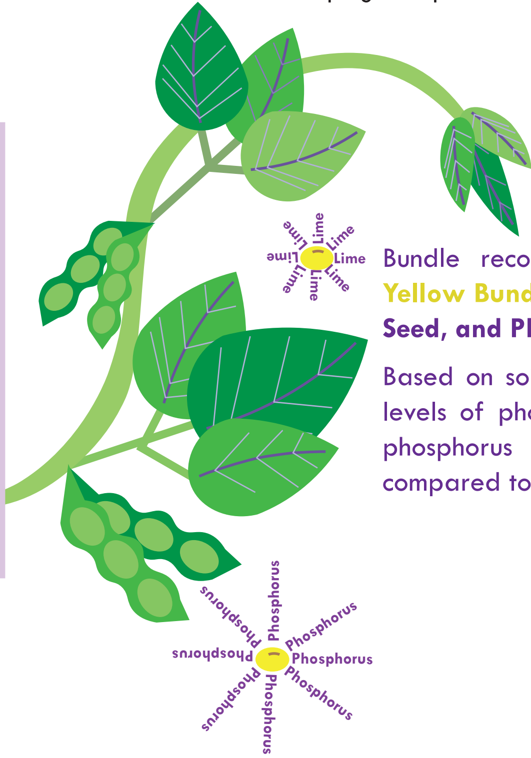
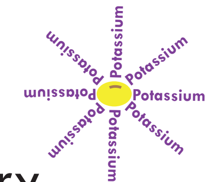
SMART Farm Trials

Results from Zambia: GNA 2019-2020

In partnership with the Soybean Innovation Lab (SIL), Good Nature Agro conducted a SMART (Soybean Management with Appropriate Research and Technology) Farm input omission trial at Chipata, Malawi (**Figure 1; Table 1**). This trial provides information on which inputs are best suited to maximize soybean yield and are a valuable resource for developing an input bundle approach to soybean production.

Figure 1: Good Nature Agro trial location for 2019-2020 season





Summary

Bundle recommendation for the Chipata field site: Yellow Bundle - Best Management Practices, Certified Seed, and Phosphorus Fertilizer.

Based on soil fertility results, the Chipata site has low levels of phosphorus and acidic soils. The addition of phosphorus fertilizer significantly increased yields compared to the no input control.

The input omission trial is composed of 16 treatment combinations (**Table 2**) of P, K, Lime (I), and Inoculum (I) (**Table 3**). Each set of 16 treatments were randomized and replicated 4 times. The soybean variety “Kafue” from IITA was planted in 3 meter by 5 meter plots with a seed spacing of 5 cm. Each plot contained 4 rows with a spacing of 75 cm. Seeds were treated with Hi-Stick Inoculum 1 hour prior to planting. Calciprill Lime was applied in furrow at planting. Approximately 21 days after germination at the V2 or V3 developmental stage, Triple Super Phosphate and Muriate of Potash were applied to treated plots as a side-dress 5 centimeters from the furrow, and 5 centimeters deep.

Treatment	L	I	P	K	S
1					+
2		+			+
3			+		+
4				+	+
5		+	+		+
6		+		+	+
7			+	+	+
8		+	+	+	+
9	+				+
10	+	+			+
11	+		+		+
12	+			+	+
13	+	+	+		+
14	+	+		+	+
15	+		+	+	+
16	+	+	+	+	+

Table 2: Treatment combinations for the omission trial. L=Lime, I=Inoculum, P=Phosphorus, K=Potassium, S=Seeds.

Country	Location	Planting Date	Harvest Date	Latitude	Longitude	Elevation
Zambia	Chipata	26/12/2019	23/4/2020	-13.656389	32.557778	1123m

Table 1: Site information for the Good Nature Agro omission trial, including planting and harvest date.

	Phosphorus	Potassium	Inoculum	Lime	Seed
Product	Triple Super Phosphate	Muriate of Potash	Hi-stick	Calciprill	Kafue
Source	-	-	BASF	OMYA	IITA
Concentration	P2O5-46%	K2O-60%	-	CaO-52%	-
Application Rate	75 kg ai/ha	75 kg ai/ha	400 g/100 kg	300 kg/ha	320000 seeds/ha

Table 3: The product names, sources, concentrations and application rates of inputs used for the omission trial. kg ai/ha – Kilograms of active ingredient per hectare.

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Figure 2: Field plots at the Chipata SMART Farm omission trial.

Test	Method	Units	Chipata	Rating
Soil pH	1:1 - Water pH	-	5.6	-
Phosphorus (P)	Mehlich 3	ppm	3	Low
Potassium (K)	Mehlich 3	ppm	317	Very High
Calcium (Ca)	Mehlich 3	ppm	1575	Medium
Magnesium (Mg)	Mehlich 3	ppm	221	Optimum
Sulfur (S)	Mehlich 3	ppm	10	Low
Boron (B)	Mehlich 3	ppm	0.2	Low
Copper (Cu)	Mehlich 3	ppm	5.1	Very High
Iron (Fe)	Mehlich 3	ppm	63	Medium
Manganese (Mn)	Mehlich 3	ppm	271	Very High
Zinc (Zn)	Mehlich 3	ppm	1.2	Low
Sodium (Na)	Mehlich 3	ppm	34	Very Low
Organic Matter	Loss On Ignition	%	3.2	Medium

Table 5: Soil fertility results for the Chipata site generated from Waypoint Analytics. Soil nutrient amounts are displayed in parts-per-million (mg/kg). The nutrient rating provides a general description of nutrient presence in the tested soil and is ordered as follows: very low, low, medium, optimum, very high.

Rating	Very Low	Low	Medium	Optimum	Very High
Probability of Crop Response	~100%	~75%	50%	0-25%	0-10%

Figure 3: Descriptions of the "Rating" column in Table 5. Indicates the probability that additional nutrient amendments will positively impact crop performance.

Month	Max Temperature (°C)	Min Temperature (°C)	Rainfall (mm)
October	32.4	21.0	67.2
November	31.8	22.4	131.2
December	29.2	21.4	200.1
January	27.6	20.5	323.2
February	27.7	20.4	170.6
March	28.4	19.6	115.4
April	29.4	19.1	16.0

Table 4: Monthly averages for maximum and minimum temperatures and the total monthly rainfall for 2019-2020 season at the Chipata site.

Seasonal temperature and precipitation information for the field sites are displayed in **Table 4**. Temperatures peaked a month before planting in November reaching 31.8°C. A minimum temperature of 19.1°C was observed in April. Between the months of October and April, the total observed rainfall was 1023.7 mm.

Soil properties for Chipata are shown in **Table 5** with descriptions of the nutrient ratings indicated in **Figure 3**. The field site had a sandy clay loam texture with very low to very high fertility. The soil has a pH of 5.6, so additional liming to raise the pH closer to the optimal level of 6.5 would benefit nutrient uptake. Phosphorus and potassium levels are shown to be low and very high, respectively.

Data collection metrics for the input omission trial are described in **Table 6**. Stand count was measured at V2 and R8 developmental stages. Measurements for nodule count and viability were measured at the R3 developmental stage.

Trait	Unit	Measurement Metrics
Yield	tonnes/hectare	Plants harvested and threshed, seed winnowed and weighed at 13% moisture
Stand Count	count	Sum of plants in row 2 and 3
Days to Flowering	days	Days after planting when the first flower is observed
Plant Height	centimeters	Distance from soil to the shoot apical meristem on main stem
Nodule Count	count	number of rhizobium nodules on roots collected at R3-pod filling stage
Nodule Weight	grams	mass of rhizobium nodules on roots collected at R3-pod filling stage
Nodule Viability	%	Percentage of counted nodules that are active and viable
100 Seed Weight	grams	Random sets of 100 seeds selected and weighed
Seed Moisture	%	Percent moisture at harvest

Table 6: Data metrics for the 2019-2020 SMART Farm omission trial

Treatment	Rank Yield	Yield	V2 Stand Count	R1 Flowering	R1 Height	Nodule Count	Nodule Weight	R8 Stand Count	R8 Height	100 Seed Weight	Seed Moisture
		tonnes/ha	count	days	cm	count	g	count	cm	g	%
P+K	1	3.08	184	44	43	137	3.4	176	66	13.7	8.8
I+P+K	2	3.00	174	44	43	131	3.5	184	61	13.4	8.4
P (***)	3	2.90	194	44	45	123	4.5	184	69	13.6	8.5
L+P+K	4	2.83	156	44	43	124	5.3	171	62	13.4	7.6
L+I+P	5	2.69	190	44	41	125	4.3	182	65	13.3	8.1
L+P	6	2.67	175	44	40	126	4.0	167	62	13.3	9.0
L+I+P+K	7	2.48	160	44	41	130	3.8	176	57	13.5	8.2
I+P	8	2.47	175	44	39	132	4.3	164	63	13.4	7.9
L+K	9	2.23	184	44	41	131	2.3	166	56	13.3	8.8
L+I	10	2.15	175	44	40	122	5.0	167	54	13.3	9.4
I	11	2.11	167	44	42	109	3.8	146	58	13.1	8.2
L+I+K	12	2.09	174	44	36	110	3.0	167	53	13.4	7.9
No Input	13	1.99	147	44	39	156	4.5	137	58	13.5	8.9
I+K	14	1.88	172	44	38	108	2.8	159	51	13.3	8.7
K	15	1.88	176	44	38	106	2.8	165	55	13.1	7.4
L	16	1.65	182	44	38	121	4.0	170	54	13.2	8.2
	AVG	2.38	173.9	44.0	40.3	124.3	3.8	167.3	59.0	13.4	8.4
	LSD	0.91	45.4	0.0	6.6	47.0	2.2	42.7	13.1	0.6	1.3
	CV%	29.76	17.4	0.0	11.5	25.3	42.1	17.3	16.1	2.8	11.6

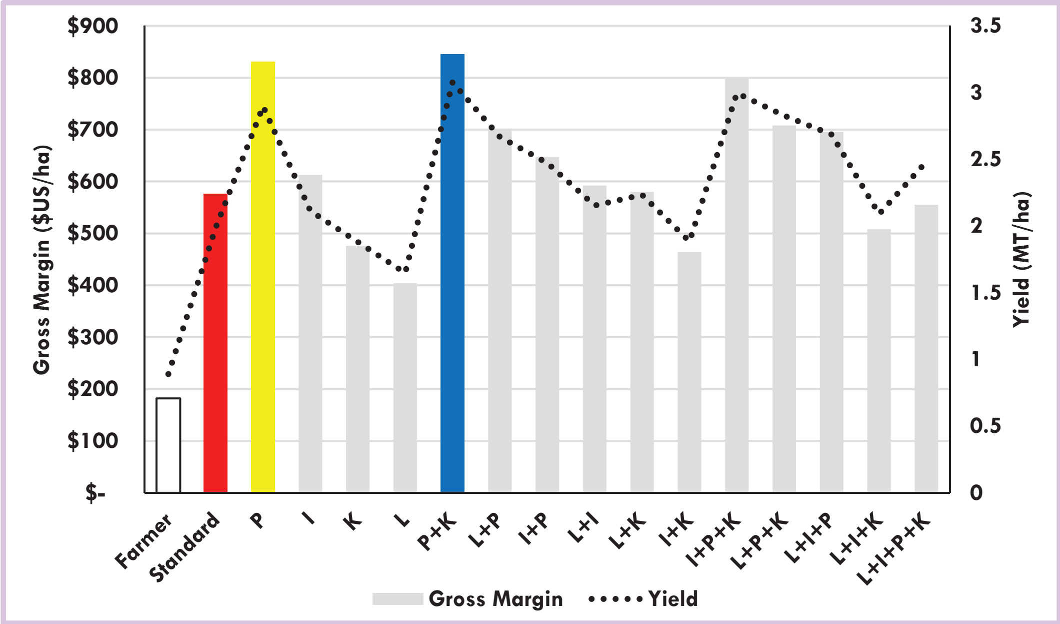
Table 7: Averages, Least Significant Differences (LSD) at an alpha of 0.05, and Coefficient of Variations (CV%) for Yield, Stand Count, R1 Flowering, Nodule Count and Viability, R8 Stand Count, 100 Seed Weight, and Seed Moisture for the 2019-2020 omission trials at Chipata, Zambia. In the treatment column: I-Inoculum, P-Phosphorus, K-Potassium, L-Lime. P-values for each treatment main-effect or interaction are represented as follows: (.)<0.10, (*)<0.05, (**)<0.01, (***)<0.001.

An Analysis of Variance (ANOVA) was conducted in R using the package “car” to test the main treatment effects, 2-way, 3-way, and 4-way treatment interactions in the omission trial. The Shapiro's Wikle and Brown-Forsythe test were employed to confirm residual normality and homogeneity of variance respectively. **Based on the ANOVA, the main-effect of phosphorus was shown to significantly ($P < 0.001$) increase soybean grain yields by 46%.**

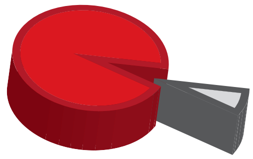
Mean yields ranged from 1.65 tonnes/ha (L) to 3.08 tonnes/ha (P+K). Stand count ranged from 147 (No Input) to 194 (P) plants and 137 (No Input) to 184 (P and I+P+K) plants at V2 and R8 developmental stages respectively. R1 flowering was 44 days after planting. Plant heights ranged from 36 cm (L+I+K) to 45 cm (P) and 51 cm (I+K) to 69 cm (P) for R1 and R8 growth stages, respectively. Nodule counts ranged from 106 (K) to 156 (No Input) nodules per plant and weighed between 2.3 (L+K) to 5.3 (L+P+K). Mean values for 100 seed weight ranged from 13.1g (K and I) to 13.7g (P+K) and seed moisture ranged from 7.4% (K) to 9% (L+P). No other variables had significant main effects or interactions.

For further information on the 2019-2020 trials at Chipata with Good Nature Agro, contact the trial operator Justin Nkhoma at justin.nkhoma@goodnatureagro.com.

Figure 4: Treatment yields (line graph) and gross margins (bar graph)

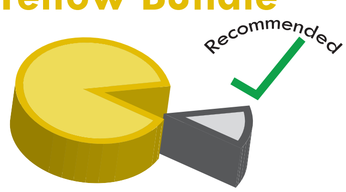


Red Bundle



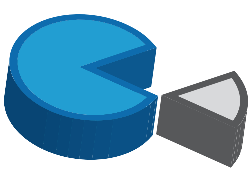
Best Management Practices
Certified Seed
9x return on additional input costs compared to farmer practices
Marginal Ratio: 3.17

Yellow Bundle



Best Management Practices
Certified Seed
Phosphorus Fertilizer
2x return on additional input costs compared to Red Bundle
Marginal Ratio: 1.44**

Blue Bundle



Best Management Practices
Certified Seed
Phosphorus Fertilizer
Potassium Fertilizer
2x return on additional input costs compared to Red Bundle
Marginal Ratio: 1.46**

*Marginal Ratio compared to farmer practices
**Marginal Ratio compared to Red Bundle

Agricultural inputs such as Lime, Inoculum, Phosphorus, and Potassium contribute to increases in soybean yield. However, the combination of specific field conditions and a farmer's limited cash funds may make using all four inputs either unnecessary or financially impractical. The 2019 SMART Farm omission trial has assessed the usage of these inputs and has assembled three input bundles for the Chipata field site. To balance the financial risk of applying new inputs, SIL recommends a stepwise investment in new technology. This prioritizes the maximum financial returns on the minimum input costs and allows initial successes to feed into additional future inputs. The gross margins and yield averages are displayed in Figure 4. The "Farmer" treatment represents typical soybean farming practices in southern Africa. It is assumed that saved seed is used with no additional inputs, and that labor costs are absorbed by the household. Under these conditions it is estimated that a typical farmer will generate a gross margin of $182 USD and a yield of 0.89MT per hectare laboring between 60 and 70 work days in a season. This generates an implicit wage of $1.05 USD for every $1.00 USD of labor spent.

The **Red Bundle** is the standard growing package. This includes the usage of certified soybean seeds and the adoption of best management practices (early planting, planting in rows, increased seed population, and timely weeding). The red bundle generated an average gross margin of $577 USD, a marginal ratio increase of 3.17 compared to the standard farmer, and yielded 1.99 MT per hectare. This produces an 9x return on certified seed costs and provides an implicit wage of $3.33 USD for every $1.00 USD of labor spent (a 233% increase in wages compared to the typical farmer).

The **Yellow Bundle** includes the use of phosphorus fertilizer along with certified soybean seed and the adoption of best management practices in the Red Bundle. The Yellow Bundle generated an average gross margin of $831 USD, a marginal ratio increase of 1.44 compared to the Red Bundle, and yielded 2.90 MT per hectare. This produces an 2x return on phosphorus fertilizer costs and provides an implicit wage of $4.80 USD for every $1.00 USD of labor spent (a 380% increase in wages compared to the typical farmer). The **Blue Bundle** includes the use of potassium fertilizer and phosphorus fertilizer along with certified soybean seed and the adoption of best management practices in the Red Bundle. The blue bundle generated an average gross margin of $845 USD, a marginal ratio increase of 1.46 compared to the Red Bundle, and yield-ed 3.08 MT per hectare. This produces an 2x return on fertilizer costs and provides an implicit wage of $4.88 USD for every $1.00 USD of labor spent (a 388% increase in wages compared to the typical farmer). **The Blue Bundle generated the highest gross margin of all treatments for the Chipata site.**

SMART Farm Trials
Results from Zambia: GNA-BASF 2019-2020

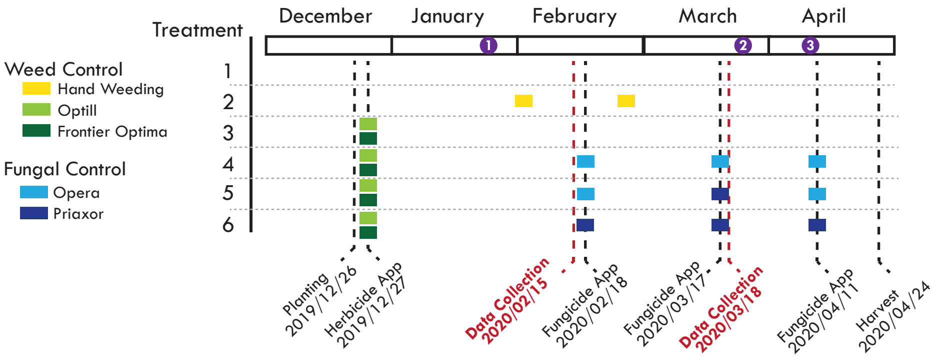


Figure 5: Timeline of field activities. Methods of weed control (yellow= hand weeding, light green=Optill, dark green= Frontier Optima), and fungal control (light blue= Opera, Dark Blue= Priaxor) are overlaid on dashed lines corresponding to their application date. Periods of data collection are represented as red dashed lines. The purple circles containing a "1", "2", or "3" represent time points when photographs were taken of the different treatment plots.

Treatment	Herbcide	Fungicide
1	No Weeding	None
2	Hand Weeding	None
3	Optill, Frontier Optima	None
4	Optill, Frontier Optima	Opera, Opera, Opera
5	Optill, Frontier Optima	Opera, Priaxor, Opera
6	Optill, Frontier Optima	Priaxor, Priaxor, Priaxor

Table 8: Herbicide and fungicide applications used in trial treatments. The inoculum Hi-Stick was used in all treatments

Building off previous successful product trials in Ghana using the SMART farm platform, the Soybean Innovation Lab has partnered with BASF and Good Nature Agro to continue those successes in Southern Africa. The SMART farm platform provides evidence based, demand-driven recommendations to soybean growers in sub-Saharan Africa and serves as a test bed for industry partners to expand the marketplace for their products.

In this trial we observed 6 treatments testing the impact of preemergent Optill and Frontier Optima herbicide application, and different cycles of Priaxor and Opera fungicide application (**Table 8**, **Table 9**). Each set of 6 treatments were randomized and replicated 4 times. The soybean variety "Kafue" developed by the International Institute of Tropical Agriculture (IITA) was planted in 3 meter by 10 meter plots with a seed spacing of 5cm. Each plot contained 4 rows with a spacing of 75cm.

Seeds from all treatments were coated with Hi-Stick inoculum 1 hour prior to planting on December 26th, 2019. The following day on December 27th, 2019, Optill and Frontier Optima herbicides were applied before any evidence of soybean emergence. Treatment 2 was hand-weeded twice at the beginning and end of February. Fungicide application was to be applied either at the first sign of fungal infection, or at the onset of R3 pod formation in the absences of infection. After the first fungicide application, a second round would be applied 3-4 weeks later, and a third round 3-4 weeks after the second.

No fungal pressure was observed during this trial. Accordingly, the first fungicide application occurred on February 18th, 2020 during R3 pod development. The second and third fungicide cycles occurred on March 17th, 2020 and April 11th, 2020 respectively. The trial was harvested on April 24th, 2020 (**Figure 5**).

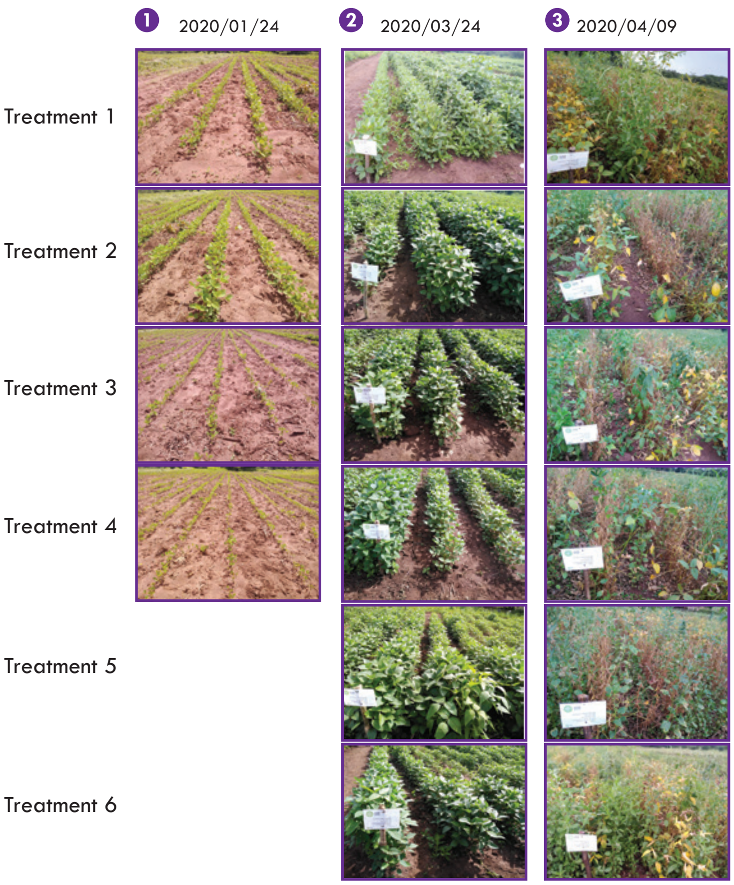


Figure 6: Images of the 6 treatments at three different timepoints during the field season. The purple circles in this figure correspond to the purple circles in Figure 1. In time point "1" (January 24, 2020), the images for treatments 3 and 4 are representative of how the plots appeared for treatments 5 and 6.

	Inoculum	Herbicide	Herbicide	Fungicide	Fungicide	Seed
Product	Hi-stick	Optill	Frontier Optima	Opera	Priaxor	Kafue
Source	BASF	BASF	BASF	BASF	BASF	IITA
Active Ingredient	-	95g ai/ha	720g ai/ha	91g ai/ha	135g ai/ha	-
Appication Rate	400g/100kg	0.14kg/ha	1.0L/ha	0.5L/ha	0.6L/ha	320000 seed/ha

Table 9: The product names, sources, active ingredients, and application rates of inputs used for the omission trial. g ai/ha –Grams of active ingredient per hectare.

Trait	Unit	Measurement Metrics
Stand Count	count	Sum of plants in Row 2 and 3
Plant Vigor	Score	Visual assessment of plant vigor (defined as visible soybean biomass) on a 0-10 scale compared to un-weeded check plots. **0**=soybean plants are dead. **1**= ~80% less vigor than checks. **2**= ~60% less vigor than checks. **3**= ~40% less vigor than checks. **4**=~20% less vigor than checks. **5**= treated plants are of equal vigor to un-weeded checks. **6**= ~20% more vigor than checks. **7**= ~40% more vigor than checks. **8**= ~60% more vigor than checks. **9**=~80% more vigor than checks. **10**= over 100% more vigor than checks
Weed Control	%	Visual assessment of weed presence per plot. Using a scale of 0-100 %. where 0 represents no weed control (high weed presence) and 100 % represents total weed control (no weeds present).
Estimated Crop Injury	%	Evaluated as the number of plants exhibiting visual injury in Rows 2 and 3, over the total number of plants in Row 2 and Row 3 for each plot. Represented as the ratio of injured plants/ total plants as a percentage. Crop injury includes chlorosis, necrosis, blistering, cupping, and/or wrinkling on the leaves.
Yield	Ton/Hectare	Plants harvested and threshed, seed winnowed and weighed at 13% moisture
100 Seed Weight	Gram	Random sets of 100 seeds selected and weighed

Table 10: Data metrics for the 2019-2020 herbicide-fungicide trial

Data on plant vigor, weed control, and estimated crop injury due to infection symptoms were collected on February 15th, 2020 prior to the first application of fungicide, and March 18th, 2020 after the second application of fungicide. Yield information was collected at harvest. After seedling emergence, treatments where Optill and Frontier Optima herbicides were applied (treatments 3 ,4 , 5, and 6), experienced moderate to severe herbicide suppression as shown in **Figure 6** at time point 1. The effects of this herbicide suppression were seen throughout the growing season, resulting in smaller, less vigorous plants in herbicide treated plots, although by the second data collection point on March 18th the treated plants were of a similar vigor to non-treated plants. A possible reason for the herbicide suppression is the mode of action for Optill combined with weather conditions at Chipata during planting. Optill contains the Group-14 PPO-inhibitor, saflufenacil, as an active ingredient. Under cool, wet conditions, particularly in lighter soils with low organic matter, saflufenacil has been reported to cause herbicide suppression in soybean. Just including the day before and after Optill application, the trial site experienced over 40mm of rainfall, which may have been sufficient to injure the treated soybeans.

The three broad-leaf weed species pervaded un-weeded checks, *Solanum spp.* (**Figure 7**), *Spilanthes spp.* (**Figure 8**), and *Trichodesma spp.* (**Figure 9**). While no fungal pressure was observed over the course of the trial, during the second round of data collection symptoms of bacterial pustule were observed (**Figure 10**). Caused by the bacterium *Xanthomonas axonopodis pv. glycines*, bacterial pustule can be transmitted through stored seed or crop residue in addition to wind or rain. Crop rotation can be an effective method of disease control to limit previous infections from persisting into future seasons.

At 51 days after planting (**Table 11**), prior to the first fungicide application, hand weeded (treatment 2) and un-weeded (treatment 1) checks had comparable plant vigor scores of 5.25 and 5.00 respectively. Treatments 3, 4, 5, and 6 displayed plant vigor scores ranging from 3.00-3.75, or approximately 20-40% less observable biomass than un-weeded checks due to herbicide suppression. Treatments including Optill and Frontier Optima herbicides displayed weed control ranging from 63-81%, which is comparable with the 70% weed control observed in the hand-weeding check. The un-weeded check at 51 days after planting displayed 48% weed control. No biotic pressure, and thus no crop injury was observed at this time.


Figure 7: *Solanum spp.*


Figure 8: *Spilanthes spp.*


Figure 9: *Trichodesma spp.*

				Pre-Fungicide: 51 DAP				Post-Fungicide: 83 DAP			Harvest: 120 DAP		
Treatment	Weed Control	Fungal Control	Rank Yield	Stand Count	Plant Vigor	Weed Control	Estimated Crop Injury	Plant Vigor	Weed Control	Estimated Crop Injury	Yield	100 seed Weight	Seed Mositure
				count	Score	%	%	Score	%	%	ton/ha	g	%
2	Hand Weeding	None	1	205	5.25	70	0	5.5	48	5.7	2.39	13.0	11.3
1	None	None	2	193	5	48	0	5	13	6.6	2.23	12.8	10.9
6	Optill, Frontier Optima	Priaxor, Priaxor, Priaxor	3	206	3	65	0	5.25	53	2.0	2.09	13.5	9.7
3	Optill, Frontier Optima	None	4	207	3.25	81	0	4	60	5.6	1.77	13.5	9.2
4	Optill, Frontier Optima	Opera, Opera, Opera	5	205	3.25	63	0	5.25	53	1.8	1.75	13.0	9.7
5	Optill, Frontier Optima	Opera, Priaxor, Opera	6	208	3.75	68	0	5.25	48	1.3	1.74	13.3	9.3
AVG				203.9	3.9	65.6	0.0	5.0	45.4	3.8	1.9	13.2	10.0
LSD				10.9	2.3	14.4	0.0	2.6	16.5	2.9	0.8	0.8	1.9
CV%				4.2	43.8	20.8	0.0	33.8	41.2	74.3	28.7	4.3	14.4

Table 11: Averages, Least Significant Differences (LSD), and Coefficient of Variations (CV%) for Stand Count, Plant Vigor, Weed Control, Estimated Crop Injury, Yield, 100 Seed Weight, and Seed Moisture for the 2019-2020 herbicide-fungicide trial at Chipata, Zambia. DAP= "Days After Planting".

Figure 10: Evidence of bacterial pustule 83 days after planting. These symptoms are caused by the bacterium *Xanthomonas axonopodis pv. glycines.*

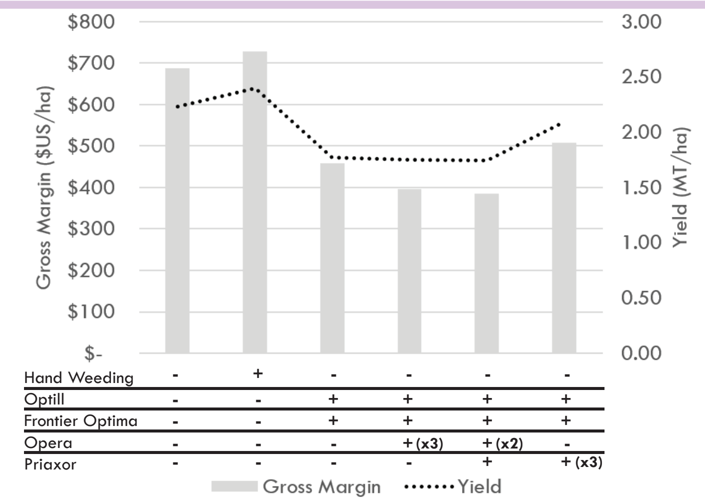


Figure 11: Treatment yields and gross margins. A "+" indicated that the corresponding weed control or fungal control treatment was applied. "x3" and "x2" indicate that the treatment was repeated three times and two times respectively.

At 83 days after planting, after the second fungicide application, hand weeded (treatment 2) and un-weeded (treatment 1) checks had plant vigor scores of 5.50 and 5.00 respectively. Treatments 3, 4, 5, and 6 displayed plant vigor scores ranging from 4.00-5.25, at this point appearing approximately as vigorous or 20% less vigorous than the un-weeded checks. Treatments including Optill and Frontier Optima herbicides displayed weed control ranging from 48-60%, which is comparable with the 43% weed control observed in the hand-weeding check. The un-weeded check at 83 days after planting displayed 13% weed control. At this point, evidence of bacterial pustule (**Figure 10**) began appearing on foliar tissue across treatments, but at this late stage in soybean development it is unlikely this infection had a meaningful impact on yield.

The hand-weeded check generated the largest yield and gross margin (**Figure 11**) at 2.39 ton/ha and $729 USD/ha respectively. The un-weeded check generated the second largest yield and gross margin at 2.2 ton/ha and $688 USD/ha respectively. Treatments including Optill and Frontier Optima herbicides generated yields ranging from 1.74-2.09 ton/ha, likely a result of herbicide suppression early in soybean development. In terms of returns, the herbicide treated treatments generated gross margins ranging from $384- 509 USD/ha.

Application of pre-emergent herbicide had superior to comparable weed control to the hand weeded check for much of the season as seen in **Figure 6** time point 2, but due to the lack of canopy closure in herbicide treated plots, weeds began to accumulate in all plots except the hand weeded checks as seen in **Figure 6** time point 3. The labor involved in two rounds of hand weeding was more cost effective than herbicide application, but this relationship may vary depending on field size, and seasonal weed severity. Incidentally, the lack of canopy closure may have contributed to the absence of fungal pressure. The increased airflow and sunlight between the planted rows likely assisted in keeping the soil and lower-foliage dry, creating an environment that was not conducive to fungal growth. This absence of fungal pressure also skews the gross margins for treatments 4-6 where fungicide was applied. In the absence of infection it is unclear how much yield protection, and by extension monetary protection, the fungicides Opera and Priaxor provide.

SMART Farm Trials
Appendix for Economic Costs, Definitions, and Assumptions

Economic Assumptions

- For the typical Southern African farmer it is assumed that soybean seeds are saved from one year to the next, and that no additional inputs are purchased.
- A season of labor is estimated to be 60-70 workdays (472-560 hours) from land preparation to harvest. It is assumed that for a given household any necessary field labor will be conducted by members of that household.
- Fixed costs such as leasing costs for land, property tax, insurance, managerial overhead, or transportation costs are not included in the variable cost estimates. It is assumed that these costs are consistent across treatments.
- It is assumed that the labor involved in applying different input treatments is equal.
- It is assumed that local African soybean prices are linked to and stabilized by world-wide soybean prices.

Definitions

Gross Margin: For the SMART Farm reports, SIL defines the Gross Margin as the variable costs of soybean production minus the revenue generated from seed sales.

Marginal Ratio: The quotient between two gross margin values.

Return on Input Costs: The return on input costs compares how much was spent on inputs to how much additional monetary value that input provides.

Values for Economic Analysis

Item	$ USD/ Hectare	Source
Input Costs		
Certified Soybean Seed	$44.40	1
Rhizobium Inoculum	$14.13	2
Phosphorus Fertilizer	$109.00	3
Potassium Fertilizer	$58.14	4
Lime	$37.25	5
Labor Costs		
Labor (Land preparation, planting, weeding, harvest, bagging)	$173.01	6
Soybean Selling Price		
Item	$USD/ Kg of Seed	Source
Seed Price	$0.40 ($400.00/MT)	7

*Costs and prices are average values aggregated from multiple sources

Source

1) Internal SIL communications, Analysis of the Soya Bean Value Chain in Zambia's Eastern Province (2012), Soybean Value Chain-AECOM International Development (2011), IAPRI-soybean value chain and market analysis -Zambia (2014), Profitability and technical efficiency of soybean production in northern Nigeria (2017), Income and Cost Budgets for summer crops in South Africa- (2018-2019), Soybean Production Guide In Uganda (2015)

2) Internal SIL communications, IAPRI-soybean value chain and market analysis -Zambia (2014), N2F-Production and use of Rhizobial inoculants in Africa (2011)

3) Internal SIL communications, Income and Cost Budgets for summer crops in South Africa- (2018-2019), South African Fertilizer Market Analysis Report (2018), Agricultural Prices, USDA, National Agricultural Statistics Service (2020), Spatial variation in fertilizer prices in Sub-Saharan Africa (2020)

4) Internal SIL communications, Income and Cost Budgets for summer crops in South Africa- (2018-2019), South African Fertilizer Market Analysis Report (2018), Agricultural Prices, USDA, National Agricultural Statistics Service (2020), Spatial variation in fertilizer prices in Sub-Saharan Africa (2020)

5) Internal SIL communications, Income and Cost Budgets for summer crops in South Africa- (2018-2019)

6) Internal SIL communications, Soybean Costs of Production-(2019), Soybean Value Chain-AECOM International Development (2011), IAPRI-soybean value chain and market analysis -Zambia (2014), Profitability and technical efficiency of soybean production in northern Nigeria (2017), Soybean Production Guide In Uganda (2015)

7) Internal SIL communications, www.selinawamucii.com (2020), Soybean Prices (2019), Zambia National Farmers Union (2020), USDA Market News (2020)