Preliminary Report: Evaluation of Agro-Forestry Plants for Soil Fertility Restoration and Enhancement of Sustainable Agriculture in the Petauke District, Eastern Zambia (10th May 2010)

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Abstract

A field trial for demonstration and evaluation of agro-forestry plants to restore soil fertility is being conducted at the plots adjacent to the RIHN plots in Eastern Province, Zambia. Good growth of agro-forestry plants were observed. Three rainy seasons after planting, *Glilicidia sepium* and pigeon pea plants grew well to reach their heights to about 3 m. We will cut them down to plant maize so that we can estimate the effects of them as agroforestry plants on the improvement of the maize productivity.

1. Introduction

This progress report presents an update of the activities on 'Evaluation of Agro-Forestry Plants for Soil Fertility Restoration and Enhancement of Sustainable Agriculture', being carried out in eastern Zambia at Mwelwa Village, Chief Sandwe, Petauke District. It covers the 2009/2010 crop-growing season (November 2009 to April 2010).

The study serves as a demonstration to evaluate the effectiveness of agro-forestry technologies in enhancing soil ecological resilience as measured by the efficacy of some selected agro-forestry and green manure plant species for soil fertility restoration and enhancement of sustainable agricultural practices. Three specific objectives are:

1) To demonstrate the effect of the named plant species in soil fertility improvement for improved short fallow agricultural technology practices,

2) To measure soil property dynamics and characteristics that occur as a result of defined land use practices and imposed field practices and

3) To assess any socioeconomic impact of (long-term) benefits achieved following adoption of the technologies by various households and communities, thereby reinforcing ecological and social resilience concepts and principles.

Below is a sketch drawing of the ZARI trial and demonstration layout.

F 13	D 14	A 15	C 16	B 17	E 18
A 12	C 11	D 10	E 9	B 8	F 7
B 1	E 2	C 3	F 4	D 5	A 6

N

Note: A = Treatment; 1 = Sub-plot No. 1

Treatments

A *Grilicidia sepium* fallow (GSF)

B Maize continuous fertilizer (MCF)

C Native Forest fallow (NFF)

D   Maize, no Fertilizer (MoF)

E Green Manure fallow (GMF *Mucuna*)

F *Cajanus cajan* fallow (CCF)

2. Methodology

Measurement of initial soil conditions

a) At the beginning of the experiment (October 2007) the soil in each subplot (measuring 20×20 m) was sampled at two depths, the topsoil at 0–20 cm and the subsoil at 40–60 cm for subsequent laboratory analyses for pH, bases, CEC, organic carbon, total nitrogen, available phosphate and particle size distribution (PSD).

b) Grilicidia was initially raised in nursery beds, and later planted into the field from potted seedlings at a spacing of 1 m × 1 m. The spacing for pigeon pea (Cajanus cajan) in the field was the same as for Grilicidia, but the crop was direct planted from seed.

c) A hybrid maize variety MM 604 was used as the test crop and planted at a spacing of 90 cm between rows and 25 cm between plants within the rows. The fertilizer application rate followed the LIMA recommendation of 4×50 kg/ha of compound D (10N, $20P_2O_5$, $10K_2O$, 4–6 S), and the same rate for urea (46% N) as top-dressing in the continuous maize with fertilizer treatment. (MCF).

d) The native forest fallow treatment had no land clearing or preparation with the bush left in the virgin or natural state it was in before beginning the study.

e) The green manure plot was planted with Velvet bean (Mucuna).

f) On all the cultivated plots initial land preparation consisted of felling and stumping all trees, followed by digging with hand hoes well before the onset of the rainy season in October.

g) After planting, crop performance monitoring was instituted. It included replanting (filling in gaps where necessary), weeding and scoring for disease, pests, etc. Grain yield and stover were harvested in the maize plots and measured by weight to determine the yield performance. Pigeon pea seed is harvested from dry pods later in the dry season (August–September) when the fields are being protected from fire by clearing the fire breaks around the trial plots.

The current cropping season (2009/2010) marks the third year of crop growth in all the plots.

Field Day

No field day was held at the site in the 2009/2010 cropping season because, having held one the previous year, researchers believed that little difference would be apparent from what was shown the previous season (2008/2009). However, in the coming season after three-years of imposed treatments, more interesting results are expected.

Biomass Estimation

Aboveground plant biomass in the agro-forestry and native fallow plots was estimated by measuring plant height and stem girth (diameter) at ground level. Results for the different agro-forestry and native fallow plots are shown in the tables below.

3. Performance of the various treatments

Field measurements were made in 5 × 5 m units within the 20m × 20m plots.

Native Forest - Plot 3

Serial No. (Subplot)	Average Height (m) /Subplot	Average Girth (mm)
1	2.43	35.54
2	2.78	50.30
3	3.46	69.02
4	2.92	57.00
5	3.26	50.36
Av.	2.97	52.44

Average native forest trees were about 3 meters tall, with a girth of about 52.4 mm at ground collar level.

Cajanus cajan - Plot 4

Serial No. (Subplot)	Average Height (m) /Subplot	Average Girth (mm)
1	2.64	50.76
2	3.73	51.58
3	3.04	45.02
4	3.48	40.28
5	3.61	54.68
Av.	3.3	48.46

Grilicidia sepium - Plot 6

Serial No. (Subplot)	Average Height (m) /Subplot	Average Girth (mm)
1	2.05	49.96
2	2.26	44.9
3	2.48	50.08
4	2.06	46.78
5	2.2	35.2
Av.	2.21	45.38

This plant shows resilience for survival.

Cajanus cajan - Plot 7

Serial No. (Subplot)	Average Height (m) /Subplot	Average Girth (mm)
1	3.28	36.76
2	3.11	38.82
3	3.25	36.48
4	3.2	33.94
5	2.9	33.14
Av.	3.15	35.83

Native Forest - Plot 11

Serial No. (Subplot)	Average Height (m) /Subplot	Average Girth (mm)
1	3.59	56.08
2	4.21	75.62
3	4.4	83.4
4	3.93	66.02
5	2.57	56.04
Av.	3.73	67.43

There is high termite activity in this plot.

Grilicidia sepium - Plot 12

Serial No. (Subplot)	Average Height (m) /Subplot	Average Girth (mm)
1	2.84	46.93
2	2.53	50.98
3	2.65	62.14
4	4.88	82.32
5	3.35	53.5
Av.	3.25	59.17

The plants in this plot showed resilience. Also the *Grilicidia* plants grew faster in subplot # 04 where there was a termite mound, in contrast to other parts of the plot.

Cajanus cajan - Plot 13

Serial No. (Subplot)	Average Height (m) /Subplot	Average Girth (mm)
1	3.74	35.48
2	3.54	40.54
3	3.74	38.2
4	3.94	55.9
5	3.52	37.48
Av.	3.70	41.52

Grilicidia sepium - Plot 15

Serial No. (Subplot)	Average Height (m) /Subplot	Average Girth (mm)
1	2.34	43.68
2	2.52	48.8
3	1.7	33.88
4	1.93	39.98
5	1.89	42.94
Av.	2.08	41.86

Plants were stunted.

Native Forest - Plot 16

Serial No. (Subplot)	Average Height (m) /Subplot	Average Girth (mm)
1	4.26	63.02
2	4.43	76.88
3	3.56	57.02
4	4.54	64.9
5	5.17	69.96
Av.	4.39	66.36

Trees in this plot were sparsely populated and there was little branching.

Mean values of performance

Plant Species	*Height (m)*	*Girth (mm)*
Native forest	3.70	62.08
Cajanus cajan	3.38	41.94
Grilicidia sepium	2.51	48.80

Maize Harvesting

Within the maize plots, five (5m × 5m) subplots were measured and maize cobs harvested from each subplot were counted. After sun-drying the cobs for about three days, grain was shelled from the cobs. The weight of the maize grain was then measured and the moisture content determined. The results are presented in the tables below.

Remarks

Plot 1: The stover sample for moisture determination from this plot was 1.9kg. The diseased cobs were due to cob rot (*Fuserium*). The dominant weed species were shrubs (Chikoswa, Nyazongo and Kabalukila), followed by grasses (Kankululu).

Plot 14: The dominant weed was the yellow head shrub weed followed by Miombo trees (regrowth) and red head grass. The stover weight for moisture determination was 1.6kg.

Plot 10:The stover weight for moisture determination was 1.2kg. One maize cob from subplot #3 was eaten by rats.

Plot 17: The stover weight for moisture determination was 2.5kg. The dominant weed is the yellow head weed. There are few grasses and more herbaceous type of weeds.

Plot 8: The dominant weed in this plot is the purple head shrub with sparse yellow head weeds. There was hardly any grass in this plot. The stover weight for moisture determination was 1.7kg.

Plot 5: The stover weight for moisture determination was 1.1kg.

Plot	Treatment	Subplot #	Cob No.	Wt. of Cobs (kg)	Stover Wt. (kg)	Diseased Cobs	Grain Wt. (kg)	Corn Moisture	Dry Grain Wt/25m²	Grain yield (Mg/ha)
5	M0F	1	71	5.6	5.2	19	3	12.2	2.6	
		2	66	8.4	6.7	11	7	13.2	6.1	
		3	66	5.8	5.8	14	3.5	12.7	3.1	
		4	74	6.1	5	11	5	12.5	4.4	
		5	58	6.5	5.3	4	6	12.8	5.2	
		Average	67	6.48	5.6	11.8	4.9	12.68	4.3	1.71
10	M0F	1	69	7.2	7.6	11	4	13.2	3.5	
		2	81	8.2	8.8	5	5.1	13.2	4.4	
		3	72	5.2	4.7	7	4.5	12.7	3.9	
		4	57	4.9	5.5	7	4	12.4	3.5	
		5	59	4.2	4	6	3.5	12.9	3.0	
		Average	67.6	5.94	6.12	7.2	4.22	12.88	3.7	1.47
14	M0F	1	56	5.8	5.8	8	4	13.2	3.5	
		2	59	3.8	3.9	3	3.5	12.5	3.1	
		3	61	7.2	6.4	10	3	13.5	2.6	
		4	61	6.3	6	6	5	13.3	4.3	
		5	55	3.2	3.7	5	3	12.1	2.6	
		Average	58.4	5.26	5.16	6.4	3.7	12.92	3.2	1.29
1	MCF	1	105	23.3	24.9	3	14	16.1	11.7	
		2	85	18.2	24.4	2	10.5	16.3	8.8	
		3	90	19.4	21.8	3	12	17.4	9.9	
		4	103	19.4	16.2	3	12.5	14.6	10.7	
		5	110	25.4	28.2	2	16.5	17.5	13.6	
		Average	98.6	21.14	23.1	2.6	13.1	16.38	10.9	4.38
8	MCF	1	98	18.2	18	6	13	14.4	11.1	
		2	122	17.5	15.7	4	5.5	14.9	4.7	
		3	205	24.3	23.7	3	16	19.1	12.9	
		4	120	19.4	20.7	4	13.5	15.5	11.4	
		5	109	22.2	18.8	1	13.5	15.9	11.4	
		Average	130.8	20.32	19.38	3.6	12.3	15.96	10.3	4.12
17	MCF	1	239	23	31	7	11.5	15.9	9.7	
		2	190	23.1	24.2	13	14.5	16.7	12.1	
		3	180	20.8	25.6	4	12.5	16.9	10.4	
		4	83	11.6	15.8	14	9	15.2	7.6	
		5	103	17	24.3	5	10	17	8.3	
		Average	159	19.1	24.18	8.6	11.5	16.34	9.6	3.85

4. Other Results

Maize Yield

Yield measurement data for the maize crop is still to be obtained.

Soil Analysis

Using the NEWS method, soils were sampled from depths of 0-20cm (topsoil) and 40-60 (subsoil) from all plots.

Soil Laboratory Analytical Results

Soil samples are being prepared for laboratory analyses. Exchangeable bases (Ca, Mg, K, Na), soil pH ($CaCl_2$), organic carbon (C), nitrogen (N), phosphate and cation exchange capacity (CEC) are the soil properties to be used to assess soil fertility status.

Plant Survival Rate

To obtain the plant survival rate, dead plants in each plot were counted. Results are presented in the table below.

PLOT #	ROW Spp.	1	2	3	4	5	6	7	8	9	10	11	∑	Mean	%
4	Pigeon pea	2	5	3	4	4	4	4	5	5	4	2	42	3.82	0.382
6	*G. sepium*	0	2	2	1	1	0	2	1	1	3	2	15	1.36	0.136
7	Pigeon pea	4	3	3	4	3	1	2	3	3	2	3	31	2.82	0.282
12	*G. sepium*	2	2	3	2	1	1	2	0	0	1	2	16	1.45	0.145
13	Pigeon pea	3	2	5	3	3	4	3	6	4	5	4	42	3.82	0.382
15	*G. sepium*	3	1	0	0	1	2	0	1	2	4	1	15	1.36	0.136

Climatic Data

Climate conditions are monitored by an automatic weather station at the research site. Rainfall was 'normal' and well distributed for crop growth. The total rainfall for this season was 950mm.