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Kunj Bihari Meena
Assistant field officer, soil & land use survey of India, Hyderabad, Telangana, India

Md. Sarware Alam
Department of Soil Science, CCS HAU, Hisar, India

Hanumant Singh
Assistant field officer, soil & land use survey of India, Ahmedabad, India.

Mohammad Amin Bhat
Department of Soil Science, CCS HAU, Hisar, India

Abhinaw Kumar Singh
Department of Agronomy, CCS HAU, HISAR, India

AK Mishra
Graduate School of Global Environmental Studies, Kyoto University, Kyoto, Japan

Tarence Thomas
Department of Soil Science SHUATS Allahabad, India

Correspondence
Kunj Bihari Meena
Assistant field officer, soil & land use survey of India, Hyderabad, Telangana, India

Influence of farmyard manure and fertilizers on soil properties and yield and nutrient uptake of wheat

Kunj Bihari Meena, Md. Sarware Alam, Hanumant Singh, Mohammad Amin Bhat, Abhinaw Kumar Singh, AK Mishra and Tarence Thomas

Abstract
The influence of sole application of FYM @ 10 tonnes ha^{-1} either alone and or integrated use of NPK and FYM ($T_8$100% RDF + FYM @10 t ha-1) and vis-a-vis no application of fertilizers and manures (control) on changes in on soil physical properties, yield of nutrient uptake of wheat. The results revealed that soil pH and bulk density decreased, while soil organic carbon, porosity, grain and straw yield, uptake of nutrient increased in the treatments where farmyard manure (FYM) either alone, or in combination with inorganic fertilizer as compared to control. wheat Seeds of cv. Halana (K-7903) experiment was conducted during Rabi season 2011-12 on crop research farm of the Department of Soil Science, Sam Higginbottom University of Agriculture, Technology & Sciences (U.P.).The results of FYM either alone and or combined use of NPK and FYM was resulted in significant ($P < 0.07$) decrease of bulk density 20.73%, 20.12% than control treatment respectively and soil organic carbon content increased 49.0% and 32.7% compared to control. Increase in KMnO4-N,P,K in surface soil was 47.2, 51.7% 33.22 %,52.26 %,19.43% and 37.72% in plots receiving FYM applied either alone or in combination with NPK than control respectively. The grain yield of wheat was significantly higher (62.74%) in FYM either alone or in combination with NPK (67.8%) than in control plots and Similar was the trend in straw yield). The uptake of N, P and K was higher in all the treatments from that in control plots. Application of FYM either alone or in combination with NPK was higher N-68.51%, 69.75%, P- 64.73%, 65.7%, and K-51.2%, 58.36% respectively, resulted in considerable changes, N, P and K uptake was affected by balanced fertilizer application. Better soil physical environment coupled with sufficiency of water and nutrients helped in better uptake of water and nutrients and hence the yield of wheat in FYM and inorganic fertilizer plots from that in control plots.

Keywords: FYM, inorganic fertilizer, soil properties, grain yield.

Introduction
Wheat (*Triticum astivum* L) belongs to the family Poaceae. Wheat is an annual, self-pollinated long day winter cereal. Wheat species are triticum aestivum (hexaploid) and triticum durum (tetraploid). In India it is second important staple food crop, rice being the first. Wheat compares well with other important cereals in its nutritive value. It contains more protein than other cereals. Wheat has a relatively high content of niacin and thiamine. Wheat proteins are special significance besides, their significance in nutrition. In India it is cultivated over an area of 27.92 mha^{-1} with the production of 80.71mt with an average productivity of 2891 kg ha^{-1}. (Anonymous, 2010) [1]. The low productivity of wheat in Rajasthan compared to Punjab and Haryana is mainly due to arid and semi-arid climate. Sandy soils are of wide occurrence in such regions of Rajasthan. These soils are excessively permeable mainly because of their coarse texture and poor organic matter content. The moisture retention capacity of these soils is also very low and more than one third of applied water or rains get lost through deep percolation (Manna *et al.*, 2005) [21]. In UP ranks first in respect of crop coverage area 9.64 million hectares and production 30.00 million tones but average productivity is 3.11 t ha^{-1}(FAO, STATE -2011-12) [12].
Despite the past gains in wheat production through chemical fertilizers, recent observations of stagnant or declining yields have raised concerns about the long-term sustainability of the crop production. 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. Organic materials such as FYM have traditionally been used by rice farmers. FYM supplies all major nutrients (N, P, K, Ca, Mg, S,) necessary for plant growth, as well as micronutrients (Fe, Mn, Cu and Zn). Hence, it acts as a mixed fertilizer. FYM improves soil physical, chemical and biological properties. Improvement in the soil structure due to FYM application leads to a better environment for root development. FYM also improves soil water holding capacity. The fact that 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 a 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) [32, 33].

Sustaining soil organic carbon (SOC) is of primary importance in terms of cycling plant nutrients and improving the soils' physical, chemical and biological properties. SOC is an important index of soil quality because of its relationship with crop productivity (Lal, 1997) [18]. A decrease in SOC leads to a decrease in soil's structural stability (Le Bissonnais and Arrouays, 1997) [19] Also restoration of SOC in arable lands represents a potential sink for atmospheric CO2 (Lal and Kimble, 1997) [17]. Agricultural utilization of organic materials, particularly farmyard manure (FYM) has been a rather common traditional practice (Shen *et al.,* 1997) [27], Alam *et al*. (2014) [4]. As it enhances the soil organic C level, which has direct and indirect effect on soil physical properties The application of inorganic fertilizers has been widely observed to increase the crop yields. The inorganic fertilizers affect soil physical environment by increasing the above ground and root biomass due to immediate supply of plant nutrients in sufficient quantities. This in turn increases the soil organic matter content (Bostick *et al.,* 2007) [11]. The inorganic fertilizers have been reported to increase rooting depth and root proliferation in cereals (Belford *et al.*, 1987) [7]. Application of inorganic fertilizers alone decreased the stability of macro-aggregates and moisture retention capacity but increased the bulk density (Rasool *et al.,* 2007) [23] observed that balanced inorganic fertilization in rice (*Oryza sativa* L.) Wheat (*Triticum aestivum* L.) system in a sandy loam soil improved the mean weight diameter of aggregates, total porosity and water holding capacity of soils. The combined application of inorganic and organic amendments like FYM green manures and residue straw improve their effectiveness. Yaduvanshi and Sharma (2008) [34] found that application of FYM with chemical amendment increase the wheat yield and N, P, K, uptake in grain yield.

Materials and Methods

This experiment was conducted during rabi season 2011-12 on crop research farm of the Department of Soil Science, Sam Higginbottom University of Agriculture, Technology & Sciences (U.P.). It is positioned at 25.570N Latitude and 81.50E longitude and about 98 M above sea level. Allahabad has a sub – tropical and semi – arid climate with rain mostly during July- September. These treatments were evaluated in Randomized Block Design having three replications., The experiment was consisting of eight (8) treatment viz., T0 (control), T1 (0% RDF + FYM @ 5 t ha^{-1}),T2 50% RDF + FYM @10 t ha^{-1}),T3 50% RDF + FYM @ 0 t ha^{-1}), T4 50% RDF + FYM @ 5 t ha^{-1}),T5 50% RDF + FYM @ 10 t ha^{-1}),T6 (100% RDF + FYM @ 0 t ha^{-1}), T7 100% RDF + FYM @ 5 t ha^{-1}),T8100% RDF + FYM @10 t ha^{-1}). The soil of experimental field was sandy loam in texture with bulk density of 1.40Mg m^{-3} (pH = 7.6), 4.4g kg^{-1} organic carbon, 0.3 dsm^{-1} electrical conductivity. The soil is medium in available N (alkaline KMNO4 oxidizable-N as per Subbiah and Asija, (1956) (234.05 $kgha^{-1}$) and P (0.5MNaHCO_3 extractable P as per Olsen *et al*., (1954) [22] (12.46 kg ha^{-1}) but medium in available K (neutral ammonium acetate extractable K as per Toth, S.J. and Prince, A.L. (1949) [31] (246.00 kg ha^{-1}). Recommended dose of fertilizers for wheat was at 120, 60, 40 and Kg ha^{-1} N, P_2O_5, K_2O respectively and FYM dose 0,5,10 tonnes. The wheat Seeds of cv. Halana (K-7903) was sown 17.5 x 5.0 cm apart using a seed rate of 125 kg ha^{-1} in 26th November and harvested after 120 days crop age. Observations on yield parameter of wheat were recorded. Available N, P_2O_5 and K_2O content in soil at 15 cm depth from each plot after wheat harvest was estimated separately.

Results and Discussion

Soil pH

The pH of the soil in different treatments ranged from 7.81 to 7.39 in surface soil (0–15 cm). Lower pH values of 7.39and 7.40 in surface soil were observed in FYM alone and FYM +NPK fertilizer treatments, respectively as compared to the pH values of 7.75 and 7.81 in NPK fertilizer and control treatments, respectively A comparison of fertilizer treatments within each cropping system indicated that the long-term application of manure and N fertilizer also led to a decrease in soil pH. The decrease in the pH in the N fertilized treatment may have been due to nitrification of ammonium ($NH4^+$) to nitrate ($NO3^-$). 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 complexing of free and exchangeable aluminum ions and thus decrease the pH (Grewal *et al.,* 1981) [14]

Soil bulk density and total porosity

The bulk density, application of FYM either alone and or integrated use of NPK and FYM was 9.72% and15.56% lower than NPK and 20.73%, 20.12% lower than control treatment respectively, after post-harvest soil (Table1). SchjØnning *et al.,* (1994) [26] also reported reduction in the bulk density of soil due to application of cattle manure in a long term integrated nutrient management experiment. The decrease in the bulk density might be due to higher soil organic carbon content of soil (Tiraks *et al.,* 1974) [30], better aggregation and increased root growth and biopores in the fertilizer and manure treated plots. The bulk density (BD) of 0– 15 cm soil layer was significantly correlated with the soil organic carbon (SOC). reveal that FYM decreased soil bulk density significantly in comparison to that in control plots It could be due to higher root biomass of wheat in the lower layers The mean total porosity of soil increased significantly with the application of FYM either alone and or use of NPK and FYM (Table 1) in wheat crops. The FYM promotes total porosity of FYM either alone and or integrated use of NPK and FYM was

17.77% and15.90% higher than the control treatment of the soil as the microbial decomposition products of organic manures such as polysaccharides and bacterial gums are known to act as soil particle binding agents. These binding agents decrease the bulk density of the soil by improving soil aggregation and hence increase the porosity (Bhatia and Shukla 1982) [8]. Increase in total porosity with inorganic fertilization has also been reported by Schjonning *et al.*, (1994). The higher total porosity of the soil particularly of the surface layer helps in ready exchange of O_2 and CO_2 between the soil and the atmosphere, thereby, promoting better root growth in the soil.

Table 1: Effect of different level of chemical fertilizer and farmyard manure and their interaction on soil properties post-harvest

Treatments	B.D (Mgm^{-3})	pH (1:2.5)	EC (dSm^{-1})	OC (gkg^{-1})	Available N (Kg ha^{-1})	Available P (Kg ha^{-1})	Available (Kg ha^{-1})	Total soil porosity (%)
C0F0 (Control)	1.64	7.81	0.24	4.9	234.05	12.46	246.00	37
C0F1(0% RDF + FYM 5 t ha^{-1})	1.45	7.43	0.19	4.8	265.48	15.60	278.33	40
C0F2(0% RDF + FYM 10 t ha^{-1})	1.30	7.39	0.15	7.3	277.62	18.66	305.33	45
C1F0(50% RDF + FYM 0 t ha^{-1})	1.51	7.74	0.20	4.1	268.00	15.70	307.66	38
C1F1(50% RDF + FYM 5 t ha^{-1})	1.44	7.55	0.17	5.2	270.42	16.90	344.66	40
C1F2(50% RDF + FYM 10 t ha^{-1})	1.35	7.54	0.16	6.0	274.27	17.46	333.00	43
C2F0 (100% RDF +FYM 0 t ha^{-1})	1.44	7.79	0.23	5.1	250.66	23.60	390.00	38
C2F1(100%RDF +FYM 5 t ha^{-1})	1.35	7.64	0.20	5.6	277.37	24.93	391.00	43
C2F2(100% RDF +FYM10 t ha^{-1})	1.31	7.40	0.15	6.50	286.22	26.10	395.00	44
C.D5%	0.07	-	-	0.05	8.2	2.12	25.2	-

Soil organic carbon

Application of FYM either alone or in combination with NPK resulted in considerable changes of SOC in the surface (0–15 cm) soil layer than that of unfertilized control as well as NPK treated plots. The plots that received FYM (7.3 g kg^{-1}) and FYM+NPK (6.50 g kg^{-1}) had significantly higher build-up in SOC over unfertilized control (4.9 g kg^{-1}) and NPK treated plots (5.1 g kg^{-1}) in the surface soil. The increase in build-up in SOC under FYM and FYM+NPK treatments was 43.1 and 27.5 per cent greater over treatment receiving NPK fertilizer alone and 49.0 and 32.7 per cent greater over treatment receiving no fertilizer or manure (control), (Table1). Addition of organic matter through FYM and higher crop growth and biomass addition due to leaf shedding and root biomass addition under NPK + FYM might have contributed to higher soil organic carbon content (Acharya *et al*., 1988) [3] Based on 25 years of continuous cropping in long term fertilizer experiments also concluded that integrated use of NPK and FYM in soybean–wheat system, significantly improved soil organic carbon content in a Haplustalf and Chromustert. Similarly Aoyama *et al.,* (1999b) [5] reported that after 18 years, manure increased the organic matter level of whole soil and favoured formation of slaking-resistant macro-aggregates (250–1000 mm). This effect was primarily a result of the organic matter added by manure whereas NPK fertilizer did not affect soil organic matter or macro-aggregates. Agreement with Aoyama *et al.,* (1999b) [5], who observed that organic carbon addition through manure led to higher concentration of total carbon in dry sieved macro-aggregates than in micro aggregates.

Available of N, P, K post-harvest soil.

Available Nitrogen

Increase in KMnO4-N in surface soil was 47.2 and 51.7% in FYM and FYM + NPK fertilizer treated plots over control, respectively. The increase in KMnO4-N 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, as suggested by Yadav *et al.* (2000) [32, 33], Gami *et al.* (2001) [13] Farmyard manure is known to stimulate biological N2 fixation in the soil, which may also have been responsible for the increase in soil N (Ladha *et al.,* 1989) over NPK treatment, apart from FYM's own N contribution. In addition, soils under NPK + FYM treated plots produced more biomass and, therefore, possibly had more extensive root systems that may have contributed to increased N levels. Increased significantly with increasing levels of FYM table (1) recorded in treatment T_8-(N 120 kg ha^{-1}, P 60 kg ha^{-1} K 40 kg ha^{-1} +FYM 10t ha^{-1}) recorded 286.22,26.10,395.0 kg ha^{-1} respectively and at par T_3 treatment. Which was significant superior with followed by rest of all treatments, while minimum in treatment T_1 (control) 234.05, 12.46, 2460 kg ha^{-1}. The increase in Available potassium in plots receiving FYM applied either alone or in combination with NPK 19.43 % and 37.72 % than control status may be ascribed to the direct potassium addition in the potassium pool of the soil. The result are corroborated by choudhary *et al.* (2010), *shukla et al.,* 1978.

Available Phosphorus

The increase in Olsen-P in plots receiving FYM applied either alone or in combination with NPK 33.22 % and 52.26 % than control due to release of organically bound P during decomposition of organic matter, solubilization of soil P by organic acids produced during decomposition of organic matter. Continuous application of FYM also reduced the activity of polyvalent cations such as Ca, Fe, and Al due to chelation which, in turn, considered responsible for reduction in P-fixation (Gupta *et al.*, 1988) [15]. The application of FYM increased Olsen-P because of its P content, and possibly by increasing retention of P in soil. A positive effect of FYM on P availability was also observed by Roy *et al.* (2001) [24].

Table 2: Yield and nutrient uptake by wheat under inorganic fertilization and FYM treatments

Treatments	Yield		Nutrient uptake (kg ha^{-1})		
	Grain (Mgha^{-1})	Straw (Mg ha^{-1})	N	P	K
C0F0 (Control)	1.9	2.42	32.3	6.1	12.2
C0F1(0% RDF + FYM 5 t ha^{-1})	2.0	2.9	60.7	9.1	14.7
C0F2(0% RDF + FYM 10 t ha^{-1})	5.1	5.7	102.6	17.3	25.7
C1F0(50% RDF + FYM 0 t ha^{-1})	3.1	3.5	77.9	12.8	17.8
C1F1(50% RDF + FYM 5 t ha^{-1})	3.3	4.3	80.6	13.4	19.7
C1F2(50% RDF + FYM 10 t ha^{-1})	5.0	5.1	98.9	14.2	21.1
C2F0 (100% RDF +FYM 0 t ha^{-1})	5.3	5.5	101.8	16.1	28.7
C2F1(100%RDF +FYM 5 t ha^{-1})	5.2	5.4	102.3	16.2	26.6
C2F2(100% RDF +FYM10 t ha^{-1})	5.9	5.8	105.8	17.8	29.3
C.D5%	0.50	0.40	-	-	-

Crop performance

The grain yield of wheat was significantly higher (62.74%) in FYM either alone or in combination with NPK (67.8%) than in control plots and Similar was the trend in straw yield. (Table 2) Higher yield was obtained in FYM + NPK as compared to FYM, which revealed that FYM alone cannot be a substitute for fertilizers. higher yield was obtained in FYM + NPK as compared to FYM, which revealed that FYM alone cannot be a substitute for fertilizers. may have been due to the immediate release and availability of nutrients as compared to organic sources of nutrient, which release the nutrient slowly. The yield advantage on application of organic sources of nutrients was due to addition of secondary and micronutrients (Manna *et al.*, 2005; Banik *et al.*, 2006) [21, 6] along with the major nutrients, increased nutrient absorption capacity due to the higher root density. It also improved soil physical (Boparai *et al.*, 1992) [10] and biological properties by increasing the soil pore space, water holding capacity (Lehmann *et al.*, 1999) [20] and improving the soil structure (Biswas *et al.*, 1971) [9]. Combined use of organic and inorganic sources of nutrient could be attributed to better synchrony of nutrient availability to the wheat crop, which was reflected in higher grain yield and biomass production and also the higher nutrient use efficiency. The higher wheat yield obtained on FYM + NPK fertilizer-treated plots was possibly caused by other benefits of organic matter such as improvements in microbial activities, better supply of secondary and micronutrients which are not supplied by inorganic fertilizers, and lower losses of nutrients from the soil besides supply of N, P and K (Abrol *et al.*, 1997 and Yadvinder-Singh *et al.*, 2004) [2, 35]. The uptake of N, P and K was higher in all the treatments from that in control plots. Application of FYM either alone or in combination with NPK was higher N-68.51%, 69.75%, P- 64.73%, 65.7%, and K- 51.2%, 58.36% respectively, resulted in considerable changes, N, P and K uptake was affected by balanced fertilizer application. Better soil physical environment coupled with sufficiency of water and nutrients helped in better uptake of water and nutrients and hence the yield of wheat in FYM and inorganic fertilizer plots from that in control plots. Yang *et al.* (2004) [36] observed that incorporation of organic residues significantly increased uptake of N, P and K by maize plants and facilitated the allocation and transfer of nutrient elements to the maize ears and grains. The application of balanced inorganic fertilizers improved the crop yields. The uptake of N, P and K also improved significantly with the application of FYM and FYM +NPK.

Conclusion

it may be concluded that integrated use of farmyard manure at 10 tonnes ha^{-1} and the recommended dose of fertilizers in every crop season resulted in the significant improvement in the physical, biological and chemical properties of soil, i.e. decrease in bulk density, penetration resistance and increase in hydraulic conductivity, soil aggregation and aggregate associated carbon, increase soil organic carbon, increase in macro-micro nutrient compared to alone use of fertilizer NPK and non-use of fertilizer and manure. It was also observed that integrated use of farmyard manure and recommended dose of chemical fertilizers led to improvement in crop growth para meters, viz., root length density, leaf area duration, and resulted in higher nitrogen uptake and higher grain, straw yield and water and nitrogen use efficiency of wheat than that of sole use of recommended dose of fertilizers and non-use of fertilizers and manures. So integrated use of farmyard manure at 10 tonnes ha^{-1} and recommended dose of chemical fertilizers in every crop season may be practiced in soil to improve soil physical environment and enhance carbon sequestration and for achieving higher productivity through efficient utilization of water and nutrients in wheat.

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