Green manuring for tropical organic cropping – A comparative analysis

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Abstract

Green manuring is an essential component of tropical organic farming. Field studies evaluated the use of three legumes as in situ or ex situ green manures, along with a nonlegume green manure and a control to ascertain their impacts on soil properties and yields of maize and mung bean grown in major (wet) and minor (dry) seasons. In situ green manuring, especially with legumes, had the most beneficial impact on soil properties, while with ex situ methods, the use of leaves alone improved soil properties. Yields were increased to a greater extent by green manuring in the minor season, and the in situ system proved to be more beneficial. In ex situ green manuring, greater benefits were obtained by the application of leaves alone. The impact of different green manures and their application methods is presented.

Introduction

Green manures are an ideal method of sustaining soil fertility in the tropics (Joergensen, 2002, Fageria, 2007), and in organic farming, for both soil fertility and microbial activity (Palm et al., 2001). Many studies in Asia (e.g. Katyal et al., 2001) highlight the value of green manures, although no studies report the benefits of *ex situ* or *in situ* application of the same material in comparison to that of only *ex situ* green manures on tropical upland crops. Field studies were carried out to compare how green manures grown *in situ* and *ex situ* affected selected soil properties and yields of maize (*Zea mays*) and mungbean (*Vigna radiata*) cultivated in the major and minor seasons of tropical Asia, in contrast to application of only *ex situ* manures.

Materials and methods

The study was carried out at the Experimental Station (418 m above sea level, 8°N, 81°E) of the University of Peradeniya, Sri Lanka, located in the mid-country intermediate zone, over the period October 2004 to August 2005, to encompass the major (WET) and minor (DRY) season corresponding to the Northeast and Southwest monsoons. The soil was an Ultisol (Rhodoult) with a sandy clay loam texture. The site received 722 mm and 236 mm of rainfall in the major and minor seasons and the me an temperature and humidity were 29°C $\pm$ 2.3°C and 69.5 $\pm$ 2.33%

The experiment had 9 treatments per species (maize and mungbean), namely ex situ application of gliricidia (*Gliricidia sepium*) or tithonia (*Tithonia diversifolia*) leaves, or twigs and leaves, *in situ* or *ex situ* application of crotolaria (*Crotalaria juncea*) or sesbania (*Sesbania rostrata*), and a control with no green manures, replicated three times in a randomized block design.

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The land was well prepared manually in August 2004 and March 2005 on adjacent blocks, with 18 plots of 2x2 m demarcated per replicate. Seeds of crotalaria or sesbania were broadcast on the selected plots for the two crops, and populations of these two species were maintained in an adjacent block for *ex situ* green manuring. In early October 2004 or May 2005, with the rains of the major and minor seasons, the biomass of the two planted green manures were estimated and the selected green manures were applied *in situ* or *ex situ* to the plots at a rate equivalent to 4 t/ ha of dry matter. The *ex situ* green manures – gliricidia and tithonia leaves or leaves and twigs, and sesbania or crotalaria *ex situ* were obtained nearby. C:N ratios of samples were determined. At 15 days after incorporation, soils of the plots were sampled to a depth of 30 cm using cores and analyzed for pH, bulk density, water holding capacity, and soil N by standard techniques as described by Anderson and Ingram (1993). Thereafter, seeds of maize (Var Ruwan OPV) or mungbean (Var MI5) were planted and maintained as per local recommendations without any chemical inputs. Seed yields were determined at crop maturity. The data was subjected to analysis of variance using a general linear model.

Results and Discussion

Sesbania and crotalaria had the highest N contents (Table 1) and the lowest C:N ratios, which are important in green manures. The inclusion of twigs, which is done by most tropical farmers in *ex situ* mulching, reduced N content and increased the C:N ratios of gliricidia and tithonia. Furthermore, tithonia had the lowest N contents and hence the highest C: N ratios thus indicating its inability to provide N to plants in organic systems, although it is known to provide P to crops (Cong and Merkcx, 2005).

Tab. 1. Nitrogen and C: N ratios of the selected green manures

Green manure	N %	C:N ratio
Gliricidia leaves	3.25	18.4
Gliricidia leaves and twigs	2.91	20.9
Crotalaria juncea plants	4.08	14.8
Sesbania rostrata plants	4.56	14.1
Tithonia leaves	0.58	25.7
Tithonia leaves and twigs	0.45	29.4
Probability (n=24)	0.018	0.009

Green manures had no significant impact on soil pH, although bulk density declined significantly when compared to the control (Table 2). *In situ* green manures reduced bulk density to the greatest extent. In *ex situ* mulching, leaves and twigs reduced bulk density more than when leaves alone were added, because of the higher lignin content of the former. The WHC followed the same trend as bulk density, and there was a significant positive correlation (r= 0.76*) between these two variables. Soil N was increased significantly by the legume green manures when compared to the control and tithonia. Again, *in situ* green manuring had a greater significant impact and also the use of leaves alone of gliricidia. This illustrated the benefits of *in situ* green manuring for enhancing soil properties and N. If *ex situ* manuring is adopted, the use of leaves alone would develop a better soil for organic farming

Tab. 2 Selected soil properties at planting as affected by green manures in wet (S1) and dry (S2) seasons, Es = addition *ex situ*, IS = addition *in situ*

Green manure	Ad.	pH (1:2.5 H_2O)		Bulk density $Mg.m^{-3}$		WHC %		Soil N (% Dry wt)	
		S1	S2	S1	S2	S1	S2	S1	S2
Gliricidia L*	Es	6.14	6.23	1.24	1.25	18.4	18.7	2.15	2.02
Gliricidia L & T	Es	6.25	6.39	1.22	1.21	19.9	19.2	2.04	1.98
Crotalaria	Is	6.46	6.52	1.18	1.21	20.2	19.6	2.24	2.15
	Es	6.38	6.27	1.21	1.24	18.5	19.3	2.14	2.05
Sesbania	Is	6.34	6.18	1.19	1.23	19.8	18.7	2.21	2.11
	Es	6.15	6.22	1.23	1.25	18.6	19.1	2.11	1.99
Tithonia L	Es	6.50	6.58	1.29	1.31	19.5	19.4	1.76	1.77
Tithonia L & T	Es	6.24	6.43	1.24	1.25	18.2	19.8	1.62	1.65
Control		6.15	6.13	1.35	1.36	15.6	14.8	1.58	1.54
Probability (p=0.05)		0.049	0.057	0.038	0.024	0.046	0.018	0.021	0.017

*L & T refer to leaves and twigs respectively

Green manures enhanced yields of both crops, especially the lower yields in the minor dry season, which could be attributed to the enhancement of soil water holding capacity. The legume material when grown *in situ* had a greater beneficial impact. In *ex situ* green manuring, the use of leaves alone had the greatest beneficial impact. Tithonia, although it provides P to plants, could not have the same impact on yields as N is the most limiting nutrient in most tropical soils (de Costa and Sangakkara (2006).

Tab. 3. Yields of maize and mungbean (kg ha^{-1}) in major and minor seasons as affected by green manures and method of application

Green manure	Addition	Maize		Mungbean	
		Major	Minor	Major	Minor
Gliricidia L	Ex situ	3251	2471	956	674
Gliricidia L & T		2433	1958	825	615
Crotalaria	In situ	3998	2941	999	701
	Ex situ	3704	2665	921	756
Sesbania	In situ	3790	2781	1001	795
	Ex situ	3410	2485	954	741
Tithonia L	Ex situ	3041	2104	825	642
Tithonia L & T	Ex situ	2534	1917	758	542
Control		1844	1452	458	329
Probability (p=0.05)		0.038	0.027	0.005	0.019

Thus, the study highlighted the importance of green manuring for tropical organic cropping. Legumes, especially as *in situ* green manures, had a greater beneficial impact, especially in the minor dry seasons. If *ex situ* green manuring is adopted, the use of leaves is the best option rather than the common practice of adding the entire shoot.

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