Results from the fertilizer demonstration experiment with maize at Farm for the Future Tanzania in Iringa, in 2021

FINAL NARRATIVE REPORT

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Summary

In 2021, an experiment was run for the fourth consecutive season at the Farm for the Future Tanzania Ltd (FFF) which is part of Ilula Orphan Program (IOP)'s Farm, Ilula, Iringa Region, in Tanzania. The FFF farm, is training farmers in 16 villages, with a focus on dissemination activities at regional, as well as national level. The purpose of the experiment is to experimentally test and demonstrate low-emission crop fertilisation strategies that combine high maize yields with high nutrient use efficiency and low emissions. Four nutrient management treatments were combined in a full factorial setup with two tillage options. Lowest yields were obtained with no fertilizer addition (control treatment) under conventional tillage and reduced tillage (1-2 t/ha), while the treatments with fertilizer addition consistently showed very high yields (close to 10 t/ha). Root number and root length were larger for reduced tillage compared to conventional tillage at the control treatment, but this difference was not significant. Root penetration resistance was significantly higher at conventional tillage compared to reduced tillage for the control treatment. Around 100 pupils from primary as well as secondary school made two field visits to the trial. Also, a farmers field day was organized, and from the sixteen villages surrounding the farm, a total of about 400 farmers attended the planting session and the field day.

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 practiced, yields are low because of inherent low soil fertility, low use of costly inputs and unpredictable weather (resulting in a very narrow planting window). As a result, actual farmers' yields are usually 20% or less of potential yields under rainfed conditions (yieldgap.org). For the fourth consecutive season, a field experiment was set-up addressing farmers' dilemmas by introducing demonstrations on reduced tillage, and proper, efficient fertilization.

The objectives of the (large-scale) experiment are: test fertilisation and tillage practices in maize and their potential to close the yield gap with low emissions; analyse nutrient use efficiencies and other agro-environmental aspects (e.g. GHG emissions); and use the trial as demonstration and discussion object for farmers in the region.

2. Location

The experimental location of Farm For the Future Tanzania Ltd (FFF, https://fffftanzania.com/) is on the Ilula Orphan Program (IOP)'s Farm, Ilula, Iringa Region, in Tanzania (http://ioptanzania.org/home/) (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 that started operation in 2018, which is also used 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 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 eight different treatment combinations (Table 1). The trial has a split-plot design with tillage as main plots and the four fertilizer treatments as split plots. 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 showed 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).

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. The F2 and F3 treatments supply nitrogen (N), phosphorus (P), and potassium (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 a combination of both the Global Yield Gap Atlas (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 (70% of the yield potential). We assumed 20 kg N uptake per tonne of grain produced, which resulted in 98 kg N/ha application rate (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). This treatment assumes that farmers can afford at least half the recommended rate of industrial fertilizer and supplement it with the readily available compost manure, with an application rate of 12.8 t/ha. Further, it is assumed that after a few years of application, the manure should be able to replace 50% of the mineral fertilizer and lead to better soil physical conditions (i.e., increased Soil Organic Matter content, a very important soil attribute that is generally low in soils of the tropics).

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 conservation) tillage means for this season planting was done in ripped lines made last season.

4. Activities and measurements

At the start of the season, land preparation (tillage) was done and trial set up, seeding, herbicide application (both pre- and post-emergence), application of well decomposed manure and fertilizer activities were executed. Planting was done at the first week of December 2020. A total of four weeding cycles were carried out in the conventional tillage plots during the season. Fig. 2a depicts one of the weeding sessions in February 2021.

Root sampling was done on 30 April 2021 using the 'Pit Method'. Root measurements were performed in F1 plots with a view to uncover the reason for Reduced Tillage plots to produce twice the grain produced under Conventional Tillage under F1 fertilization. Two representative plants were selected per plot and the roots carefully dug, cleaned and then counted. The length of each root was then measured and the total root length per plant calculated. Then an average of the two plants was calculated and recorded.

Penetration resistance in Conventional and Reduced Tillage was determined using a hand-held cone penetrometer (Fig 2b) . Four spots were selected in F1 plots and penetration measurements taken at 5 cm-depth intervals down to 35 cm.

Maize was harvested on 18 June 2021 at a moisture content of 12 %. It was then shelled (Fig. 2c) and weighed (Fig. 2d).

Fig. 2. A) Weeding the paths before weeding in the Conventional Tillage plots. B) Penetration resistance determination. C) Maize shelling. D) Grain weighing.

5. Results

There was no significant interaction between tillage and fertilizer treatment (*P*=0.39). The lowest yield was obtained in the control treatment (F1) with Conventional Tillage, and the control treatment with the Reduced Tillage (Fig. 3); the yield in the Reduced Tillage plot was significantly higher than in the Conventional Tillage plot. Similar high yields (almost 10 t/ha) were obtained for all other treatments (Fig. 3).

There was no significant difference in yield for all the fertilizer treatments between conventional and reduced tillage (P=0.78). Root number and root length at the F1 treatment were larger for reduced tillage compared to conventional tillage, but this difference was not significant (P=0.18, P=0.48 respectively) (Figs. 4 and 5). That the difference is not significant could be explained by the low number of replicates, namely four. The penetration resistance was significantly higher in conventional tillage compared to the reduced tillage for the F1 treatment (P=0.01) (Fig. 5).

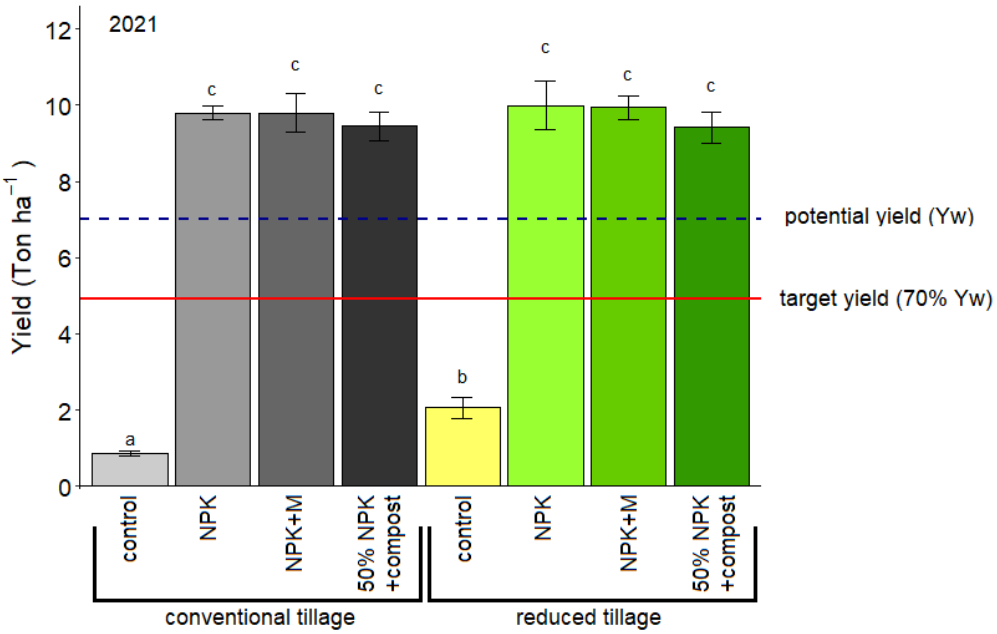

Fig. 3. Average maize yield (at 88% dry matter) with standard deviation for the different treatments (see Table 1 for treatment explanations). Bars labelled with different letters indicate significant differences in yield between the treatments ($P<0.05$). Blue dashed line indicates the estimated average water-limited potential yield, and the red continuous line is 70% of the water-limited yield potential.

Fig. 4. A) Roots from a Conventional Tillage plot. B) Roots from a Reduced Tillage plot.

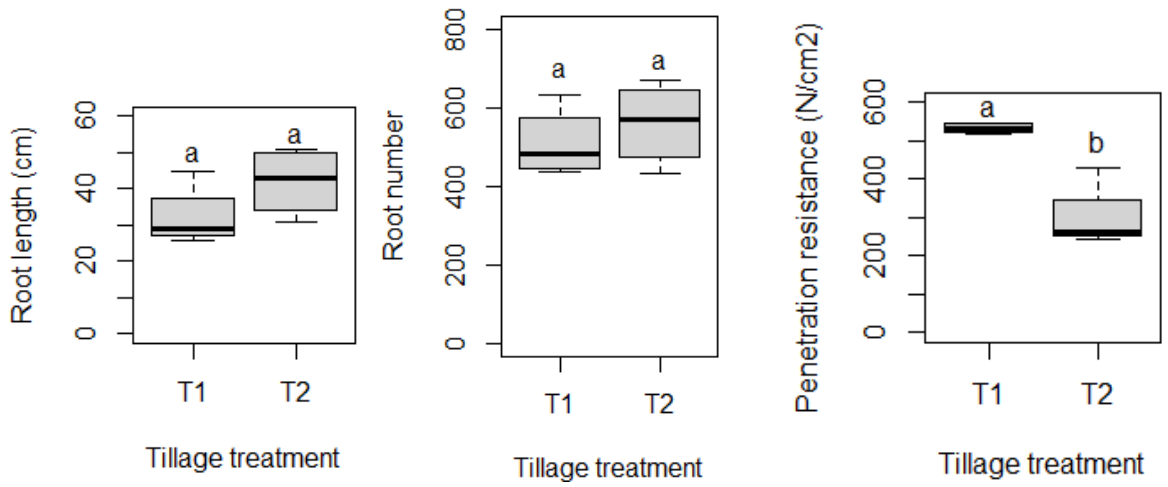

Fig. 4. Boxplots of A) Root length, B) root number, and C) penetration resistance from Conventional Tillage (T1) and Reduced Tillage (T2). Bars labelled with different letters indicate significant differences in yield between the treatments (P<0.05).

6. Communication and outreach

One of the major aims of Farm for the Future (Tanzania) Company is to encourage youngsters to appreciate that when well planned and carried out, agriculture is a lucrative business. For that matter, primary as well as secondary school children are encouraged to study agriculture at the farm. On 6 March 2021 a total of 50 pupils attended a field visit of the Trial. They expressed their desire to become farmers using Conservation Agriculture because, according to them (a fact), it demands much less and protects the land. They again visited on 18 June to appreciate experimental crop harvesting. Fig. 6 depicts transport used by the pupils as well as the pupils at the Trial as well as at the FFF Headquarters for further briefing.

Fig. 6 A) Bus carrying pupils from Sollerud Primary School just before offloading at the Trial Site. B) Sunflower Pre-& Primary School Bus at FFF Hq. C) The pupils at the Trial Site. D) The pupils a FFF Hq. for further briefing

Another strategy of both FFF and the SUA_WU_Yara Trial is to get farmers to see first-hand (hands-on) how proper agriculture can transform their lives. On 27 March 2021, FFF organized a Farmers Day that involved a visit to both FFF fields and the Trial. A total of about 400 farmers from 16 surrounding villages attended the show (see Fig. 7)

Fig. 7 Farmers from 16 surrounding villages attend a Farmers day at FFF and the Trial, 27 March 2021

Acknowledgements

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Our thanks go to FFF 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 the first year of maize production in their farm. During the third year of the Trial, FFF has taken up supervision of the trial through the company's farm manager, Ms Grace Kimonge: we greatly thank them. Towards the end of the second as well as the last season we received services of final year BSc (Agronomy) students. They helped with harvesting and, later, root depth and penetration resistance analysis. Their contribution is very much appreciated. The picture is not complete 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.