Original Research Article

EffcetEffect of INM on physiochemical properties of pearl millet-mustard cropping sequence in typic Ustochrepts

ABSTRACT

Though Iin northern plains of India, pearl millet-mustard is efficient, potential and sustainable cropping system (Parihar *et al*.,2009), . Tthere are indications of stagnation or even decline in the productivity of the pearlmillet-mustard cropping system due to decline in soil organic matter, deficiency of secondary and micronutrients and also non-availability of cost effective fertilizers. Hence, forIn amelioration of the soil, it is necessary to use organic source like FYM in conjunction with fertilizers to so the soil enriched the soil with all the essential plant nutrients and also to maintain it in good health. FYM, is not only source of macronutrients but also helps to overcome the requirement of micronutrients. Keeping these points in view, the experiments were conducted during 2018-19 on pearl millet-mustard with sixteen treatments in randomized block designR. B.D. with three replications. The SOC content in soil increased where optimal, super optimal and optimal or sub optimal dose with FYM was appliedgiven i.e 100% NPK, 150% NPK, 50% NPK + FYM and 75% NPK + FYM, 100% NPK + FYM whereas decreased in 50% NPK and 75%NPK, imbalanced fertility treatments (100% N, 100% NPS-K) and control plot with some exceptions. The optimal dose of fertilisationty (100%NPK) with or without FYM, Azotobacter and PSB and 150% NPK treatment showed build up of all major nutrients status at the end of study period, and improved soil physical as well as chemical properties over the sub-optimal dose fertility treatments, imbalanced fertilizer treatments and control.

Key words : pearl millet, mustard, FYM, physical, chemicals

1. Introduction

Integrated nutrient management (INM) practices with the combined use of inorganic and organic sources of nutrients have long been advocated to farmers with a goal to enhance soil health and ecosystem services. Integration ed application of inorganic fertilizers along side organic manures and using them has been found to enhance not only ~~the~~ nutrient status of soil but, also ~~the~~ soil fitness and quality of soils. Integrated nutrient management has been reported to be helpful greatly in increasing soil quality index (Singh 2007). Recycling of organic wastes and use of bio-fertilizers, *viz*., Rhizobium cultures may play a big role in soil nutrient management ~~of soils~~.

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Soil quality is closely associated with soil organic matter; high soil organic matter means high potential productivity and better health of soil. Management practices like application of fertilizer and organic amendments played important role in maintaining soil quality and improves soil health. Balanced and integrated use of fertilizer with farm yard manure significantly improves soil organic carbon (SOC) content~~s also~~ as well as overall soil quality, which are developed by encompassing different physical chemical and biological properties of soil. The sequestration of C in soil under various cropping systems, manuring and fertilizer practices provide to reinforce soil quality there by inducing~~cluding~~ soil fertility and productivity through improvements in physical and biological properties of soil.

Soil carbon sequestration may be a process during which CO_2 is far away from the atmosphere and stored within the soil carbon pool. This process is primarily mediated by plants through photosynthesis, with carbon stored within the sort of SOC. Carbon sequestration describes long-term storage of CO_2 or other sorts of carbon to either mitigate or defer heating and avoid dangerous global climate change.

Manures alone or together with fertilizers are often utilized in agriculture to extend crop production and improve soil fertility. But only a fraction of C added as organic manure is sequestered in soil, and major ~~a~~ part of it is~~'s~~ converted to CO_2 after decomposition thus returning the CO_2 fixed by plant back to atmosphere.

~~Soils comprise the most important pool of organic carbon (OC) within the terrestrial biosphere.~~

2. Material 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 the latitude of 26^0 13'N and longitude 76^0 10'E with an altitude of 197 meters above~~from~~ mean sea level (MSL). The soil of the experimental field was alluvial, sandy clay loam in texture and classified as Typic Ustochrepts at sub group level. The soil samples were collected from various depths (0-15, 15-30, 30-60 and 60-100 cm) of soil profile with the help of a screw and tube auger to study the impact of various fertility treatment on soil properties ~~of profile~~ of experimental site. The experiment was laid out in a ~~with~~ randomized block design with three replications comprising of 16 treatments. The treatment details we~~a~~re as follows. 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 dose for pearl_millet and mustard as per the treatments were applied (80:40:20 and 100:60:40 N, P_2O_5 and K_2O kg ha^{-1}, respectively) in the form of urea, single superphosphate and muriate of potash, at 5.0 cm away from the seed line and 5 cm deep in the soil. In all, 50 per cent of nitrogen and entire dose of P_2O_5 and K_2O were~~as~~ applied at the time of sowing and remaining 50 per cent of nitrogen was top dressed in the form of urea for pearl_millet at 30 days after sowing and for mustard after first irrigation (Mention DAS). In treatment 100 % NPK-S, P was added through DAP to make it S free treatment. As per treatment, FYM was added @10 tonnes ha^{-1} yr^{-1} before sowing of *kharif* crop. The seeds were inoculated with *Azotobactor* (AZO) and phosphate solubilising bacteria (PSB) both @10 g ~~K~~kg^{-1} seed. The pearlmillet (Cv. JBV-3) and mustard (Cv. Pusa bold) @ 5 kg ha^{-1} were sown by driving about 3 cm deep in furrows. Chemical fertilizers were applied below the seed in furrows before sowing and seeds were covered with soil to level the opened furrows. Row to row distance in pearl_millet and mustard was maintained at~~was~~ 45 cm and 30 cm, respectively. In p~~P~~lant to plant a distance of -10 cm was maintained for~~under~~ both crops.

3. **Results and Discussion**

3.1 Effect of integrated nutrient management on soil physical properties

3.1.1 Soil bulk density (~~M~~mg m^{-3}) (Mg means one tonne i.e. Mega Gram)

The perusal of data indicates that the bulk density (BD) of soil varied from 1.10 to 1.57 Mg m^{-3} at 0-15 cm soil depth at the end of study period (table 1). The maximum bulk density was reported in the treatment T_7 followed by T_1 and T_6 where full dose of NPK or FYM was not applied. This increased bulk density has been attributed to the deterioration of soil structure with N-fertilizer when applied alone or as imbalanced fertilization (Walia *et al*., 2010). The treatments receiving 100% NPK alone or in combination with Azotobacter and/or PSB and 150%NPK showed a~~the~~ decreasing trend of bulk density over the sub optimal fertility dose (50% and 75% NPK), which could be attributed to increased biomass production with consequent increase in organic matter content of soil (Selvi *et al*., 2005). A definite trend was not noticed at the end of study period (reason out), and decreased value with respect to treatments may be ascribed to continuous application of fertilizer under long term fertility experiment. Decrease of bulk density in the treatments of integrated use of chemical fertilizers and FYM may be mainly attributed to higher organic matter content of the soil which results increase of porosity in the manure treated plots. The FYM treated plots (T_{13}, T_{14}, T_{15} and T_{16}) in combination with various levels of NPK observed lower values for ~~of~~ bulk density. Decrease in BD of soil may be due to higher organic carbon content of soil, more pore space and better soil aggregation. Similarly were also reported by Thakur *et al*. (2011) studied the impact of continuous use of inorganic fertilizers and organic manure on soil properties under soybean-wheat intensive cropping on a Vertisol.

3.1.2 Soil porosity

The porosity of various fertility treatments ranged from 47.33 to 56.58 % at the end of study period (table 1) and indicated that different nutrient management practices had significant influence on porosity of soil. The maximum porosity of soil was recorded in under treatment 100% NPK+FYM @10 t $ha^{-1}yr^{-1}$+ Azotobacter +PSB and showed a the build up by 19.0 % over the control, 11.2 % over 100% NPK and 10.7 % over 150% NPK treated plots. The treatments receiving various levels of NPK in combination with FYM @ 10 t ha^{-1} yr^{-1} (T_{13}, T_{14}, T_{15}, and T_{16}) produced athe higher porosity compared to same levels of NPK treated plots (T_2, T_3, and T_4) without FYM. The continuous addition of organic manure not only influenced the BD bulk density but also brought about a favourable change in the total porosity of soil which in turn also influenced the other physical properties. Selvi *et al*., (2005) in long term field experiment found the significantly highest porosity (58.9%) with the application of 100% NPK + FYM@ 10 t ha^{-1} than absolute control (50.2%) in Vertic Haplustep.

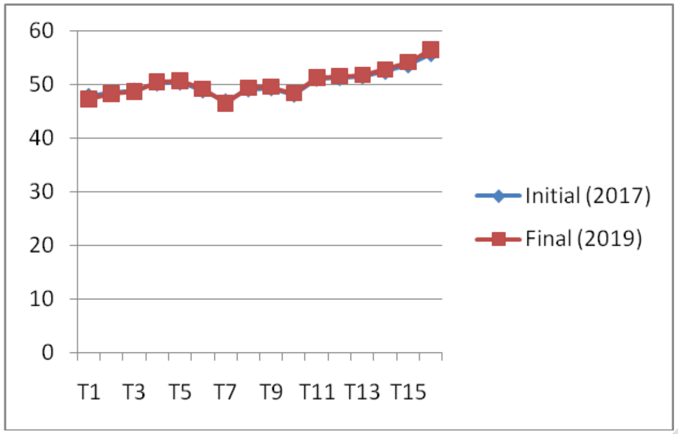
3.1.2 Infiltration rate (cm hr^{-1})

The terminal infiltration rate recorded in under the plots receiving different fertility levels varied from 1.83 to 2.61 cm hr^{-1} (table 1) and this may considered good for well drained soils. The infiltration rate was observed the highest in plots treated with 100%NPK+FYM @10 t $ha^{-1}yr^{-1}$+*Azotobacter*+PSB (2.6 cm hr^{-1}) followed by 100%NPK +FYM@10t $ha^{-1}yr^{-1}$ (2.59 cm hr^{-1}), which wasere significantly higher over the other treatments (fig 2.c). The treatment receiving 100%N alone showed the lowest infiltration rate (1.83 cm hr^{-1}) as compared to all fertility treatments and control (1.87cm hr^{-1}). There was only narrowslight difference in infiltration rates but, found statistically significant. The FYM in combination with chemical fertilizer treated plots (T_{13}, T_{14}, T_{15} and T_{16}) recorded relatively higher infiltration rates over the plots receiving no treatment (control) or only chemical fertilizers (T_2, T_3 and T_4). The continuous addition of organic manure not only influenceds any single physical properties but also brought about a favourable change in all the physical properties. Similar findings were reported by Bajpai *et al*. (2006) who studied the integrated nutrient management in Inceptisols of Chhattisgarh on physico-chemical properties and productivity of rice-wheat system.

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



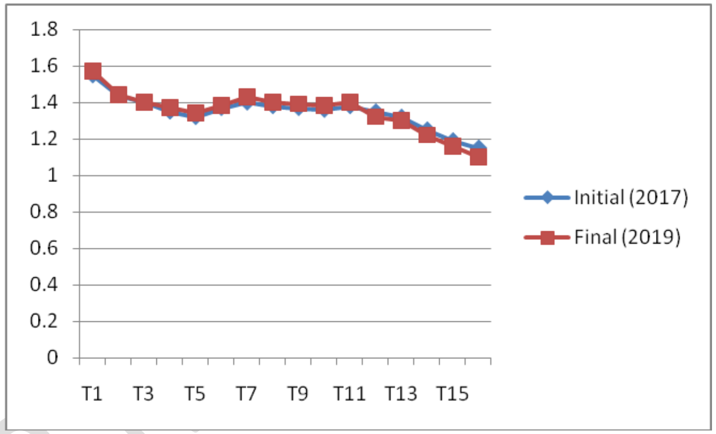
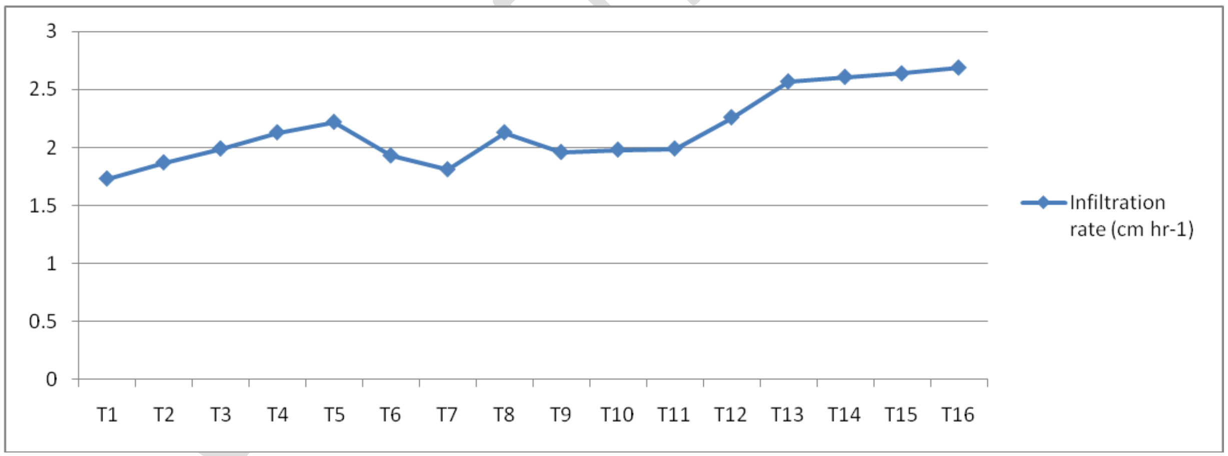


Fig.: 1.(a) Bulk density (Mg m^{-3}) at initial and final study periods (2017-19)

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)



3.2 Effect of integrated nutrient management on soil chemical properties

3.2.1 Soil reaction (pH)

The value of pH varied from 7.63 to 7.83 under various treatments at the surface soil and there was some increase with respect to increase in soil depth. Sawarkar *et al*. (2013) reported that the soil pH increased with depth. The control treatment has highest value of pH and it was fall due to application of urea and maximum decline takes place where N alone was applied. This is due to acid producing nature of these nitrogenous fertilizers (Prasad *et. al.* 2010, Yaduvanshi *et. al.* 2013)

It is~~was~~ seen that the FYM @10 t $ha^{-1}yr^{-1}$ applied in conjunction with various chemical fertilizer levels (T_{13}, T_{14}, T_{15} and T_{16}) decreased soil pH as compared to the same level of chemical fertilizer alone, which may be attributed to the production of organic acids during decomposition of organic manure. Gupta *et al*. (2000) reported reduction in soil pH, as a result of microbial decomposition of organic manures.

It is observed from the results that soil pH was not significantly influenced ~~non-significantly~~ by long term integrated nutrient management, however, ~~. Though~~ there ~~was no significant variations seen but there~~ were numerical changes in soil pH values.

3.2.2 Electrical conductivity (dSm^{-1})

The electrical conductivity of soil under various treatments ranged from 0.108 to 0.244 dSm^{-1} for surface soil at the end of experiment and decreased with soil depth. The electrical conductivity of various treatments ~~data~~ indicated that the changes were only theoretical and there was no threat as it was always well in safe limits. The electrical conductivity of soil was not significantly affected by different levels of NPK and FYM, but there was slight numerical increase under different treatments over control. It may be due to application of inorganic fertilizer. These results supported~~s~~ the findings of Babu *et al*. (2007).

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

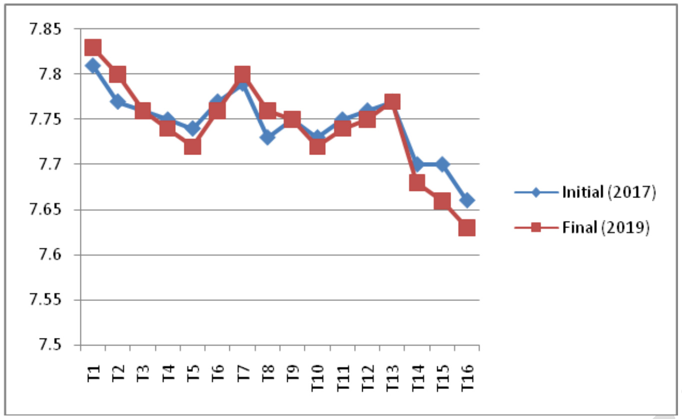


Fig.: 2.(a) Soil reaction (pH) at 0-15cm soil depth.

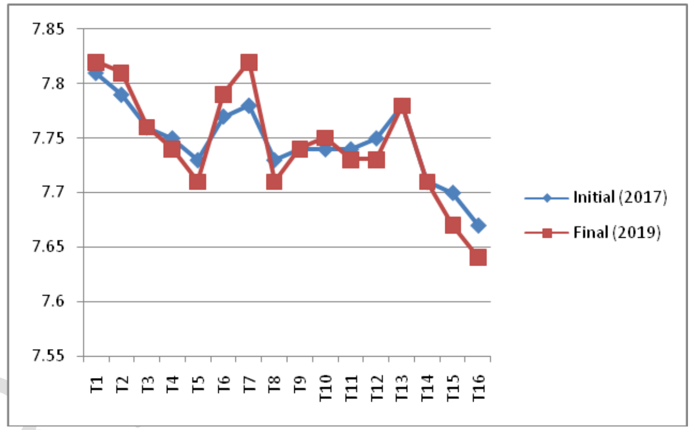


Fig.: 2.(b) Soil reaction (pH) at 15-30cm soil depth

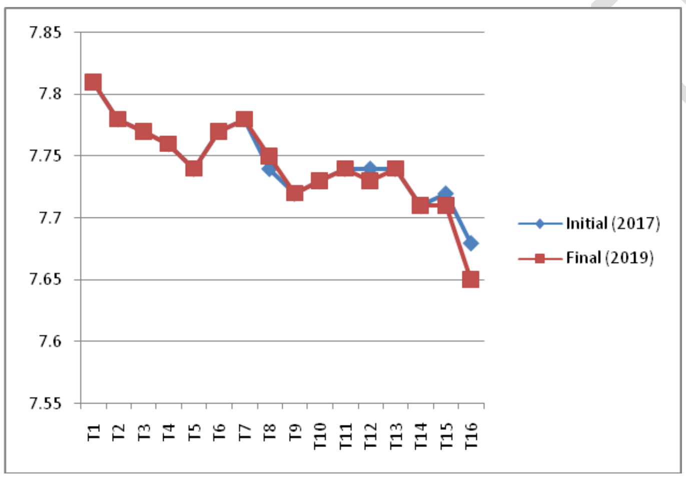


Fig.: 2 (c) Soil reaction (pH) at 30-60 cm soil depth.

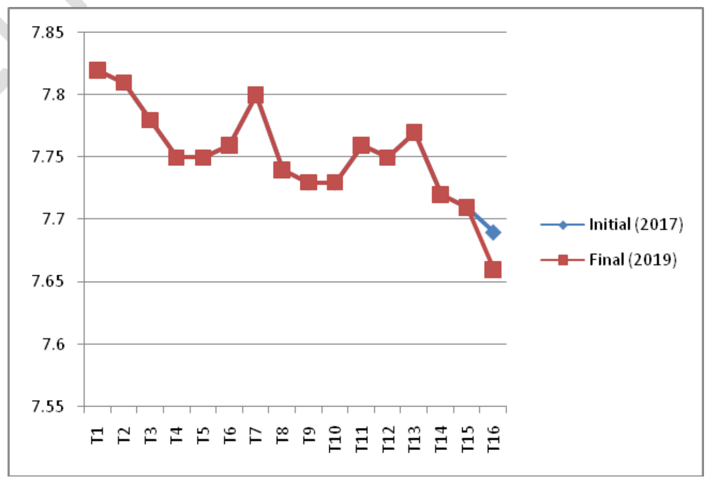


Fig.: 2.(d) Soil reaction (pH) at 60-100cm soil depth

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

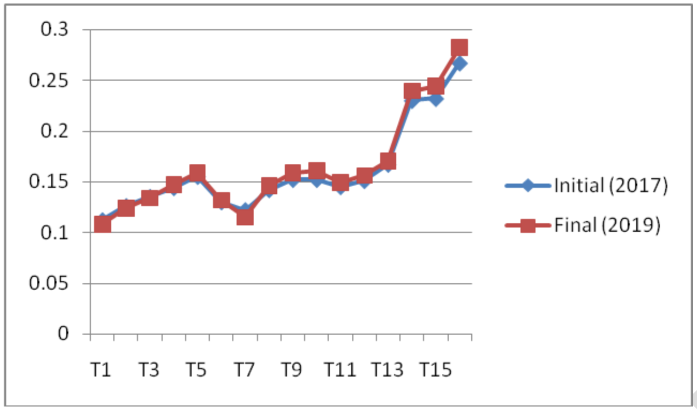


Fig.: 3.(a) Electrical conductivity (dSm^{-1}) at 0-15cm soil depth.

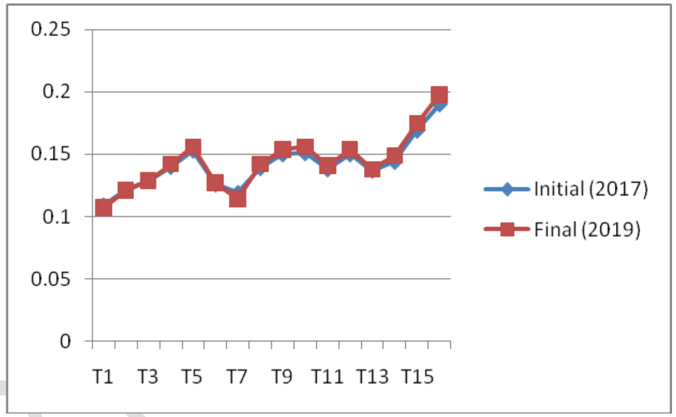


Fig.: 3.(b) Electrical conductivity (dSm^{-1}) at 15-30cm soil depth

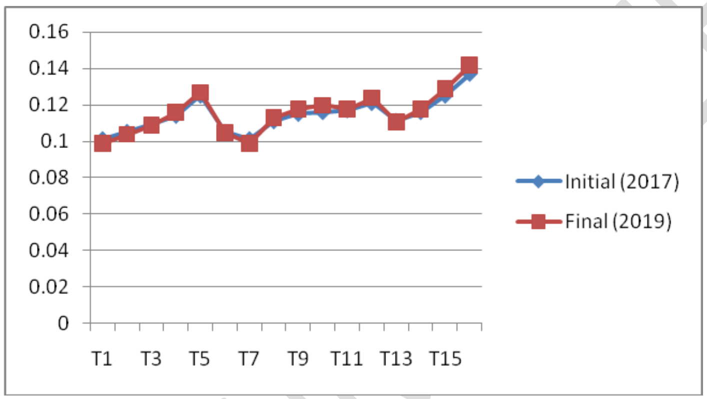


Fig.: 3.(c) Electrical conductivity (dSm^{-1}) at 30-60 cm soil depth.

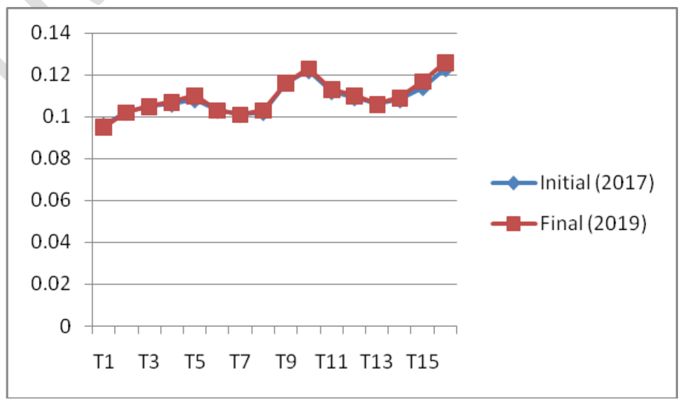


Fig.: 3.(d) Electrical conductivity (dSm^{-1}) at 60-100cm soil depth.

Conclusion

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

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