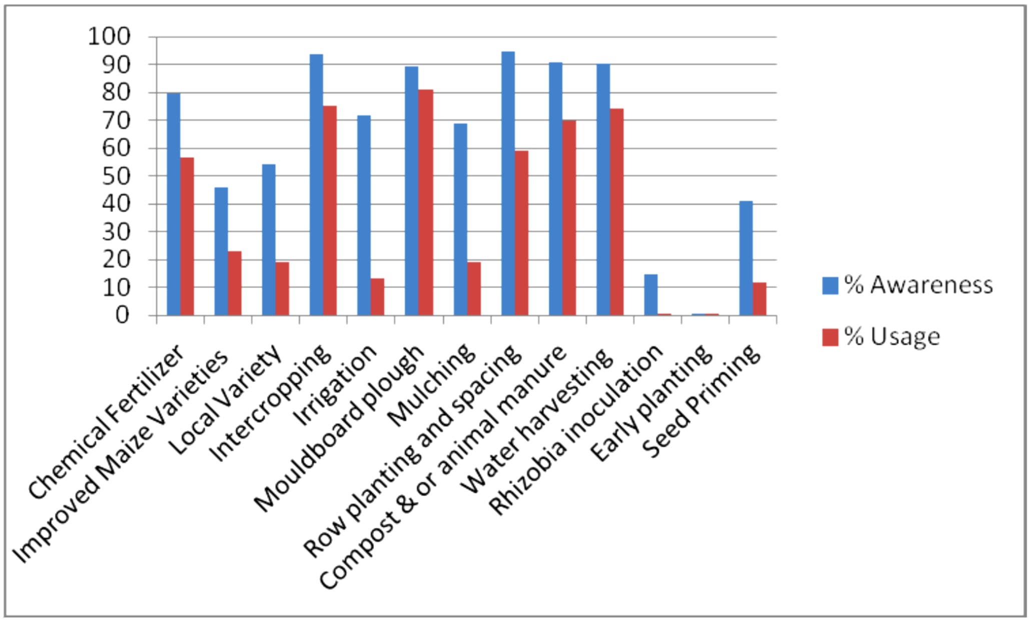

Figure 2. Awareness and usage of soil and crop improvement technologies

Technology awareness, accessibility to farm inputs, education and gender had a positive relationship on technology use, while unavailability of improved seeds, little or no benefit and input cost had a negative relationship on technology uptake see (Table 1).

Table 1. Association between study variables and use of Agricultural productivity enhancing technologies using the Poisson model

Variable	Coefficient	P value α 0.05
Education	0.3535	0.026
Input Cost	-0.3802	0.041
Little/No Benefit	-0.4602	0.05
Gender	0.1948	0.024
Input Access	0.5084	0.001
Labor intensive	-0.0392	0.032
Lack of improved varieties	-0.7502	0.001
Technology Awareness	0.7866	0.002

Education level, gender, input access, and awareness reported a positive co-efficient, with awareness scoring the highest (78.66%) and highly significant (P = 0.002) relationship with gender association being the lowest (19.48%; P = 0.024). On the other hand, input cost, little/ no benefit, labor demand, unavailability of improved seed variety reported negative association with agricultural productivity enhancing technologies. Unavailability of improved varieties seed scored the highest (75.02%; P = 0.001). among external factors hindering use of agricultural productivity enhancing technologies. Approximately 4% was the lowest negative coefficient attributed to labor intensiveness. Therefore, an increase in education level and awareness among respondents will likely trigger adoption and coverage of agricultural productivity enhancing technologies.

Conclusion/ Recommendations

The study aimed at quantifying the extent of ISFM knowledge and application in the Mwania watershed of Machakos county, Kenya and factors influencing the adoption of these technologies. Thus, factors retarding uptake of ISFM practices in ASAls areas such as Machakos were well articulated. From our study, we conclude that low agricultural productivity in ASALs areas is caused by low adoption of ISFM technologies. Therefore, wide malnutrition, dependency on government food aid and undignified living can be reversed with increased uptake of ISFM technologies, by focussing on farm specific recommendations implimented at communal level. Based on maize yield, farmer's yields were highly depended on a combination of different practices. Therefore, it is our recommendation that researchers test protocols that have worked elswhere and give site-specific recommendations on ASALs where land degredation is highly pronounced.

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References

Bationo, A. and Waswa, B. S. 2011. New challenges and opportunities for integrated soil fertility management in Africa. pp. 3-17 In: Innovation as Key to the Green Revolution in Africa: Exploring the Scientific Facts. Springer New York.

ICARDA. 2012. Conservation agriculture: opportunities for intensified farming and environmental conservation in dry areas. A synthesis of research and trials with smallholder farmers in drylands systems; benefits and constraints to adoption. Farmer experiences and potential for uptake in Iraq, Syria, Morocco and Tunisia.

Iqbal, M., Khan, A.G., Hassan, A. U., Raza, M.W. and Amjad, M. 2012. Soil health indices: Soil organic carbon, nitrate contents, physical properties and maize growth as influenced by dairy manure andnitrogen rates. *International Journal of Agriculture and Biology*14: 20-28.

IUSS Working Group WRB. 2015. World reference base for soil resources 2014, updated

2015. In International soil classification system for naming soils and creating legends for soil maps World Soil Resources Reports No. 106. FAO, Rome.

Jaetzold, R., Schmidt, H., Hornetz, B., Shisanya, C.A. 2006. Farm Management Handbook of Kenya: Natural conditions and farm management information, 2nd Edition, PART C, Sub part C1 Eastern Province. Nairobi, Kenya: Ministry of Agriculture/GTZ.

Vanlauwe, B., Bationo, A., Chian,u J., Giller, K. E., Merckx, R. Mokwunye, U., Ohiokpehai, O., Pypers, P., Tabo, R., Shepherd, K., Smaling, E., Woomer, P.L. and Sanginga, N. 2011. Integrated soil fertility management: operational definition and consequences for implementation and dissemination. *Outlook on Agriculture* 39:17–24.