International Journal of Plant & Soil Science

34(19): 183-193, 2022; Article no.IJPSS.87161
ISSN: 2320-7035

Effect of Integrated Nutrient Management (INM) on physico-chemical Properties of Soils under Pearl Millet-mustard Cropping Sequence in Typic Ustochrepts

Vinay Arya [a*], S. K. Trivedi [a], P. S. Tomar [a], Muneshwar Singh [a] and Hemlata Dhakad [a]

[a] *Department of Soil Science and Agricultural Chemistry, RVSKVV Gwalior (M. P.), India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i1931101

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/87161

Original Research Article

Received 12 March 2022
Accepted 20 May 2022
Published 24 May 2022

ABSTRACT

In northern plains of India, pearl millet-mustard is an efficient, potential and sustainable cropping system (Parihar *et al*., 2009). There are indications of stagnation or even decline in the productivity of pearl millet-mustard cropping system due to low soil organic matter, soil nutrient deficiency (secondry and micronutrients) and non-availability of fertilizers to meet farmers' needs. To ameliorate the soil, it is necessary to use organic manures like FYM in combination with inorganic fertilizers to enriched the soils with essential plant nutrients and maintain good soil health. The objective of study is nutrient management on crop productivity and other soil properties. The experiments were conducted during 2018-19 using pearl millet-mustard with sixteen fertilizer treatments in RCBD with three replications. The treatments are: Control (T_1), 50 % NPK (T_2), 75 % NPK (T_3), 100 % NPK (T_4), 150 % NPK (T_5), 100 % NP (T_6), 100 % N (T_7), 100 % NPK-S (T_8), 100 % NPK + 25 Kg $ZnSO_4$/ha (T_9), 100 % NPK + 50 Kg $FeSO_4$/ha (T_{10}), 100 % NPK + 1% $FeSO_4$ spray at 25 and 45 DAS (T_{11}), 100 % NPK + Azotobacter + PSB (T_{12}), 50 % NPK + FYM (T_{13}), 75 % NPK + FYM (T_{14}), 100 % NPK + FYM (T_{15}), 100 % NPK + FYM + Azotobacter + PSB (T_{16}). The SOC content increased with the applications of 100% NPK, 150% NPK, 50% NPK + FYM and 75 %NPK + FYM and 100 % NPK + FYM while it decreased with the application of 50% NPK and 75%

**Corresponding author: E-mail: aryavinay2@gmail.com;*

NPK, 100%N, 100% NPS-K and control. The optimal dose of fertility (100%NPK) with or without FYM, Azotobacter and PSB and 150% NPK treatment showed build up of all major nutrients NPK while the soil physical and chemical properties were improved relative to the 50% NPK and 75% NPK, 100%N, 100% NPS-K and the control. It improved the productivity, soil physical as well as chemical properties over the sub-optimal dose fertility treatments with or without FYM, imbalanced fertilizer treatments and control.

Keywords: Chemical; FYM; mustard; pearl millet; physical.

1. INTRODUCTION

Integrated nutrient management (INM) practices which involves the combined use of inorganic and organic nutrient sources had long been advocated to farmers. The usage is with a goal to enhance good soil health and soil ecosystem balance. Integrated usage of inorganic fertilizers alongside organic manures has been found to enhance not only the nutrient status but also the fitness and soil quality. Integrated nutrient management has been reported to be helpful greatly in increasing soil quality index [1] and it has been found that the recycling of organic wastes and use of bio-fertilizers play vital roles in soil nutrient management.

Soil quality is closely associated with soil organic matter hence; high soil organic matter content means high potential productivity and better soil health. Soil management practices like application of inorganic fertilizers and usage of organic amendments played important roles in maintaining soil quality and improves soil health. Balanced and integrated use of fertilizer with farm yard manure significantly improves soil organic carbon (SOC) contents [1]. It also has overall soil quality improvement which encompasses different physical, chemical and biological properties of the soils.

The C sequestration in soils under various cropping systems, manuring and fertilizer practices provide clues to reinforcing soil quality, soil fertility and productivity through improvements in the soil physical and biological properties.

Soil carbon sequestration is a process that involves the storage of atmospheric CO_2 within the soil carbon pool mediated by plants through photosynthesis [2]. Carbon sequestration describes long-term storage of CO_2 orother sortsof carbon to either mitigate or deter atmospheric heating and avoid overall dangerous global climate change.

Soils comprise the most important pool of organic carbon (OC) within the terrestrial biosphere. Manures used alone or in combination with inorganic fertilizers are often utilized in agriculture to improve soil fertility in order to increase crop production. But only a fraction of C added through organic manure application is sequestered in the soil, while major part is converted upon decomposition to CO_2 thereby returning same back to atmosphere [2].

Orhan *et al.* (2006) observed application of phosphate solubilising bacterial inocula without application of insoluble phosphorus fertilizer enhanced soil available phosphorus perheps by solubilization of native insoluble phosphorus in soil. Bacterial inocula applied in combination with organic manure and smaller dose of inorganic nitrogen and phosphorus fertilizer has been found to enhance crop yield and soil physical, chemical, and biological properties which contributed towards long – term sustainable production of rice – legume – rice system.

2. MATERIALS AND METHODS

The experiment was carried out during *kharif* 2017 to *rabi* 2019 in research farm of the Department of Soil Science and Agricultural Chemistry, College of Agriculture, R.V.S.K.V.V., Gwalior, situated in Grid zone at latitude 26^0 13'N; longitude 76^0 10'E on altitude 197 meters from mean sea level (MSL). The soil of the experimental field was alluvial, sandy clay loam in texture and classified as Typic Ustochrepts. Soil samples were collected at 0-15, 15-30, 30-60 and 60-100 cm of soil profile with the help of screw and tube auger to study the impact of various fertilizer treatments on the soil properties within the soil profile of experimental site. The experiment was laid out under randomized complete block design (RCBD) with three replications comprising of 16 treatments. The treatments include the control (T_1), 50 % NPK (T_2), 75 % NPK (T_3), 100 % NPK (T_4), 150 % NPK (T_5), 100 % NP (T_6), 100 % N (T_7), 100 %

NPK-S (T_8), 100 % NPK + 25 Kg $ZnSO_4$/ha (T_9), 100 % NPK + 50 Kg $FeSO_4$/ha (T_{10}), 100 % NPK + 1% $FeSO_4$ spray at 25 and 45 DAS (T_{11}), 100 % NPK + Azotobacter + PSB (T_{12}), 50 % NPK + FYM (T_{13}), 75 % NPK + FYM (T_{14}), 100 % NPK + FYM (T_{15}), 100 % NPK + FYM + Azotobacter + PSB (T_{16}).

The recommended fertilizer doses for pearl millet and mustard were 80:40:20 and 100:60:40 of N, P_2O_5 and K_2O kg ha^{-1}, respectively as urea, single superphosphate and muriate of potash, applied at 5 cm away from the seed line and 5 cm deep in the soil. In all, 50% of the N and entire P_2O_5 and K_2O were applied at the time of sowing while the remaining 50% N as top dressing 30 days after sowing. For mustard, fertilizer application was carried out after first irrigation. In treatment with 100 % NPK-S, P was added through DAP to make it S free treatment, while FYM was added at 10 tonnes ha^{-1} yr^{-1} before the sowing of *kharif*. The seeds were inoculated with *Azotobactor* (AZO) and phosphate solubilising bacteria (PSB) both at 10 g Kg^{-1} seed. The pearl millet (Cv. JBV-3) and mustard (Cv. Pusa bold) at 5 kg ha^{-1} were sown 3 cm deep in furrows. Chemical fertilizers were applied below the seed in furrows before the seed sowing and covered with soil. The inter row distance between pearl millet and mustard was 45 cm and 30 cm respectively, with 10 cm inter plant spacing.

3. RESULTS AND DISCUSSION

3.1 Effect of Integrated Nutrient Management on Soil Physical Properties

3.1.1 Soil bulk density (Mg m^{-3})

The data indicates that bulk density of the soils varied from 1.10 -1.57 Mg m^{-3} at 0-15 cm (Table 1). The highest bulk density was obtained for T_7 and followed by T_1 and T_6. The increased bulk density was attributed to the deterioration of the soil structure due to N-fertilizer used alone [3]. The plots receiving 100% NPK alone or in combination with Azotobactor and or PSB and 150% NPK had decreasing bulk density value over the plots treated with 50% and 75% NPK, attributed probably to increase biomass production with consequent increased in the soil organic matter content [4]. However, no definite trend in the soil bulk density was observed at the end of study period but the decreased values obtained may be ascribed to continuous inorganic fertilizer under long term fertilizer experiment. The FYM treated plots (T_{13}, T_{14}, T_{15} and T_{16}) in combination with various levels of NPK had lower value of bulk density which may be due to the higher organic carbon content of soils resulting to more pore spaces and better soil aggregation. Similar trends had been reported by Thakur *et al*. [5] when they studied the impact of continuous use of inorganic fertilizers and organic manures on soil properties under soybean-wheat intensive cropping on a Vertisol.

3.1.2 Soil porosity

The soil porosity as a result of the various fertilizer treatments ranged from 47.33 to 56.58 % (Table 1) indicating that the different fertilizer treatments had significant influences on porosity of the soils. The maximum soil porosity was recorded under 100% NPK+FYM at 10 t $ha^{-1}yr^{-1}$+ Azotobactor +PSB which increased by 19.0 %, 11.2 % and 10.7 % compared to the control, 100%NPK, and 150% NPK treated plots respectively. The plots NPK treatments in combination with FYM at 10 t ha^{-1} yr^{-1} (T_{13}, T_{14}, T_{15}, and T_{16}) had higher soil porosity compared to sole NPK treated plots (T_2, T_3, and T_4). It is pertinent to note that continuous organic manure usage not only influenced the bulk density but also brought about a favourable change in the soil porosity and other soil physical properties. Selvi *et al*., [4] in long term field experiment reported significantly higher soil porosity (58.9%) when 100% NPK + FYM at 10 t ha^{-1} compared to the control (50.2%) on a Vertic Haplustep soil.

3.1.3 Infiltration rate (cm hr^{-1})

The soil infiltration rate due to the treatments varied from 1.83 - 2.61 cm hr^{-1} (Table 1). The rate was observed to be highest with value of 2.6 cm hr^{-1} in plots treated with 100% NPK+FYM at 10 t $ha^{-1}yr^{-1}$+*Azotobactor*+PSB and was followed by 2.59 cm hr^{-1} with 100% NPK +FYM at 10t $ha^{-1}yr^{-1}$. The values were significantly higher compared to other treatments (Fig. 2.c). The sole use of 100% N resulted to the lowest infiltration rate (1.83 cm hr^{-1}) compared to the control (1.87cm hr^{-1}). The plots with FYM in combination with chemical fertilizers as treatments (T_{13}, T_{14}, T_{15} and T_{16}) had relatively higher infiltration rates than the control and sole chemical fertilizers (T_2, T_3 and T_4). Similar trend had been reported by Bajpai *et al*. [6] when they studied the integrated nutrient management on

Table 1. Soil physical properties as affected by integrated nutrient management (2017-2019)

Treatments	BD (Mg m^{-3}) (0-15cm)			Porosity (%) (0-15cm)			Infiltration rate (cm hr^{-1})
	Initial (2017)	Final (2019)	B/D	Initial (2017)	Final (2019)	B/D	
T_1-CONTROL	1.55	1.57	0.02	47.85	47.33	-0.5	1.73
T_2-50%NPK	1.44	1.44	0.00	48.44	48.41	0.0	1.87
T_3-75%NPK	1.40	1.40	0.00	48.86	48.83	0.0	1.99
T_4-100%NPK	1.35	1.37	0.02	50.21	50.53	0.3	2.13
T_5-150%NPK	1.32	1.34	0.02	50.38	50.73	0.4	2.22
T_6-100%NP	1.37	1.38	0.01	48.93	49.31	0.2	1.93
T_7-100%N	1.40	1.43	0.03	46.88	46.55	-0.3	1.81
T_8-100%NPK-S	1.38	1.40	0.02	49.12	49.47	0.3	2.13
T_9-100%NPK+25 Kg/ha ZnSO4	1.37	1.39	0.02	49.34	49.64	0.3	1.96
T_{10}-100%NPK+50 Kg/ha FeSO4	1.36	1.38	0.02	48.16	48.45	0.3	1.98
T_{11}-100%NPK+1% spray at 25 and 45 DAS	1.38	1.40	0.02	51.09	51.39	0.3	1.99
T_{12}-100%NPK+AZO+PSB	1.35	1.32	-0.03	51.23	51.64	0.4	2.26
T_{13}-50%NPK+FYM	1.32	1.30	-0.02	51.55	51.86	0.3	2.57
T_{14}-75%NPK+FYM	1.25	1.22	-0.03	52.36	52.89	0.5	2.61
T_{15}-100%NPK+FYM	1.19	1.16	-0.03	53.56	54.23	0.7	2.64
T_{16}-100%NPK+FYM+AZO+PSB	1.15	1.10	-0.05	55.64	56.58	0.9	2.69
SEm±	**0.07**	**0.04**		**3.09**	**3.29**		**0.09**
CD(P=0.05)	**NS**	**0.10**		**NS**	**NS**		**0.26**

Note: AZO: Azotobacter, PSB phosphate solubilizing bacteria, FYM: farmyard manure, D/B: decrease or buildup

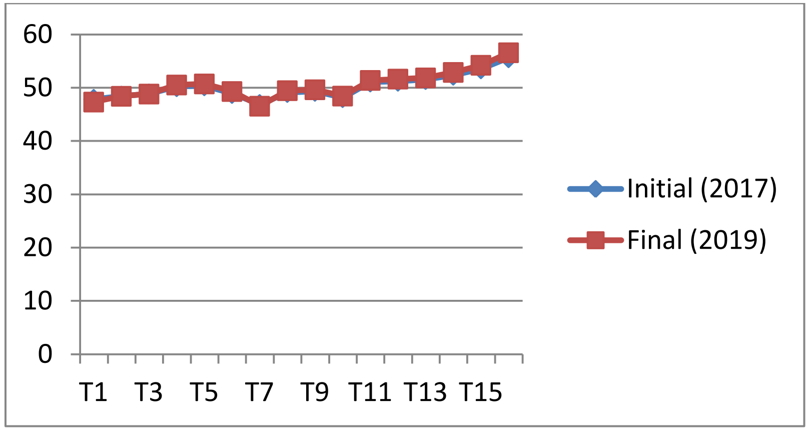

Fig. 1. (a) Bulk density (Mg m^{-3}) at initial and final study periods (2017-19)

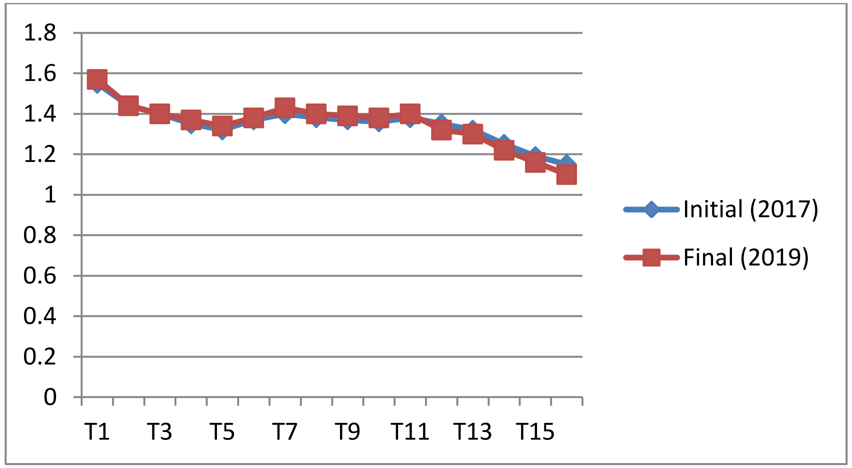

Fig. 1. (b) Porosity (%) (0-15cm)at initial and final study periods (2017-19)

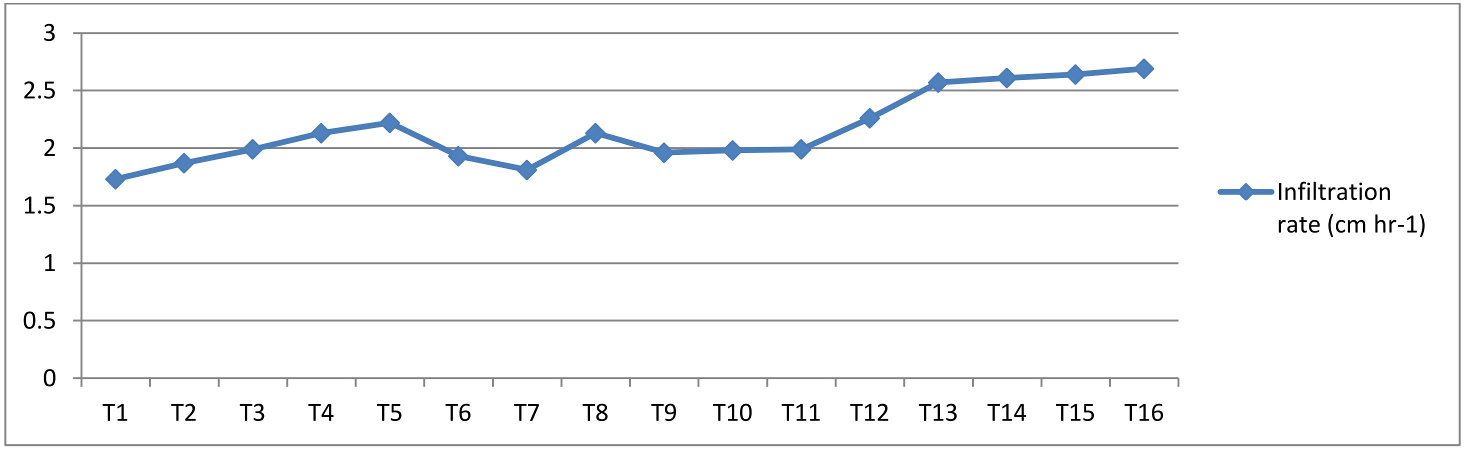

Fig. 1(c). Effect of integrated nutrient management on soil Infiltration rate (cm ha^{-1}) at study periods (2017-19)

Table 2. Soil reaction (pH) as affected by nutrient management practices under a long term study

	Initial (2017)				Final (2019)				D/B			
Treatments/ Depth (m)	**0-15**	**15-30**	**30-60**	**60-100**	**0-15**	**15-30**	**30-60**	**60-100**	**0-15**	**15-30**	**30-60**	**60-100**
T_1-CONTROL	7.81	7.81	7.81	7.82	7.83	7.82	7.81	7.82	0.02	0.01	0.00	0.00
T_2-50%NPK	7.77	7.79	7.78	7.81	7.80	7.81	7.78	7.81	0.03	0.02	0.00	0.00
T_3-75%NPK	7.76	7.76	7.77	7.78	7.76	7.76	7.77	7.78	0.00	0.00	0.00	0.00
T_4-100%NPK	7.75	7.75	7.76	7.75	7.74	7.74	7.76	7.75	-0.01	-0.01	0.00	0.00
T_5-150%NPK	7.74	7.73	7.74	7.75	7.72	7.71	7.74	7.75	-0.02	-0.02	0.00	0.00
T_6-100%NP	7.77	7.77	7.77	7.76	7.76	7.79	7.77	7.76	-0.01	0.02	0.00	0.00
T_7-100%N	7.79	7.78	7.78	7.80	7.80	7.82	7.78	7.80	0.01	0.04	0.00	0.00
T_8-100%NPK-S	7.73	7.73	7.74	7.74	7.76	7.71	7.75	7.74	0.03	-0.02	0.01	0.00
T_9-100%NPK+25 Kg/ha ZnSO4	7.75	7.74	7.72	7.73	7.75	7.74	7.72	7.73	0.00	0.00	0.00	0.00
T_{10}-100%NPK+50 Kg/ha FeSO4	7.73	7.74	7.73	7.73	7.72	7.75	7.73	7.73	-0.01	0.01	0.00	0.00
T_{11}-100%NPK+1% spray at 25 and 45 DAS	7.75	7.74	7.74	7.76	7.74	7.73	7.74	7.76	-0.01	-0.01	0.00	0.00
T_{12}-100%NPK+AZO+PSB	7.76	7.75	7.74	7.75	7.75	7.73	7.73	7.75	-0.01	-0.02	-0.01	0.00
T_{13}-50%NPK+FYM	7.77	7.78	7.74	7.77	7.77	7.78	7.74	7.77	0.00	0.00	0.00	0.00
T_{14}-75%NPK+FYM	7.70	7.71	7.71	7.72	7.68	7.71	7.71	7.72	-0.02	0.00	0.00	0.00
T_{15}-100%NPK+FYM	7.70	7.70	7.72	7.71	7.66	7.67	7.71	7.71	-0.04	-0.03	-0.02	0.00
T_{16}-100%NPK+FYM+AZO+PSB	7.66	7.67	7.68	7.69	7.63	7.64	7.65	7.66	-0.05	-0.04	-0.03	0.00
SEm±	**0.04**	**0.06**	**0.04**	**0.07**	**0.03**	**0.06**	**0.06**	**0.08**				
CD(P=0.05)	**NS**	**NS**	**NS**	**NS**	**0.09**	**NS**	**NS**	**NS**				

Note: AZO: Azotobacter, PSB phosphate solubilizing bacteria, FYM: farmyard manure, D/B: decrease or buildup

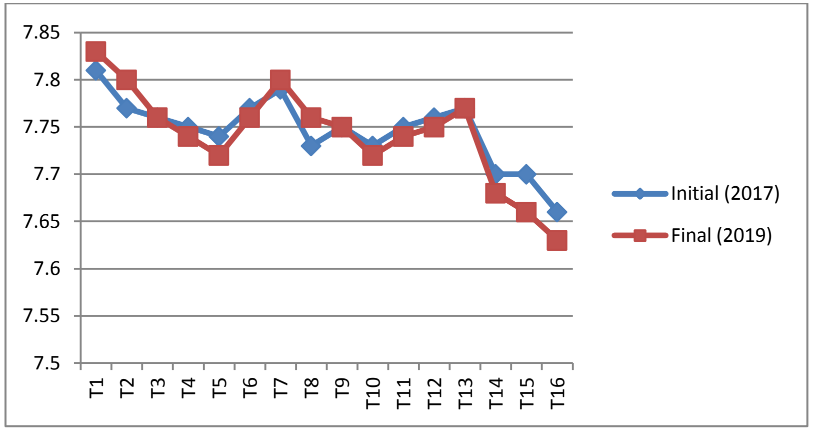

Fig. 2.(a) Soil reaction (pH) at 0-15cm soil depth.

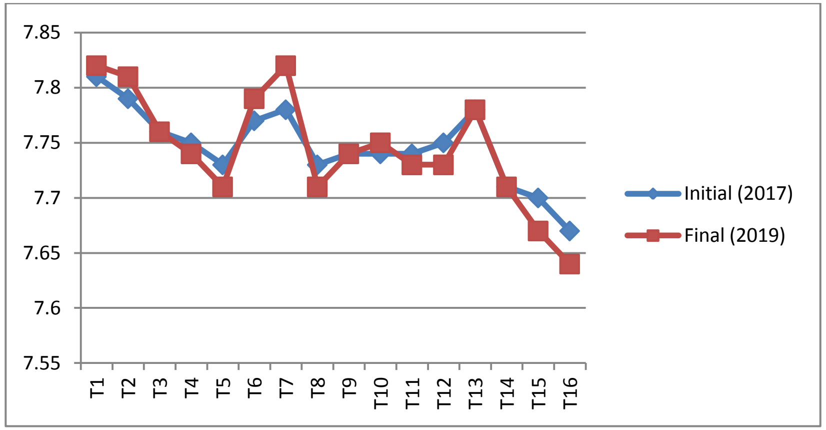

Fig. 2.(b) Soil reaction (pH) at 15-30cm soil depth

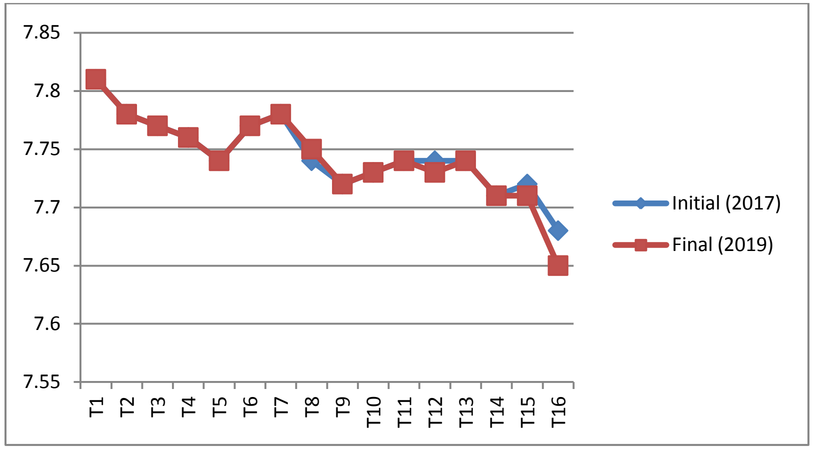

Fig. 2 (c). Soil reaction (pH) at 30-60 cm soil depth.

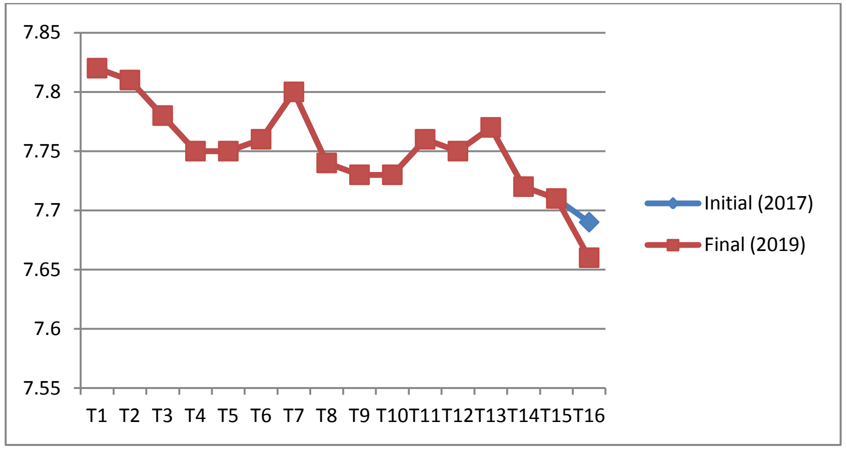

Fig. 2.(d) Soil reaction (pH) at 60-100cm soil depth

Fig. 2. Effect of integrated nutrient management on Soil reaction (pH) at initial and final study periods (2017-19)

Table 3. Electrical conductivity (dSm^{-1}) affected by integrated nutrient management (2017-2019)

Treatments/ Depth (m)	Initial (2017)				Final (2019)				D/B			
	0-15	**15-30**	**30-60**	**60-100**	**0-15**	**15-30**	**30-60**	**60-100**	**0-15**	**15-30**	**30-60**	**60-100**
T_1-CONTROL	0.112	0.109	0.101	0.096	0.108	0.107	0.099	0.095	-0.004	-0.002	-0.002	-0.002
T_2-50%NPK	0.126	0.122	0.105	0.102	0.124	0.121	0.104	0.102	-0.002	-0.001	-0.001	0.000
T_3-75%NPK	0.135	0.129	0.109	0.105	0.134	0.129	0.109	0.105	-0.001	0.000	0.000	0.000
T_4-100%NPK	0.144	0.140	0.114	0.106	0.147	0.142	0.116	0.107	0.003	0.002	0.002	0.001
T_5-150%NPK	0.155	0.153	0.125	0.108	0.159	0.156	0.127	0.110	0.004	0.003	0.002	0.002
T_6-100%NP	0.130	0.126	0.105	0.103	0.132	0.127	0.105	0.103	0.002	0.001	0.000	0.000
T_7-100%N	0.122	0.119	0.101	0.101	0.115	0.114	0.099	0.101	-0.007	-0.005	-0.002	0.000
T_8-100%NPK-S	0.142	0.139	0.111	0.102	0.146	0.142	0.113	0.103	0.004	0.003	0.002	0.001
T_9-100%NPK+25 Kg/ha ZnSO4	0.152	0.150	0.115	0.116	0.159	0.154	0.118	0.116	0.007	0.004	0.003	0.000
T_{10}-100%NPK+50 Kg/ha FeSO4	0.152	0.151	0.116	0.122	0.161	0.156	0.120	0.123	0.010	0.005	0.004	0.001
T_{11}-100%NPK+1% spray at 25 and 45 DAS	0.145	0.138	0.117	0.112	0.149	0.141	0.118	0.113	0.004	0.003	0.001	0.001
T_{12}-100%NPK+AZO+PSB	0.151	0.150	0.121	0.109	0.156	0.154	0.124	0.110	0.005	0.004	0.003	0.001
T_{13}-50%NPK+FYM	0.167	0.137	0.111	0.106	0.170	0.138	0.111	0.106	0.003	0.001	0.001	0.000
T_{14}-75%NPK+FYM	0.230	0.144	0.116	0.108	0.239	0.149	0.118	0.109	0.009	0.005	0.002	0.001
T_{15}-100%NPK+FYM	0.232	0.169	0.125	0.114	0.244	0.175	0.129	0.117	0.013	0.006	0.003	0.003
T_{16}-100%NPK+FYM+AZO+PSB	0.267	0.190	0.137	0.123	0.282	0.198	0.142	0.126	0.015	0.009	0.005	0.003
SEm±	**0.022**	**0.033**	**0.021**	**0.015**	**0.025**	**0.024**	**0.028**	**0.020**				
CD(P=0.05)	**0.063**	**NS**	**NS**	**NS**	**0.072**	**NS**	**NS**	**NS**				

Note: AZO: *Azotobacter* , PSB phosphate solubilizing bacteria, FYM: farmyard manure, D/B: decrease or buildup

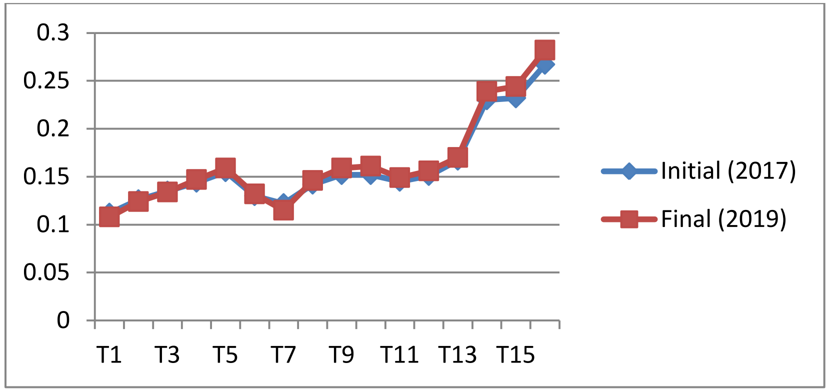

Fig. 3.(a) Electrical conductivity (dSm^{-1}) at 0-15cm soil depth

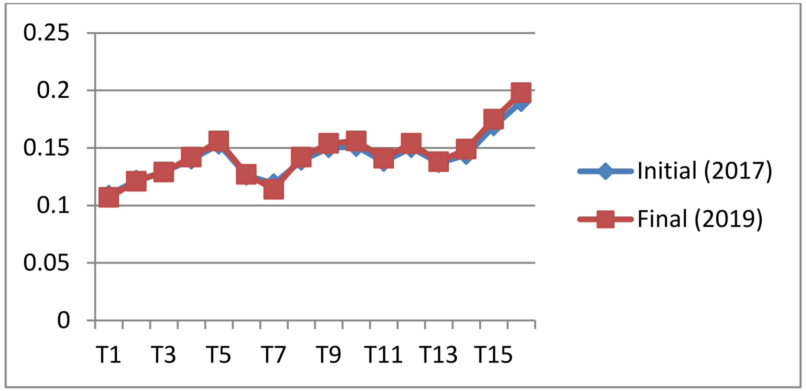

Fig. 3.(b) Electrical conductivity (dSm^{-1}) at 15-30cm soil depth

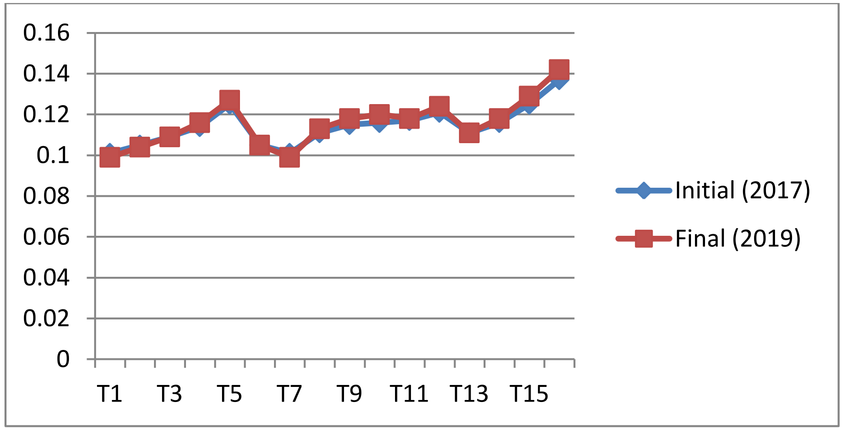

Fig. 3.(c) Electrical conductivity (dSm^{-1}) at 30-60 cm soil depth.

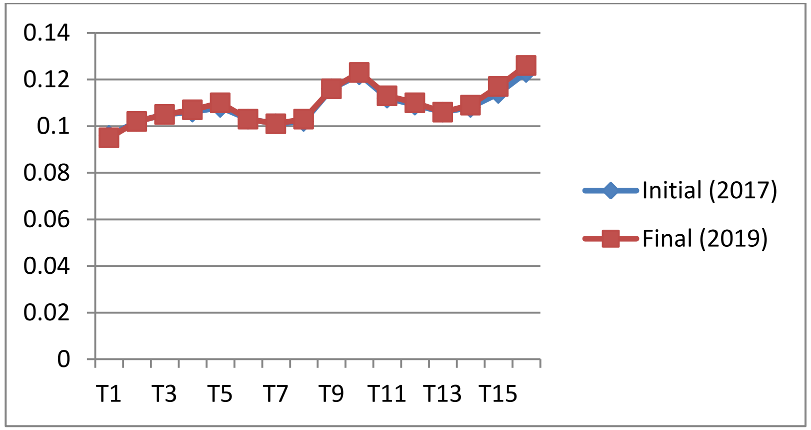

Fig. 3.(d) Electrical conductivity (dSm^{-1}) at 60-100cm soil depth.

Fig. 3. Effect of integrated nutrient management on Electrical conductivity (dSm^{-1}) at initial and final study periods (2017-19)

Inceptisols of Chhattisgarh as it affects the soil physico-chemical properties and the productivity of rice-wheat system.

3.2 Effect of Integrated Nutrient management on Soil Chemical Properties

3.2.1 Soil reaction (pH)

The soil pH varied from 7.63 -7.83 which increased with soil depth. This was in trend with Sawarkar *et al*. [5] who reported that soil pH increased with depth. The control treatment has highest value of pH and it was very low due to application of urea and was least when N alone was applied probably due to acid producing nature of nitrogenous fertilizers [7,8].

The FYM at 10 t $ha^{-1}yr^{-1}$ in combination with chemical fertilizers (T_{13}, T_{14}, T_{15} and T_{16}) resulted to insignificantly decreased soil pH compared to sole use of chemical fertilizers, which may be attributed to the production of organic acids during decomposition of organic manure mediated by microbial organisms in the soil (Gupta *et al*., 2000).

3.2.2 Electrical conductivity (dSm^{-1})

The soil electrical conductivity (EC) ranged from 0.108-0.244 dSm^{-1} at 0-15 cm and decreased with soil depth. The EC was not significantly affected by different levels of NPK and FYM. However, there was slight increase under the various fertilizer treatments over the control. The electrical conductivity indicated that there was no threat since the values were within safe limits, which was in trend with findings of Babu *et al*. [9,10].

4. CONCLUSION

The results indicated that, the management practices such as application of fertilizer and organic amendments together plays an important role in maintaining soil physico-chemical properties and under the pearl millet - mustard cropping sequence.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Singh AK. Evaluation of soil quality under Integrated Nutrient Management. Journal of the Indian society of soil science. 2007;55:58 – 61.
2. Lal R. Soil carbon sequestration impact on global climate change and food security. Science. 2004;304:1623-1627.
3. Walia MK, Walia SS, Dhaliwal SS. Long-term effect of integrated nutrient management of properties of Typic Ustochrept after 23 cycles of an irrigated rice (*Oryza sativa L*.) – wheat (*Triticum aestivum L*.) system. Journal of Sustainable Agriculture. 2010;34(7):724-743.
4. Selvi D, Santhy P, Dhakshinamoorthy M. Effect of inorganics alone and in combination with farmyard manure on physical properties and productivity of vertic Haplustepts under long-term fertilization. Journal of Indian society of soil science. 2005;53(3):302-307.
5. Thakur R, Sawarkar SD, Vishya UK, Singh M. Impact of continuous use of inorganic fertilizers and organic manures on soil properties and productivity under soyabean – wheat Intensive cropping of a Vertisols. Journal of the Indian society of soil science. 2011;59 (1):74 -81.
6. Bajpai RK, Chitale S, Upadhyay SK, Urkarkar JS. Long-term studies on soil physico-chemical properties and productivity of rice-wheat system influenced by integrated nutrient management in Inceptisols of Chhattisgarh. Journal of the Indian Society of Soil Science. 2006;54(1): 24-29.
7. Prasad J, Karmakar S, Kumar R, Mishra B Influence of Integrated Nutrient Management on Yield and Soil Properties in Maize-Wheat Cropping System in an Alfisol of Jharkhand. Journal of the Indian Society of Soil Science. 2010;58 :2.
8. Yaduvanshi NPS, Sharma DR, Swarup A Impact of Integrated Nutrient Management on Soil Properties and Yield of Rice and Wheat in a Long-Term Experiment on a Reclaimed Sodic Soil. Journal of the Indian Society of Soil Science. 2013;61 :3.
9. Babu MVS, Reddy CM, Subramanyam A, Balaguravaiah D. Effect of integrated use

of organic and inorganic fertilizers on soil properties and yield of sugarcane. Journal of the Indian Society of Soil Science. 2017;55 (2):161-166.

10. Parihar CM, Rana KS, Parihar MD. Crop productivity and nutrient up take of pearlmillet (*Pennisetum glaucum*) Indian mustard (*Brassica juncea*) cropping system as influenced by land configuration and direct and residual effect of nutrient management. Indian Journal of Agricultural Sciences. 2009;79(11):927-30.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/87161