SUBNATIONAL CLIMATE FUND

Biobuu Product Performance Trials
Crops: Potato & Maize
Short Rains 2023

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Evaluating the performance of the application of the BSF organic fertilizer at two different rates, in combination with different levels of synthetic fertilizer.

Acknowledgements

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Executive Summary

Two separate agricultural trials were conducted at Shomoro Farm in Narok, Kenya, focusing on potato and maize cultivation, respectively, with an emphasis on testing the efficacy of BSF (Black Soldier Fly) products in combination with synthetic fertilizers.

In the first study, Cropnuts conducted a product performance trial on an irrigated potato crop. The objective of the trial was to test and quantify the yields derived from the application of the BSF organic fertilizer produced by Biobuu using different rates of synthetic fertilizer.

In the second study, Cropnuts conducted a product performance trial on an irrigated maize crop. The objective of the trial was to test and quantify the yields derived from the application of the BSF organic fertilizer using different rates of synthetic fertilizer.

Report Part 1: Performance Trials for Potatoes

Introduction

Cropnuts conducted a product performance trial on an irrigated potato crop, commissioned by Catalytic Finance Foundation. The objective of the trial was to test and quantify the yields derived from the application of the BSF organic fertilizer produced by Biobuu using different rates of synthetic fertilizer.

The trial produced interesting results. The main findings were that the BSF products in combination with different rates of chemical fertilizer produced similar yields to the farmer control treatment – representing a standard farmer practice. The BSF products produced the highest yields when applied at a rate of 500kg/ha and in combination with 50% synthetic fertilizers.

The distribution of tubers in the different diameter classes seems not to have been compromised by the reduced rates in synthetic fertilizer in conjunction with the BSF product. Both these findings indicate that the BSF products can reduce the dependency towards synthetic fertilizers without compromising yield quantity and quality. While these findings are encouraging, further research is required in order to validate these results and to fine tune the rates of the products.

It is important to note that the BSF product should be considered as an organic soil conditioner. It is therefore not a fertilizer per se since it improves the general health of the soil (soil structure, organic matter, soil biology) meaning that the beneficial effects of the product should last more seasons and improving the soil resilience against, for example, conditions of drought. Soil structure improves soil aeration and drainage creating an environment in the soil which is more favourable for root growth, tuber expansion and, as a subsequence, to crop productivity.

Site of the potato trial in Narok, Kenya

EXPERIMENTAL DESIGN

The potato trial was carried out in Shomoro Farm, located in Narok. The site was manually prepared using hoes, preparing 0.6m wide raised beds. The drip lines were put in place and then the different plots delineated and fertilizers according to protocol and incorporated. Planting was done on the 13th of October 2023: the tubers were manually planted 30cm apart along each bed. Topdressing was done one the 14th of November 2023 according to specifications. No major disease of pest challenges was experienced by the crop. The trial was finally harvested on the 30th of January 2024.

Trial Site: Narok, Shomoro Farm.

Tested Crop: Potato, Variety: *Shangi*. This is a stable variety and not highly susceptible to late blight.
Planting Date: 13th of October 2023
Tested Products:
BSF – The Biobuu Organic Fertilizer is a made with organic waste processed by insects (black soldier flies). On the basis of the analysis of nine batches of fertilizer the BSF fertilizer contains Nitrogen (0.42%), Potassium (K_2O, 0.58%), Phosphorus (P_2O_5, 0.32%), Calcium (0.29%), Sulphur (0.07%) and Magnesium (0.09%).
Treatments: The trial consisted of nine treatments (including a farmer control and a zero control). The BSF product was tested at two rates, a low rate of 300 kg/ha and a high rate of 500 kg/ha. Both these have then been tested with varying rates of chemical fertilizer; either at 50%, 75% or 100%. See Table 1 and Table 2 for the description of the treatments.

Table 1 Description and coding of trials treatments

TREATMENT	ABBREVIATION	CODE
Control (0% Fert)	**Zero Control**	TR01
Farmer Control (100%)	**Farmer Control**	TR02
0% Synthetic Fertilizer + BSF (500 kg/ha)	**BSF(H)+0%**	TR03
50% Synthetic Fertilizer + BSF (500 kg/ha)	**BSF(H)+50%**	TR04
75% Synthetic Fertilizer + BSF (500 kg/ha)	**BSF(H)+75%**	TR05
100% Synthetic Fertilizer + BSF (500 kg/ha)	**BSF(H)+100%**	TR06
50% Synthetic Fertilizer + BSF (300 kg/ha)	**BSF(L)+50%**	TR07
75% Synthetic Fertilizer + BSF (300 kg/ha)	**BSF(L)+75%**	TR08
100% Synthetic Fertilizer + BSF (300 kg/ha)	**BSF(L)+100%**	TR09

Table 2 presents the rates of BSF products and synthetic fertilizers applied in all the treatments. The synthetic fertilizer rates are derived from the 100% fertilizer program (control) determined from the soil test carried out pre-planting (Annex I). The program targeted a yield of 40 ton/ha: 230 kg/ha of DAP basal application and 130 kg/ha of Amidas topdressing in one application – targeting 93 kg/ha of N and 105 kg/ha of P2O5.

Table 2 Rates of products for each trial treatment

TREATMENT	CODE	GYPSUM (kg/ha)*	DAP** (kg/ha)	BSF (kg/ha)	AMIDAS*** (kg/ha)
Zero Control	TR01	1000	0	0	0
Farmer Control	TR02	1000	230	0	130
BSF(H)+0%	TR03	1000	0	500	0
BSF(H)+50%	TR04	1000	115	500	65
BSF(H)+75%	TR05	1000	172.5	500	97.5
BSF(H)+100%	TR06	1000	230	500	100
BSF(L)+50%	TR07	1000	115	300	65
BSF(L)+75%	TR08	1000	172.5	300	97.5
BSF(L)+100%	TR09	1000	230	300	130

***Gypsum was used to counteract the sodicity of these soils, the high sodium content has a negative impact on the soil structure*

***DAP is a Diammonium phosphate, a basal fertilizer containing Nitrogen (18%), Phosphorus (P2O5, 46%)*

****AMIDAS is a granular fertilizer that contains nitrogen (40 N) and sulphate sulphur (5.6 S) that is available to the crops in an ideal N:S ratio of 7:1.*

Experimental design: Each of the 9 treatment was repeated four times for a total of 36 plots. A randomized complete block design was used to determine the distribution of the treatments in the trial area. Each plot measured 5 meters in length with 4 ridges per plot each measuring 0.60 meters in width (total width of 2.4m) for a total plot size of 12 m^2. Within each ridge the plants were spaced 0.30m, resulting in 68 potatoes per plot. There was 0.5-meter spacing between plots. The layout of the trial is show in Figure 1.

Beds:	4	4	4	4
m	**9.6**			
49	T02	T05	T03	T09
	T05	T04	T01	T04
	T07	T08	T05	T01
	T03	T01	T04	T03
	T04	T09	T02	T05
	T06	T07	T06	T02
	T08	T03	T09	T07
	T01	T06	T07	T08
	T09	T02	T08	T06
	BLOCK 01	**BLOCK 02**	**BLOCK 03**	**BLOCK 04**

Figure 1 Trial Layout

Annex II presents a collection of photos captured throughout the trial season from planting to harvesting.

RESULTS

Plant Population Count

A plant population count was carried out on the 1st of November 2023 to determine the number of plants per unit area of land and ensure successful survival of the tubers. The target plant population was 68 plants per plot.

Figure 2 provides a comparison of the distribution of the average plant population for each treatment expressed as a percentage of the target population of 68 plants per plot.

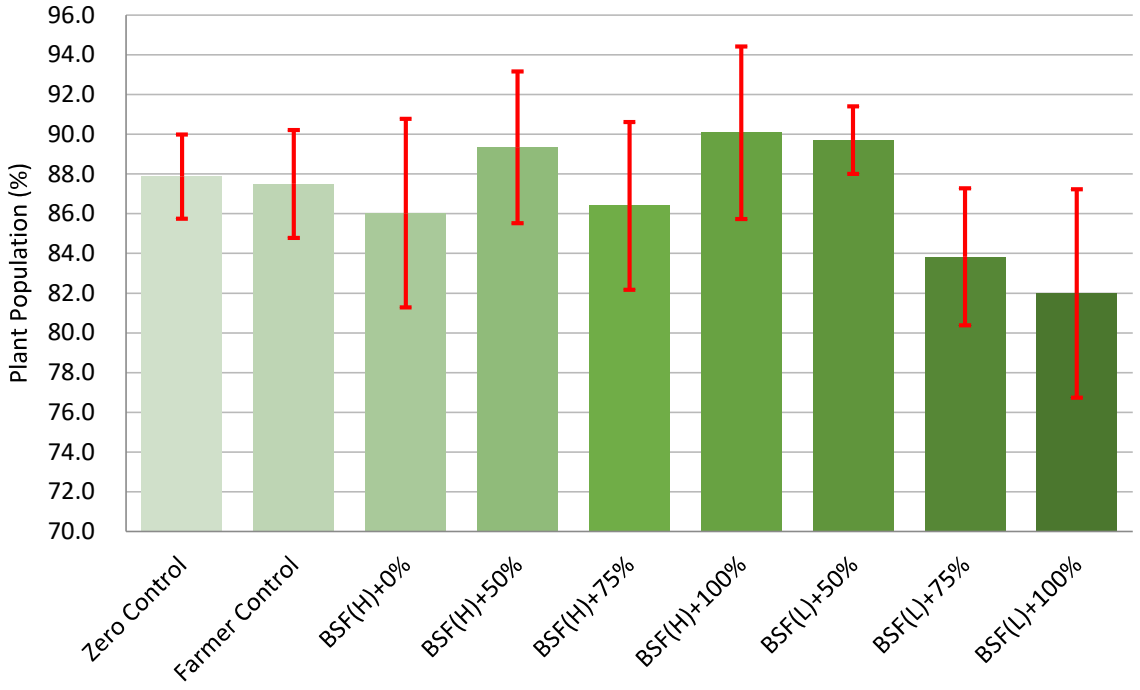

Figure 2 Average plant population count per treatment with standard error bars.

The plant population was variable amongst the treatments ranging from 82.0% to 91.1%. In all cases a satisfactory plant population to guarantee a successful trial.

Weed, Pest, Disease and Spray Program

Throughout the potato crop cycle there was no visible damage caused to the crop by either pests or diseases. The crop was hand weeded once on the 14th November 2023.

The trial followed a vigorous spray program (Table 3) ensuring the crop was protected against pests and diseases throughout its crop cycle. All plots were treated with the same spray program: same product, same application rate, same date. The applications of the products followed a program and depended on the regular visual assessments done on the site on crop health, disease and general trial status. The products, application dates and rates used are listed in Table 3.

Table 3 Products applied with application rate and application date

APPLICATION DATE	PRODUCTS AND RATE
13/10/2023	Aistar (1 l/ha); Biocel (0.2 l/ha)
10/11/2023	Cadilac (0.5 kg/ha)
23/11/2023	Cadilac (0.5 kg/ha); Electra (1 l/ha)
1/12/2023	Cadilac (0.5 kg/ha); Electra (1 l/ha)
7/12/2023	Cadilac (0.5 kg/ha); Electra (1 l/ha)
14/12/2023	Funguran (1 kg/ha); Electra (1 l/ha)
21/12/2023	Funguran (1 kg/ha); Electra (1 l/ha)
28/12/2023	Farmcozeb (2 kg/ha); Electra (1 l/ha)
4/1/2024	Farmcozeb (2 kg/ha); Electra (1 l/ha)
10/1/2024	Farmcozeb (2 kg/ha); Electra (1 l/ha)

Harvest

All plots were harvested by hand on the 30th of January 2024, collecting yield data for each individual plot. During harvest the soil around the potato tubers was loosened using a hand and the tubers were dug up carefully to avoid bruising or damaging them. All the potatoes in the middle two rows of each plot were harvested and their total weight recorded. The yields of each plot were then doubled to account for the 4 rows that constituted the full plot and then converted to a ton per hectare value using the plot size of 12 m^2.

The potatoes within each plot were grouped, counted and weighed per class size using five diameter classes: 0-28mm, 28-35mm, 35-50mm, 50-60mm, >60mm.

Yield

Total average yields per treatment ranged from a minimum of 39.0 tons/ha to a maximum of 48.1 tons/ha, the lowest being for TR03, BSF(H)+0%, and the highest in TR02, the farmer control. Table 4 and Figure 3 present the yield data in tabular and graphical form. The average potato yield across the whole trial site was of 44.1 ton/ha which is a good potato yield.

Table 4 Minimum and maximum yield, average yield (ton/ha) and standard deviation for each treatment group

TREATMENT GROUP	CODE	MIN ton/ha	MAX ton/ha	AVERAGE ton/ha	STD. DEV.
Zero Control	TR01	35.0	50.7	**41.3**	7.64
Farmer Control	TR02	40.8	53.5	**48.1**	5.33
BSF(H)+0%	TR03	36.0	43.2	**39.0**	3.09
BSF(H)+50%	TR04	41.6	51.3	**46.5**	4.81
BSF(H)+75%	TR05	33.8	56.8	**47.0**	10.36
BSF(H)+100%	TR06	27.2	55.4	**42.3**	13.40
BSF(L)+50%	TR07	27.7	56.6	**41.3**	13.32
BSF(L)+75%	TR08	37.9	53.9	**44.4**	7.54
BSF(L)+100%	TR09	30.4	56.1	**47.1**	11.62

- TR02 (farmer control) recorded the highest yield, 48.1 ton/ha, followed by TR09 (BSD(L)+100%) with 47.1 tons/ha and TR 05 (BSF(H)+75%) with 47.0 ton/ha.

- The zero control (TR01) and the 0% fertilizer treatment with BSF at a high rate, TR03, where the lowest yielding treatments. Statistically yielding the same and thus Indicating that the total lack of fertilizer, regardless of whether there is the BSF product, has had a reducing effect on the yield.

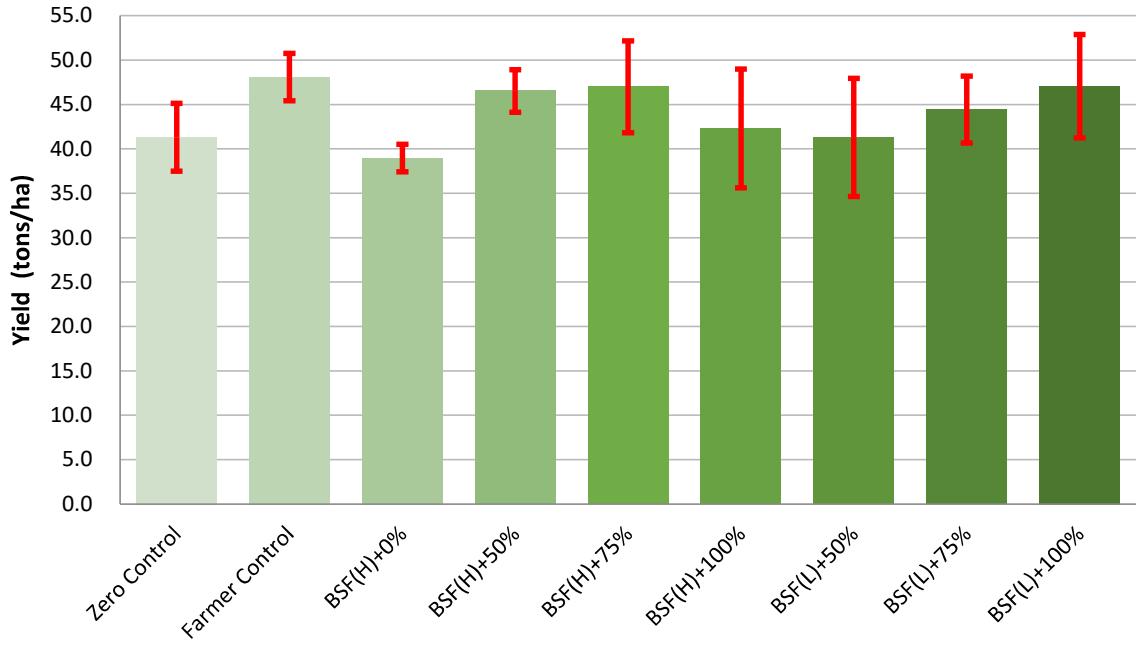

Figure 3 Average yield per treatment (tons/ha) with standard error bar

- There is some variation between the yields of the different treatments. The zero-fertilizer control yielded exceptionally high considering that no synthetic fertilizer was applied. This shows that good agronomic practices together with non-limiting irrigation can have a notable impact on production.
- The standard deviation within each treatment was high for TR05 (BSF(H)+75%), TR06 (BSF(H)+100%), TR07 (BSF(L)+50%) and TR09 (BSF(L)+100%), all of these having either a high rate or a low rate of BSF. Despite yielding lower than the farmer control, the maximum yields of the individual plots in these four treatments and in TR08 were all higher than the maximum yield of the farmer control. While the average yields were lower, the maximum yields obtained seem to show good potential for the BSF product.
- While the treatments with the BSF and synthetic fertilizer yielded lower than the farmer control, the trials do provide an indication that applying the BSF product can reduce synthetic fertilizer by up to 50% without compromising the yield of the farmer control. The most ideal combination seems to be a high rate of BSF (500 kg/ha) with 50% of synthetic fertilizer.
- At a low rate of BSF (300 kg/ha), increasing the fertilizer rate from 50% to 75% and finally to 100% has had an incremental effect on the yield. The same was not observed for high rates of BSF (500 kg/ha).

Tuber Size Grades

The distribution of size is important to determine the marketability of the potatoes. Potato tuber grading is done based on size and shape, leading to different categories. The tubers were categorized after harvest into the following size grades using a potato grid: 0-28mm, 28-35mm, 35-50mm, 50-60mm and >60mm. Ideally our crop will have many potatoes in the range of 35 to 60mm and larger.

The total number of tubers per size class were counted and weighed. The total average weight of each size class was then converted to a percentage out of the total weight of potatoes harvested in each treatment.

Figure 4 below shows the average percentage contribution of each class, in weight, to the total yield of each treatment.

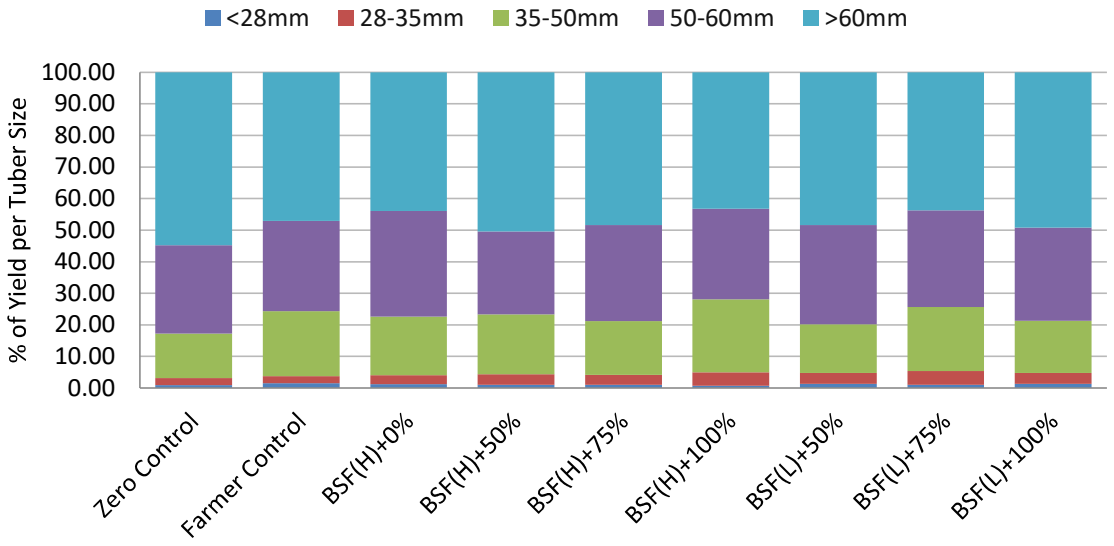

Figure 4 Percentage contribution of each tuber class's weight to the total yield of each treatment

- The distribution of sizes tends to be similar in all the treatments, with the most represented class being the >60mm size, averaging 47.7% for all, and the least represented being the smallest class of <28mm, averaging 1.1% for all.
- All BSF treatments but TR03 (BSF(H)+0%) recorded a slightly higher percentage in the 28-35mm tubers than the other treatments.
- No clear patterns can be seen from the data on the tuber size distribution. This does indicate that the BSF product at both rates used in conjunction with the synthetic fertilizers seems to have had no significant impact on the quality of the yield in terms of potato grades.

DISCUSSION AND CONCLUSION

The potato trial was concluded successfully. The trial gave an insight into the effect of BSF products, on the yields of irrigated potatoes. Below the main findings.

- A high rate of BSF (500 kg/ha) 50% synthetic fertilizer produced the highest yield out of all BSF products, yielding 96.8% of the farmer control. This indicates that the use of BSF can reduce the use of synthetic fertilizer by up to 50% without compromising potato yields. The BSF products can be a viable alternative to synthetic fertilizers for potato production, improving the sustainability of potato production.
- At a low rate of BSF product (300 kg/ha) there is an incremental benefit in yields when increasing the rate of synthetic fertilizer.
- The distribution of tuber grades did not seem to be compromised by the reduction in synthetic fertilizers in combination with the BSF product at both rates applied, producing good quality, sizeable potatoes having good marketability.
- BSF products can reduce the dependency of synthetic fertilizers, improving the sustainability of potato production.
- The zero-control produced high yields, indicating that good agronomy practices and sufficient water play a key role in determining yield.

NEXT STEPS

Further research and trials are necessary to ensure the reproducibility of these results. Based on the results of this trial, some possible avenues for further research could include:

1. It is advisable to repeat the experimental design both in the same agroclimatic condition as much as in other conditions, with different soils and different varieties of potatoes, to check the repeatability of the results. It is always advisable to repeat trials to ensure the repeatability of results also within the same conditions
2. Moreover, further research should be carried out on rainfed conditions.
3. Different rates of BSF product in conjunction with varying fertilizers can also be tested to fine tune the ideal combination. In particular further increasing the rate of BSF fertilizer (up to levels which are economically and practically feasible for farmers).
4. Examining the impact of BSF products on crop quality parameters such as nutritional value and shelf life.
5. Investigating the long-term effects of different rates of BSF and fertilizer treatments on soil health, including nutrient retention, microbial diversity, and overall soil quality is advisable. The BSF products being soil conditioners will have beneficial effects on soil quality: structure, organic matter content. These improvements have longer term benefits and as such cannot be quantified in a trial running for a single season. The BSF products should be considered as a long-term soil conditioner with benefits extending across more seasons/years – more trials should be focused on this aspect.
6. Separate trials should be carried out to test the efficacy of the BSF products against weeds and pest, whereby plots having no spray programs, with reduced rates of and with full spray programs to control pest and disease can be assessed.

Disclaimer

Please note that the information and conclusion presented in this report are based solely on the data and information collected by the Cropnuts trial team in Narok. The results of this trial may not be applicable to other regions or growing conditions, and therefore, should not be used for making critical business or agricultural decisions without proper consultation with local agronomists and experts. The trial team also acknowledges that unforeseen factors, such as weather conditions, can impact crop performance and yield. As a result, readers should use this information as a guide and exercise caution when interpreting the results.

ANNEX I – Soil Data

Parameter	Unit	Result	Guide Low	Guide High	Low	Optimum	High
pH (H2O)		7.64	5.50	7.20			
*EC (Salts)	uS/cm	206		< 800			
Phosphorus	ppm	11.2	40.0	100			
Potassium	ppm	1540	317	1010			
Calcium	ppm	4140	3250	4550			
Magnesium	ppm	448	312	702			
Sulphur	ppm	22.2	10.0	200			
*Sodium	ppm	667		< 523			
Iron	ppm	112	50.0	350			
Manganese	ppm	168	20.0	250			
Boron	ppm	1.42	0.80	2.00			
Copper	ppm	0.72	1.50	10.0			
Zinc	ppm	5.33	2.00	20.0			
*C.E.C	meq/100g	32.5	15.0	30.0			
*Total Nitrogen	%	0.20	0.20	0.50			
*Organic Matter	%	4.70	3.50	4.50			
*C/N ratio		13.7	10.0	25.0			
***PERCENTAGES AND RATIOS**							
Calcium %	%	63.7	50	70			
Magnesium %	%	11.5	8	18			
Potassium %	%	12.1	2.5	8			
Sodium % (ESP)	%	8.92	0	7			
Other Bases %	%	3.76	3	10			
Hydrogen %	%	0.00	10	15			
Total	%	100.00					
Ca:Mg Ratio	%	5.54	4	6			

Soil Analysis Results, 3rd October 2023

The soil data was used to generate the farmer control treatment.

ANNEX V – Trials Photos Potatos

TR01 Zero Control (0%)

TR02 Farmer Control (100%)

TR03 BSF (H) + 0%

TR04 BSF (H) + 50%

TR05 BSF (H) + 75%

TR06 BSF (H) + 100%

TR07 BSF (L) + 50%

TR08 BSF (L) + 75%

TR09 BSF (L) + 100%

Report Part 2: Performance Trials for Maize

Introduction

Cropnuts conducted a product performance trial on an irrigated maize crop, commissioned by Catalytic Finance Foundation. The objective of the trial was to test and quantify the yields derived from the application of the BSF organic fertilizer using different rates of synthetic fertilizer.

The trial yielded intriguing results. Key findings revealed that combining BSF products with varying rates of chemical fertilizer resulted in yields similar to those of the farmer control treatment, which represents a standard farming practice. The highest yields from BSF products were observed when applied at a rate of 300kg/ha in conjunction with 100% synthetic fertilizers. The trials further revealed that applying BSF products at a rate of 300 kg/ha, in combination with 75% and 100% fertilizer, resulted in increased plant height, suggesting greater biomass in the maize plants. This higher biomass implies a larger root mass, which is advantageous in bolstering plant resilience against stress conditions, ultimately enhancing crop resilience.

It's worth emphasizing that the BSF product functions primarily as an organic soil conditioner rather than a fertilizer itself. Its role lies in enhancing overall soil health, including soil structure, organic matter, and soil biology. Consequently, the beneficial effects of the product are expected to endure over multiple seasons, bolstering soil resilience against factors such as drought. Improved soil structure enhances soil aeration and drainage, creating a conducive environment for root growth, tuber expansion, and ultimately, crop productivity.

Site of the maize trial in Narok, Kenya

EXPERIMENTAL DESIGN

The maize trial was carried out in Shomoro Farm, located in Narok. The site was manually prepared using hoes, preparing 0.6m wide raised beds. The drip lines were put in place and then the different plots delineated and fertilizers according to protocol and incorporated. Planting was done on the 13th of October 2023: the seeds were manually planted 30cm apart along each bed. Topdressing was done one the 29th of November 2023 according to specifications. No major disease of pest challenges was experienced by the crop. The trial was finally harvested on the 4th of April 2024.

Trial Site: Narok, Shomoro Farm.

Tested Crop: Maize, Variety: *DK 777*. This variety has a good stand and not highly susceptible to adverse weather conditions and disease pressure.
Planting Date: 13th of October 2023

Tested Products:
BSF – The Biobuu Organic Fertilizer is a made with organic waste processed by insects (black soldier flies). On the basis of the analysis of nine batches of fertilizer the BSF fertilizer contains Nitrogen (0.42%), Potassium (K_2O, 0.58%), Phosphorus (P_2O_5, 0.32%), Calcium (0.29%), Sulphur (0.07%) and Magnesium (0.09%)

Treatments: The trial consisted of nine treatments (including a farmer control and a zero control). The BSF product was tested at two rates, a low rate of 300 kg/ha and a high rate of 500 kg/ha. Both these have then been tested with varying rates of chemical fertilizer; either at 50%, 75% or 100%. See Table 1 and Table 2 for the description of the treatments.

Table 5 Description and coding of trials treatments

TREATMENT	ABBREVIATION	CODE
Control (0% Fert)	**Zero Control**	TR01
Farmer Control (100%)	**Farmer Control**	TR02
0% Synthetic Fertilizer + BSF (500 kg/ha)	**BSF(H)+0%**	TR03
50% Synthetic Fertilizer + BSF (500 kg/ha)	**BSF(H)+50%**	TR04
75% Synthetic Fertilizer + BSF (500 kg/ha)	**BSF(H)+75%**	TR05
100% Synthetic Fertilizer + BSF (500 kg/ha)	**BSF(H)+100%**	TR06
50% Synthetic Fertilizer + BSF (300 kg/ha)	**BSF(L)+50%**	TR07
75% Synthetic Fertilizer + BSF (300 kg/ha)	**BSF(L)+75%**	TR08
100% Synthetic Fertilizer + BSF (300 kg/ha)	**BSF(L)+100%**	TR09

Table 2 presents the rates of BSF products and synthetic fertilizers applied in all the treatments. The synthetic fertilizer rates are derived from the 100% fertilizer program (control) determined from the soil test carried out pre-planting (Annex I). The program targeted a yield of 9 ton/ha: 250 kg/ha of DAP basal application and 250 kg/ha of Amidas topdressing – targeting 145 kg/ha of N and 115 kg/ha of P2O5.

Table 6 Rates of products for each trial treatment

TREATMENT	CODE	GYPSUM (kg/ha)*	DAP** (kg/ha)	BSF (kg/ha)	AMIDAS*** (kg/ha)

Zero Control	TR01	500.0	0.0	0.0	0.0
Farmer Control	TR02	500.0	250.0	0.0	250.0
BSF(H)+0%	TR03	500.0	0.0	500.0	0.0
BSF(H)+50%	TR04	500.0	125.0	500.0	125.0
BSF(H)+75%	TR05	500.0	187.5	500.0	187.5
BSF(H)+100%	TR06	500.0	250.0	500.0	250.0
BSF(L)+50%	TR07	300.0	125.0	300.0	125.0
BSF(L)+75%	TR08	300.0	187.5	300.0	187.5
BSF(L)+100%	TR09	300.0	250.0	300.0	250.0

***Gypsum was used to counteract the sodicity of these soils, the high sodium content has a negative impact on the soil structure*

***DAP, Diammonium phosphate, is a basal fertilizer containing Nitrogen (18%), Phosphorus (P2O5, 46%),*

****AMIDAS is a granular fertilizer that contains nitrogen (40 N) and sulphate sulphur (5.6 S) that is available to the crops in an ideal N:S ratio of 7:1.*

Experimental design: Each of the 9 treatment was repeated four times for a total of 36 plots. A randomized complete block design was used to determine the distribution of the treatments in the trial area. Each plot measured 5 meters in length with 4 ridges per plot each measuring 0.60 meters in width (total width of 2.4m) for a total plot size of 12 m^2. Within each ridge two rows were planted and along each row the plants were spaced 0.30m, resulting in 136 plants per plot. There was 0.5-meter spacing between plots. The layout of the trial is show in Figure 1.

Beds:	4	4	4	4
m	**9.6**			
49	T02	T05	T03	T09
	T05	T04	T01	T04
	T07	T08	T05	T01
	T03	T01	T04	T03
	T04	T09	T02	T05
	T06	T07	T06	T02
	T08	T03	T09	T07
	T01	T06	T07	T08
	T09	T02	T08	T06
	BLOCK 01	**BLOCK 02**	**BLOCK 03**	**BLOCK 04**

Figure 5 Trial Layout

Annex II presents a collection of photos captured throughout the trial season from planting to harvesting.

RESULTS

Plant Population Count

A plant population count was carried out on the 27th of October 2023 to determine the number of plants per unit area of land. The target plant population was 136 plants per plot.

Figure 2 provides a comparison of the distribution of the average plant population for each treatment expressed as a percentage of the target population of 136 plants per plot.

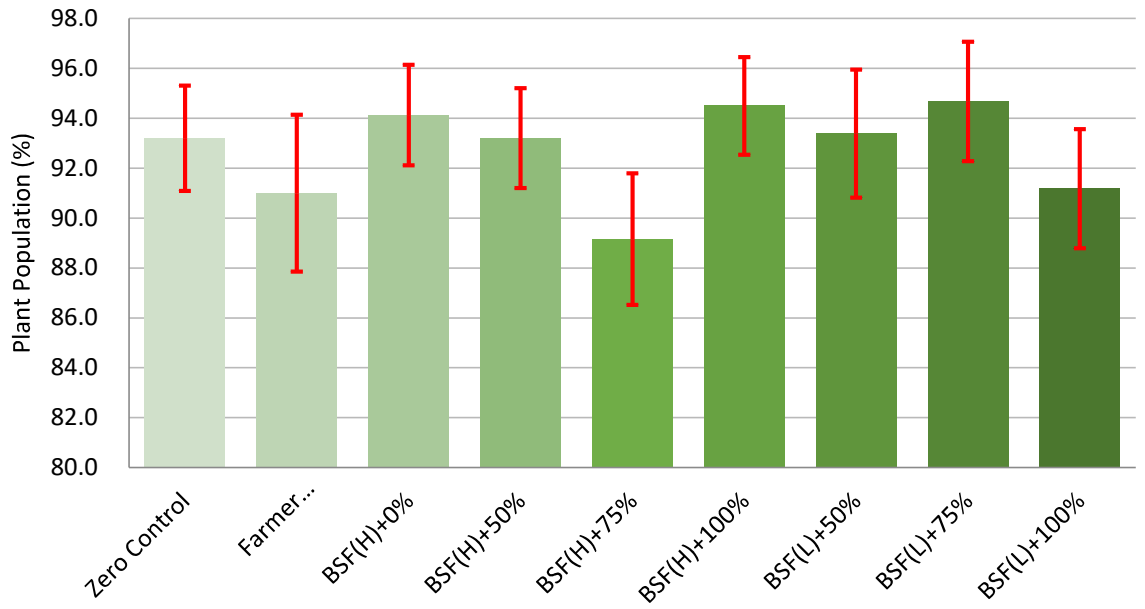

Figure 6 Average plant population count per treatment with standard error bars.

The plant population was variable amongst the treatments ranging from 89.2% to 94.7%, with an average of 92.7%. In all cases a satisfactory plant population to guarantee a successful trial.

Weed, Pest, Disease and Spray Program

Throughout the Maize crop cycle there was no visible damage caused to the crop by either pests or diseases. Weeding was done post emergence on the 20th of November 2023. No significant Fall Army Worm pressure was experienced due to the consistent spray program.

The trial followed a vigorous spray program (Table 3) ensuring the crop was protected against pests and diseases throughout its crop cycle. All plots were treated with the same spray program: same product, same application rate, same date. The applications of the products followed a program and depended on the regular visual assessments done on the site on crop health, disease and general trial status. The products, application dates and rates used are listed in Table 3.

Table 7 Products applied with application rate and application date

APPLICATION DATE	PRODUCTS AND RATE
9/10/2023	Amigad (200 gr/ha)
20/11/2023	Governor (2.5 l/ha)
23/11/2023	Amigad (200 gr/ha)
7/12/2023	Amigad (200 gr/ha)
14/12/2023	Amigad (200 gr/ha)
21/12/2023	Amigad (200 gr/ha)
10/12/2023	Tukom (1 l/ha)

Harvest

All plots were harvested by hand on the 4th of April 2024, collecting yield data for each individual plot. During harvest all the cobs were removed from each plot, these were then shelled and weighted. The yields of each plot were then converted to a ton per hectare value using the plot size of 12 m^2.

Cob height and plant height were recorded at the time of harvests as well as number of cobs per plant.

Yield

All treatments had a single cob per plant. The total average yield per treatment ranged from a minimum of 13.8 tons/ha to a maximum of 15.2 tons/ha, the lowest being for TR04, BSF(H)+50%, and the highest in TR09, BSF(L)+100%. Table 4 and Figure 3 present the yield data in tabular and graphical form. The average Maize yield across the whole trial site was of 14.3 ton/ha which is a good Maize yield.

Table 8 Minimum and maximum yield, average yield (ton/ha) and standard deviation for each treatment group

TREATMENT GROUP	CODE	MIN ton/ha	MAX ton/ha	AVERAGE ton/ha	STD. DEV.
Zero Control	TR01	13.2	16.1	**14.5**	1.21
Farmer Control	TR02	14.8	15.4	**15.1**	0.26
BSF(H)+0%	TR03	13.0	16.4	**14.3**	1.49
BSF(H)+50%	TR04	13.0	14.5	**13.8**	0.65
BSF(H)+75%	TR05	13.1	14.6	**13.9**	0.63
BSF(H)+100%	TR06	11.3	15.3	**13.9**	1.77
BSF(L)+50%	TR07	11.1	15.3	**14.0**	1.95
BSF(L)+75%	TR08	12.9	15.1	**14.5**	1.05
BSF(L)+100%	TR09	14.9	15.5	**15.2**	0.26

- TR09 (BSF(L)+100%) recorded the highest yield, 15.2 ton/ha, followed by TR02 (Farmer control) with 15.1 tons/ha.
- TR04 with BSF at a high rate and 50% fertilizer was the lowest yielding treatment, however still yielding an average of 13.8 ton/ha which is an exceptional yield.
- At a low rate of BSF (300 kg/ha), increasing the fertilizer rate from 50% to 75% and finally to 100% has had an incremental effect on the yield, increasing the yield from 14.0 to 14.5 and then finally to 15.2 ton/ha respectively. The same was not observed for high rates of BSF (500 kg/ha).

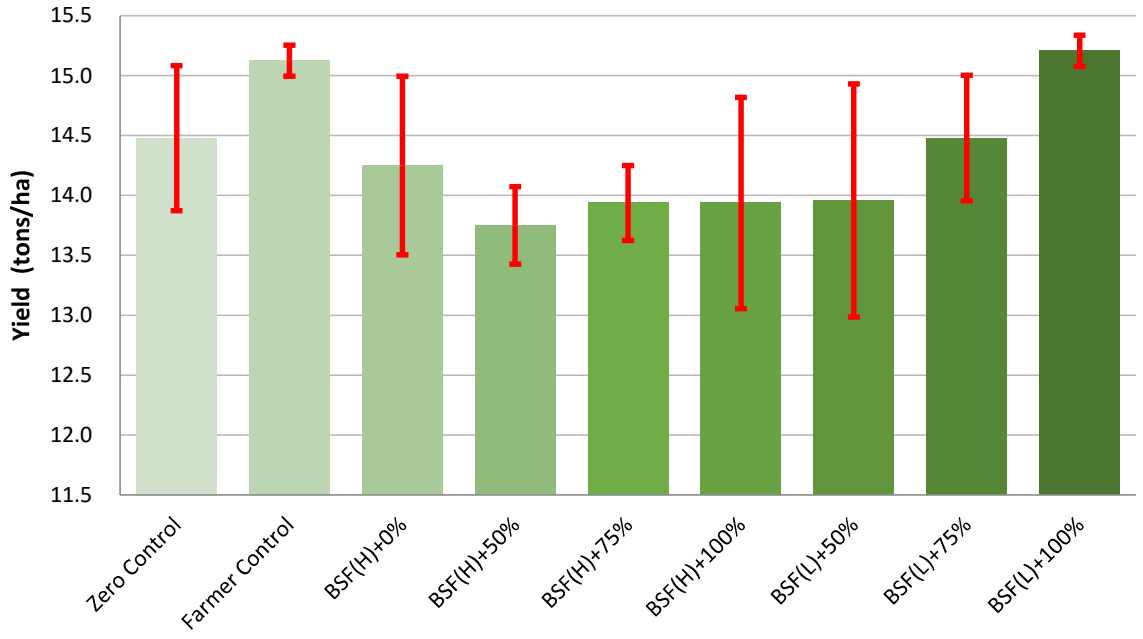

Figure 7 Average yield per treatment (tons/ha) with standard error bar

The data on cob height and plant height at time of harvest (Figure 4) shows that the average plant height ranged from a minimum of 209.8 to a maximum of 234.3 cm. The tallest plants were those in TR08 (BSF(L)+75%) and TR09 (BSF(L)+100%). The placement of the cob ranged from a minimum of 102.5 to a maximum of 114.8 cm, once again the highest placed cobs were in treatments TR08 and TR09.

Interesting that the lowest rate of BSF (300 kg/ha) produced, seemingly, the most biomass in terms of plants (taller plants). This could be an indication of higher root mass.

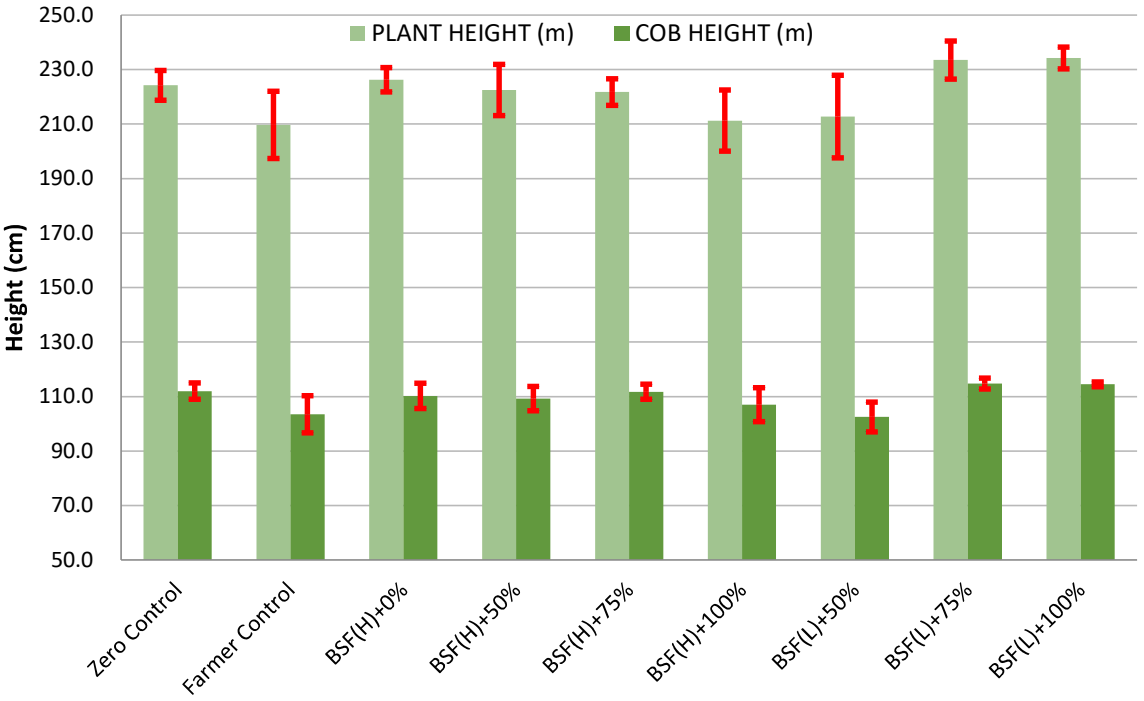

Figure 8 Average height of plant and average height of cob at harvest

DISCUSSION AND CONCLUSION

The maize trial was concluded successfully. The trial gave an insight into the effect of BSF products, on the yields of irrigated maize. Below the main findings.

- The combination of a low rate of BSF (300 kg/ha) with 100% synthetic fertilizer resulted in the highest yield among all trial treatments.
- Yields across the trial plots were notably high, reflecting the positive influence of good agronomic practices and sufficient water availability. Even in the zero-control group, maize yields were optimal, underscoring the importance of agronomy and water management in crop productivity.
- Increasing the rate of synthetic fertilizer alongside a low rate of BSF product (300 kg/ha) led to incremental improvements in yields.
- The BSF treatments at 300 kg/ha have produced, when used in combination of 75% and 100% fertilizer, taller plants, suggesting higher biomass. It is reasonable to think that this translates to a higher root mass which means that plants may build better resilience, for example, in times of drought.
- It's essential to recognize that the BSF product functions as a soil conditioner rather than a fertilizer in itself. Its benefits, such as enhanced soil structure and increased organic matter content, may manifest over subsequent seasons. Soils treated with BSF products are likely to exhibit greater resilience, particularly in challenging conditions like drought.

These findings highlight the potential of BSF products to improve soil health and contribute to long-term agricultural sustainability.

NEXT STEPS

Further research and trials are necessary to ensure the reproducibility of these results. Based on the results of this trial, some possible avenues for further research could include:

- It is advisable to repeat the experimental design both in the same agroclimatic condition as much as in other conditions, with different soils and different varieties of maize, to check the repeatability of the results. It is always advisable to repeat trials to ensure the repeatability of results also within the same conditions
- Further research should be carried out on rainfed conditions.
- Examining the impact of BSF products on crop quality parameters such as nutritional value and shelf life.
- Pot trials in a greenhouse (controlled) environment are also advisable. The same treatments can be used on pots and at regular intervals plants from individual pots can be uprooted to measure root mass, total biomass and mineral composition.
- Investigating the long-term effects of different rates of BSF and fertilizer treatments on soil health, including nutrient retention, microbial diversity, and overall soil quality is advisable. The BSF products being soil conditioners will have beneficial effects on soil quality: structure, organic matter content. These improvements have longer term benefits and as such cannot be quantified in a trial running for a single season. The BSF products should be considered as a long-term soil conditioner with benefits extending across more seasons/years – more trials should be focused on this aspect. For this reason trials should be carried out for a minimum of three seasons using the same plots.
- Separate trials should be carried out to test the efficacy of the BSF products against weeds and pest, whereby plots having no spray programs, with reduced rates of and with full spray programs to control pest and disease can be assessed.

Disclaimer

Please note that the information and conclusion presented in this report are based solely on the data and information collected by the Cropnuts trial team in Narok. The results of this trial may not be applicable to other regions or growing conditions, and therefore, should not be used for making critical business or agricultural decisions without proper consultation with local agronomists and experts. The trial team also acknowledges that unforeseen factors, such as weather conditions, can impact crop performance and yield. As a result, readers should use this information as a guide and exercise caution when interpreting the results.

ANNEX I – Soil Data

Parameter	Unit	Result	Guide Low	Guide High	Low	Optimum	High
pH (H2O)		7.64	5.50	7.20			
*EC (Salts)	uS/cm	206		< 800			
Phosphorus	ppm	11.2	40.0	100			
Potassium	ppm	1540	317	1010			
Calcium	ppm	4140	3250	4550			
Magnesium	ppm	448	312	702			
Sulphur	ppm	22.2	10.0	200			
*Sodium	ppm	667		< 523			
Iron	ppm	112	50.0	350			
Manganese	ppm	168	20.0	250			
Boron	ppm	1.42	0.80	2.00			
Copper	ppm	0.72	1.50	10.0			
Zinc	ppm	5.33	2.00	20.0			
*C.E.C	meq/100g	32.5	15.0	30.0			
*Total Nitrogen	%	0.20	0.20	0.50			
*Organic Matter	%	4.70	3.50	4.50			
*C/N ratio		13.7	10.0	25.0			
***PERCENTAGES AND RATIOS**							
Calcium %	%	63.7	50	70			
Magnesium %	%	11.5	8	18			
Potassium %	%	12.1	2.5	8			
Sodium % (ESP)	%	8.92	0	7			
Other Bases %	%	3.76	3	10			
Hydrogen %	%	0.00	10	15			
Total	%	100.00					
Ca:Mg Ratio	%	5.54	4	6			

Soil Analysis Results, 3rd October 2023

The soil data was used to generate the farmer control treatment.

ANNEX V – Trials Photos Maize

TR01 Zero Control (0%)

TR02 Farmer Control (100%)

TR03 BSF (H) + 0%

TR04 BSF (H) + 50%

TR05 BSF (H) + 75%

TR06 BSF (H) + 100%

TR07 BSF (L) + 50%

TR08 BSF (L) + 75%

TR09 BSF (L) + 100%

SUBNATIONAL CLIMATE FUND

About the Subnational Climate Fund:

The Subnational Climate Fund (SCF) is a global blended finance initiative that aims to invest in and scale mid-sized (5 – 75 M $USD) subnational infrastructure projects in the fields of sustainable energy, waste and sanitation, regenerative agriculture and nature-based solutions in developing countries.

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