Crop performance and soil nutrient dynamics under different cropping systems and organic inputs in central Kenya.

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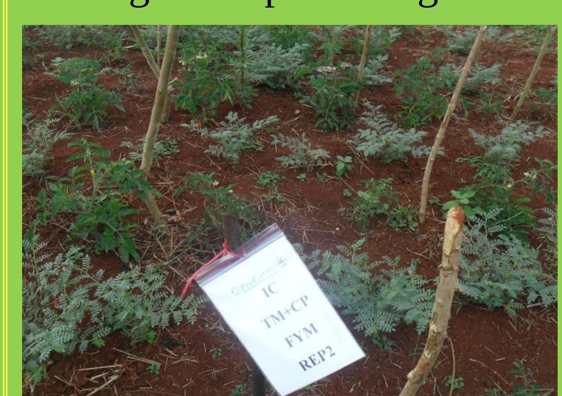
1.0 Background

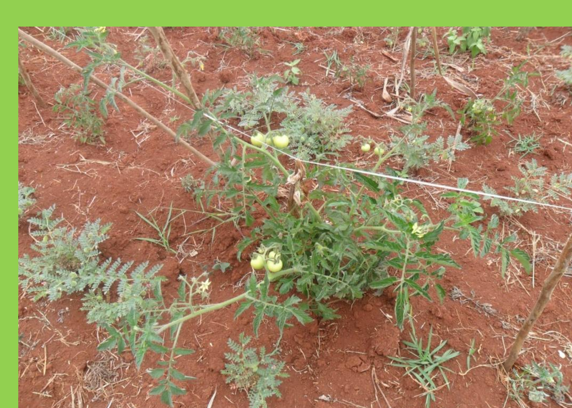
Most soils in Kenya have been degraded and depleted of essential nutrients rendering them unsuitable for crop production (Drinkwater *et al*., 1995). Prolonged application of inorganic fertilizers on the other hand has resulted in negative environmental impacts such as accumulation of heavy metals in soil, crop and water (Halberg *et al*., 2006). Intercropping systems are deliberately designed and manipulated to optimize the use of spatial, temporal, and physical resources both above and belowground, by maximizing positive interactions and minimizing negative ones among the components (Silwana and Lucas, 2002). Continuous mono-cropping minus application of fertilizers result in mining of plant nutrients and depletion soil organic matter (Lal, 2008). In the current agricultural production environment, conventional farming methods pose the greatest risks in terms of reduced crop yields (Keating, 2003). This coupled with the vagaries of weather that have made crop production unreliable, hence the need for alternative means of soil fertility management.

Soil fertility depletion can be addressed through use of organic inputs and integration of legumes into cropping systems. This will ultimately lead to increased crop yields and marketability. In view of the ever changing weather patterns, discontent among farmers over long term field experiments and resources required for conducting the same there is need for decision support tools to aid farmers decision making in crop production. One such tool is APSIM model that has been tested and validated across a wide range of environments for simulation of nutrient dynamics and crop responses to different inputs and climate. It is thus hypothesized that, legume integration and application of organic inputs will improve soil fertility status and enhance crop productivity. This study, therefore, aims to determine and model crop performance and soil nutrient dynamics under different cropping systems and organic inputs using APSIM.



Organic tomatoes integrated with chickpea & Mexican marigold

Organic maize integrated with chickpea



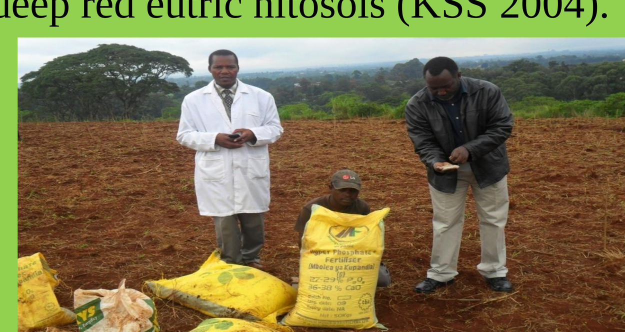
A fruiting organic tomato plant

2.0 Materials and methods

2.1 Site Description

The study is being conducted both on-farm (one farmer's field in Ngong, Kajiado County) & on-station at Kabete Campus field station, University of Nairobi, Kenya. The Ngong site lies between latitude 01.42254ºS & longitude 036.66036ºE with an elevation of 2070m a.s.l and categorized under agro-ecological zone IV (Sombreak *et al*., 1982).The climate is typically semi-arid with mean annual temperature varying from 20º C and 28ºC with a mean of 25ºC and a total annual rainfall ranging between 450-1200mm (Braunn & Weg, 1977). Rainfall is bimodal in distribution with the long rains starting from April to June and short rains from October to November. Ngong soils are red dystic andosols (Kenya soil survey, 2004). The Kabete site lies between latitude 01.24356^0 S & longitude 036.74186^0 E with an elevation of 1856m a.s.l and categorized under agro-ecological zone III (Sombreak *et al*., 1982). The climate is typically sub humid with mean annual temperature varying from 23ºC -12ºC & a total annual rainfall ranging between 1200-1800mm (Braunn & Weg, 1977). Rainfall is bimodal in distribution with the long rains starting from March/April to May/June and short rains from October to December. Kabete soils are deep red eutric nitosols (KSS 2004).

Hired casuals during 1st season planting at Ngong & Kabete



PoGrOV members during 1st crop planting

2.2 Study Approach

The study involves both surveys & field experiments.

2.2.1 Survey

A stratified random sampling procedure was used to select respondents with locations forming the stratum. 4 locations were selected with 25 farmers each. A computer random number generator was employed to select the number of households in each stratum. To ensure the questionnaire's ability to accurately measure and capture the intended objectives, it was subjected to review by experts, supervisors and peers. The questionnaires were pre-tested to check on content and clarity of questions. Questionnaires were administered to the organic farmers so as to get feedback on the market product qualities that are most desired, their farming practices, general livelihoods and understanding of climate change.

2.2.2 Field Experiments

Experimental design and Treatments

The experimental design was a randomized complete block design (RCBD) with four replications in a split plot arrangement where the main plots were the three cropping systems; monocropping of maize & tomatoes, test crops, intercropping of maize/chickpea, tomato/chickpea and crop rotations of chickpea-maize, chickpea-tomatoes and the split plots were the P sources (rock phosphate & FYM) with a control. The plot measures 4.8x3.75m with a foot path of 0.5m & 1m between the replicates.

2.3 Agronomic Practices

A nursery was established for tomato seed germination and after 6 weeks the seedlings were transplanted. FYM was applied at 10tha^{-1}. Since PR contains 28% $P_2 0_5$, 490kg ha^{-1} was applied to supply the recommended 60 kg P ha^{-1} (KARI, 2004). Spacing of 30x75cm for maize, 45x75cm for tomatoes and 10x30 cm for chickpea pure stands were adopted. Weeding was done twice. Approved organic pesticides and local plant extracts are used in pests and diseases management.

Organic RP for planting

ProGrOV members in the trial field

Spraying copper oxychloride against tomato blight

2.4 Soil and Plant Tissues Sampling and Analyses

Soil was sampled initial and will be done at crop harvesting using the zigzag technique described by (KARI, 2004). Plant tissue sampling will be done at 3 stages; flowering/seeding, fruiting & harvesting to assess nutrient changes (KARI).

Laboratory analysis

The soil, FYM and plant samples will be analyzed at the Department of Land Resource Management and Agricultural Technology (LARMAT) of the University of Nairobi. The FYM samples will be analyzed for; pH, P, C, K, N, Na, Mg, Ca, Mn, Fe, Cu, Zn and CEC. The soil samples will be analyzed for; soil texture, bulk density, pH, available phosphorus, organic carbon and total nitrogen (Okalebo 2002). The plant tissues will be; oven dried, ground & analyzed for :N, P, K, C, Mg, Ca, Mn, Cu, Fe, Zn & Na (Okalebo 2002).

2.5 Yield Determination

Chickpea

At pod maturity, ten plants will be randomly selected from each plot and tagged. The harvested pods from the sampled plants will be shelled and seeds counted for each plant. The average numbers of seeds per plant/plot will be obtained. The final grain yield will be determined by weighing all the seeds from the sampled plants and converting the yield in kgha^{-1}. Plant height, biological yield per plant, pods per plant, seeds/pod, and grain yield will be collected.

Tomatoes

Ten plants per plot were selected for biweekly determination of plant height and number of leaves. The number and weight of the fruits will be evaluated at end of season. The final fruit yield will be determined by counting and weighing all the fruits from the sampled plants and converting the yield into kgha^{-1}. Marketable traits will be; color, shelf-life, shape & weight.

Maize

Ten plants per experimental unit will be tagged to provide data at harvest on; number of usable ears and grain yield of maize. Data to be collected' days to emergence & germination, number of ears harvested, the grain field weight (kg/plot) and grain moisture content. The grain yield & biomass (t/ha) & harvested plant population/hectare will be calculated using the relevant variables collected.

Soil sampling for bulk density & HC

Initial crop performance data collection

A staked tomato plot

2.6 Modeling with APSIM

APSIM will be used to model maize/chickpea growth & development under the imposed treatments.

APSIM calibration: The APSIM model comes bundled and distributed with databases of previously tested crops & soil parameters to minimize the laborious process of parameterization/calibration (Daniel, *et al.*, 2006).

Model Validation: To be done using Sensibility test (Rykiel, 1996) by means of graphical method through comparison of model predictions with observed data.

2.6 Statistical Analyses

Questionnaires were cleaned from errors made during field data collection then data analyzed using the Statistical Package for Social Sciences (SPSS version 17). The obtained data on soil & plant parameters will be subjected to analysis of variance (ANOVA) appropriate for a split plot design using General Statistics package (Genstat, 1995). The differences among the treatment means will be compared using Fisher's Protected LSD test at 5% probability level (Steel & Torrie, 1987).

3.0 References

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