Rwanda | 2016B | Sorghum Fertilizer and Planting Methods

ONE ACRE FUND

Farmers First

PHASE:	(1) Research Station	(2) 50 – 500 Farmers	(3) 500 – 20,000 Farmers	(4) Full Scale

Introduction

Sorghum is a regionally important crop in the drier parts of Rwanda, primarily grown in the B season[1]. The average proportion of farmers growing sorghum in 2016B was 25%, but this was closer to 70-80% in the Southern districts of Nyaruguru, Gisagara and Huye, and 50% in the Eastern districts of Rwamagana and Gatsibo.[i]


Photo by Kelvin Owino. 2013

Current sorghum yields in farmer fields in Rwanda are around 2.7 t/ha, compared with the yield achieved in trial plots 3.6 t/ha[ii]. A large reason for this gap is potentially the low use of inputs and modern planting methods for sorghum – currently farmers report using compost on only 54% of their sorghum land, chemical fertilizer on 19%, and row planting on 5%.[iii]

Sorghum is a commercially and socially important crop in the country used for human consumption in the form of grain milled for porridge, production of sorghum beer *Ikigage,*[iv] and fodder for livestock. Improved sorghum yields would therefore be particularly beneficial to Rwandan farmers, and by addressing the fertilizer and planting-practice challenges, the trials outlined in this report seek to identify interventions to address the yield gap.

59%	**Average of farmers who preferred the One Acre Fund planting method and fertilizer products**
27-53%	**Yield increase when using the One Acre Fund planting method + fertilizer, depending on the ag zone**
280	**Farmers participating in the research**
25%	**One Acre Fund clients who currently grow sorghum**

Objectives

- To determine the effect of using recommended One Acre Fund planting methods and fertilizer on yield and profit, compared with local planting practices. This was compared in 3 different agro-ecological zones.

Hypotheses

- One Acre Fund planting methods will produce a significantly higher yield and profit compared with local planting methods, while fertilizer use will significantly affect yields and profit compared with no fertilizer. Furthermore, the combination of the One Acre Fund planting methods and fertilizer use will result in the best outcome for yield and profit. It is also hypothesized that these results will vary according to agro-ecological zone.

[1] A Season in Rwanda refers to crops planted in Aug-Oct of the preceding year and harvested in Jan-Feb of the relevant year, so 2016A crops are planted in Aug-Oct 2015. B Season in Rwanda refers to crops plants in Feb-March of the given year and harvested in May-June of that same year.

Methodology

One Acre Fund district(s): The trial was conducted in the Central Plateau agro-ecological zone in the Southern province district of Huye, the Congo-Nile agro-ecological zone in the Southern provincial district of Nyaruguru and in the Eastern Ridges agro-ecological zone in the Eastern provincial districts of Ngoma and Gatsibo. A description of the agro-ecological parameters in these selected zones is presented in the table below. These districts were selected because of the prevalence of sorghum cultivation, which is higher in these Southern and Eastern districts compared with the rest of the country in B season.

Agro-ecological parameters*: Averages of selected parameters in the agro-ecological zones where this trial was conducted

Agro-ecological zone	Alt	MAR	ATR (Min-Max)	Soil pH
Central Plateau	2,035 masl	1565 mm	17-19°C	4.6-5.5
Congo-Nile	2,193 masl	1555 mm	13-21°C	4.2-5.5
Eastern Ridges	1,880 masl	1517 mm	18-25°C	4.8-5.7

**Alt = Altitude (meters above sea level); MAR = mean annual rainfall (mm); ATR = annual temperature range (˚C)*

Experimental design and treatments:
A randomized complete block design was employed. Blocking was performed for any field variation, meaning the treatment plots were planted in a direction that allowed for control of any variation in field topography. This trial consisted of 3 treatments and a control. The plot sizes were 75 m^2. The trial was replicated across districts in different agro-ecological zones. The trial involved 20 replications in the Central Plateau agro-ecological zone, 16 replications in the Congo-Nile agro-ecological zone, and 34 replications in the Eastern Ridges agro-ecological zone. Treatments were as follows:

Treatment code	Variety	Planting method	Organic compost	Chemical fertilizer
A	Local (farmer choice)	Broadcast planting	Always applied at planting	None
B		Broadcast planting		Planting: 100 kg/ha DAP Top dress: 50 kg/ha urea
C		TUBURA planting: In rows, with 60 cm x 10 cm spacing	Quantity determined by farmer	None
D		TUBURA planting: In rows, with 60 cm x 10 cm spacing		Planting: 100 kg/ha DAP Top dress: 50 kg/ha urea

Although different local varieties were used in different regions, the same variety was planted across treatments in each field. No pesticides were used in this trial. Weeding and thinning practices were performed at the appropriate period for all variations.

Variables measured:
Based on the trial objective, the variables of particular importance in this trial were:

- Yield, sampled from a 25 m^2 harvest box within each plot and extrapolated to t/ha
- Profit, calculated from estimates of revenue from the yield minus the input costs of fertilizer (treatments C and D), labor, and seed cost (all treatments)
- Analysis of these results was performed using a two-way ANOVA, with agro-ecological zone and treatment as factors, and a post hoc mean separation was done using Tukey's HSD, with significance at $P < 0.05$. Further analysis included a multiple linear regression of different variables on yield.

Results

This study showed that, overall, yield and profit were improved by a combination of One Acre Fund planting methods and fertilizer use. This is evident from the results of the ANOVA presented below. However, the results

show a different effect across agro-ecological zones, as was hypothesized. The effect of combining One Acre Fund planting methods and fertilizer use was significantly higher than the control with regards to yield and profit in the Central Plateau and Eastern Ridges agro-ecological zones. In Eastern Ridges and Congo-Nile, there was no significant difference in profit between the One Acre Fund and local planting practices. In all agro-ecological zones, farmers expressed high preference for the One Acre Fund planting methods combined with fertilizer use. Overall, when the data was analyzed with all agro-ecological zones combined, the use of fertilizer was noted as a factor that significantly increased sorghum yield.

Results of ANOVA showing the effect of agro-ecological zone and treatment on yield, profit and farmer preference

Agro-ecological zones	Treatment	Sample size	Yield t/ha (vs control %)	Profit USD/ha (vs control)	Farmer preference
Central Plateau	Control: Local planting, no fertilizer	20	1.36 a[2]	$ 492 a	0%
	Local planting, with fertilizer	20	1.86 bc (+37%)	$ 574 ab (+17%)	29%
	One Acre Fund planting, no fertilizer	20	1.61 ab (+18%)	$ 575 ab (+17%)	5%
	One Acre Fund planting, with fertilizer	20	2.07 c (+53%)	$ 650 b (+32%)	67%
Eastern Ridges	Control: Local planting, no fertilizer	34	2.76 a	$ 947 a	5%
	Local planting, with fertilizer	34	3.48 bc (+26%)	$ 1,096 a (+16%)	43%
	One Acre Fund planting, no fertilizer	34	3.00 a (+8%)	$ 1,017 a (+7%)	13%
	One Acre Fund planting, with fertilizer	34	3.47 bc (+25%)	$ 1,094 a (+16%)	40%
Congo Nile	Control: Local planting, no fertilizer	16	1.86 a	$ 673 a	6%
	Local planting, with fertilizer	16	2.19 a (+18%)	$ 697 a (+4%)	24%
	One Acre Fund planting, no fertilizer	16	1.70 a (-8%)	$ 611 a (-9%)	0%
	One Acre Fund planting, with fertilizer	16	2.36 a (+27%)	$ 763 a (+13%)	71%
All Zones Combined	Control: Local planting, no fertilizer	70	2.20 a	$773 a	4%
	Local planting, with fertilizer	70	2.70 bc (+23%)	$878 a (+14%)	39%
	One Acre Fund planting, no fertilizer	70	2.30 a (+4%)	$818 a (+6%)	7%
	One Acre Fund planting, with fertilizer	70	2.80 c (+27%)	$915 a (+ 18%)	61%

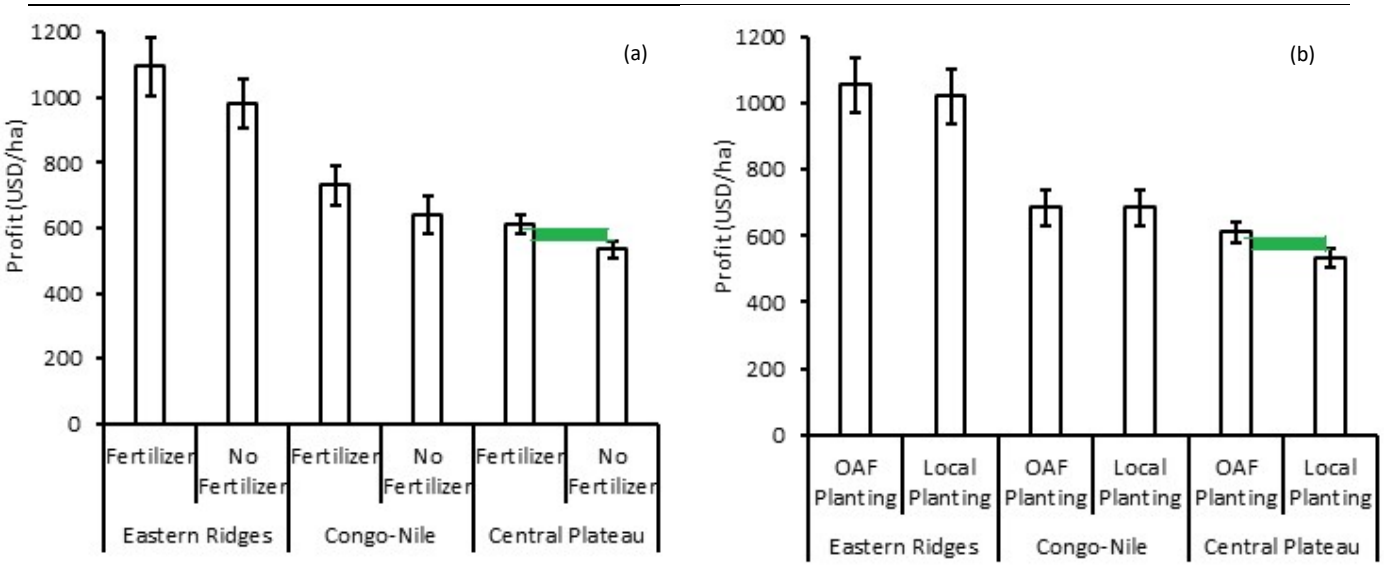
A multiple linear regression analysis was performed to determine the effect of different factors in this study on the recorded yield. From the results below, it is apparent that fertilizer use had the highest effect on the observed yield, while the effect of planting method was not statistically significant. Land slope also had a significant effect on recorded yield. The amount of compost used also showed a significantly positive, albeit smaller, effect.

[2] Evaluated at p = 0.05 (95% confidence level). In this chart and subsequent charts, yield followed by a similar letter indicates no statistically significant difference between other yield numbers followed by the same letter.

Regression Results on Yield (kg/are)

Variable	Coefficient	P-value	Significance
Fertilizer	5.33	0.000	***[3]
Planting method	1.20	0.403	ns
Land slope	-0.84	0.000	***
Compost amount	0.07	0.025	**

To determine the effect of fertilizer and planting methods on profit, a bar chart showing means and standard errors was plotted for the effect of the 2 factors on profit in the agro-ecological zones tested. The graphs presented below show that although profitability was high in the Eastern Ridges compared to all other agro-ecological zones, only the Central Plateau agro-ecological zone showed a significant difference in profit attributed to fertilizer use or planting practice, as seen by the lack of overlap between the standard errors bars (areas of difference shown in green).



The effect of fertilizer (a) and planting method (b) on profit in the different agro-ecological zones. These graphs show profit to be significantly (P <0.05) different only in the Central Plateau agro-ecological zone. The standard errors are plotted in these graphs

Interpretation and Discussion

- Overall, the effect of fertilizer use appears to have played a major role in any observed yield increases, and suggests that One Acre Fund should push fertilizer use for sorghum in the future.
- One Acre Fund planting methods when used without fertilizer do not consistently lead to higher yields or profits, though they seem to have a synergistic effect with fertilizer use in Congo Nile and Central Plateau (though not Eastern Ridges). The higher seed rate used in the One Acre Fund planting method may have negatively influenced profit from this practice. Furthermore, the impact from One Acre Fund planting was only significantly different in the Central Plateau agro-ecological zone. The lack of significance may be attributed to the high labor cost in the Eastern Ridges (USD 8.74/ha) and high seed cost (USD 11.47/ha) in the Congo-Nile districts.
- The farmers surveyed at harvest, however, selected the combined One Acre Fund planting method and fertilizer use as their top choice in Congo-Nile and Central Plateau. Therefore, even though fertilizer use was noted as the main driver, it appears that farmers in the area are likely to adopt both practices.

[3] Statistical significance levels: ***99%, **:95% *90%

Next Steps

- Recommend that farmers planting sorghum in the Central Plateau ag zones, which mostly include districts in the South, apply fertilizer and plant in rows
    - Adoption is so low currently, we could start promotion of the practice with demonstration parcels
    - We can encourage farmers to try these practices on at least a small portion of their land, as a personal trial, during the first season
    - Any concerted push for the adoption of fertilizer use on sorghum will require the permission of local governments, so we will need to share these results with them and get their approval first
- Continue trials on sorghum at Phase 2 (on-farm) trials in future seasons to learn more:
    - Test other agro-ecological zones compared with Central Plateau again to see if the lack of effect of planting methods and fertilizer continues or changes
    - Run trials on different rates of application of fertilizer, using less than 100 kg/ha of DAP and 50 kg/ha of urea
    - Consider running trials on different seed rates

References

[i] Crop Mix Survey 2016B. One Acre Fund Rwanda M&E Team. Link

[ii] FAOStat- Rwanda National Averages 2014.

[iii] 2016A Extended Crop Mix Survey. Agricultural Integration Team- One Acre Fund Rwanda. September 2015.

[iv] Lyumugabe, F, Uyisenga, JP, Songa, EB and Thonart, P. 2014. Production of Traditional Sorghum Beer "Ikigage" Using Saccharomyces cerevisae, Lactobacillus fermentum and Issatckenkia orientalis as Starter Cultures. Food and Nutrition Sciences. 5, 507-515. http://file.scirp.org/pdf/FNS_2014031109481998.pdf