Research Application Summary

Pigeon pea-groundnut intercrop maize rotation cropping system: A tool for improving maize production in Malawi

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Abstract

A two year study to investigate how to optimally utilize applied mineral nutrients by maize grown in rotation with pigeon pea-groundnut intercrop is under way at Chitedze Agricultural Research Station (S 13^0 59' 23.2", E033^0 38' 36.8"). An experiment with eight treatments replicated three times in a randomized complete block design has been established. Two pigeon pea varieties, long and medium duration and groundnut (CG7) were grown as monocultures and intercrops. The intercrops involved planting either of the pigeon pea varieties with groundnut. Baseline soil data indicate that the soil is acid (mean pH=5.3), with low N (mean %N = 1.33), marginally adequate P (mean = 21.7 ug/g) and low organic carbon (mean %OC= 1.5%), suggesting low soil fertility. Grain yield assessment for the groundnut indicate a mean yield range of 549-873 kg/ha across the treatments with mean biomass yield range of 413-656 kg/ha. Extremely low pigeon pea grain yield was observed in the two varieties (mean range of 3-227 kg/ha), attributed largely to late planting that resulted into flower abortion and poor pod filling. Initial assessment of the biomass from the defoliating leaves of the pigeon pea varieties indicate a mean yield range of 1,047-2,114 kg/ha. Nutrient analysis of the yield components in this system is underway for quantification of nutrient uptake and partitioning to the grain by the legumes. The pigeon pea has since been ratooned with its biomass and that of groundnut incorporated into the soil. Maize will be planted in the second season thus transforming the system into a maize pigeon pea intercrop. A detailed study on the decomposition and mineralization pattern of nutrients from the incorporated biomass and subsequent uptake by the maize crop will be conducted in the second season. Mineral fertilizer will be applied at different rates to maize for the assessment of the potential to improve nutrient use efficiency by the maize crop in this system.

Key words: Intercrop and rotation, groundnut, maize, pigeon pea

Résumé

Une étude de deux ans pour étudier les moyens d'utiliser de façon optimale les nutriments minéraux appliqués par le maïs cultivé en rotation avec le pois d'Angole (pois de pigeon) et l'arachide en culture intercalaire est en cours à la station de recherche agronomique de Chitedze (S 130 59' 23.2", E0330 38' 36.8"). Une expérience de huit traitements répétés trois fois dans une conception en bloc complet aléatoire a été mise en place. Deux variétés de pois d'Angole, de longue et moyenne durée, et les arachides (CG7) ont été cultivées en monocultures et en cultures intercalaires. Les cultures intercalaires consistaient à planter l'une ou l'autre des variétés de pois de pigeon avec les arachides. Les données de référence sur les sols indiquent que le sol est acide (pH moyen = 5,3), avec faible teneur en N (% moyen de N = 1,33), très légèrement efficace en P (moyenne = 21,7 ìg / g) et de faible teneur en carbone organique (% moyen en CO= 1,5%), ce qui suggère une faible fertilité du sol. L'évaluation du rendement en grain pour les arachides indique une plage de rendement moyen de 549-873 kg / ha dans les traitements avec la gamme de rendement en biomasse moyenne de 413-656 kg / ha. Un rendement en grains de pois d'Angole extrêmement faible a été observé pour les deux variétés (gamme moyenne de 3-227 kg / ha), en grande partie attribué à la plantation tardive qui a abouti à l'avortement des fleurs et au pauvre remplissage des gousses. L'évaluation initiale de la biomasse à partir des feuilles défoliantes des variétés de pois d'Angole indique une gamme moyenne de rendement de 1.047-2.114 kg / ha. L'analyse des nutriments des composantes du rendement de ce système est en cours pour la quantification de l'absorption des nutriments et le partitionnement pour le grain par les légumineuses. Le pois d'Angole a depuis été rationné avec sa biomasse et celle de l'arachide incorporée dans le sol. Le maïs sera planté durant la deuxième saison, transformant ainsi le système dans une culture intercalaire de pois d'Angole et du maïs. Une étude détaillée sur le modèle de décomposition et de minéralisation des éléments nutritifs de la biomasse incorporée et l'absorption subséquente par la culture du maïs sera menée durant la deuxième saison. Les engrais minéraux seront appliqués à des taux différents pour le maïs afin d'évaluer le potentiel pour améliorer l'efficacité d'utilisation des nutriments par la culture du maïs dans ce système.

Mots clés: Pois d'Angole, Arachide, Maïs, Culture Intercalaire et Rotation

Background

Malawian smallholder farms' productivity is constrained by a myriad of limitations that are biophysical, economic and social in nature. One of the outstanding biophysical constraints is the inherent low fertility status of the soils which is being aggravated by the continuous loss of nutrients like nitrogen (N) and phosphorus (P). On average Malawi is losing of 40 kg N ha^{-1} and 6.6 kg P ha^{-1} annually (Smaling *et al.*, 1997). Additionally, nutrient use efficiency (NUE) is low (Sakala, 2004), as a result of declining levels of soil organic matter (SOM) and associated deficiencies of other macro and micronutrients. According to Waddington *et al.* (2004) the NUE is usually below 20 kg maize grain kg^{-1} of nutrients applied.

Recently, intercropping pigeon pea with groundnut has been touted to be a viable soil fertility improving technology (Kanyama-Phiri *et al.*, 2008). This has been attributed to increased N and organic matter (OM) input by the legumes into the soil. In Malawi, twenty years before the 2005/06 season, national yields of maize averaged 1.3 t ha^{-1} (FAO, 2008), against a yield potential range of 6 to 10 t ha^{-1} of the maize hybrid varieties grown by Malawian farmers. A strong Government-led Farm Input Subsidy Program (FISP) increased the nation average maize yield to over 2.5 t ha^{-1} in the 2006/07 season (ACIAR, 2010). The sustainability of the programme has been questioned due to its high dependence on donor funding and the sole use of inorganic fertilizers without addition of OM to the soils. This approach will continue to chemically and biologically degrade the soils thereby decreasing crop response to applied mineral fertilizer. As a solution, Bezner-Kerr (2007) proposed large scale integration of legumes like the pigeon pea and groundnut in the maize production systems and the incorporation of their biomass into the soil to improve crop productivity. Additionally, Kanyama-Phiri *et al.* (2008) indicate that the potential of the pigeon pea-groundnut intercrop for soil fertility improvement is high. The aim of study is therefore to investigate the below ground process and interactions that may enhance nutrient use efficiency in this system for the development of technologies for sustainable soil fertility management for increased crop production and hence food security.

Literature Summary

Intercropping refers to the growing two or more crops at the same time on a single field (Machado, 2009). The cropping system has four general subcat-egories, namely; mixed, row, strip and relay intercropping (Machado, 2009). Intercrop-ping

is more stable than monocrop-ping due to the partial restoration of diversity that is lost under monocropping. Other advantages of the system include; supression of weeds, soil erosion control and reduced damage from pests and diseases (Machado, 2009). On the other hand, annual crop legumes, grown in rotation with cereal crops, can improve yields of the cereals and contribute to the total N pool in soil. Reported yield responses to previous legume crops are in the range of 50-80% increases over yields in cereal-cereal sequence (Hayat, 2005). Benefits of legumes have also been attributed to control of cereal diseases and insect pests and improvements in soil structure.

Study Description

A two year study intended to investigate how to optimally utilize applied mineral nutrients by maize grown in rotation with pigeon pea-groundnut intercrop is under way at Chitedze Agricultural Research Station (S 13^0 59' 23.2", E033^0 38' 36.8"). An experiment with eight treatments replicated three times in a randomized complete block design was established. Two pigeon pea varieties, long and medium duration and groundnut (CG7) were grown as monocultures and intercrops. The intercrops involved planting either of the pigeon pea varieties with groundnut. Baseline soil data indicate that the soil is acid (mean pH=5.3), with low N (mean %N = 1.33), marginally adequate P (mean = 21.7 ug/g) and low organic carbon (mean %OC= 1.5%), suggesting low soil fertility. Grain yield assessment for the groundnut indicate a mean yield range of 549-873 kg/ha across the treatments with mean biomass yield range of 413-656 kg/ha. Low pigeon pea grain yield was observed in the two varieties (mean range of 3-227 kg/ha), attributed largely to late planting that resulted into flower abortion and poor pod filling. Initial assessment of the biomass from the defoliating leaves of the pigeon pea varieties indicate a mean yield range of 1,047-2,114 kg/ha.

Preliminary Results

Table 1. Baseline soil data.

Treatment	pH	%N	P (ug/g)	%OC
Sole maize	5.2	0.132	25.0	1.5
MD Pp	5.3	0.131	19.7	1.5
LD Pp	5.5	0.12	18.8	1.4
Sole Gn	5.4	0.124	20.5	1.4
MD Pp +Gn	5.4	0.135	20.2	1.6
LD Pp + Gn	5.3	0.132	21.3	1.5
MD Pp + Gn	5.2	0.139	24.0	1.6
LD Pp + Gn	5.3	0.146	24.5	1.7
$LSD_{0.05}$	0.21	0.013	4.8	0.08

MD Pp= Medium duration pigeon pea, LD Pp= Long duration pigeon pea, Gn= Groundnut

Table 2. Yield data.

Treatment	Pigeon pea grain yield (kg/ha)	Pigeon pea leaves (kg/ha)	Groundnut grain yield (kg/ha)	Groundnut haulms (kg/ha)	Maize grain yield (kg/ha)	Maize stover yield (kg/ha)
Sole maize	-	-	-	-	646	327
MD Pp	82	1,047	-	-	-	-
LD Pp	3	1,235	-	-	-	-
Sole Gn	-	-	647	656	-	-
MD Pp +Gn	28	1,753	569	612	-	-
LD Pp + Gn	73	1,620	691	479	-	-
MD Pp + Gn	227	1,467	549	698	-	-
LD Pp + Gn	14	2,114	873	413	-	-
$LSD_{0.05}$	275.7	1,370	98.9	98.9	-	-

MD Pp= Medium duration pigeon pea, LD Pp= Long duration pigeon pea, Gn= Groundnut

Nutrient analysis of the yield components in this system is underway for quantification of nutrient uptake and partitioning to the grain by the legumes. The pigeon pea has since been ratooned with its biomass and that of groundnut incorporated into the soil. Maize will be planted in the second season thus transforming the system into a maize- pigeon pea intercrop. A detailed study on the decomposition and mineralization pattern of nutrients from the incorporated biomass and subsequent uptake by the maize crop will be conducted in the second season. Mineral fertilizer will be applied at different rates to maize for the assessment of the potential to improve nutrient use efficiency by the maize crop in this system.

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