Long term effect of organic sources of nutrients on productivity and soil health in maize+soybean—wheat+gram cropping system

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Key words: Organic, soil health, nutrients, vermicompost, manures and cropping system

Abstract

Recent approach to soil fertility management in India is shifting from the chemical management to organic agriculture, because of both ecological and economic concern. Maintaining the soil health ensures sustainability in crop productivity. Hence, a long term field experiment was conducted under rainfed conditions during 2006-07 to 2012-13 at CSK Himachal Pradesh Agricultural University, Palampur, India in maize/maize+soybean—wheat+gram cropping system in randomized block design with three replications. During conversion to organic i.e. for the first three years of study (2006-2008) the yields of maize were low, however, after third year of study i.e. from 2009-2012 the yields were improved. Similarly, in wheat+gram cropping system the wheat equivalent yields were low during 2006-07 and 2007-08 but thereafter, an impressive increase was observed due to the improvement of soil health in the form of nutrients and microbial status. Combined application of composts i.e. FYM, Himcompost (HC) & Vermicopmost (VC) (FYM + HC, VC + HC and FYM + VC), being at par with each other and with HC produced higher maize and wheat equivalent yields, gross & net returns and B:C ratio.

Introduction

Organic farming has emerged as an important priority area globally in view of growing demand for safe and healthy food which provides health and environmental benefits. The long term sustainability and concerns on environmental pollution associated with indiscriminate use of agrochemicals call for use of organic farming practices in agriculture for maintaining soil health and crop productivity. Therefore, to study the effect of different composts on the productivity of crops and soil health in terms of nutrient and microbial status in maize/maize + soybean-wheat + gram cropping system, a long term field experiment was conducted at Model Organic Farm of CSK Himachal Pradesh Agricultural University, Palampur (H.P.), India

Materials and Methods

A long term field experiment was conducted under rainfed conditions during 2006-07 to 2012-13 having maize/maize+soybean in *kharif* and wheat + gram in *rabi* seasons at CSK Himachal Pradesh Agricultural University, Palampur (H.P.), India in randomized block design with three replications and seven treatments. From 2006 to 2008 only maize was taken during *kharif* season whereas, after that soybean was included as an intercrop in maize till *kharif* 2012. The treatments consisted of Farm Yard Manure (FYM 20 t/ha), Vermicompost (VC 15 t/ha), Himcompost (HC 5 t/ha), FYM + VC (10+10 t/ha), FYM+ HC (10+2 t/ha), VC + HC (10+1 t/ha) and control (FYM 5.0 t/ha) *w.e.f*. 2006 to 2008 in maize and 2006-07 to 2008-09 in wheat+gram. Himcompost is a compost, enriched with locally available biomass, cow dung, cow urine, oil seed cake, rock phosphate, gypsum, slaked lime, bone meal, ash, egg shell *etc*. However, the doses of the composts were reduced after 3rd year of experimentation *i.e.* after the conversion period in both the seasons and the treatments were slightly modified as FYM (15 t/ha), Vermicompost (VC 10 t/ha), Himcompost (HC 5 t/ha), FYM+VC (7.5+5.0 t/ha), FYM+HC (7.5+2.5 t/ha), VC+HC (5.0+2.5 t/ha) and control. Henceforth, these treatments will be given without their doses as Farm Yard Manure (FYM), Vermicompost (VC), Himcompost (HC), FYM+VC, FYM+HC and VC+HC.

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Results

Effect on yield

Maize grain equivalent yield

During the first three years of study *i.e*. 2006-2008, FYM+VC, FYM+HC and VC +HC being at par with each other produced significantly higher yields over their individual application. However, after third year there was no significant difference in the maize equivalent yields among the compost treatments whether, applied alone or in combination due to the improvement in nutrients and microbial status of the soil to the desired level in all the treatments. Similar results have also been reported by Johnson *et. al* (1995) who observed that the crop yields were increased by using animal manures due to the corresponding improvement in soil quality.

Table 1: Effect of treatments on maize grain equivalent yield during *kharif* seasons

Treatments	Maize grain equivalent yield (MEY q/ha)						
	During conversion			After conversion			
	2006	2007	2008	2009	2010	2011	2012
FYM	17.9	16.3	12.3	30.6	27.1	35.0	36.1
VC	17.3	16.9	13.4	34.4	31.8	35.5	36.7
HC	21.1	17.4	15.9	37.6	32.9	38.8	36.3
FYM+HC	28.1	28.6	19.8	33.8	33.6	39.0	36.5
VC+HC	25.2	29.9	17.1	35.7	33.8	37.4	38.2
FYM+VC	28.2	26.8	17.1	33.8	31.0	38.0	36.1
Control	13.7	8.2	9.5	27.9	22.1	31.2	33.5
CD (P=0.05)	3.9	5.4	3.5	3.8	3.6	3.5	3.1

Wheat grain equivalent yield

In general, the yield levels during the first two years of study *i.e*. 2006-07 and 2007-08 were lower and almost similar due to the poor soil health during conversion period and after that there was a continuous increase in the yields over the years till 2011-12. However, there was no further increase in yield in the ensuring years showing that the maximum yield levels were achieved under the present situation. During the first two years of study (2006-07 & 2007-08) the combined application of composts (FYM+HC, VC+HC and FYM+VC) produced significantly higher wheat equivalent yield over the treatments when the composts were applied alone however, after 2007-08 these treatments were reduced. During 2008-09 and 2009-10 there was no significant difference in yield among the compost treatments except FYM which produced significantly lower yields. However, during the last three years of study (2010-11 to 2012-13) there was no significant difference in the wheat equivalent yield in various compost treatments whether applied alone or in combination due to the buildup of nutrients and microbial status to a desired level in all the treatments.

Table 2: Effect of treatments on wheat grain equivalent yield during *rabi* seasons

Treatments	Wheat grain equivalent yield (WEY) (q/ha)						
	During conversion			After conversion			
	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
FYM	17.9	17.2	30.7	35.8	38.8	42.2	41.3
VC	18.2	18.8	36.0	39.7	39.0	42.1	43.8
HC	19.9	19.8	37.0	39.8	40.2	43.1	42.3
FYM+HC	29.4	28.5	38.1	40.2	41.9	43.9	42.2
VC+HC	23.5	25.1	37.5	39.8	42.0	44.9	43.7
FYM+VC	22.4	23.3	39.8	39.6	42.1	44.4	43.6
Control	14.4	16.5	23.5	30.5	32.8	36.6	40.8
CD (P=0.05)	2.8	3.5	4.2	3.2	2.8	3.7	4.2

System's maize grain equivalent yield and economics

The total maize grain equivalent yield of the system was statistically similar in all the compost treatments whether applied alone or in combination except FYM which produced significantly lower yields (Table 3). The use of organic manures in farming was also observed to be effective means of improving soil structure, enhancing soil fertility and increasing crop yields by Johnson *et.al.1*995 and Simnis *et.al.*1998). FYM being at par with VC gave significantly lowest gross returns, net returns and B:C ratio over other compost treatments. VC+HC, FYM+VC, FYM+HC and HC being at par with each other produced significantly higher gross & net returns and B:C ratio over the remaining treatments calculated on the basis of system maize equivalent yield.

Table 3: Effect of treatments on maize grain equivalent yield of the system and economics after the conversion period

Treatments	System's maize grain equivalent yield	Gross return (Rs)	Net return (Rs)	B:C ratio
FYM	79.63	155108	92108	1.46
VC	83.98	163399	97099	1.46
HC	86.02	167096	106096	1.74
FYM+HC	86.19	167628	105628	1.70
VC+HC	87.40	169968	106318	1.67
FYM+VC	85.64	166777	102077	1.60
Control	70.89	138070	79670	1.36
CD (P=0.05)	4.90	9872	6278	0.24

Effect on soil health

Fertility status

In the span of six years (2006-2012) maximum OC (%) was recorded in VC+FYM and FYM alone *i.e*. 1.10 and 1.02 percent, respectively which was about 77.4 and 64.5 percent higher than the initial status. Available nitrogen increased significantly from the initial status of 188.16 kg/ha to the maximum of 278.0, 276.4 and 272.4 kg/ha in the treatments *viz*. VC+FYM, HC and HC+FYM, respectively. There was about 58.7 to 68.0 percent increase in available phosphorus in different compost treatments as compared to the initial status. In general, the plots receiving FYM alone or in combinations resulted in higher available potassium as compared to the remaining treatments (Table 4).

Table 4: Effect of treatments on Soil fertility status

Treatments (Composts t/ha)	pH	OC (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potassium (kg/ha)
FYM	5.82	1.02	269.4	15.6	288.4
VC	5.64	0.90	265.7	15.4	279.6
HC	5.61	0.83	276.4	14.6	275.3
FYM + HC	5.79	1.00	272.4	15.5	285.6
VC + HC	5.47	0.87	269.6	15.3	271.3
VC +FYM	5.82	1.10	278.0	15.6	294.1
Control	5.65	0.69	225.7	11.8	234.3
CD (P=0.05)	NS	0.14	12.2	1.1	10.4
Initial soil fertility status	5.40	0.62	188.16	9.50	179.08

Microbial status

Maximum microbial count was observed in treatment FYM+VC and FYM alone which was 13.31 and 12.57 log cfu/ml, respectively. In case of N fixers with emphasis on *Azotobacter* and *Rhizobium*, maximum population was obtained in FYM+VC and FYM alone *i.e.* 9.87 and 9.47 log cfu /ml, respectively.

Table 5: Effect of treatments on soil microbial status

Treatments (Composts t/ha)	Total Microbial Load (*log cfu/ml*)	*N fixers* (*log cfu/ ml*)	P. solublizers (*log cfu/ml*)	*Fungus* (*log cfu/ ml*)	*Actinomycetes* (*log cfu/ml*)
FYM	12.57	9.47	8.17	6.49	8.61
VC	12.19	8.43	8.38	5.89	7.53
HC	12.38	8.65	9.05	5.78	7.50
FYM +HC	12.11	8.43	9.28	6.62	7.99
VC +HC	12.19	8.17	9.12	5.80	8.46
FYM + VC	13.31	9.87	8.72	6.84	7.90
Control	8.06	6.84	5.99	6.01	5.18

Highest count of phosphate solubilizing bacteria (9.28 log cfu/ml) was obtained in FYM + HC treated soil. Fungal population was highest in FYM+VC *i.e.* 6.84 closely followed by FYM+HC *i.e*. 6.62. Highest *Actinomycetes* count was obtained in FYM alone followed by VC+HC *i.e.* 8.61 and 8.46 log cfu/ml, respectively.

Discussion

The long term study on the effect of organic sources of nutrients on productivity and soil health in maize+soybean—wheat+gram cropping system showed that in general, irrespective of sources of nutrients the yields of the crops both in *kharif* and *rabi* seasons during the first 2-3 years (during conversion period) was low however, there was a continuous increase in the yields after 3rd year due to the buildup of nutrients and microbial status of the soil over the years. Initially, during the conversion period application of different composts in combinations (FYM+VC, FYM+HC, VC+HC) were observed to be more effective in increasing yields however, after that the yield levels were statistically similar in all the compost treatments due to the improvement in soil health to the desired level in all the treatments. Himcompost (HC) which is an enriched compost being at par with other treatments except FYM resulted in higher system's maize grain equivalent yield, net returns and B:C ratio over FYM and control (Table 3). Hence, the conclusion is that in general, the productivity of the crops during the conversion period (2-3 years) is low and after that due to improvement in soil health (nutrients & microbial status), the productivity of the crops is also enhanced to its full potential irrespective of organic sources of nutrients.

Suggestions to tackle with the future challenges of organic farming:

To promote organic agriculture as low cost resource conserving sustainable form of agriculture, the organic policy and strategies should be such that these should give due consideration to the farming needs, potential niches as strengths for commercial development and threats of not adopting alternatives. Further, the mission must strengthen the institutional and human resource capacities of the state/country to enable it implement various components of mission.

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