Nitrogen Dynamics, Growth and Yield of A Cereal Legume Intercropping System as Affected by Effective Microorganisms and Kyusei Nature Farming

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Abstract : *Intercropping is recommended for increasing productivity of smallholder tropical farming systems. In organic farming, these systems play a prominent role due to the inclusion of a legume, which could fix atmospheric nitrogen. However, the component crops do need organic matter to procure nutrients. Effective Microorganisms (EM) have the ability to release nutrients from organic matter through fermentation and decomposition Thus a study was carried out to determine the impact of EM on N dynamics in a cereal - legume cropping system, using 15N labeled corn or mungbean residues. EM increased 15N concentrations of corn at the V8 growth stage indicating better use of applied nutrients from organic matter. The uptake of 15N was greater from mungbean residues rather than from corn. EM also increased biological N fixation. The synergistic effects of EM in organic systems were evident from this field study.*

Introduction

Organic or nature farming, in their most developed forms is both philosophies and systems of agriculture. The systems are diverse and occur throughout the world in different forms and in different degrees of adoption of the real themes of organic farming (Stockdale et al, 2001). Critics of organic farming do state that the ability of the organic systems to achieve the stated objectives is a myth (Trewavas, 2001). The reality is that the numbers of farmers changing from conventional chemical systems to organic programs, due to the many benefits, are increasing, especially in the developed world (Rigby and Caceres, 2001, Stockdale et al, 2001). In the developing countries, where the green revolution of the early 1970's brought about very high levels of production through monocultures of crops and excessive use of agrochemicals, lands have become degraded due to non-adoption of proper management strategies. Thus, organic systems, either in total or at least partially are considered an alternative to improve sustainability of these farming units. The other cause for adoption of organic systems in the developing world is for the production of commodities for export to the markets of the developed countries. (Vander Werf et al, 1999).

Intercropping is often cited as a method of improving productivity of smallholder farms of the developing countries (Devendra and Thomas, 2002). Combinations of cereals which are the major sources of carbohydrates, with legumes are the most common systems of intercropping due to the well-documented benefits (e.g. Subbian et al, 2000, Pal and Shehu, 2001).

One important problem reported in organic farming is the slow release of nutrients from applied organic matter (Szott et al, 1999). The use of microbial formations to improve organic matter decomposition is a well-proven technique in agriculture (Pankhurst et al, 1996). Hence the use of Effective Microorganisms (EM), developed in Japan (Parr et al, 1996) as advocated in Kyusei Nature Farming is also a feasible method of improving nutrient availability of organic systems, and is used in many organic farming units in over 60 countries in all continents. However, the impact of EM in improving nutrient availability, especially nitrogen (N); which is the most limiting nutrient in tropical agriculture (Pal and Shehu, 2001) in an organic intercropping system as advocated in Kyusei Nature Farming has not been identified. A field study was thus carried out to determine the impact of EM on the release of N from cereal and legume organic matter when applied to an intercropping system. Emphasis was placed upon uptake of N from the two legumes by both the cereal and legume and its impact on yields.

Materials and Methods

The experiment was carried out at the Experimental Farm of the University of Peradeniya, Sri Lanka, during the wet (major) season that corresponds to the North East monsoon of 1999 beginning in October. The site is located at 8^{o}N, 81^{o}E, at 421 meters above mean sea level, in the mid country intermediate zone of the country. The soil of the site is an Ultisol (Rhododhult) (Panabokke, 1996), with a pH (1: 2.5 H2O) of 6.33 ± 0.15, total N content of 87 mg/g of soil, CEC of 22.61 ± 5.87 m.eq/100 g of soil. The organic C content in the 0 - 40 cm layer of soil was 0.91%.

The rainfall over the wet season was 761 mm while the mean evaporation over the same period was 424. mm. The mean temperature was 29.7^{o}C.

At the onset of the season in 1999, land was prepared and plots of 9 x 4 m demarcated. Maize (*Zea mays L.*) cv Ruwan was planted at the recommended spacing of 60 x 30 cm. The plots were intercropped with mungbean (*Vigna radiata L*) a food legume which was planted in-between the rows of maize at the same time. The spacing between plants of the legume varied between 5 - 7 cm.

Soon after planting 15N labeled residues of maize (1.52% enrichment) or mungbean (0.9% enrichment) obtained from a previous trial was applied to two microplots of dimensions 1 x 1 m located in each intercropped plot at a rate equivalent to 6 Mt per ha. (600g m^{-2}). The distance between the two microplots in one major plot was 3 m. Unlabelled residues of the same material were applied to the others areas of the plots at the same rate. The solution of EM (dilution 1:500) was applied to one microplot in each treatment. The other areas did not receive the microbial solution and extreme caution was adopted to avoid contamination. Thus the experiment had two main treatments, namely the addition of a cereal or legume residue, with subtreatments of the use or non-use of EM. These were arranged within a randomized block design with three replicates.

The crops were not supplied with fertilizers or pesticides. Hand weeding was carried out on three occasions.

At the V8 growth stage of beans and the maize, 4 plants of each species were uprooted from each microplot, carefully washed, nodule numbers of the mung bean plants counted and dry weights of all plants determined. Thereafter the plants were finely ground, total N contents determined and 15N enrichment measured through Emission Spectrometry. At crop maturity, the yields of maize and mungbean seeds were determined (corrected to 15% moisture).

The data was subjected to appropriate statistical analysis to determine the significance of differences at a probability of 5.0%.

Results and Discussion

The use of mungbean residue with its higher N content (2.98%) improved biomass accumulation of both maize and mungbean in the intercropping system (Table 1). This clearly validated the benefits of using a legume to supply nutrients in tropical cropping systems (Subbian et al, 2000). This feature is also important in organic systems (Stockdale et al, 2001). The mean increment in biomass of maize at the V8 growth stage due to the use of mungbean residue was 10% In mungbean the increment was 24%. This suggested that the impact of the type of organic matter was greater on the legume.

Application of EM increased biomass of both species. In maize, the use of EM increased biomass by 8% when supplied to corn residues, while the increment was 10% with mungbean residue. In mungbean the addition of the microbial solution to corn and mungbean residues increased biomass by 30% and 43% respectively. This clearly demonstrated that EM enhances the benefits of a legume manure, which could be attributed to its better nutrient value.

Table 1. Impact of Organic Matter and Effective Microbes on Biomass and N Dynamics of Maize and Mungbean in an Intercropping System

A: Maize Crop Residue	EM*	Biomass ($g.m^{-2}$)	Plant N (%)	15N% Enrichment	**N Uptake Efficiency (%)
Maize	-	384	0.86	0.08	37
	+	416	0.89	0.14	44
Sx		10.4	0.14	0.02	3.4
Mungbean	-	421	0.95	0.15	47
	+	465	0.99	0.26	54
Sx		24.5	0.24	0.04	5.4
B: Mungbean					
Maize	-	126	2.46	0.11	43
	+	164	2.59	0.16	49
Sx		18.6	0.58	0.09	2.4
Mungbean	-	148	2.65	0.24	48
	+	212	2.92	0.38	54
Sx		29.5	0.49	0.06	5.7

*EM + and - indicate the addition or non addition of the microbial solution

** N uptake efficiency = 15N enrichment of crop/15N enrichment of residue

Mungbean had a higher N content, being a legume. However, the use of EM had no impact on the plant N content, which a characteristic of each species. In contrast the supply of a labeled legume residue increased N contents of both species. This is due to the greater N content of the legume residue. The supply of the legume residue also increased N uptake efficiency due to greater availability. However the most important aspect was the increment of both 15N enrichment and N uptake efficiency due to the application of EM. This significant impact is due to the more rapid breakdown of the residue due to EM, which supplies the plant greater quantities of N at the required times, a phenomenon that is very important in low input systems.

Table 2. Nodulation and N Fixation of Mungbean as Affected by Crop Residue and EM

Crop Residue	EM#	Nodules/Plan	N Fixation (mg N/Plant)##
Maize	-	37	43
	+	48	49
Mungbean	-	56	48
	+	69	54
p=0.05	Residue	0.021	0.041
	EM	0.005	0.034
	Interaction	*	*

#EM + and - indicate the addition or non addition of the microbial solution

N fixation measured using the isotope dilution method of Peoples et al (1996)

The use of legume residues improved nodulation and N fixation, again due to the greater quantity of N supplied, as most tropical legumes requires some N for this biological process (Giller and Wilson, 2001). The supply of EM again increased this biological phenomenon significantly, which can be attributed to the stimulation of the soil microbes through the application of the beneficial microbes though EM.

Table 3. Impact of crop residues and EM on the yields of a maize - mungbean Intercrop

A: Maize Residue	EM*	Yields(g-m-^{2})
Maize	-	214
	+	236
Mungbean	-	229
	+	265
Sx		14.5
B: Mungbean		
Maize	-	98
	+	121
Mungeban	-	119
	+	156
Sx		20.4

*EM + and - indicate the addition or non addition of the microbial solution

The benefits of a technology are derived from its impact on crop yields. The supply of mungbean residue increased yields of both species to a greater extent than with the maize residue. This again is due to the better quantity of the residue, with its higher N content, a nutrient that is often limited in tropical soils and in organic systems (Stockdale et al, 2001). However greater benefits are derived from the supply of EM. The addition of the microbial solution increased yields of maize by 10% and 15% with maize and mungbean residues respectively . In mungbean, the increments in yields due to the EM and maize and mungbean residues were 23% and 31% respectively. This again implied the greater benefits derived by legume though EM and also the greater impact of the legume residue.

Tropical organic farming systems need to optimize the use of organic matter, especially in supplying nutrients. Intercropping cereals and legumes could derive mutual benefits of N transfer, but organic matter needs to be supplied to maintain productivity and sustainability. The study illustrates that legume residues do impart greater beneficial effects. The more important aspect is the benefits of EM, a solution made with common microbes found in all ecosystems. Thus, organic farming practices need to consider these solutions for increasing productivity of their farming systems, especially under tropical conditions where nutrients and organic matter could be limited.

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