Agric Res J **54** (4) : 505-509, *December* 2017
DOI No. 10.5958/2395-146X.2017.00097.7

LONG- TERM EFFECT OF FARM YARD MANURE AND INORGANIC FERTILIZERS ON CROP YIELD AND PHYSICO-CHEMICAL PROPERTIES OF LOAMY SAND SOIL

H V Amipara* and N J Jadav

Department of Agricultural Chemistry and Soil Science
Anand Agricultural University, Anand - 388110, Gujarat

ABSTRACT

A study was conducted to determine long-term effects of FYM and inorganic fertilizers on crop yield and soil properties by utilizing on-going experiment on continuous cropping which commenced in 1980. Two levels of FYM (0 and 10 t ha^{-1}) were applied once in a year to *kharif* pearl millet and four levels of recommended dose of NP fertilizers (0, 50, 100 and 150% of RD) applied to each crop (pearl millet-mustard-summer cowpea in RBD (factorial) with three replications. The FYM application was found beneficial to increase yield due to its residual effect on summer cowpea (fodder). The highest green and dry fodder yield of cowpea was observed under the treatments of FYM application @ 10 t ha^{-1} and NP application @ 150% RD as compared to control. The treatments of FYM and fertilizers improved WHC, OC and availability of major (N and P_2O_5, K_2O and S) and micronutrients (Fe, Mn Zn and Cu) in soil but decreased BD as well as pH and EC in 0-15 and 15-30 cm depths of soil.

Key words: Continuous cropping, FYM, Long-term fertilizer application, Soil properties, Yield

Long-term fertilizer experiments play an important role in understanding the complex interactions involving soils, plants, climate and management practices and their effects on crop productivity. It is well recognized that long-term fertilizer experiments are repositories of valuable information regarding the sustainability of intensive agriculture. Such experiments serve as an important tool to understand the changes in soil properties due to intensive cropping and continuous fertilization. Consistent use of chemical fertilizers and manures in soil alters the physico-chemical and biological properties of the soil (Hemalatha *et al*., 2013).

Intensive cultivation and growing exhaustive crops could make the soil deficient in macro as well as in micronutrients. The success of any cropping system depends upon the appropriate management of resources including balanced use of manures and fertilizers. The cultivation of legumes has made radical improvement in the economic status of farming community. However, it is considered as an exhaustive crop demanding more nutrition when grown either with low nitrogen and phosphorus or with lesser quantities of organic sources in soil. This has resulted in decline in crop productivity and deterioration in soil health and productivity. Use of organic manures may prove to be a viable option for sustaining the productivity of legumes and add life to the soil. (Vidyavathi *et al*., 2011). The present study was planned to investigate long-term effects of FYM and inorganic fertilizers on crop yield and soil properties by utilizing the on-going experiment on continuous cropping which commenced in 1980.

MATERIALS AND METHODS

A long-term experiment was started by the Micronutrient Project (ICAR), Anand Agricultural University, Anand in the year 1980 for studying the effect of continuous cropping on depletion pattern of nutrients, especially micronutrients. The soil is alluvial in nature, light brown in colour and locally known as *goradu* soil. The texture is loamy sand (*Typic Ustochrept*).

The experiment was commenced with the following treatments keeping three replications under RBD experimental design: (1) No fertilizers, N_0P_0 -F_0 (Control), (2) 50 % of recommended dose, N_1P_1 –F_1 (Low), (3) 100 % of recommended dose, N_2P_2 –F_2 (Medium) and (4) 150 % of recommended dose, N_3P_3 –F_3 (High). The experiment was later modified in the year 1994 after harvest of 40th (cowpea) crop to study the role of FYM in maintenance of soil fertility and productivity at different levels of fertility under intensive cropping. Accordingly, treatments of FYM were imposed in half of the replication under pearlmillet (*kharif)* -mustard (*rabi*) - cowpea (F) (summer) cropping sequence. The experiment included four fertility levels and two levels of FYM *i.e.* M_0 (no-FYM) and M_1 (FYM @ 10 t ha^{-1}) to be applied once in a year to the *kharif* pearlmillet in a factorial randomized block design. Fertilizer dose for cowpea (fodder) consists of 25:50:00 kg of N, P_2O_5 and K_2O ha^{-1} supplied through urea and DAP. Methods used for soil analysis and physic-chemical properties of soil at the initial values are mentioned in Table 1 and Table 2, respectively.

RESULTS AND DISCUSSION

Crop yield

The long-term significant effect of FYM application

*Corresponding author : amiparahetal8@aau.in
Date of receipt : 11.04.2017, Date of acceptance : 28.10.2017

Table 1. Methods used for soil analysis

Parameters	Extraction method	Reference
pH (1:2.5 soil:water)	Potentiometry	Jackson (1979)
EC (1:2.5 soil:water)	Conductivity meter	Jackson (1979)
Organic carbon (OC)	Walkley Black's wet oxidation method	Jackson (1979)
Bulk density	Cylindrical core method	Jalota *et al*. (1998)
W. H. C	Gravimetric	Piper (1966)
Available N	Alkaline $KMnO_4$ (0.32%) method	Subbiah and Asija (1956)
Available P_2O_5	0.5 M $NaHCO_3$, pH 8.5, Spectrophotometry	Olsen *et al.* (1954)
Available K_2O	1*N* NH_4OAC pH 7.0 (Flame photometric)	Jackson (1979)
Available S	0.15 % $CaCl_2$ (Turbidimetric)	Williams and Steinbergs (1959)
Available micronutrients	0.005M DTPA (pH 7.3) (Atomic Absorption (Spectrophotometric)	Lindsay and Norvell (1978)

Table 2. Important physico-chemical properties of soil

Character and method	Initial value (2002)	
	0-15(cm)	15-30 (cm)
Bulk density (Mg m^{-3})	1.34	1.34
Water holding capacity (%)	41.88	42.44
$pH_{2.5}$	8.18	8.15
$EC_{2.5}$ (dSm^{-1})	0.195	0.174
Organic carbon (%)	0.291	0.206
Available N (kg ha^{-1})	198	153
Available P_2O_5 (0.5 M $NaHCO_3$ extractable-P) (kg ha^{-1})	51.7	53.2
Available K_2O (NH_4OAc extractable-K) (kg ha^{-1})	643	702
Available S (0.15% $CaCl_2$ extractable-S) (mg kg^{-1})	16.32	14.94
Micronutriments (0.005 M DTPA-extractable) (mg kg^{-1})		
Fe	6.32	4.82
Mn	9.26	7.29
Zn	1.71	1.14
Cu	2.94	2.18

was noticed on green and dry fodder yield of cowpea. The increase in green and dry fodder yield was to the tune of 19 and 31 per cent, respectively, with FYM over no FYM. This increas in fodder yield could be attributed to improvement in physico- chemical and biological properties of soil due to addition of FYM @ 10 t ha^{-1} every year to *kharif* pearl millet (Table 3). Similar beneficial effect of manurial application with fertilizers under continuous cropping has been recorded by other workers (Yadav and Kumar, 2009; Singh *et al.,* 1980; Pandya, 2000).

The increase in green and dry fodder yield was to the extent 32 and 70 percent under application of 150 % RDF (F_3) over F_0. Addition of major nutrients (N and P) through chemical fertilizer could increase growth of the crops due to their involvement in functions like cell multiplication, cell elongation as well as tissue differentiation.

Available major nutrients

The available N, P, K and S status was significantly improved by FYM application over no FYM at both the soil depths (Table 4). It is reported that the inclusion of FYM in treatment schedule improved the available N, P, K and S in soil thereby sustained the soil health. The application of 150 % RDF also significantly increased available major nutrient status in soil at both the depths.The increase in available N due to organic material application might be also attributed to greater multiplication of microbs caused by the addition of organic materials for the conversion of organically bound N to inorganic form (Tolanur and Badanur, 2003).

Increase in available P with FYM and GM might be due to additional application of P and mobilization of P from lower level of the soil. This increase in P may be attributed to

Table 3. Long-term effect of FYM and inorganic fertilizers on fodder yield of cowpea (fodder)

Treatments	Fodder yield (kg ha^{-1})	
	Green fodder	Dry fodder
M_0	8282	2178
M_1	9907	2855
SEm ±	72.6	49.8
C.D. (P=0.05)	220	151
F_0	8075	1825
F_1	8405	2289
F_2	9204	2857
F_3	10694	3095
SEm ±	103	70
C.D. (P=0.05)	311	213
M × F	Sig.	Sig.
C.V.%	2.8	6.9

the decomposition of organic matter accompanied by release of appreciable quantity of CO_2. The appreciable build up in available P in organic and inorganic forms may be due to the influence of organic matter in increasing the labile P in soil through complexing cations like Ca^{+2} and Mg^{+2}, which are mainly responsible for fixation of P (Bajpai, 2006; Tandon, 1987; Bhardwaj and Omanwar, 1994). The beneficial effect of FYM on available K_2O may be ascribed to the reduction in K fixation and release of K due to interaction of organic matter (Tandon, 1987; Bhardwaj and Omanwar, 1994; Santhy *et al.,* 1998).

Available micronutrients

The results revealed that DTPA extractable micronutrient cations content of soil was higher under FYM application (M_1) than no FYM at both the depths (0-15 and 15-30 cm); and increased over control (Table 5). The effect inorganic fertilizer was significant for available micronutrients at both the depths, wherein maximum values for DTPA extractable micronutrient cations were noticed under F_3. Long term use of FYM @ 10 t ha^{-1} every year given to *kharif* pearl millet has increased or maintained micronutrient cations above threshold levels in the soil depths, may be on account of enhanced microbial activity in the soil and consequently release of complex organic substances (chelating agents), which could have prevented micronutrients from precipitation or fixation, oxidation and leaching and also supplementation of these nutrients through FYM (Bellakki and Badanur, 1997).

Physico-chemical properties of soil

The bulk density of soil was decreased due to application of FYM and inorganic fertilizers in both the depths of soil, but difference was non-significant. The FYM addition and increasing inorganic fertilizer levels showed increase in WHC at both the depths of soil profile (Table 6). The FYM was effective in formation of larger aggregates. The quantity of biomass added to soil through different organic sources and quality of end product of decomposition of organic matter capable of imparting bonding effect on soil particles might have been responsible to improve aggregation, porosity and humus which, in turn might have induced favourable effect on physical properties of soil. Formation of certain polysaccharides during decomposition of organic residues by microbial activity as well as the cementing action of bacteria and fungi might also be one of the reasons for improving physical properties of soil under organo-inorganic combination (Sharma *et al.,* 2007).

Table 4. Long-term effect of FYM and inorganic fertilizers on available major nutrients in loamy sand soil after harvest of fodder cowpea

Treatments	N		P_2O_5		K_2O		S	
	(kg ha^{-1})						(mg kg^{-1})	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
M_0	214	155	37.8	34.3	284	274	8.24	6.07
M_1	228	160	50.6	42.4	301	292	9.39	7.18
SEm ±	1.90	1.45	1.58	0.60	2.18	1.63	0.05	0.06
C.D. (P=0.05)	5.75	4.39	4.78	1.83	6.62	4.94	0.14	0.19
F_0	200	149	27.1	26.7	278	270	8.28	5.86
F_1	216	156	43.3	37.1	289	281	8.64	6.58
F_2	226	159	50.5	42.9	299	289	9.13	6.77
F_3	241	167	55.9	46.7	305	293	9.23	7.27
SEm ±	2.68	2.05	2.22	0.85	3.08	2.30	0.07	0.08
C.D. (P=0.05)	8.12	6.22	6.75	2.59	9.36	6.99	0.19	0.27
M × F	Sig.	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig
C.V.%	2.98	3.18	12.4	5.45	2.58	1.99	1.81	3.32

Table 5. **Long-term effect of FYM and inorganic fertilizers on DTPA extractable micronutrients content in loamy sand soil after harvest of cowpea (fodder)**

Treatments	Fe (mg kg^{-1})		Mn (mg kg^{-1})		Zn (mg kg^{-1})		Cu (mg kg^{-1})	
	Soil profile depth (cm)							
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
M_0	3.24	3.04	5.23	4.14	0.77	0.65	1.64	1.32
M_1	3.86	3.33	5.87	4.69	1.09	0.93	2.00	1.60
SEm ±	0.04	0.02	0.03	0.03	0.03	0.03	0.03	0.02
C.D. (P=0.05)	0.12	0.07	0.10	0.09	0.11	0.10	0.10	0.06
F_0	3.34	3.07	5.35	4.31	0.80	0.67	1.66	1.37
F_1	3.49	3.16	5.53	4.38	0.88	0.74	1.79	1.45
F_2	3.65	3.22	5.64	4.42	0.95	0.84	1.91	1.51
F_3	3.71	3.31	5.69	4.53	1.08	0.89	1.95	1.53
SEm ±	0.06	0.03	0.05	0.04	0.05	0.05	0.04	0.03
C.D. (P=0.05)	0.17	0.10	0.14	0.13	0.16	0.13	0.14	0.09
M × F	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	3.86	2.56	2.05	2.46	14.7	14.2	6.40	4.95

Biswas *et al.* (1967) reported that phosphatic fertilizers and FYM application had improved soil structure due to enhanced bacterial activity as well as organic carbon status of soil. The increase in water holding capacity could be probably be due to increased root biomass as the yields of all the crops were improved with the increase in fertility levels.

The application of FYM significantly decreased the pH and EC of soil at 0-15 cm depth, but there was no significant difference in sub-surface soil (Table 6). The soil pH and EC were also not-significantly affected due to inorganic fertilizers treatments at 0-15 and 15-30 cm depths of soil profile. The soil pH showed little variations over years while soil EC gradually decreased at both the depths. However, the soluble salts content under FYM treatments were comparatively higher than no FYM. This could be mainly due to addition of salts through organics besides its action to solublize the native salts with organic acids librated upon its decomposition and restricted downward movement of nutrients. Further, due to light texture nature of the soil, the most of the salts might have leached to lower depths as its content were not found much accumulated in surface layer. Also, due to continuous cropping, the salts might have leached with irrigation to a lower depth; and the soil sampling immediately after harvest of cowpea did not allow the salts further move towards surface through capillary action.

Table 6. **Long-term effect of FYM and inorganic fertilizers on physico-chemical properties of loamy sand soil after harvest of cowpea (fodder)**

Treatments	BD (Mg m^{-3})		WHC (%)		pH		EC (dSm^{-1})		OC (%)	
	Soil profile depth (cm)									
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
M_0	1.36	1.36	8.16	8.23	0.192	0.173	0.320	0.269	44.2	40.5
M_1	1.34	1.33	8.12	8.18	0.179	0.178	0.338	0.294	49.2	44.5
SEm ±	0.008	0.01	0.01	0.02	0.003	0.003	0.006	0.040	0.39	0.48
C.D. (P=0.05)	NS	NS	0.02	NS	0.01	NS	0.02	0.01	1.18	1.47
F_0	1.36	1.37	8.15	8.21	0.185	0.168	0.308	0.276	44.3	40.2
F_1	1.35	1.33	8.15	8.20	0.186	0.170	0.310	0.279	45.9	41.6
F_2	1.35	1.33	8.14	8.20	0.187	0.178	0.347	0.283	47.8	42.5
F_3	1.35	1.33	8.13	8.19	0.185	0.185	0.351	0.288	48.7	45.7
SEm ±	0.01	0.02	0.01	0.03	0.01	0.004	0.01	0.01	0.55	0.69
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	0.03	NS	1.67	2.08
M × F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	2.25	3.61	0.31	0.73	6.15	5.83	6.25	4.83	2.89	3.95

Long-term application of FYM improved organic carbon status of soil significantly at 0-15 and 15-30 cm depths of soil profile over no FYM. The soil OC significantly increased due to application of 150 % RDF at 0-15 cm depth of soil profile only. Incorporation of organic amendments induced an increasing effect of organic carbon status might due to improvement of physical and biological properties of the soil (Nayyar, 2002). Suresh *et al.* (1999) found build up of organic carbon status of soil due to organic manure application.

It can be concluded from the study that application of FYM @ 10 t ha^{-1} along with 150 % RDF helped in acquiring the highest yield of cowpea (fodder). Application of FYM @ 10 t ha^{-1} to *kharif* pearl millet was found beneficial to improve physico-chemical properties of soil and thereby the productivity of crop. Integration of FYM and inorganic fertilizers was found more advantageous to sustain soil fertility and crop productivity.

Authors' contribution

Conceptualization of research work and designing of experiments (NJJ); Execution of field/lab experiments and data collection (HVA); Analysis of data and interpretation (NJJ, HVA); Preparation of manuscript (NJJ, HVA).

LITERATURE CITED

Bajpai R K 2006. Long-term studies on soil physico-chemical properties and productivity of Rice-Wheat as influenced by integrated nutrient management in *Inceptisol* of Chhattisgarh. *J Indian Soc Soil Sci* **54**: 24-29.

Bellakki M A and Badanur V P 1997. Long-term effect of integrated nutrient management on properties of Vertisol under dryland agriculture. *J Indian Soc Soil Sci* **45**(3): 438-42.

Bhardwaj S and Omanwar P K 1994. Long-term effects of continuous rotational cropping and fertilization on crop yields and soil properties – II effects on EC, pH, organic matter and available nutrients of soil. *J Indian Soc Soil Sci* **42**: 387-92.

Biswas T D, Pharande K S and Naskar G C 1967. Building up of soil structure by phosphate fertilization of a legume in a crop rotation. *J Indian Soc Soil Sci* **15**: 289-300.

Hemalatha S, Radhika K, Maragatham S and Katharine S P 2013. Influence of long-term fertilization on soil fertility - A review. *J Agric Al Sci* **3**(2): 30-36.

Jackson M L 1979. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.

Jalota S K, Khera R and Ghuman B S 1998. *Methods of Soil Analysis*. Narosa Publishing House, New Delhi.

Kumar M and Sharma H C 1992. Effect of nitrogen and sulphur on growth, yield attributes, seed and oil yield of Indian mustard. *Indian J Agron* **37**(4): 748-54.

Lindsay W L and Norvell W A 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Sci Soc American J* **42**(3): 421.

Nayyar V K 2002. Soil fertility management. In: *Fundamentals of Soil Science*. Indian Society of Soil Science, pp. 489-98.

Olsen S R, Cole C V, Watanbe F S and Dean L A 1954. Estimation of available phosphorus in soil with sodium bicarbonate. USDA, Circular 939.

Pandya C B 2000. *Nutrient management in continuously cropped soil with varying fertility levels*. M.Sc. (Agri.) thesis submitted to Gujarat Agricultural University, Anand, India.

Piper C S 1966. *Soil and Plant Analysis*. Hans Publishers, Bombay, India.

Santhy P, Muthuvel P, Murrigappan V and Selvi D 1998. Long-term effects of continuous cropping and fertilization on crop yields and soil fertility status. *J Indian Soc Soil Sci* **46** (3): 391-95.

Sharma R P, Pathak S K, Jha R N and Raman K R 2007. Effect of integrated nutrient management on productivity, nutrient uptake and changes in soil fertility in rice-wheat cropping system. *Ann Agric Res New Series* **28**(1): 219-25.

Singh L J, Verma R N S and Lohia S S 1980. Effect of continuous application of FYM and chemical fertilizers on some soil properties. *J Indian Soc Soil Sci* **28**: 170-72.

Suresh S, Subramanian S and Chitdeshwari T 1999. Effect of long-term application of fertilizer and manures on yield of sorghum-cumbu in rotation on *Vertisol* under dry farming and soil properties. *J Indian Soc Soil Sci* **47**: 272-76.

Subbiah B V and Asija G L 1956. A rapid procedure for determination of available nitrogen in soils. *Curr Sci* **25**: 259-60.

Tandon H L S 1987. Phosphorus research and agricultural production in India. FDCO, New Delhi.

Tolanur S I and Badanur V P 2003. Changes in organic carbon, available N, P and K under integrated use of organic manure, green manure and fertilizer on sustaining productivity of pearl millet-pigeonpea system and fertility of an inceptisol. *J Indian Soc Soil Sci* **51**(1): 37-41.

Vidyavathi, Dasog G S, Babalad H B, Hebsur N S, Gali S K, Patil S G and Alagawadi A R 2011. Influence of nutrient management practices on crop response and economics in different cropping systems in a vertisol. *Karnataka J Agric Sci* **24**(4): 455-60.

Yadav D S and Kumar A 2009. Long-term effect of nutrient management on soil health and productivity of rice (*Oryza sativa*) - wheat (*Triticum aestivum*) system. *Indian J Agron* **54**: 15-23.

Williams C H and Steinbergs A 1959. Soil sulphur fractions as chemical indices of available sulphur in some Australian soils. *Aust J Agri Res* **10**: 340-52.