Soil quality and crop yields as affected by microbial inoculants in nature farming

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Abstract

A field study tested the possibility of demonstrating the impact of Nature Farming with microbial solutions on soil quality and crop yields over one year, encompassing tropical wet and dry seasons. Adding green manures or compost was superior to using weeds as organic matter for improving soil quality and crop yields. Among the microbial inoculants, EM had a greater impact than vermiwash or cattle manure slurries on soil properties and yields of the selected crops. The prospects of Nature Farming with EM are presented as a possible method for tropical organic farming.

Introduction

Nature Farming, as advocated by Mokichi Okada in the 1930's as an alternative to the traditional systems of organic farming, relies on organic material available within the farming system to maintain soil fertility and crop productivity (Amano, 2012). However this practice is difficult in most tropical soils, where soil fertility and quality are low due to the rapid decomposition of organic matter. Thus soils in the warm humid tropics, especially those of smallholder farming systems are of low quality and adopting practices such as Nature Farming or conventional organic farming is difficult.

Microbial inoculants help to overcome the problems of low soil quality (Rigby & Caceres 2001), and using traditional inoculants such as manure slurries and vermiwash, which are accepted by the organic world are recommended additions primarily to enhance soil microbial activity, while providing some plant nutrients. However a problem of these solutions is time, labour and skills required for their preparation and applications. In contrast, Effective Microorganisms (EM) (Higa 1991), a microbial solution containing food based organisms and used in over 150 nations worldwide with successful results is used in Nature Farming.

The benefits of this solution is reported through scientific studies on enriching soil microflora (e.g. Jilani et al, 2007), and crop production in the temperate and tropical nations (e.g. Daly and Stewart, 1999, Sangakkara *et al* 2011). However a comparison of the benefits of EM as against traditional microbial inoculants has not been reported, especially in the context of Nature Farming. Thus, as a continuation of a series of studies, (Sangakkara *et al,* 2011), a field study evaluated the impact of EM and two other traditional microbial inoculants on some soil fertility and quality parameters using two test crops, over the major and minor season of Sri Lanka, using a low fertility soil. The organic matter used for this study was primarily gathered within the cropping ecosystem, as advocated in Nature Farming.

Material and methods

The study was carried out in 2009/10over a period of 12 months on a farm with a soil of very low quality (pH (1:2.5 H_2O) 5.4, Organic C g.kg^{-1},4.92; N mg.kg^{-1}10.4, Exchangeable K 175 g.kg-1; soil respiration 6.4 µ g CO2 C. g$^{-\ day}$) located in the intermediate zone of Sri Lanka. The rainfall received at the site was 11123 mm and the mean temperature was 29.4°C over the period of study.

In August 2009, a total of 48 plots of 4 x 4m were prepared to cover 3 replicates; each replicate having 16 plots to accommodate the treatments. The 16 plots per replicate were further subdivided into 4 equal lots, and to each lot the following treatments imposed: - The weeds at the inception and throughout the growing periods were incorporated after quantifying the amount using a 50 x 50 cm quadrat (i.e. 50 g.m^2), green manure (Gliricidia leaves obtained from the fences @ 200 g.m^2) at the beginning and middle of each season or compost prepared using cattle manure and dry leaves added at the same rate as the green manure. One lot of 4 plots were left without any organic matter as the control. To each subplot in every group, the following microbial solutions added - . Activated EM; a cattle manure slurry made by mixing 1 Kg fresh cattle manure

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in 15 l water or a solution of vermiwash, added at a rate equivalent to 5 litres per ha, (vermiwash dilution 1:500 @ 6 litres per plot) 1 week before planting and at 4 weekly intervals). The control subplots received the same quantify of water. This was done in both seasons (wet – October – January, dry April – August).Within 7 days of adding the organic matter, in the wet season the maize (*Zea mays* L) variety Ruwan and in the dry season capsicum (*Capsicum annum*)) variety MI 1were planted as per local recommendations. The crops were maintained over the season and seed yields of maize and of fresh pods in capsicum determined.

At the beginning of the study, soil samples were taken from the site and at the end of the study from each plot to a depth of 30 cm and the following determined: pH (1:2.5 H_2O), Soil C (dichromate oxidation) N (Kjeldhal), K (NH_4OAc), soil respiration at 55% moisture and incubation for 7 using NaOH to trap the CO_2 (Salamanca *et al.* 2002), and the data of both seasons were analysed using a GLM procedure.

Results and Discussion

Organic materials and microbial inoculants had a significant impact on most soil properties (Table 1). While the use of organic additives and microbial inoculants had no impact on soil pH, all other measured parameters and crop yields were enhanced by the selected treatments, when compared with the control, The microbial inoculant increased soil N, K, organic carbon and soil respiration, illustrating the benefits of enhancing soil microbial life, irrespective of the organic matter added, thus complementing the recent report on the value of soil life in farming (East, 2013). As expected, among the organic additives, green manure and compost had the greatest beneficial impact on measured soil parameters due to their better quality in terms of C: N ratios (data not presented, when compared to the weeds. However, in traditional Nature Farming, weeds serve as a very valuable source of organic matter in situations where other types of organic manures are not available.

Among the microbial inoculants used, the best results were obtained with EM, made with lactic acid bacteria, phototrophic bacteria and yeast. These results collaborate well with earlier published work (Jilani *et al*, 2007, Sangakkara *et al*, 2011), on the usefulness of this popular microbial inoculant in tropical cropping.

The beneficial impact of vermiwash, although labor intensive in preparation was greater than that of cattle manure slurry on soil parameters, (Table 1), especially soil respiration, indicating its beneficial role in promoting soil life, with all three types of organic matter.However, vermiwash and cattle manure slurry are difficult to prepare when compared to EM, which is available at a low cost and is accepted by organic systems and in Nature Farming as a useful addition for soil quality and life.

Organic farming generally produces lower yields when compared to conventional chemical farming (e.g. Azadi and Ho, 2010), and crop productivity is the final measure of success of organic cropping. Crop yields, as denoted by maize and capsicum in the wet and dry seasons respectively, were enhanced by organic matter and microbial inoculation. As in soil parameters, the most significant beneficial impact of organic matter was in the dry season, when the added material could retain soil moisture. The best impact was with compost and green manure, which collaborates well with the soil measurements. However the use of weeds as organic matter also brought about significant increments in yields over that from the bare soil, again highlighting the usefulness of these “unwanted plants” as advocated in the traditional Nature Farming practices by Mokichi Okada.

Conclusions

Nature Farming places emphasis on a closed system and soil quality is replenished by organic matter obtained within the ecosystem to the greatest posible extent, coupled with microbial inoculation. Weeds, in situ green manures and compost are encouraged in this system with mulching to supply organic matter and retain soil moisture. Microbial inoculation enhances the value of organic matter and EM has become a part of this process. In this study, microbial inoculation, especially EM, followed by vermiwash and cattle manure slurry, enhanced the value of orgainc matter, improved soil quality and increased crop yield, especially in dry seasons when water stress ocurs. Thus Nature Farming could be considered a very suitable system of organic agriculture for resource poor organic farmers in the tropics, as microbial solutions, including EM is available in most nations in all continents and is used widely.

Table 1. Impact of organic matter and microbial inoculants on soil properties in at the end of two seasons (wet and dry) and crop yields in the two seasons

Organic matter	Inoculation	pH(1:2.5 H_2O)	N $mg.Kg^{-1}$	Exch K $g.Kg^{-1}$	Org. C $g.Kg^{-1}$	Resp.µ g CO2 C. g^{-day}	Crop yields $g.m^2$	
							Maize	Capsicum
None (Bare soil)	Water	5.8	21.5	198	8.4	7.8	185	654
	CM slurry	5.6	24.7	224	9.9	9.5	204	704
	V.wash	5.6	26.7	238	9.4	9.7	211	711
	EM	5.5	20.4	207	8.1	10.8	185	652
Weeds ($500g.m^{-2}$)	Water	5.9	29.6	215	10.4	8.4	204	699
	CM slurry	5.7	30.4	249	11.5	10.6	241	725
	V washh	5.5	32.1	268	13.4	11.4	257	784
	EM	5.5	34.5	290	15.2	12.8	268	799
Green manure ($400. m^{-2}$)	Water	5.7	38.9	245	11.9	9.1	211	725
	CM slurry	5.8	42.5	281	13.5	12.7	239	768
	V.wash	5.5	46.8	299	15.4	13.9	258	776
	EM	5.5	49.0	310	17.0	15.7	274	801
Compost ($400. m^{-2}$)	Water	5.8	37.9	239	10.4	9.2	208	715
	CM slurry	5.9	44.5	255	12.8	13.8	243	774
	V.wash	5.7	48.1	280	15.4	15.4	261	798
	EM	5.5	51.2	311	15.9	16.3	278	811
Probability	O.M	0.16	0.03	0.02	0.01	0.01	0.03	0.05
	Inoculum	NS	0.19	0.04	0.41	0.33	0.04	0.04
	Interaction	NS	*	NS	NS	NS	NS	NS

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