D1940: Results from the Fertilizer demonstration experiment with maize at IOP Farm in Iringa, Tanzania in 2018

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Crop Nutrient Gap Project

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Table of contents

Summary

In 2018, an experiment was run at the IOP farm in Tanzania. Four nutrient management treatments were combined factorial with two tillage options. The results show that the lowest maize yield was obtained under conventional tillage without fertilizer application, and the highest with reduced tillage and NPK fertilizer to target 70% of water-limited yield and the addition of micronutrients.

A number of field visits was organized, and from the six villages surrounding the farm, hence a total of 120 farmers made at least 4 visits to the farm, one every month between February and June. That brings the number of farmers that learned from the 2018 trial to 480+. In addition, the Tanzania Uhuru Torch made a stop at the Trial, to recognize the importance of the training tool for the farmers. During this festive day a large array of different stakeholders visited the farm, such as village leaders, region and district level leaders and young and older farmers.

Keywords

Tanzania; experiment; nutrient management; tillage; maize; yields

1. Introduction

Large parts of land suitable for agriculture in Tanzania are currently not under cultivation, presenting both threats and opportunities. In places where agriculture is practised, yields are low because of low fertility, low use of costly inputs and unpredictable weather (very narrow planting window). As a result, actual farmers' yields are usually 20% or less than what is the potential under rain fed conditions (www.yieldgap.org). A field experiment was set-up addressing the farmers' dilemma by introducing demonstration on reduced tillage, and proper, efficient fertilization. Visits for farmers and stakeholders were organised.

The objective of the (large-scale) experiment is to test crop nutrition and tillage practices in maize and their potential to close the yield gap and analyse nutrient use efficiencies and other agro-environmental aspects (e.g. GHG emissions), and to use it as demonstration and discussion object.

2. Location

The experimental location is on the Ilula Orphan Program (IOP)'s Farm, Ilula, Iringa Region, in Tanzania (7°38'51.4"S 36°04'05.0"E) (Fig. 1). IOP is a non-governmental organization in Tanzania dealing with impact mitigation to: 1) determine the root cause and help to uproot the most vulnerable children (orphans from extremely poor families, children from poor single mothers or single fathers); 2) empower the elderly; 3) empower young mothers and the youth through training. IOP owns a modern commercial farm, named Farm for the Future Tanzania Ltd (FFF) that started operation in 2018, which is also used to as a training centre. It is a registered Farm aimed to generate income, empower single mothers through training (socio-economic and agriculture) and encourage school children (kindergarten all the way to secondary school) to develop love for the agriculture by providing visits and activities that will stimulate them to grow with a positive image of this number 1 employer in Tanzania. This trial experiment is part of the FFF.

Fig. 1 Map of Tanzania showing the experimental location

3. Trial lay-out

3.1. Trial set-up and treatments

Four nutrient management options were combined with two tillage options, resulting in a total of eight different treatments (Table 1). The trial has a split-plot design with tillage as main plots and the four fertilizer treatments as split plots (Fig. 2). There are four replications of each treatment with a plot size of 10.4 m by 10.8 m (16 rows at 65 cm, and 36 planting holes placed at 30 cm apart, resulting in a plant density of 5.13 plants/m^2). Net plot (harvesting) size is 9.75 m x 10.5 m, equivalent to 102.375 m^2. Liming was not required since former soil analysis shows an average pH of 5.5 (4.6-6.3).

Table 1. Experimental treatments, which are a combination of the nutrient management and tillage options.

Treatment	Tillage	Compost applied	Nutrient application rates (kg nutrient/ha)					
			N	P_2O_5	K_2O	MgO	S	Zn
CT-F1	Conventional	No	0	0	0	0	0	0
CT-F2	Conventional	No	98	42	42	0	0	0
CT-F3	Conventional	No	98	43	42	9	13	1
CT-F4	Conventional	Yes	49	21	21	0	0	0
RT-F1	Reduced	No	0	0	0	0	0	0
RT-F2	Reduced	No	98	42	42	0	0	0
RT-F3	Reduced	No	98	43	42	9	13	1
RT-F4	Reduced	Yes	49	21	21	0	0	0

[1]Yw is the water-limited potential yield, and is estimated as 7.0 t/ha, the yield target is 70% of Yw which is 4.9 t/ha (85% dry matter).

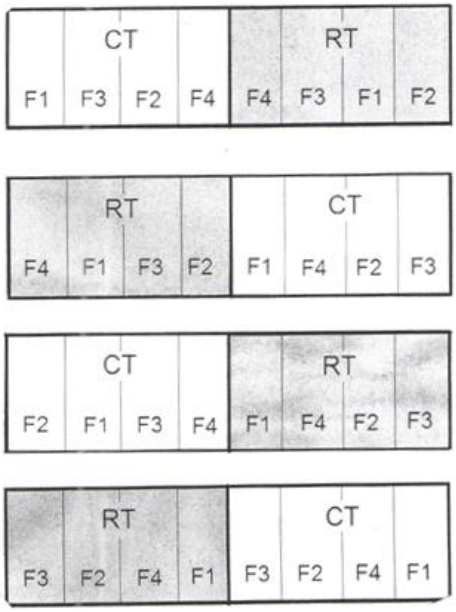

Fig. 2 Trial set-up and treatments. CT = conventional tillage, RT = reduced tillage, F1 – F4 are the fertilizer treatments (see Table 1)

3.2. Fertilizer treatments

The fertilizer treatments include a control treatment (F1) without any fertilizer application, which is required to assess crop response to fertilizer application and to calculate fertilizer use efficiency. The unfertilized control is also close to prevailing farmer practice in the region in particular if formerly barren land is cultivated for the first season as it was in this case. The F2 and F3 treatments supply N, P, and K at a rate that could accommodate NPK uptake of maize at 70% of its water-limited yield potential identified for the site at IOP Farm. Based on the GYGA and expert judgement the water-limited yield potential was estimated at 7 t maize grain per ha (at 85% dry matter), i.e. resulting in a target yield of 4.9 t/ha maize yield. We assumed 20 kg N uptake per t of grain, which resulted in 98 kg N/ha application rate (see Table 1). P and K rates were determined by the N-P-K ratio of the recommended fertilizer product YaraMila Cereal (used in F3). The F3 treatment investigates the potential benefit of applying the additional plant nutrients sulphur (S), magnesium (Mg) and zinc (Zn), knowing from previous soil analysis that these nutrients are frequently in deficiency. This treatment also represents the current Yara recommendation for maize grown in the Southern Highlands of Tanzania. The fourth fertilizer treatment (F4) includes the use of organic material (composted manure) assuming to replace 50% of the mineral fertilizer.

3.3. Tillage treatments

All fertilizer treatments were combined with two different tillage practices, (1) conventional (CT) and (2) reduced tillage (RT). Conventional tillage represents common farmer's practice. At IOP Farm this means using a disc plough on the whole field. Reduced (or conservational) tillage means for this experiment using a ripper instead of a disc plough and ploughing only the planting lines, leaving the remainder of the field untouched. This minimizes soil exposed to the vagaries of weather (reduces erosion), minimizes destruction of soil flora and fauna (hence encouraging a richer biodiversity). It ensures exact placement of fertilizer (in the furrow), and hence better use of the fertilizer by the plant, leading to, presumably, bigger harvests. It reduces the use of fossil fuel, hence a cleaner environment and cheaper farming operations (fewer runs than when whole field is tilled). Ripping results into better water harvesting and storage due to least soil exposure (no inversion/turning of the soil) and the deep strips that are formed collect and store more water. In the long run, this might enable minimum use of herbicides and tillage.

4. Activities and measurements

At the start of the experiment soil samples were taken (32 samples at 0-20 cm; 32 at 20-40 cm). Afterwards land preparation (tillage), trial set up, seeding, herbicide application, application of well decomposed manure and fertilizer and trial fencing out activities were done.

In a second stage of the experiment the following management activities were performed: weeding, fertilizer top dressing, herbicide application.

In a third stage of the experiment the following management activities were performed: foliar top dressing, pesticide application, leaf sampling (32 samples).

Finally, the maize plants in the trial experiment were harvested and soil samples (32 samples at 0-20 cm) were taken.

Planting

Mineral fertilizer application

Compost application

Maize plants end January

Maize plants early March

Maize plants April

Maize plants May

Maize plants May

Maize plants May



Fig. 3 Photos taken during the maize growing season by scientists from SUA and Yara representatives.

5. Results

Reduced tillage (RT) resulted on average in a 11% higher yield compared to conventional tillage (CT), but this difference was not significant (*P*=0.38). However, there were significant differences between the fertilizer treatments. If no fertilizer was added (F1) this resulted in the lowest yields, while the highest yields were obtained with the addition of NPK to target 70% of Yw (both the treatment with (F3) and without micronutrients (F2)).

F1

CT-F2

CT-F3

RT-F4

Fig. 4 Photos from some of the different experimental treatments during the growing season. See Table 1 for explanation on the treatments.

Overall, the lowest maize yield was obtained under conventional tillage without fertilizer application (CT-F1), and the highest with reduced tillage and NPK fertilizer to target 70% of Yw and the addition of micronutrients (RT-F3) (Fig. 5). Interestingly, reduced tillage resulted in an increase of almost 2 tonnes per ha when no fertiliser was applied (F1). Reduced tillage did not significantly increase maize yield when fertiliser was applied (F2 to F4)

The amount of fertilizer applied was aimed to target 70% of Yw, but in all cases it resulted in yields which were higher than the target, and in several cases ca. 100% of Yw was reached (Fig. 5). One reason for the higher yields than expected could be the well distributed and sufficiently high precipitation during the growing season.

A more detailed evaluation of the data will follow when lab analyses and further information (e.g. on applied organic material) are available. The experiment is repeated (with addition of one extra fertiliser treatment) in 2019.

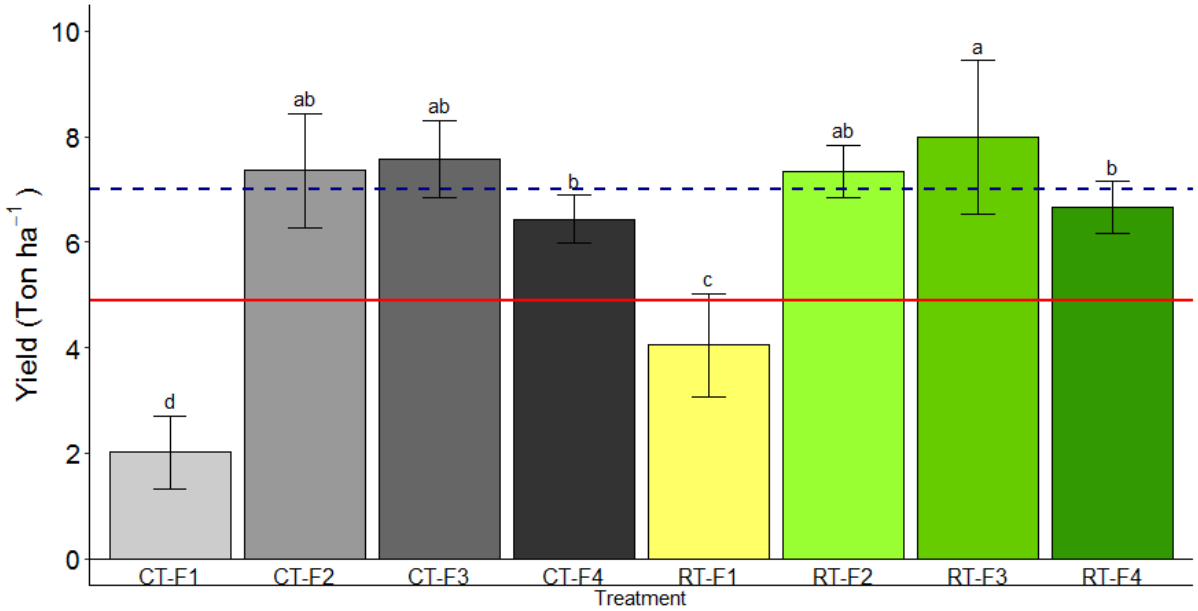

Fig. 5 Average maize yield (at 85% dry matter) with standard deviation for the different treatments (see Table 1 for treatment explanations). Bars labelled with different letters indicate significant differences in yield between the treatments (P<0.05). Blue dashed line indicates the estimated water-limited potential yield, and the red continuous line is 70% of the water-limited yield.

6. Communication and outreach

Combining Commercial farming and Training is a completely new approach in Tanzania. Involving children is very much hailed by the regional authorities as the right way forward. The experiment at the IOP farm supports creating a knowledge base on nutrient management and tillage options to improve maize yields.

A number of field visits by farmers were organised to the experiment in 2018. Village leaders were requested to come with at least 20 farmers each, divided equally between male and female (it actually meant 10 household members, a man and his wife to consolidate learning) to an inaugural meeting where they were introduced to the IOP and Farm for the Future philosophy, then to the tillage-fertilizer planned trial. During the trial life, these farmers, plus any other farmer interested in what was going on, were taken through the trial by the IOP Agricultural Officer, Mrs Tulia MKWAMA. We have six villages surrounding the Farm, hence a total of 120 farmers made at least 4 visits to the farm, one every month between February and June. That brings the number of farmers that learned from the trial last season to 480+.

Fig. 6: Fig. 6: Left: Bill board bearing witness that this is a Farmer's Field School Trial. Left is Peter of Sokoine Univ Agriculture, Grace the FFF Farm Manager and Faith, a Research Associate Masinde Muliro University of Science and Technology (Kenya) doing a sandwich PhD on Conservation Agriculture at SUA under Peter's supervision. Right: Mr. Edson MSIGWA, the IOP Director, Peter the SUA Team leader and Grace, the FFF Farm Manager: Trial crop in the rear.

Visitors unanimously agreed F1 (Control) gave the worst performance in both treatments followed by F2 in Conventional Tillage OR followed by F4 in the Conservation tillage system. The best performance came from F3 (in Conv. Tillage sometimes in both tillage systems) OR F4, mainly in Conservation tillage.

On 28 May 2018 the Tanzania Uhuru Torch made a stop at the trial, to recognize the importance of the training tool for farmers. During this festive day, Village leaders, Region and District level leaders, large and influential farmers as well as single mother young farmers were in attendance. The young single mothers offered the explanation of what was happening and made up their fertilizer regime of their choice, which was undoubtedly F4 followed by F3. This was recorded and broadcast for all Tanzanians to see. This year farmers are also attending to the trial and there will be a jointly (SUA_WU_Yara_FFF) organized Farmer's Field Day around 3 May (date to be confirmed in the near future). Additionally, the Uhuru Torch will make a stop at the main FFF cultivated field (some 210 odd hectares) to view what happens when a full fertilization is accorded to a crop.

Fig. 7:An assembly of pictures from the visit of the Uhuru Torch at FFF farm on 17 May 2018.

Acknowledgements

Our thanks goes IOP for providing the much needed on-site supervision of the Trial and arranging for labour. Farm for the Future supported and advertised this Trial very much; they also adopted the complete dose regime that has proven so successful even during this first year of maize production in their farm: we greatly thank them. The picture will not be completed without thanking the clients and users of the results from this Trial: Regional Commissioner, District Commissioner, the Village Leaders, Farmers and Single mothers. To them we say *asante sana* for patronizing us.

7. Partners involved in the Crop Nutrient Gap Project

- Wageningen University and Research
- International Fertilizer Association
- University of Nebraska Lincoln
- Yara
- CIMMYT
- Sokoine University of Agriculture