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Long Term Effects of Integrated Nutrient Management on Soil Organic Carbon Content and K-fractions

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ABSTRACT: *An ongoing long-term experiment under pearl millet-wheat cropping system was initiated in 1985 and selected to investigate the effect of Integrated Nutrient Management, i.e. organic manures (Farmyard manure, Wheat straw and Green manure) and fertilisers to evaluate changes in soil organic matter and K-fractions in soil. Continuous application of organic manures (FYM and Green manure) in conjunction with fertilizers recorded the higher level of soil organic matter and also, higher K-fractions in soil in comparison to all other treatments. The highest soil organic carbon content was found in the plot receiving FYM in conjunction with NPK fertilizers and also increase in K fractions was obtained when FYM was applied in conjunction with NPK fertilizers. The build-up of soil organic matter and soil K-fractions was higher in surface soil as compared to sub-surface soil.*

Keywords: *organic matter, K-fractions, organic manures, fertilizer*

Escalating costs coupled with increasing demand for chemical fertilizers and depleting soil fertility necessitates the integrated use of organic and inorganic sources of nutrients for sustainable crop production and better soil health (Yang, 2006). The soil organic matter plays an important role in improvement of soil physical, chemical and biological properties and ultimately increasing soil productivity and crop yields (Antil *et al.*, 2011, Bhagat *et al.*, 2003, Marinari *et al.*, 2000). Tiwari et al. (2002), from an experiment conducted on Typic Haplustalf, reported that the continuous application of fertilizers alone also helped in increasing the organic carbon content of soil, which could be attributed to higher contribution of biomass to soil in the form of crop stubbles and residues.

Continuous use of organic and inorganic fertilizers also largely affects the status and distribution of potassium fractions which are also equally important contributors to soil fertility and crop productivity.

Potassium is one of the essential nutrients required for plant growth and exists in soil in different forms, viz., water soluble-K which is taken up directly by plants; exchangeable-K held by negative charges on clay particles and is available to plants; and non-exchangeable-K held within the clay lattices and difficultly available to plants. Knowledge and an understanding of the conditions controlling their availability to growing crops are important for the appraisal of the available K in the soil.

Long term experiments have shown that organic manures incorporation increases the organic carbon content as well as nutrient availability as compared to chemical fertilizers alone.

MATERIALS AND METHODS

A long term ongoing experiment, which is in progress at research farm of CCS Haryana Agricultural University, Hisar since 1985, having sandy loam soil under pearl millet-wheat cropping sequence was selected for the study. The experimental site is located at $29^0$16′N latitude and $75^0$7′E longitude in North-West part of India. The climate of the experimental area is semi-arid. The average nutrient composition of farm yard manure, wheat straw and green manure applied in the experiment is given in Table 1 and the treatments laid in the experiment are presented in Table 2.

Table 1
Average nutrient composition of organic manures used in the experiment

Organic manure	*OC (%)*	*N (%)*	*P (%)*	*K (%)*
FYM	38.00	1.30	0.97	1.87
Wheat straw	40.60	0.50	0.06	1.71
Green manure	51.80	2.50	0.33	2.03

Table 2
Details of different treatments laid in the experiment

Treatment	*Kharif*	*Rabi*
T_1	Control (no fertilizer /manure)	Control (no fertilizer /manure)
T_2	50% recommended NPK dose through fertilizers	50% recommended NPK dose through fertilizers
T_3	100% recommended NPK dose through fertilizers	100% recommended NPK dose through fertilizers
T_4	50% recommended NPK dose through fertilizers + 50% N through FYM*	100% recommended NPK dose through fertilizers
T_5	50% recommended NPK dose through fertilizers + 50% N through wheat straw	100% recommended NPK dose through fertilizers
T_6	50% recommended NPK dose through fertilizers + 50% N through GM**	100% recommended NPK dose through fertilizers
T_7	Farmer's Practice	Farmer's Practice

*FYM: Farm Yard Manure **GM: Green Manure
Recommended dose of NPK in pearl-millet: N = 125 kg ha^{-1} and P_2O_5 = 62.5 kg ha^{-1}, while recommended dose of NPK in wheat: N = 150 kg ha^{-1} and P_2O_5 = 60 kg ha^{-1}, respectively. No potassium fertilizer was added to the crops due to initial high K status.

Soil samples were collected from 0-15 cm and 15-30 cm soil depths after harvest of wheat in the year 2014. Five cores were collected from each treatment and were mixed thoroughly for composite sample. Soil samples were air dried, ground and sieved for analysis. Soil organic carbon was estimated using Walkley and Black's Rapid Titration method (Walkley and Black, 1934) and soil K fractions was estimated using Flame photometer (Knudsen *et al*., 1982). The experiment was laid out in a Randomized Block Design (RBD) with seven treatments as depicted in Table 2 with a plot size 10m x 8m in pearl millet and wheat crops.

RESULTS AND DISCUSSION

Potassium fractions

As shown in Table 3, the water soluble K under different treatments ranged from 14.16 to 21.16 mg kg^{-1} and 7.25 to 10.08 mg kg^{-1} in 0-15 and 15-30 cm soil depths, respectively. The water soluble K was found higher in the plots receiving organic manures along with fertilizers than all other treatments at all soil depths. The highest magnitude of increase was recorded in FYM treated plots followed by green manure. This may be due to the fact that FYM increases soil physical conditions, improves K availability and reduces K fixation. Similar results have also been reported by Das *et al.* (2000) and Santhy *et al.* (1998) in red and laterite soils.

Exchangeable K also followed the similar trend as in water soluble K, i.e. the control plots recorded the lowest amongst all other treatments and the highest value of exchangeable K was found in FYM treated plots followed by green manure amended plots. Highest amount of exchangeable K in FYM treated plots may be due to the increase in CEC of soil which was responsible for holding more amount of exchangeable K and also helped in release of exchangeable K from non-exchangeable pool (Yaduvanshi and Swarup, 2006).

For non-exchangeable K, the magnitude of increase was found to be non-significant. For all three K-fractions, the surface layer recorded the higher values as compared to the sub-surface layer.

Table 3
Distribution of different fractions of potassium (mg kg^{-1}) as affected by organic manures and fertilizers after wheat harvest

Treatment	*Water soluble-K*		*Exchangeable-K*		*Non-exchangeable-K*	
	0-15 cm	*15-30 cm*	*0-15 cm*	*15-30 cm*	*0-15 cm*	*15-30 cm*
T_1	14.16	7.25	87.50	76.26	1,613.33	1,544.67
T_2	14.91	7.75	90.91	82.58	1,632.00	1,686.33
T_3	17.83	8.58	106.00	93.33	1,892.67	1,748.00
T_4	21.16	10.08	138.00	120.33	1,963.33	1,819.33
T_5	17.16	8.58	104.75	91.50	1,793.33	1,724.00
T_6	18.33	9.33	108.83	99.41	1,929.33	1,771.33
T_7	16.08	8.16	92.66	86.41	1,728.67	1,714.67
CD (p = 0.05)	4.13	1.17	21.48	23.54	250.70	NS

Soil organic carbon

The application of organic manures along with fertilizers resulted in higher soil organic carbon content in comparison to the plots where only fertilizers were applied. This is due to the direct addition of organic matter through organic manures (Table 4). The highest soil organic carbon content was found in FYM treated plots followed by the plots receiving green manuring and recommended doses of fertilizers. The plots receiving 100% NPK also recorded more soil organic carbon in comparison to the remaining plots whereas lowest organic carbon was recorded in control plots. The increase in soil organic carbon for the plots with the application of organic manures and fertilizers may be due to more production of roots and their subsequent decomposition (Antil *et al.,* 2007). Also, higher content of organic carbon in surface soil as compared to sub-surface soil may be due to accumulation of crop residues in surface layer (Antil *et al.,* 2011).

Table 4
Organic carbon (%) in soil as affected by organic manures and fertilizers after wheat harvest

Treatment	*0-15 cm*	*15-30 cm*
T_1	0.33	0.28
T_2	0.35	0.32
T_3	0.46	0.39
T_4	0.50	0.43
T_5	0.45	0.36
T_6	0.49	0.39
T_7	0.39	0.35
CD (p = 0.05)	0.08	0.07

CONCLUSION

The study showed that long-term application of organic manures (FYM and green manures) along with fertilizers was found to be more effective in increasing the soil organic carbon and potassium fractions in soil. Also, straw yield for wheat was recorded to be highest in FYM amended treated plot followed by green manure amended treated plot. The different K fractions and soil organic carbon decreased with increasing soil depth. The distribution of K fractions at 0-15 and 15-30 cm soil depth as in the order: non-exchangeable K > exchangeable K > water soluble K. The results concluded that the input of organic manures like FYM and green manure are of major importance that must be advocated in the nutrient management and combining organic manures with fertilizers is necessary for ensuring sustainability on long-term basis and thus maintaining the soil quality.

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