Potential Of Leguminous Cover Crops In Improving Maize Yield In Semi-Arid Ghana.

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Abstract
Leguminous cover crops can be an alternative to mineral fertilizer, particularly for the small scale, resource-poor farmer in West Africa. The effectiveness of a cover crop as an organic soil amendment to improve cereal production will depend largely on its biomass production and total nutrient contribution to the succeeding crop.

Four cover crops supplied with P and K at the rate of 17 and 33 kg ha^{-1}, respectively were assessed in 1996-1997 at three locations in Northern Ghana for their dry matter production and nutrient accumulation, and their effect on the yield of succeeding maize crop. The dry matter yield of cover crops across locations ranged from 4.9 to 15.0 t ha^{-1} with a corresponding total N accumulation of 115 to 306 kg ha^{-1}. All cover crop residue amendments resulted in maize yield increase 2 to 4-fold above the weed fallow control. *Calopogonium mucunoides* was the best cover crop in increasing maize yield. On the other hand, *Crotalaria retusa* which out-performed all the cover crops in terms of dry matter production and N accumulation, did not increase maize yield commensurate with its dry matter and nitrogen yields.

Small scale farmers in Northern Ghana may improve their maize yields by growing cover crops in rotation with their maize.

Keywords: Cover crop, green manure, maize yield, semi-arid, Ghana.

Introduction
Cereal production is a major component of small-scale farming in West Africa. Among the cereals, maize is perhaps the most important as it forms the major staple for most communities. Despite the notable adoption of high-yielding maize varieties by small-holders in Africa (33-50% of Africa's maize area), national per-hectare increase in maize productivity are disappointing (Kumwenda et al., 1996).
Average maize yields per unit of land have fallen in Africa partly because maize production has expanded into drought-prone, semi-arid areas (Gilbert et al., 1993) and partly due to declining soil fertility. In addition to this expansion, intensification of cultivation of the presently used area has become necessary in most farmer communities in West Africa due to pressure on the land (Whittome et al., 1995). The most important factor limiting the

productivity of maize however, is the low and declining soil fertility. The highly weathered soils of the semi-arid zones of Africa have low OM, N and P status which directly impacts on arable crop production.

In most farming communities in West Africa, the limited access to mineral fertilizer exacerbated by high cost prevents the farmers from improving their yields. Long fallow periods to restore soil fertility are no longer possible and resort to shortening the fallow period without effective soil fertility management has resulted in lowering of crop yields

Farmers in West Africa can rely on the use of organic residues as a means of improving soil fertility and organic matter status of the soils which is crucial for sustainable use of these soils. Three sources of organic residues are possible: Crop residues, farmyard manure and planted fallows. Crop residues have many competing uses in the semi-arid regions of West Africa. They are often used for housing, as fuel for cooking, for livestock feeding and handicrafts. Very little farmyard manure is available as livestock is often kept on free range. The most reliable means by which organic residues can be increased for crop production is to produce them in a rotational fallow management system.

Planted fallows with leguminous cover crops can contribute to improve crop production and soil fertility management through the release of plant nutrients, particularly, nitrogen during decomposition. Cover crops perform other functions apart from nitrogen release. These include weed control, increased availability of phosphorus (Agboola, 1975), promotion of mycorrhizae in succeeding crops and increase in P availability (Lathwell, 1990), and trap crop for striga (Kranz, 1997 quoted in Kroschel, 1998).

Several screening studies of cover crop research have shown wide variations in dry matter and nitrogen accumulation. Variability in dry matter and nitrogen accumulation have been very high (Becker and Johnson, 1998).
To evaluate the effectiveness of a cover crop in improving cereal yields in a particular agro-ecology, the biomass and N yields need to be known.
The objective of this trial was to evaluate the above parameters and their effects on maize yield at three locations in semi-arid Ghana.

Materials and methods

Three locations, Cheshegu, Tingoli and Nyankpala were used for the experiments. The mean annual temperature is about 28 ^{o}C and the mean annual rainfall is about 1100 mm. The rainfall is monomodal and last for 5-6 months. Its major features are the high intensity and erratic occurrence.
The soils are Paleustalfs with low contents of OM, N and P. Selected properties of the soils at the three locations are presented in Table 1.

Table 1. Selected characteristics of soils of the three experimental sites

	Cheshegu	Tingoli	Nyankpala
Classification			
FAO/UNESCO	Gleyi-ferric Lixisol	Ferric Lixisol	Ferric Lixisol
USDA	Paleustalf	clayey-skeletal isohyperthemic Paleustalf	
Soil parameters			
Sand (%)	61.3	62.9	66.7
Silt (%)	31.2	30.3	27.3
Clay(%)	7.5	6.8	6.0
pH ($CaCl_2$)	6.2	5.5	4.4
OC (%)	0.9	0.5	0.5
N_{tot} (‰)	0.5	0.4	0.3
P_{avail} (mg kg^{-1})	7.3	1.4	18.3
CEC (cmol$^+$ kg$^-$	6.6	3.8	3.8
Base saturation	77.6	60.6	26.1

Four cover crops, *Crotalaria juncea* (sunn hemp), *Crotalaria retusa* (devil bean), *Calopogonium mucunoides* (calopo) and *Mucuna pruriens* (mucuna) were sown at the three locations in June1996 and fertilized with P and K at the rate of 17 and 33 kg ha^{-1}, respectively. Mineral fertilizer and weed fallow treatments were also maintained. In June 1997, the cover crops were incorporated with a hoe into the soil to a depth of about 10 cm and the fields sown to a 120-day maize variety (Okomasa) one week after incorporation (WAI).

Results and discussions

Devil bean produced the highest DM and N yield across locations presumably due to adaptation as a local species. Mucuna and calopo had similar DM and N yield and sunn hemp produced the least DM across locations (Table 2), though in a shorter time of 6 weeks.

Table 2. Dry matter (t ha^{-1}) and N accumulation (kg ha^{-1}) of cover crops measured in December 1996 at the three locations

	Cheshegu		Tingoli		Nyankpala		Across loc.	
cover crop	DM	N_{tot}	DM	N_{tot}	DM	N_{tot}	DM	N_{tot}
Devil bean	15.8	340	15.1	301	14.1	276	15.0	306
Calopo	8.1	172	8.6	156	11.2	216	9.2	181
Mucuna	8.4	180	8.8	155	9.8	206	9.0	180
Sunn-hemp	6.4	156	3.2	73	5.1	116	4.9	115
LSD (5%)	1.6	39	2.1	18	1.4	22	1.1	21

At 42 days after sowing, the DM yield of maize was higher with the improved fallow system (cover crops) than the traditional system (weed fallow) (data not shown). Mineral fertilizer treatment was also superior to the traditional system. However, mineral fertilizer and the improved fallow system had similar effect on maize DM yield at this time. A contrast comparison also showed that creeping cover crops (mucuna and calopo) were superior to erect cover crops (sunn hemp & devil bean) The maize DM yield obtained was lowest with the weed fallow system across locations. The order was calopo >devil bean>mucuna>sunn hemp/mineral fertilizer>weed fallow.

A combined analysis of treatment by location at final harvest indicated that devil bean and calopo which did not experience significant DM losses over the dry season, affected maize grain yield similarly at all locations. However, the loss of about 16% of mucuna DM during the dry season at Tingoli and Cheshegu resulted in lower maize grain yield than at Nyankpala (Table 3).

Contrasts of grain yield at final harvest indicated that at all locations, the improved fallow system (cover crops) and mineral fertilizer were superior to the weed fallow system. At Tingoli and Nyankpala, the improved fallow system was superior to the mineral fertilizer treatment, but at Cheshegu, they had similar effect on maize grain yield. The increases observed with cover crop residue application may be due to their nitrogen contribution and non-N effects such as improvement in water storage and infiltration rate, and lowering of bulk density of the soils.

Table 3. Maize grain yield at Cheshegu, Tingoli, Nyankpala and across locations.

		Maize grain yield (t ha^{-1})		
Treatment	Cheshegu	Tingoli	Nyankpala	Across loc.
Devil bean	2.4	2.9	2.7	2.7b
Calopo	3.2	3.1	3.0	3.1a
Mucuna	2.3	2.4	2.5	2.4bc
Sunn hemp	2.1	2.3	1.8	2.1c
Mineral fertilizer	2.7	2.0	1.9	2.1c
Weed fallow	0.9	0.7	0.9	0.8d
LSD (0.05)	0.4	0.3	0.3	
Contrasts	Prob.	Prob.	Prob.	
TS vs CC	<0.001	<0.001	<0.001	
TS vs MF	<0.001	<0.001	<0.001	
CC vs MF	0.16	<0.001	<0.001	
CR vs ER	0.002	0.33	<0.001	

TS = traditional system (weed fallow & sunn hemp relay); CC = cover crop (all cover crops); MF = mineral fertilizer; CR = creeping cover crops (calopo & mucuna); ER = erect cover crops (sunn hemp and devil bean).

Conclusions

The four cover crops produced enough biomass with sufficient N accumulation to improve the yield of maize in Northern Ghana with P and K application. Farmers can increase their maize yields 2-4-fold with this system, which may be equivalent to a 5-fold increase in their profit over the two-year period based on a partial budget estimate (not shown). Pre-season cultivation of cover crops particularly with sunn hemp is possible. The local species, devil bean had comparatively lower effect on maize yield due to lower residue quality and needs to be incorporated early, latest at flowering, to improve on its effect on maize yield. Application of cover crop residues will improve organic matter content of these soils in the long-run.

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