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Effects of different modes, levels of farmyard manure and fertilizer nitrogen applications on soil properties: A long term study

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Abstract
A long term field experiment started in 1967 was selected to study the effect of modes and levels of FYM as well as levels of fertilizer N on soil properties. After 50 years of experiment, results shows that soil pH of all the plots decreased as compared to initial value. However, soil EC, showed the reverse trends. Application of FYM in both the seasons (*kharif* and *rabi*) significantly improved the SOC, available N, P an K content in soils as compared to its application in single season (*kharif* or *rabi*). It was also observed that irrespective of mode of application, addition of 15 t/ha FYM showed superiority over lower doses as far as soil health was concerned. Furthermore, application of fertilizer N in combination with FYM resulted in higher values of SOC, available N and P, but available potassium content decreased with increased doses of N fertilizer alone.

Keywords: Farmyard manure, long-term, soil organic carbon, available nitrogen, chemical properties

Introduction
After green revolution, scenario of Indian agriculture has faced many problems such as stagnation or even decrease in production and productivity of major crops, deterioration of soil fertility, decline in factor productivity, low diversity of production systems and increasing cost of production. These constraints have cropped-up partially as a result of continuous cropping without proper nutrient management and indiscriminate use of agrochemicals on soil and crops (Sharma and Subehia, 2014) [13]. Continuous use of inorganic fertilizers leads to deterioration in soil chemical, physical, and biological properties, and soil health. The negative impacts of chemical fertilizers, coupled with escalating prices, have led to growing interests in the use of organic fertilizers as a source of nutrients.

The use of organic fertilizers improves soil structure, nutrient exchange, and maintains soil health has raised interests in organic farming. The use of FYM alone as a substitute to inorganic fertilizer is not be enough to maintain the present levels of crop productivity of high yielding varieties. Therefore, integrated nutrient management in which both organic manures and inorganic fertilizers are used simultaneously is the most effective method to maintain healthy and sustainably productive soil. Emerging evidence indicated that integrated soil fertility management involving the judicious use of combined organic and inorganic re-sources is a feasible approach to overcome soil fertility constraints. In general, the application of organic amendments such as crop residues and/or farmyard manure increases significantly SOC (Yadav *et al*., 2000) [20]. Fertilizers play a vital role in enhancing the production and productivity of any crop, but continuous and imbalanced use of high analysis chemical fertilizers adversely affects the production potential and soil health. Use of chemical fertilizers in combination with organic manure is essential to improve the soil health. In integrated use of inorganic and sources of N, repeated applications of organic manures is often recommended to maintain soil fertility and crop productivity (Subehia and Sepehya, 2012) [17].

Farm Yard Manure (FYM) is important and renewable organic sources of nutrients. Large quantities of organic matter are available with the farmers which can be utilized as complementary source to chemical fertilizers. Long-term field experiments using different agronomic management can provide direct observations of changes in soil quality and fertility and can help in prediction of future soil productivity and soil-environment interactions (Li *et al*., 2010 and Shen *et al*., 2010) [10, 15]. Increasing productivity and keeping pace with the rising food demand with minimum environmental disturbance has thus become a challenge to farmers and scientists alike. Continuous integrated use of organic manures and fertilizers would be quite promising in assessing the sustainability of crop yield, and plant nutrition vis à-vis soil properties. The present investigation was therefore, undertaken to study the long-term effect of FYM and N fertilizer on soil chemical properties of soil.

Materials and methods

A long term Field experiment initiated in October 1967 on soil coarse, loamy, Typic ustochrept soil at CCS Haryana Agricultural University, has been running at the research farm department of soil science was selected to study impact of the modes and level of FYM and fertilizer nitrogen on chemical properties of soils under pearl millet-wheat cropping system. The experimental treatment consisted of three level of FYM (15, 30 and 45 Mg/ha) till 2007-08 and 5, 10 and 15 ton per hectare from 2008-09 onwards. There mode of application: every Kharif crop (summer season), in every Rabi crop (winter season) and in both (Kharif and Rabi) the crop. An absolute control without application of FYM in any of the seasons was maintained as a control. These 10 treatments (3 FYM level x 3 modes of application+ I FYM control) were allocated in the main plots and each main plot was subdivided into three subplots receiving fertilizer N at 0, 60 and 120 kg N/ hectare in each season through urea using split plot design. All the treatments were replicated four times, each subplot measuring 10 x 5 m FYM was incorporated in top 15-20 cm layers 3 to 4 weeks before sowing the crops. soil sample was also collected from 0-15 cm after the harvest of wheat crop and analysed for their chemical characteristics. Initial Properties of soil was of values pH (1:2) 8.2, OC(%) 0.47, Available N(mg/kg)100, Available P(mg/kg)13, Available K(mg/kg) was 249.

Procedure adopted for analysis of soil samples

The pH of (surface and other depths) soil samples was measured (1:2 soil: water suspension) using pH meter fitted with calomel glass electrode. Electrical conductivity (EC) Electrical conductivity was determined in the supernatant liquid of 1:2 soil water suspension using solu-bridge conductivity meter. Organic Carbon (OC) Organic carbon was estimated using Walkley and Black's (1934) [19] rapid titration method. Available Nitrogen It was estimated by alkaline potassium permanganate method described by Subbiah and Asija (1965) [16]. Available P The available phosphorus of soil was extracted with 0.5 M NaHCO3 (pH 8.5) (Olsen's *et al.* 1954) [11]. The content of phosphorus in the extract was determined by ascorbic acid reductant method using spectrophotometer at 760 nm. Available Potassium Neutral 1N ammonium acetate method was used determining available potassium content of the soil.

Data were subjected to analysis of variance (ANOVA) in a split plot design by using OP stat. Mean separation for different treatments was evaluated at 95% confidence interval using least significant difference (LSD).

Results and discussion

The decrease in the pH in the N fertilized treatment may have been due to nitrification of ammonium ($NH4^{+}$) to nitrate (NO^{3-}). The decrease in soil pH in the FYM treatments might have resulted from the release of organic acids and carbon dioxide (CO_2) into the soil during the decomposition of the manure. The production of aliphatic and aromatic hydroxyl acids as a result of decomposition of FYM could also result in complexion of free and exchangeable aluminum ions and thus decrease the pH. Similar reports observed by (Grewal *et al*., 1981; Sheeba and Chellamuthu, 2000; Yaduwanshi *et al*. 2013) [5, 14, 21]. However reverse trend was observed in EC. The increase in EC might be due to the increase in base saturation of the soil where optimum rate of fertilizer and manure was applied compared to the control plots.

Soil organic carbon (SOC) is the key soil property which indicates the fertility status of the soil. The increase in SOC of all the fertilizer treatments might be due to the continuous addition of root biomass, root exudates and plant biomass in soil with time. Similar results were also reported by (Acharya *et al*., 1988; Katkar *et al*., 2011; Yaduwanshi *et al*. 2013) [1, 8, 21]. Addition of organic matter through FYM and higher crop growth and biomass addition due to leaf shedding and root biomass addition under N+ FYM might have contributed to higher soil organic carbon content. Beneficial effect of integrated use of inorganic fertilizer and organic manures was related to the incorporation of organic material in the soil and increase in number and activity of microorganism and better regulation of organic carbon dynamics in soils. This effect was further enhanced by addition of fertilizers that improved the root and shoot growth. An increase in the soil organic matter leads to an improvement in the nutrient status of the soil.

Table 1: Effect of FYM, modes and N fertilizer on pH, EC and soil organic carbon of soil (0-15cm) under pearlmillet-wheat cropping system.

FYM		pH				EC ds/m				OC %			
Level (mg ha-1)	**modes**	**0 N (kg/ha)**	**60 N (kg/ha)**	**120 N (kg/ha)**	**Mean**	**0 N (kg/ha)**	**60 N (kg/ha)**	**120 N (kg/ha)**	**Mean**	**0 N (kg/ha)**	**60 N (kg/ha)**	**120 N (kg/ha)**	**Mean**
0		7.89	7.81	7.75	7.82	0.43	0.44	0.45	0.44	0.36	0.42	0.44	0.41
5	kharif	7.88	7.77	7.74	7.80	0.53	0.55	0.57	0.55	1.08	1.12	1.14	1.11
10		7.82	7.76	7.70	7.76	0.56	0.57	0.59	0.57	1.15	1.18	1.20	1.18
15		7.78	7.75	7.66	7.73	0.6	0.62	0.64	0.62	1.21	1.25	1.29	1.25
Mean		7.83	7.76	7.70	7.76	0.56	0.58	0.60	0.58	0.58	1.18	1.21	1.18
5	rabi	7.76	7.72	7.61	7.70	0.7	0.72	0.73	0.72	1.20	1.24	1.26	1.23
10		7.73	7.70	7.58	7.67	0.7	0.73	0.75	0.73	1.25	1.27	1.30	1.27
15		7.71	7.69	7.55	7.65	0.83	0.84	0.87	0.85	1.32	1.38	1.44	1.38
Mean		7.73	7.70	7.58	7.67	0.74	0.76	0.78	0.76	0.76	1.30	1.33	1.30
5	Kharif and rabi	7.68	7.62	7.53	7.61	0.72	0.74	0.75	0.74	1.46	1.48	1.51	1.48
10		7.65	7.61	7.51	7.59	0.76	0.77	0.79	0.77	1.64	1.68	1.73	1.68
15		7.62	7.56	7.46	7.55	0.85	0.87	0.89	0.87	1.87	1.93	1.99	1.93
Mean		7.65	7.60	7.50	7.58	0.78	0.79	0.81	0.79	1.66	1.70	1.74	1.70
Overall mean		7.74	7.69	7.59	7.67	0.69	0.71	0.73	0.71	1.35	1.39	1.43	1.3

CD ($p=0.05$): pH= Mode: 0.03, FYM: 0.03, N: 0.02, Mode x FYM: 0.062, FYM x N: NS, Mode x N: NS, Mode x FYM x N: NS
EC= Mode: 0.03, FYM: 0.03, N: 0.02, Mode x FYM: 0.06, FYM x N: NS, Mode x N: NS, Mode x FYM x N: NS
OC= Mode: 0.06, FYM: 0.07, N: NS, Mode x FYM: 0.135, FYM x N: NS, Mode x N: NS, Mode x FYM x N: NS

Table 2: Effect of FYM, modes and N fertilizer on soil nitrogen, phosphorus and potassium of soil (0-15cm) under pearl Millet-wheat cropping system

Fym		Available N (kg/ha)				Available P (kg/ha)				Available K (kg/ha)			
Level (mg ha-1)	modes	0 N (kg/ha)	60 N (kg/ha)	120 N (kg/ha)	Mean	0 N (kg/ha)	60 N (kg/ha)	120 N (kg/ha)	Mean	0 N (kg/ha)	60 N (kg/ha)	120 N (kg/ha)	Mean
0		178.0	186.0	198.2	187.4	22	27	33	28	494.1	482.6	479.8	485.5
5	kharif	229.0	240.0	248.0	239.0	66	68	73	69	770.7	756.8	752.2	759.9
10	kharif	235.0	247.0	253.2	245.1	80	80	83	81	841.1	828.9	825.4	831.8
15	kharif	238.0	251.0	261.6	250.2	90	90	93	91	1165.3	1059.2	1012.8	1079.1
Mean		234.0	246.0	254.3	244.8	78	79	83	80	925.7	881.6	863.5	890.3
5	rabi	230.0	244.0	253.5	242.5	71	72	75	72	938.5	880.9	869.5	896.3
10	rabi	239.0	250.0	258.0	249.0	81	83	87	84	1134.8	1068.1	1025.4	1076.1
15	rabi	244.0	256.0	262.6	254.2	91	92	93	92	1228.1	1125.9	1088.8	1147.6
Mean		237.7	250.0	258.0	248.6	81	82	85	83	1100.5	1025.0	994.6	1040.0
5	Kharif and rabi	239.0	252.0	263.8	251.6	88	88	92	89	1116.8	1102.1	1099.4	1106.1
10	Kharif and rabi	246.0	258.0	268.5	257.5	90	94	96	93	1264.8	1220.8	1138.2	1336.0
15	Kharif and rabi	250.0	263.0	273.0	262.0	108	112	118	113	1402.7	1368.8	1251.5	1450.1
Mean		245.0	257.7	268.4	257.0	96	98	102	99	1356.8	1279.8	1255.6	1297.4
Overall mean		238.9	251.2	260.2	250.1	85	86	90	90	1127.6	1062.1	1037.9	1075.9

CD ($p=0.05$): Available N=Mode: ns, FYM: 12.3, N: 5.4, Mode x FYM: NS, FYM x N: NS, Mode x N: NS, Mode x FYM x N: NS
Available P= Mode: 3.5, FYM: 4.0, N: 1.3, Mode x FYM: 7.0, FYM x N: 2.7, Mode x N: NS, Mode x FYM x N: NS
Available K= Mode: 32.3, FYM: 37.3, N: 36.0, Mode x FYM: 64.7, FYM x N: ns, Mode x N: ns, Mode x FYM x N: ns

Available nutrients

The increase in available Nitrogen in FYM amended plots is attributed to the increase in total SOC and might have been partially due to a slow release of N from manure. Farmyard manure is known to stimulate biological N_2 fixation in the soil, which may also have been responsible for the increase in soil N over N fertilizer treatment, apart from FYM's own N contribution. In addition, soils under N + FYM treated plots produced more biomass and, therefore, possibly had more extensive root systems that may have contributed to increased N levels, as suggested by (Yadav *et al*. 2000; Gami *et al*. 2001; Katkar *et al.* 2011) [20, 4, 8].

Continuous application of FYM also reduced the activity of polyvalent cations such as Ca, Fe, and Al due to chelating which, in turn, considered responsible for reduction in P-fixation. The application of FYM increased Olsen-P because of its P content, and possibly by increasing retention of P in soil. Buildup of available phosphorus with the application of N fertilizers alone or in conjunction with organics might be due to the release of organic acids during decomposition which in turn helped in releasing phosphorus through solubilizing action of native phosphorus in the soil The organic matter also forms a protective cover on sesquioxides and makes them inactive and thus reduces the phosphate fixing capacity of the soil, which ultimately, helps in release of ample quantity of phosphorus. similar results obtained by (Gupta *et al*., 1988; Roy *et al*. 2001; Gupta *et al*. 2006; Urkurkar *et al*., 2010 and meena *et al*., 2018) [6, 12, 7, 18, 9].

Increase in Available potassium in plots receiving FYM applied either alone or in combination with N than control status may be ascribed to the direct potassium addition in the potassium pool of the soil. The results are corroborated by (Brar *et al*., 2000; Baley *et al*., 2002) [3]. There is decreased trend observed when increase in doses of N fertilizer and the possible reason of available K depression in control and inorganically treated plots might be due to higher potassium mining from the soils. Increase in available potassium due to addition of organic manures may be ascribed to the reduction of K-fixation and release of K due to interaction of organic matter with clays, besides the direct K addition to the soil. Similar result studied by (Sharma and Sepehya, 2014).

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