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INFLUENCES OF ORGANIC AND INTEGRATED NUTRIENT MANAGEMENT ON PHYSICO-CHEMICAL PROPERTIES OF SOIL UNDER BASMATI-WHEAT CROPPING SEQUENCE

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ABSTRACT

The present study entitled "Influences of organic and integrated nutrient management on physico-chemical properties of soil under basmati-wheat cropping sequence" was carried at Punjab Agriculture University, Farm on basmati-wheat sequence. The experimental treatments consisted of inorganic fertilizers, organic manures and integrated nutrient management. The cumulative infiltration ranged from 0.9 to 2.4 cm after 1 min under different treatments, the value being highest (2.4 cm after 1 min) in treatments receiving organic manures alone, recommended fertilizer + 200 kg N ha^{-1} from FYM (1.3 cm after 1 min) than control (0.9 cm after 1 min) and RF alone (1.1 cm after 1 min). The highest values of Soil organic carbon (0.6 %), mineral nitrogen (79.5 mg ha^{-1}), ammonium acetate extractable potassium (145.8 mg kg^{-1}) and bray-I Phosphorus (22.0 mg kg^{-1}) in surface soil were recorded in plots receiving 400 kg N ha^{-1} from vermicompost (VC), rice straw compost (RSC) and farm yard manure (FYM) respectively, which was significantly higher than control, recommended fertilizer alone or in combination with chemical fertilizers (the values in latter i.e RF + FYM being significantly higher than former two treatments i.e control and RF) but at par with other organic treatments, the value of all the four parameters decreased with the depth of profile. The lowest value of bulk density (1.40 gm cm^{-3}), soil pH (5.8) and Soil EC (0.11) in surface soil were observed in the plot where N from FYM at 200 kg ha^{-1} was applied in combination with recommended fertilizer, 400 kg N ha^{-1} from FYM and 400 kg N ha^{-1} from VC respectively, the value of B.D. and soil pH increased whereas that of EC decreased with the soil depth. However crop yield was significantly higher in treatments where RF along with FYM was used than organically treated plots. Thus best alternative for sustaining the soil fertility without compromising the productivity is to use inorganic fertilizers along with the organic manures.

INTRODUCTION

The increased crop output with the use of high amount of fertilizers and pesticides results in decreased food quality & soil fertility, degradation of cultivated land, water and air which threatens food safety and food security (Zhoa *et al.* 2007). Sustainability of rice-wheat system is threatened due to indiscriminate exploitation of natural resources and non judicious use of agricultural inputs without considering the carrying capacity of soil. Escalating cost of chemical fertilizers and no or less use of organics has lead to decline in soil quality. The soils under rice-wheat sequence are now showing signs of fatigue and are no longer exhibiting increased productivity even with increase in input use. The stagnating crop yields have generally been attributed to declining nutrient supplying capacity of soil, imbalanced nutrition and little or no addition of organic material affecting physico-chemical properties. The rice-wheat cropping system has also been implicated for declining water table in the central districts of Punjab. Therefore, basmati rice is being advocated as an alternative to paddy for arresting the decline in water table. Hence, it is imperative to use both organic and inorganic sources of plant nutrients to enhance food production for ever increasing population (Mahajan *et al.*, 2007). It is a challenge before the agricultural scientists to get desired production from the limited resources. Integrated nutrient management (INM) has been advocated to circumvent some of the constraints related to soil fertility and crop productivity.

In India the contribution of organic sources was 80-100 per cent in 1949-50 and it reduced to about 32 per cent in 1993-94 and 20-25 per cent in 2004-05.Organic manures promotes the growth and activity of useful microorganisms in soils. More build up in available N and P is attributed to solubilization of nutrients from their native sources during decomposition and mineralization of organic manures (Yadav and Kumar, 2002). Organic matter binds soil particles into structural units, thus improves the soil structure and maintains favorable condition for aeration and permeability. The rate of infiltration and percolation of water is enhanced by the application of soil organic matter. It increases the water holding capacity, reduces plasticity, cohesion and stickiness and resists soil erosion and loss of surface soil by wind by forming granules with soil particles (Das *et al.*, 2000). Integrated use of green manures with recommended inorganic fertilizers indicated that increase in rice and wheat yields was the largest in case of *Sesbania* along with 100 per cent NPK doses in both the crops than *Crotolaria juncia* and cowpea green manure crops (Hegde, 1998). Sharma *et al.*, 2013 reported that conjunctive use of inorganic fertilizers and organic manure along with biofertilizers and micronutrients gave highest available N, P, K, S and Zn in soil as compared to other treatment combinations. Thus, integrated resource management improved the crop yields, produces quality grain as well as improved the soil fertility. The combined application of organic manures, amendments and green manures (Farmyard manure @ 10 kg + Neem cake @ 1.25 kg + Vermicompost @ 5 kg and Wood ash @ 1.75 kg /plant + Triple green manuring with Sunhemp + Double intercropping of Cow pea + biofertilizers viz., Arbuscular Mycorrhizae @ 25 g , Azospirillum @ 50 g, Phosphate Solubilizing Bacteria @ 50 g and Trichoderma harzianum @ 50 g/plant) in banana registered the maximum growth, yield and yield attributes, leaf nutrient status of N, P and K and soil physiochemical properties at harvesting stage because the role of organic manures and amendments to make the soil has healthy and also, the unavailable form of soil nutrients to available form by enhancing mineralization and solubilization process in soil (Vanilarasu and Balakrishnamurthy, 2014). *Sesbania aculeate* (dhaincha), *Crotolaria juncia* (sunnhemp) and *Vigna unguiculata* (cowpea) are capable of accumulating 4-5 t ha^{-1} of dry mass and about 100 kg N ha^{-1} in 50-60 days. After decomposition green manures release nutrients in the soil in available forms. In addition, organic acids released during the course of decomposition of green manures favour the mobilization of soil nutrients (Bin, 1983). Crop residues on an average, contains 0.5 per cent N, 0.6 per cent P_2O_5 and 1.5 per cent K_2O. Crop residues improve the soil properties, micro nutrient supply and productivity (Sharma and Bali, 1998). Vermicomposting is the process of recycling of different type of wastes available on farm, rural areas and urban settlements. It is a natural organic product which is eco-friendly and leaves no adverse effects either in the soil, produce or the environment (Gupta and Bhagat, 2004).

Though the INM is a practical alternative that holds great prominence not only for securing high productivity but also against deterioration of soil environment, but now a days there is great demand of organic food. Since organic farming is of relatively of recent origin there is very little information available on its influence on soil properties. In the present study recommended chemical fertilizer or sunhemp green manure was incorporated to meet nutritional requirement of basmati while in wheat different organic manures such as such as FYM, vermicompost and rice straw compost were applied at equal N basis and evaluated viz-a-viz chemical fertilizer or the integrated use of chemical fertilizer with organic manures. Therefore, the present study was planned to study the effect of organics and chemical fertilizers on physico-chemical properties of soil.

MATERIALS AND METHODS

Field experiment on basmati-wheat sequence is in progress, at Research Farm, Department of Soil Science, PAU, Ludhiana (30°56´ N, 75°52´E and 247 m above sea level) since rabi 2006-07. Wheat crop was raised during rabi 2010-2011 with the following treatments applied in a randomized block design with three replications.

Treatment details

Control: Unfertilized

Recommended fertilizers (RF) (120 kg N, 60 kg P_2O_5 and 30 kg K_2O ha^{-1})

75% RF + 200 kg N ha^{-1} from FYM

RF + 200 kg N $ha^{-1}$from FYM

300 kg N $ha^{-1}$from FYM

400 kg N $ha^{-1}$from FYM

300 kg N $ha^{-1}$from Vermicompost (VC)

400 kg N $ha^{-1}$from Vermicompost (VC)

300 kg N $ha^{-1}$from rice straw compost (RSC)

400 kg N $ha^{-1}$from rice straw compost (RSC)

FYM, VC and RSC were mixed in the soil with last ploughing. Wheat variety PBW 291 was sown on 26th November, 2010 and all P and half dose of N were drilled at the time of sowing in chemical fertilizer treatments. Remaining N was applied 5 days after the first irrigation applied to wheat at critical root initiation stage (CRI).

Surface soil samples (0-15 cm) were collected from all the treatments before sowing of wheat crop (2009-10). Profile soil samples were collected with the help of soil auger from different depths (0-15, 15-30, 30-45, 45-60, 60-90 and 90-120 cm). The infiltration rate was measured after the harvest of wheat crop in April 2010 in undisturbed soil in the field with the help of double ring infiltrometers of 35 and 40 cm diameter and 28 cm height (Bower, 1986).

Bulk density was determined by dividing the dry soil mass by the volume and expressed as g cm^{-3} (Blake and Hartage, 1986).

Soil pH of surface and profile soil samples was measured (1:2 soil: water suspension) using pH meter fitted with calomel glass electrode. Electrical conductivity of 1:2 soil:water supernatent (kept overnight) was estimated using solubridge.

Total organic carbon was estimated using Walkey and Black's (1934) rapid titration method.

Mineral N was determined by shaking the sample with 2M KCl (1:10 soil: extractant) for one hour. The extract was filtered and mineral N was estimated by steam distillation of the extract using MgO and Devarda's alloy (Keeney, 1982).

Available phosphorus was determined by extracting the soil samples with 0.03N NH_4F + 0.025N HCl (Bray and Kurtz, 1945) and measuring the P content in the extract by colorimetric methods using a spectrophotometer at 760 nm wavelength using ascorbic acid method (Murphy and Riley, 1972).

Available potassium content in soil was estimated by extraction with neutral normal ammonium acetate and determined on a Flame Photometer (Merwin and Peech, 1950).

RESULTS AND DISCUSSION

Soil physical properties

Water Infiltration

Water infiltration was measured at time intervals of 1, 3, 6, 11, 21, 31, 51, 71, 101, 131, 191 and 251 minutes (Fig 1 and 2). The cumulative infiltration ranged from 0.9 to 2.4 cm after 1 min and it increased to 11.9 to 14.7 after 251 min under

Table 1: Effect of different treatments on soil pH at different soil depths

Treatments	Depth (cm) 0-15	15-30	30-45	45-60	60-90	90-120
Control	6.7	6.9	7.0	7.2	7.4	7.5
RF	6.8	7.0	7.1	7.3	7.4	7.6
75% RF+ 200 Kg N ha^{-1} (FYM)	6.6	6.8	7.0	7.2	7.3	7.5
RF+ 200 Kg N ha^{-1} (FYM)	6.6	6.7	6.9	7.0	7.2	7.4
300 Kg N ha^{-1} (FYM)	6.2	6.4	6.7	6.9	7.1	7.3
400 Kg N ha^{-1} (FYM)	5.8	6.0	6.3	6.6	6.9	7.1
300 Kg N ha^{-1} (VC)	6.1	6.4	6.6	6.8	7.0	7.2
400 Kg N ha^{-1} (VC)	6.3	6.4	6.6	6.9	7.1	7.3
300 Kg N ha^{-1} (RSC)	6.1	6.3	6.5	6.8	7.0	7.2
400 Kg N ha^{-1} (RSC)	5.8	6.1	6.3	6.7	6.9	7.1
CD (p=0.05)	0.4	0.3	0.3	0.2	0.2	0.1

Table 2: Effect of different treatments on Electrical Conductivity (dS m^{-1}) at different soil depths

Treatments	Depth (cm) 0-15	15-30	30-45	45-60	60-90	90-120
Control	0.18	0.16	0.14	0.12	0.11	0.06
RF	0.17	0.16	0.14	0.13	0.10	0.06
75% RF+ 200 Kg N ha^{-1} (FYM)	0.15	0.13	0.12	0.10	0.09	0.07
RF+ 200 Kg N ha^{-1} (FYM)	0.17	0.15	0.13	0.11	0.09	0.07
300 Kg N ha^{-1} (FYM)	0.14	0.12	0.10	0.09	0.07	0.06
400 Kg N ha^{-1} (FYM)	0.13	0.11	0.10	0.09	0.08	0.07
300 Kg N ha^{-1} (VC)	0.15	0.13	0.12	0.10	0.09	0.07
400 Kg N ha^{-1} (VC)	0.11	0.10	0.09	0.08	0.07	0.06
300 Kg N ha^{-1} (RSC)	0.15	0.13	0.12	0.10	0.09	0.08
400 Kg N ha^{-1} (RSC)	0.13	0.12	0.10	0.09	0.08	0.06
CD (p=0.05)	0.02	0.02	0.02	0.01	0.02	NS

Table 3: Effect of different treatments on soil organic carbon (per cent) at different soil depths

Treatments	Depth (cm) 0-15	15-30	30-45	45-60	60-90	90-120
Control	0.33	0.25	0.24	0.14	0.13	0.10
RF	0.34	0.26	0.26	0.18	0.15	0.12
75% RF+ 200 Kg N ha^{-1} (FYM)	0.38	0.32	0.26	0.17	0.15	0.12
RF+ 200 Kg N ha^{-1} (FYM)	0.35	0.35	0.26	0.16	0.14	0.11
300 Kg N ha^{-1} (FYM)	0.52	0.28	0.23	0.19	0.15	0.12
400 Kg N ha^{-1} (FYM)	0.54	0.32	0.23	0.24	0.16	0.13
300 Kg N ha^{-1} (VC)	0.52	0.26	0.23	0.21	0.16	0.13
400 Kg N ha^{-1} (VC)	0.60	0.39	0.27	0.21	0.15	0.12
300 Kg N ha^{-1} (RSC)	0.49	0.33	0.26	0.25	0.17	0.14
400 Kg N ha^{-1} (RSC)	0.51	0.35	0.22	0.27	0.16	0.13
CD (p=0.05)	0.08	0.06	NS	0.04	0.02	0.02

different treatments. Application of N from RSC, VC and FYM increased cumulative infiltration significantly over control, recommended fertilizer and recommended fertilizer along with 200 kg N ha^{-1} from FYM (Fig. 1). Similarly the infiltration rate upto 3 minutes was significantly higher in organic treated plots as compared to control, recommended fertilizer and recommended fertilizer along with 200 kg N ha^{-1} from FYM. Infiltration rate, however, decreased with increase in time interval (Fig. 2). The infiltration rate after 251 minutes ranged from 1.8 to 2.3 cm hr^{-1} under different treatments (Fig. 2). Application of organic manures increased the infiltration rate over control and recommended fertilizer but the effect was non-significant. The increase in infiltration rate with organic matter addition may be due to increased aggregation resulting in more pore space for movement of water. Ghuman and Sur, (2006) also reported the increase in infiltration rate with green manuring and FYM application under rainfed conditions.

Bulk density

Soil bulk density values ranged from 1.40 to 1.55 gm cm^{-3} in 0-7.5 cm of soil depth (Fig. 3) under different treatments. The lowest value of bulk density was observed in the plot where N from FYM at 200 kg ha^{-1} was applied in combination with recommended fertilizer (1.40 gm cm^{-3}). In control plot the bulk density in 0-7.5 cm soil depth was 1.55 gm cm^{-3}. There was a significant decrease in bulk density of soil where organic amendments in the form of VC, RSC and FYM were applied at 400 kg N ha^{-1} as compared to control. The lowering of bulk density in organic treated plots and with integrated nutrient management may be due to higher organic carbon, more pore space and good soil aggregation. Similar results have

Table 4: Effect of different treatments on soil mineral nitrogen (mg kg^{-1}) at different soil depths

Treatments	Depth (cm)					
	0-15	15-30	30-45	45-60	60-90	90-120
Control	54.2	53.0	51.8	48.2	42.2	41.0
RF	59.0	54.2	49.4	45.8	41.0	42.2
75% RF+ 200 Kg N ha^{-1} (FYM)	62.6	59.0	55.4	51.8	51.8	51.8
RF+ 200 Kg N ha^{-1} (FYM)	59.0	50.6	47.0	43.4	42.2	42.2
300 Kg N ha^{-1} (FYM)	63.9	57.8	55.4	51.8	47.0	45.8
400 Kg N ha^{-1} (FYM)	75.9	71.1	68.7	63.9	60.2	56.6
300 Kg N ha^{-1} (VC)	56.6	50.6	47.0	44.6	41.0	42.2
400 Kg N ha^{-1} (VC)	79.5	69.9	66.3	62.6	59.0	55.4
300 Kg N ha^{-1} (RSC)	60.2	55.4	51.8	47.0	49.4	47.0
400 Kg N ha^{-1} (RSC)	67.5	61.4	60.2	55.4	47.0	45.8
CD (p=0.05)	12.9	11.0	11.1	10.8	10.2	9.7

Table 5: Effect of different treatments on Bray-I phosphorus (mg kg^{-1}) at different soil depths

Treatments	Depth (cm)					
	0-15	15-30	30-45	45-60	60-90	90-120
Control	11.3	9.9	6.0	5.6	3.4	2.2
RF	13.3	12.0	7.9	7.6	4.6	3.5
75% RF+ 200 Kg N ha^{-1} (FYM)	14.4	13.0	9.0	8.6	5.6	4.7
RF+ 200 Kg N ha^{-1} (FYM)	16.9	15.5	11.3	10.9	7.8	7.2
300 Kg N ha^{-1} (FYM)	18.3	16.8	12.6	12.2	7.2	9.5
400 Kg N ha^{-1} (FYM)	22.0	20.5	16.1	15.7	8.4	9.3
300 Kg N ha^{-1} (VC)	18.8	17.4	13.1	12.8	8.9	8.9
400 Kg N ha^{-1} (VC)	21.4	19.9	15.5	15.5	7.9	7.1
300 Kg N ha^{-1} (RSC)	18.8	17.4	13.1	12.8	9.6	7.4
400 Kg N ha^{-1} (RSC)	19.8	18.3	14.0	13.7	10.5	8.6
CD (p=0.05)	1.3	1.3	1.2	1.2	1.0	0.8

Table 6: Effect of different treatments on ammonium acetate extractable potassium (mg kg^{-1}) at different soil depths

Treatments	Depth (cm)					
	0-15	15-30	30-45	45-60	60-90	90-120
Control	57.5	54.2	51.0	52.8	51.1	50.0
RF	63.3	65.0	65.8	58.3	59.2	56.9
75% RF+ 200 Kg ha^{-1} N (FYM)	72.5	61.7	76.7	70.0	65.0	61.7
RF+ 200 Kg ha^{-1}N (FYM)	106.7	111.7	97.5	89.2	80.8	63.3
300 Kg N ha^{-1} (FYM)	122.5	109.2	105.8	93.3	79.2	71.7
400 Kg N ha^{-1} (FYM)	125.0	110.0	115.8	103.3	90.8	79.2
300 Kg N ha^{-1} (VC)	130.0	120.0	116.7	100.8	89.2	64.2
400 Kg N ha^{-1} (VC)	132.5	122.5	117.5	99.2	95.0	66.7
300 Kg N ha^{-1} (RSC)	135.0	126.7	112.5	94.2	75.0	70.0
400 Kg N ha^{-1} (RSC)	145.8	130.8	126.7	106.7	98.3	62.5
CD (p=0.05)	20.2	17.2	18.6	17.7	12.8	7.8

been reported by Francis *et al.* (2006). Plots receiving RSC and FYM at 400 kg N ha^{-1} had the bulk density of 1.44 gm cm^{-3} and it was lower than plots where VC at 400 kg N ha^{-1} was applied (1.46). The bulk density increased with depth upto 15 cm. The value of bulk density ranged from 1.53 to 1.67 gm cm^{-3} in 7.5-15 cm soil depth (Fig 3). Similar to 0-7.5 cm soil depth, the bulk density was minimum in plots, where organic amendments were applied as compared to control, but the difference was statistically non significant.

Soil chemical properties

Soil pH

The pH values in surface soil (0-15 cm) ranged from 5.8 to 6.8 (Table 1). The highest pH value was recorded in recommended fertilizer plots and lowest pH was observed in plot receiving nitrogen from FYM and RSC at 400 kg N ha^{-1}. In control plot, pH recorded was 6.7 while with the application of N through organic sources, the value of pH decreased significantly to 6.1 in case of 300 kg N ha^{-1} applied either from VC or RSC. Application of N at 400 kg ha^{-1} from RSC had pH value of 5.8 which was significantly lower than plots where RF was applied along with 200 kg N ha^{-1} from FYM. The pH value of plots treated with 400 kg N ha^{-1} from FYM (5.8) was significantly lower than 300 kg N ha^{-1} applied from FYM. However the 300 and 400 kg N ha^{-1} rates of RSC and VC did not differ significantly. The decrease in the pH may be attributed to the production of organic acids and CO_2 released during the decomposition of organic matter and released by microbes (Singh *et al.*, 2008). The decrease in the soil pH with the application of FYM was also reported by Kumar and Singh,

Table 7: Effect of different treatments on wheat grain and straw yield (q ha^{-1})

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
Control	17.6	33.9
RF	37.3	63.4
75% RF+ 200 Kg ha^{-1} N (FYM)	36.1	66.4
RF+ 200 Kg ha^{-1}N (FYM)	38.3	54.0
300 Kg N ha^{-1} (FYM)	27.2	48.6
400 Kg N ha^{-1} (FYM)	30.9	52.0
300 Kg N ha^{-1} (VC)	25.9	44.7
400 Kg N ha^{-1} (VC)	29.6	44.8
300 Kg N ha^{-1} (RSC)	31.3	52.6
400 Kg N ha^{-1} (RSC)	30.0	51.3
CD (p=0.05)	5.5	10.5

Appendix: - Physico-chemical characteristics of experimental soil

Soil properties	Value
pH (1:2 soil water suspention)	6.8
EC (dS m^{-1}) (1:2 soil water supernatent)	0.23
OC (%)	0.35
Mineral N (kg ha^{-1})	131.4
Bray P_1 (kg ha^{-1})	26.4
Exchangeable K (kg ha^{-1})	133
$CaCO_3$	Nil
Texture	Sandy loam

(2010). The pH value increased with depth under all the treatments upto 120 cm depth. It may be due to leaching of bases from the surface to deeper soil layers. It varied from 6.1 to 7.0, 6.3 to 7.1, 6.7 to 7.3, 6.9 to 7.4 and 7.1 to 7.6 at 15-30, 30-45, 45-60, 60-90 and 90-120 cm soil depth, respectively (Table 1). There was also a significant decrease in the value of pH observed in organic applied treatments over the other treatments at all the depths. The difference in pH value of 300 and 400 kg N ha^{-1} applied from FYM were significant upto 120 cm soil depth. The variation of soil pH due to treatments was more in the surface layer and it decreased with increase in depth.

Electrical conductivity (EC)

Under various organic and inorganic treatments, electrical conductivity (EC) varied from 0.11 to 0.18 (dS m^{-1}) in surface soil (0-15 cm). The value of EC ranged from 0.10 to 0.16, 0.9 to 0.14, 0.8 to 0.13, 0.7 to 0.11 and 0.6 to 0.8 dS m^{-1} in 15-30, 30-45, 45-60, 60-90 and 90-120 cm soil depths, respectively (Table 2). In organic treated plots the values of EC were significantly lower than control, recommended fertilizer and integrated management of organic and inorganic sources. The minimum EC value (0.11) was recorded in 400 kg N from VC plots, followed by 400 kg N from RSC and FYM (0.13). In surface soil, higher EC was observed in control and inorganically treated plots over organic plots. Application of N at 400 kg ha^{-1} from VC, the EC value recorded was 0.11 which was significantly lower than the treatment when N at 300 kg ha^{-1} was applied from VC (0.15). So with the increase in dose of organic manures applied, the EC value decreased. Similarly in 15-30 cm soil depth, comparatively lower EC was observed in plots where FYM was applied at 400 kg N ha^{-1}. Significantly higher EC was observed in plots receiving recommended fertilizers as compared to plots receiving organic treatments. The electrical conductivity of soil decreased with depth under all the treatments and the differences among different treatments narrowed down with depth. The lower EC values in the organic plots may be due to the increase in the water holding capacity of manure treated plots due to improvement in soil aggregation thus reducing the salt concentration (Duhan and Singh, 2002).

Soil organic carbon

Soil organic carbon (SOC) concentration ranged from 0.33 to 0.60 per cent (Table 3) in surface soil (0-15 cm). Application of 200 kg N ha^{-1} from FYM along with recommended fertilizer significantly increased the soil organic carbon content over control. The maximum SOC content was recorded in treatments where 400 kg N ha^{-1} was applied from VC. The SOC content in recommended fertilizer plot was 0.34 per cent, which was significantly lower than the organically treated plots. Maximum SOC content was recorded in the plots where N at 400 kg N ha^{-1} was applied from VC (0.6 per cent) which was significantly higher when N was applied from RSC (0.51 per cent) but it was as par with SOC of 400 kg N ha^{-1} from FYM treatments. When 200 kg N ha^{-1} from FYM was applied along with 75 per cent RF, the SOC content was significantly higher than RF. This may be due to addition of organic carbon through FYM. The decomposition of FYM, VC and rice straw compost might have resulted in enhanced organic carbon content in soil (Singh and Pathak, 2003). Increase in SOC with application of FYM and crop residue has been reported by Yang *et al.,* 2005. These organic sources besides adding organic carbon itself to the soil enhance root growth, resulting in addition of greater root biomass and root exudates to the soil which ultimately increases soil organic carbon.

In various treatments, SOC concentration decreased with depth and the range of SOC in profile soil was from 0.25 to 0.39 per cent, 0.22 to 0.27 per cent, 0.14 to 0.27 per cent, 0.13 to 0.17 per cent and 0.10 to 0.14 per cent in 15-30 cm, 30-45 cm, 45-60 cm, 60-90 cm and 90-120 cm respectively. These results revealed that build up of SOC was more in surface layer as compared to the lower layers due to more addition of root and plant biomass in the surface layer. Kaur *et al.* (2008) also found a decrease in SOC content of soil with increasing depth.

Soil mineral nitrogen

Mineral N content in surface soil (0-15 cm) ranged from 54.2 to 79.5 mg kg^{-1}. With increase in dose of N from 300 to 400 kg

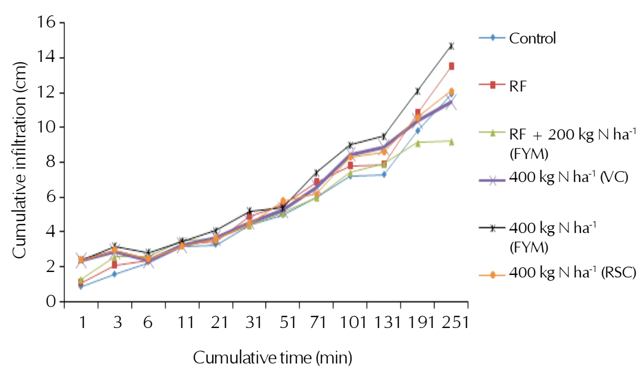

Figure 1: Effect of different treatments on cumulative infiltration (cm)

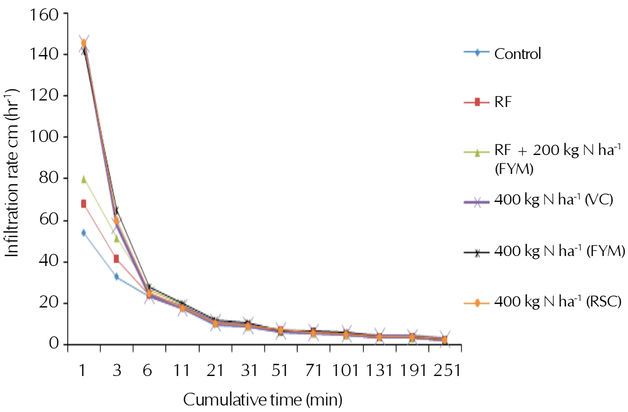

Figure 2: Effect of different treatments on infiltration rate (cm hr^{-1})

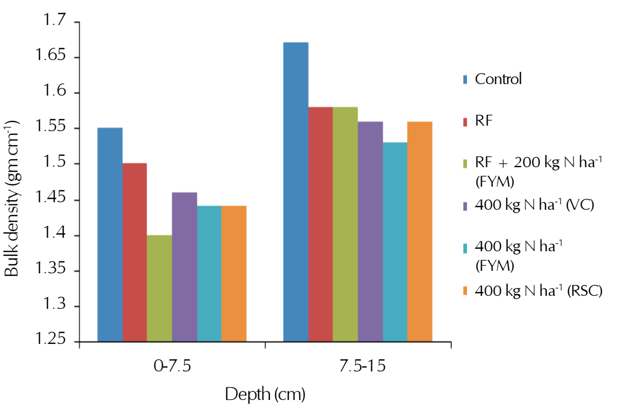

Figure 3: Effect of different treatments on bulk density (gm cm^{-3})

ha^{-1} the mineral N content increased significantly in VC but the effect was non-significant in case of RSC and FYM. Application of N either from FYM, VC and RSC at 400 kg ha^{-1} significantly increased the mineral N content over control (Table 4); the maximum value of 79.5 mg ha^{-1} was observed in the plots where vermicompost was applied. The treatments where N at 400 kg ha^{-1} was applied from FYM, the mineral N content was 75.9 which was at par with VC treatments but was significantly higher than control (54.2 mg kg^{-1}). The increase in available N content with the incorporation of crop residues along with organic manures may be attributed to N mineralization from organic manures (Sharma *et al.*, 2000). Increase in soil mineral N with the application of organic manures alone or in combination with chemical fertilizers has also been reported by Tabassum *et al.*, (2010). The non significant differences of mineral N content of control and recommended fertilizer treatments may be due to utilization by the crop. Higher mineral-N content of organic treatments may be due to slow mineralization of N from these sources.

The mineral N content decreased with depth in all the treatments. The mineral N content in soil profile ranged from 50.6 to 71.1, 47.0 to 55.4, 43.4 to 63.9, 41.0 to 60.2 and 41 to 56.6 mg kg^{-1} in 15-30, 30-45, 45-60, 60-90 and 90-120 cm of soil depth. At 15-30 cm depth, mineral N content in control was 53.0 mg kg^{-1} while in treatment where N was applied at 400 kg N ha^{-1} from FYM and VC, it was 71.1 and 69.9 mg kg^{-1}, respectively which was significantly higher than control. When N at 400 kg ha^{-1} from RSC was applied, the mineral N content was lower i.e. 61.4 mg kg^{-1}, but all these treatments were on par with each other. Similarly at 30-45 cm depth, mineral N content was significantly higher when N at 400 kg ha^{-1} was applied from VC, FYM and RSC as compared to recommended fertilizer. At 45-60, 60-90 and 90-120 cm depth, the mineral N content decreased in all the treatments. At all the depths, maximum mineral nitrogen content was in the treatment where N at 400 kg ha^{-1} was applied from FYM. The decrease in the mineral N content with the depth may be due to the decrease in soil organic carbon from surface to sub-surface layers.

Bray-I Phosphorus

Influence of different treatments on bray-I phosphorus in soil is shown in Table5. Bray-I P content in the surface soil (0-15 cm) ranged from 11.3 to 22.0 mg kg^{-1}. Application of recommended fertilizer significantly increased Bray-I P over control. The difference in Bray-I P content of recommended fertilizer and substitution of 25 per cent of recommended fertilizer with 200 kg N ha^{-1} from FYM, was non-significant. Application of N either from FYM, VC and RSC at 400 kg ha^{-1} significantly increased the Bray-I P content over recommended fertilizer plus 200 kg N ha^{-1} from FYM. Maximum bray-I P content of 22.0 mg kg^{-1} was recorded in the FYM treatment. Prabhakar *et al.*, (1991) reported that organic materials like compost at 4.4 t ha^{-1} increased the available P content by 24 per cent over control to paddy in alluvial soil. Irrespective of the treatments, the available P content decreased with depth. The available soil P content in soil profile ranged from 9.9 to 20.5, 6.0 to 16.1, 5.6 to 15.7, 3.4 to 10.5 and 2.2 to 9.5 mg kg^{-1} in 15-30, 30-45, 45-60, 60-90 and 90-120 cm of soil depth. The effect of different treatments on available P at lower layers was similar as it was observed in the surface layers.

Ammonium acetate extractable potassium

Ammonium acetate extractable potassium of the surface soil (0-15 cm) ranged from 57.5 to 145.8 mg kg^{-1} in different treatments (Table 6). The ammonium acetate extractable K in control plot was 57.5 mg kg^{-1}, while it was 106.7 mg kg^{-1} in RF along with 200 kg N ha^{-1} FYM. The ammonium acetate extractable K content increased significantly in the organically treated plots over the control and recommended fertilizer application. The maximum content of ammonium acetate extractable potassium was observed where 400 kg N ha^{-1} was applied from RSC. This may be due to higher amount of potassium in rice straw compared to FYM and VC. FYM application along with chemical fertilizers helped in reducing K fixation, thereby bringing more K in available form (Das *et al.*, 2000). The difference in ammonium acetate extractable potassium of 300 and 400 kg N ha^{-1} from FYM, VC and RSC were non-significant.

The ammonium acetate extractable K content decreased with depth in all the treatments. The ammonium acetate extractable K content in soil profile ranged from 54.2 to 130.8, 51.0 to 126.7, 52.8 to 106.7, 51.1 to 98.3 and 50.0 to 79.2 mg kg^{-1} in 15-30, 30-45, 45-60, 60-90 and 90-120 cm of soil depth. The ammonium acetate extractable K content increased significantly with the application of FYM along with recommended fertilizer over the inorganically treated plots. In

15-30 cm soil depth, with the application of organic matter alone in the form of FYM, RSC and VC, the ammonium acetate extractable K content increased significantly over the control and the plots where only recommended fertilizer was added. Ammonium acetate extractable K decreased with depth but the content was more in organically treated plots as compared to inorganically treated plots. At 30-45 cm depth there was also significantly higher, ammonium acetate extractable K in the organically treated plots as compared to treatments where recommended fertilizer was applied along with FYM and control. At 45-60 and 60-90 cm depth, the ammonium acetate extractable K content was lower than 30-45 cm depth in all the treatments. Higher content of available K in the surface horizons may be attributed to the upward movement of capillary water containing substantial amounts of K (Bishnoi and Singh, 1994) and depositing it near surface on desiccation.

Grain and Straw yield

Grain yield of wheat ranged from 17.6 to 38.3 q ha^{-1} (Table7). The grain yield of wheat increased significantly with application of recommended fertilizer over control. Highest grain yield was obtained where recommended fertilizer was applied along with 200 kg N ha^{-1} from FYM and it was significantly higher over control but it was not statistically different than RF treatment. Singh *et al*. (2008) also reported significantly higher yield of wheat sown after green manuring or application of FYM at 10 t ha^{-1} yr^{-1}. FYM application reduced the quantity of recommended fertilizer to the tune of 25 per cent. The straw yield of wheat ranged from 33.9 to 66.4 q ha-1 under different treatments. In control plot, the straw yield recorded was 33.9 q ha^{-1}. Application of recommended fertilizer alone or along with 200kg N ha^{-1} from FYM significantly increased the straw yield over the control. Application of nitrogen from organic sources such as RSC, VC and FYM significantly increased straw yield over control. However it remained significantly lower than recommended fertilizer. This indicates that supply of N from organic sources was slow that is why the effect was not much on straw yield.

REFERENCES

Bin, J. 1983. Utilization of green manure for raising soil fertility in China. *Soil Science*. **135:** 65-69.

Bishnoi, S. R. and Singh, B. 1994. Potassium nitrate and sulphate supply from underground irrigation water in Sudhar block (Punjab). *J. Potash Research*. **10:** 350-54.

Blake, G. R. and Hartage, K. H. 1986. Bulk density, In: Methods of soil analysis, Part I, Klute A (ed) Agronomy number 9. *American Society of Agronomy Madison, USA.*

Bower, H. 1986. Infiltration rate, cylinder infiltrometer, In: Methods of soil analysis, Part I, Klute A (ed) Agron no. 9. *American Society of Agronomy Madison, USA*. pp. 825-87.

Bray, R. H. and Kurtz, L. T. 1945. Determination of total, organic, and available forms of phosphorus in soils. *Soil Science*. **59:** 39-45.

Das, K., Sarkar, D. and Nayak, D. C. 2000. Forms of potassium and their distribution in some soils representing red and laterite ecosystem of West Bengal. *J. Potassium Research*. **16:** 1-6.

Duhan, B. S. and Singh, M. 2002. Effect of green manuring and nitrogen on yield and uptake of nutrients by rice. *J. Indian Society of Soil Science*. **50:** 178-80.

Francis, Z., Bobbi, L. H., Francis, J. L., Herry, J., Olaackan, O. A., and Barry, M. O. 2006. Predicting phosphorus availability from soil applying compost and non-composted cattle feedlot manure. *J. Environmental Quality*. **35:** 928-37.

Ghuman, B. S. and Sur, H. S. 2006. Effect of manuring on soil properties and yield of rainfed wheat. *J. the Indian Society of Soil Science*. **54:** 6-11.

Gupta, R. D. and Bhagat, K. C. 2004. Earthworms do miracles in agriculture. *Indian Farmer Digest*. **37(2):** 41-44.

Hegde, D. M. 1998. Effect of integrated nutrient supply on crop productivity and soil fertility in rice (Oryza sativa)-wheat (Triticum aestivum) system in semi-arid and humid ecosystems. *Indian J. Agronomy*. **43(1):** 7-12.

Kaur, T., Brar, B. S. and Dhillion, N. S. 2008. Soil organic matter dynamics as affected by long-term use of organic and inorganic fertilizers under maize-wheat cropping systems. *Nutrient Cycling in Agroecosystems*. **81:** 59-69.

Keeney, D. R. 1982. Nitrogen-Availability indices. In A.L. Page *et al.* (ed.) Methods of soil analysis. Part 2. 2nd ed. ASA and SSSA, Madison, WI. pp. 711-34.

Kumar, V. and Singh, A. P. 2010. Long-term effect of green manuring and farmyard manure on yield and soil fertility status in rice-wheat cropping system. *J. Indian Society of Soil Science*. **58(4):** 409-12.

Mahajan, A., Sharma, R., Gupta, R. D. and Trikha, A. 2007. Organic farming and sustainable agriculture. *Agriculture Today*. **10(3):** 48-50.

Mervin, H. D. and Peech, M. 1950. Exchangeability of soils potassium in the sand, silt and clay fractions as influenced by the nature of the complementary exchangeable cations. *Soil Science Society of American Proceedings*. **15:** 125-28.

Murphy, J., and Riley, J. P. 1972. A modified single solution method for determination of phosphate in natural water. *Analytical Chimical Acta*. **27:** 31-36.

Prabhakar, M., Srinivas, K. and Hegde, D. K. 1991. Effect of irrigation regimes and nitrogen fertilization on growth, yield, N uptake and water use of carrot (*Daucus carota* L.). *Gartenbauwissenschaft*. **56:** 206-09.

Sharma, M. P. and Bali, S. V. 1998. Effect of rice residue management in wheat yield and soil properties in rice-wheat cropping system. *Indian Journal of Agricultural Sciences*. **68(10):** 695-96.

Sharma, M. P., Bali, S. V. and Gupta, D. K. 2000. Crop yield and properties of inceptisol as influenced by residue management under rice-wheat cropping sequence. *J. the Indian Society of Soil Science*. **48(3):** 506-09.

Sharma G. D., Thakur, R., Raj, S., Kauraw D. L. and Kulhare, P. S. 2013. Impact of integrated nutrient management on yield, nutrient uptake, protein content of wheat (triticum astivam) and soil fertility in a typic haplustert. *The Bioscan*. **8(4):** 1159-1164.

Singh, R. N. and Pathak, R. K. 2003. Response of wheat (Triticum aestivum) to integrated nutrition of K, Mg Zn, S and biofertilization. *J. Indian Society of Soil Science*. **51:** 56-60.

Singh, R. K., Singh, S. K. and Tarafdar, J. C. 2008. Influence of cropping sequence and nutrient management on soil organic carbon and nutrient status of Typic Rhodustalfs. *J. Indian Society of Soil Science*. **56:** 174-81.

Tabassum, S., Reddy, K. S., Vaishya, U. K., Singh, M. and Biswas, A. K. 2010. Changes in organic and inorganic forms of N in a Typic Haplustert under soyabean-wheat system due to conjoint use of inorganic fertilizers and organic manures. *J. Indian Society of Soil Science*. **58(1):** 76-85.

Vanilarasu, K. and Balakrishnamurthy, G. 2014. Influences of organic manures and amendments in soil physiochemical properties and their impact on growth, yield and nutrient uptake of banana. *The Bioscan*. **9(2):**

Walkley, A. and Black, I. A. 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*. **37:** 29-39. 525-529.

Yadav, D. S. and Kumar, A. 2002. Long-term effects of organic manures on productivity and soil fertility in rice-wheat cropping system. In Extended Summaries: 2nd International Agronomy Congress New Delhi, India: ICAR. pp. 51-53.

Yang, C., Yang, L. and Ouyang, Z. 2005. Organic carbon and its function in paddy soil as affected by different nutrient and water regimes. *Geoderma*. **124:** 133-42.

Zhao, J., Luo, Q., Deng, H. and Yen, Y. 2007. Opportunities and challenges of sustainable agriculture development in china. Philosophical Transactions of the Royal Society of London B 31.