www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(7): 1095-1101

www.thepharmajournal.com
Received: 05-03-2022
Accepted: 12-06-2022

Effect of integrated nutrient management practices on physical and physico-chemical properties of soil under rice-sorghum cropping system in clay loamy soils

GK Surya Krishna, CH Sujani Rao, P Venkata Subbaiah, M Sree Rekha and V Srinivasa Rao

GK Surya Krishna
Ph.D., Scholar, Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, Andhra Pradesh, India

CH Sujani Rao
Principal Scientist, Department of Soil Science, Technical Team of Subject Expert, Integrated Call Centre, Gannavaram, Vijayawada, Andhra Pradesh, India

P Venkata Subbaiah
Senior Scientist, Saline Water Scheme, Agricultural College Farm, Bapatla, Andhra Pradesh, India

M Sree Rekha
Professor, Department of Agronomy & TO Hon'ble VC, ANGRAU, Lam, Guntur, Andhra Pradesh, India

V Srinivasa Rao
Professor and University Head, Department of Statistics and Computer Applications, Agricultural College, Bapatla, Andhra Pradesh, India

Corresponding Author:
GK Surya Krishna
Ph.D., Scholar, Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, Andhra Pradesh, India

Abstract
A field experiment was conducted at Agricultural College Farm, Bapatla during 2020-2021 and 2021-2022 to study the direct and residual effect of integrated use of organics and inorganics on soil physical and physico-chemical properties under rice-sorghum cropping system on clay loam soil. The experiment was laid out in a Randomized block design during *kharif* and split plot design in *rabi* season and replicated thrice. The organic manures along with inorganic fertilizers were applied to main plots and the three levels of inorganic fertilizers were applied to sub plot treatments for growing rice crop during *kharif* season and sorghum crop during *rabi* season respectively. The results revealed that applications of different treatments did not show any marked difference in physical (bulk density, water holding capacity, porosity, Aggregate stability) and physico-chemical properties of soil (pH, EC) at harvest stage of rice and sorghum during both the years of study.

Keywords: Direct and residual effect, cropping system, organic manures

Introduction
Sorghum in rice-fallows in coastal Andhra Pradesh, especially in Guntur and adjoining Krishna and Prakasam districts is gaining popularity. Previously, rice is succeeded by blackgram which is slowly replaced by either jowar or maize due to severe YMV infestation in blackgram. Hence, farmers of this region are showing interest in view of its low water requirement and withstands to harsh climatic conditions. It is grown under rice-fallows covering 21,000 ha area and producing 6.8 t ha^{-1} under zero till conditions (Mishra *et al.*, 2011) [1]. Awareness about crop quality and soil health increased the attention of people towards organic manures. Balanced use of nutrients through organic sources like farmyard manure, vermicompost, green manuring and poultry manure are prerequisites to sustain soil fertility, to produce maximum crop yield with optimum input level (Balasubramanian and Hill, 2002) [2]. The organic manures leave residual effect for the sequence crops. In addition, they improve various physico-chemical properties *viz.*, soil structure, bulk density, porosity, water holding capacity, reduce nutrient loss and increase microbial population and affinity. Soil microorganisms are critical to the maintenance of soil fertility because of their contributions to soil structure formation, decomposition of organic matter, toxin removal and biogeochemical cycling of carbon, nitrogen, phosphorous and sulphur (Mahajan and Timsina, 2011) [3].

Materials and Methods
Site Description: Field experiment were carried out during *kharif* and *rabi* seasons of 2020-21 and 2021-22 at Agricultural College Farm, Bapatla, geographically located at an altitude of 5.49 m above mean sea level, 15°54' North latitude, $80^0$30' East longitude and about 8 km away from Bay of Bengal. It is located in Krishna agro-climatic zone of Andhra Pradesh. The soil of experimental site was clay loam in texture with bulk density (1.34 Mg m^{-3}), water holding capacity (42.36%), porosity (40.58%) and Aggregate stability (32.63%). The soil was neutral in reaction (pH 7.41), low in electrical conductivity (0.45 dS m^{-1}), low in organic carbon (0.49%), low in available nitrogen (224.46 kg ha^{-1}), medium in available phosphorus (42.93 kg ha^{-1}) and high in available potassium (383.65 kg ha^{-1}).

Experimental design and treatments
During *Kharif*, the treatments consisted of T_1- Absolute Control, T_2- 100% RDF through

inorganic fertilizers, T_3- 125% RDF through inorganic fertilizers, T_4- 75% RDF + 25% N through FYM, T_5- 75% RDF + 25% N through GLM, T_6- 75% RDF + 12.5% N through FYM + 12.5% N through GLM, T_7- 100% RDF + 25% N through FYM, T_8- 100% RDF + 25% N through GLM, T_9- 100% RDF + 12.5% N through FYM + 12.5% N through GLM were imposed to rice crop during *kharif* season and replicated thrice. The *rabi* experiment was continued on the same site without disturbing the soil with sorghum as test crop to study the residual effect of different nutrient sources applied to preceding rice crop. During *rabi*, the treatments consisted of three levels of fertilizers *viz.*, S_1- Control, S_2- 75% RDF and S_3-100% RDF. Popular cultivars of rice and sorghum *viz*., BPT-5204 and MLSH-151, respectively were chosen for the study.

Results and Discussion

Effect of INM practices on soil physical and physico-chemical properties at harvest stage of *kharif* rice

Physical properties

Bulk density (BD)

Close examination of data presented in the table 1 indicated that there was no significant difference in bulk density among all the treatments. There was a marginal reduction in bulk density in the soil treated with combined application of organics and inorganics. Bulk density values ranged from 1.26 to 1.33 Mg m^{-3} in 2020 and 1.24 to 1.32 Mg m^{-3} in 2021 at harvest stage of rice crop.

Lowering of bulk density in organic manure applied plots along with inorganic fertilizers might be due to higher organic carbon, more pore space and good soil aggregation (Selvi *et al*., 2005) [4]. This result is in accordance with Sheeba and Kumaraswamy (2001) [5] who observed that the decrease in bulk density with increase in organic matter content. Similarly additional quantity of organic matter content delayed the development of hard pan in soil helping into lower down the bulk density. Selvi *et al.* (2005) [4] too noticed reduction in bulk density with application of organics alone or in combination with inorganics.

Water holding capacity

The data presented in the table 1 indicated that there was no significant difference in water holding capacity of soil among all the treatments. Numerically there was a slight increase in water holding capacity of soil in the treatments that received combined application of organics and inorganics. The water holding capacity values ranged from 43.43 to 48.08% in 2020 and 43.87 to 48.91% in 2021 at harvest stage of rice. The increase in WHC was mainly due to decrease in bulk density due to organic manure amended treatments (Talathi *et al.* 2010) [6].

Water holding capacity (WHC) of soil after harvest of rice increased over initial value (42.36%) during both the years of study. The maximum values (48.08% and 47.25% in 2020 and 48.91% and 47.70% in 2021) were recorded in the treatments that received FYM *i.e.*, 100% RDF + 25% N through FYM (T_7) and 75% RDF + 25% N through FYM (T_4) and the minimum values (43.43% in 2020 and 43.87% in 2021) were recorded in control (T_1) that received no fertilizers. Increased water holding capacity could be ascribed to the improvement in structural condition of soil due to the application of FYM with inorganics (Selvi *et al.* 2005) [4].

Porosity

Data pertaining to soil porosity (table 1) indicated that porosity of soil at harvest of rice was not significantly influenced among the treatments. However, an increase in porosity at harvest compared to initial value (40.58%) was observed in INM treatments compared to the other treatments. The soil porosity values ranged from 41.73 to 46.63% in 2020 and 42.28 to 47.36% in 2021 at harvest stage of the crop.

Maximum values (46.63% and 45.21% in 2020 and 47.36% and 45.87% in 2021) were recorded in FYM treated plots which received 100% RDF + 25% N through FYM (T_7) and 75% RDF + 25% N through FYM (T_4) and the minimum values (41.73% in 2020 and 42.28% in 2021) were recorded in T_1 (control) that received no fertilizers. Increase in porosity may be attributed due to decreased bulk density in organic manure applied plots which improved the soil structure and pore size distribution.

Aggregate Stability

On perusal of data presented (table 1), it is evident that there was no significant difference in aggregate stability of soil at harvest stage of the rice crop. However, numerically the mean aggregate stability values ranged from 33.16 to 41.84% in 2020 and 33.54 to 44.56% in 2021 respectively at harvest stage of the rice crop.

Maximum percentage of water stable aggregates (41.84% and 41.17% in 2020 and 44.56% and 43.82% in 2021) were recorded in treatments supplied with FYM *i.e.*,100% RDF + 25% N through FYM (T_7) and 75% RDF + 25% N through FYM (T_4) and the minimum percentage of water stable aggregates (33.16% and 33.54%) were recorded in treatment T_1 (control) which received no fertilizers at harvest stage of rice.

These results were similar to the observations made by Ijaz Ahmad *et al.* (2015) [7]. Yaduvanshi *et al.* (2013) [8] also observed the increase in aggregate stability with addition of FYM. Lowering of bulk density due to increased organic carbon also results in more pore space and hence aggregate stability increases.

Physico-chemical properties

Soil Reaction (pH)

The data on soil reaction (pH) is presented in the table 2 and the results indicated that the application of inorganics alone or in combination with organics (farmyard manure and green leaf manure) did not show any significant effect on pH of the postharvest soil. There was a marginal reduction in pH of soil treated with organics (T_4 to T_9) compared to inorganic fertilizers (T_2 and T_3). The soil pH values ranged from 7.01 to 7.26 and 6.95 to 7.22 during 2020 and 2021, respectively at harvest stage of rice crop.

Close observation of data numerically revealed decrease in pH in all the treatments when compared to control (T_1). Reduction in pH with the application of organics when compared to control might be due to release of organic acids (aminoacids, glycine and humic acid) during the process of decomposition of the organic compounds. Pattanayak *et al.* (2001) [9], Yaduvanshi (2001) [10] and Smiciklas *et al.* (2002) [11] also observed a decrease in soil pH after the use of organic materials. The production of organic acids during mineralization of organic materials by heterotrophs and nitrification by autotrophs would have caused this decrease in soil pH (Sarwar *et al.*, 2009) [12].

After 6 cycles of rice-wheat, Kumar and Singh (2010) [13] observed decrease in soil pH from initial value of 8.5 particularly when green manuring and organic manures were added. The decrease in the soil pH due to the formation of organic and inorganic acids as a result of organic matter decomposition and more CO_2 was formed with increasing the metabolic activity of the root system. The latter played an important role as H^+ pumping which also contributed to the soil pH decrement (Elshouny *et al*., 2008) [14].

Electrical conductivity (EC)

Data pertaining to electrical conductivity (EC) of soil presented in the table 2 and indicated that non-significant influence of treatments on electrical conductivity during two years of study. The soil EC values numerically ranged from 0.39 to 0.55 dS m^{-1} and 0.41 to 0.58 dS m^{-1}, respectively at harvest stage of rice crop.

The treatments that received organics in combination with inorganics decreased EC of soil compared to only inorganic treatments. Minimum values of EC were recorded in control (T_1) that received no fertilizers. The findings were in consonance with the results reported by Sharma *et al.* (2007) [15]. The reduction might be due to solubilising effect of organic acids on various compounds in soil. The decomposition of organic materials released acids or acid forming compounds that reacted with the sparingly soluble salts already present in the soil and either converted them into soluble salts or at least increased their solubility (Sarwar *et al.*, 2009) [12].

Table 1: Effect of integrated nutrient management practices on soil physical properties at harvest stage of rice

Treatments	*Kharif* (2020)				*Kharif* (2021)			
	BD (Mg m^{-3})	WHC (%)	Porosity (%)	Aggregate stability (%)	BD (Mg m^{-3})	WHC (%)	Porosity (%)	Aggregate stability (%)
T_1	1.33	43.43	41.73	33.16	1.32	43.87	42.28	33.54
T_2	1.31	44.48	42.15	34.52	1.30	44.93	42.82	35.16
T_3	1.30	44.83	42.48	34.95	1.29	45.36	43.13	35.43
T_4	1.27	47.25	45.21	41.17	1.25	47.70	45.87	43.82
T_5	1.29	45.43	43.18	37.45	1.28	45.87	43.85	40.73
T_6	1.28	46.62	44.17	39.93	1.27	47.24	44.90	42.44
T_7	1.26	48.08	46.63	41.84	1.24	48.91	47.36	44.56
T_8	1.28	45.76	43.70	38.57	1.27	46.35	44.52	41.68
T_9	1.27	46.91	44.75	40.69	1.25	47.43	45.43	43.38
SEm ±	0.05	1.76	1.90	2.03	0.06	1.84	1.88	1.84
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	7.18	6.81	7.50	9.22	7.62	7.02	7.32	12.92

Table 2: Effect of integrated nutrient management practices on soil physico-chemical properties at harvest stage of rice

Treatments	*Kharif* (2020)		*Kharif* (2021)	
	pH	EC (dS m^{-1})	pH	EC (dS m^{-1})
T_1	7.26	0.39	7.22	0.41
T_2	7.19	0.54	7.13	0.57
T_3	7.22	0.55	7.17	0.58
T_4	7.07	0.48	7.00	0.51
T_5	7.10	0.46	7.04	0.48
T_6	7.09	0.47	7.03	0.50
T_7	7.01	0.52	6.95	0.55
T_8	7.06	0.49	7.02	0.52
T_9	7.04	0.51	6.98	0.54
SEm ±	0.30	0.03	0.30	0.03
CD (P=0.05)	NS	NS	NS	NS
CV (%)	7.33	10.50	7.40	10.64

Residual effect of INM practices on soil physical and physico-chemical properties under sorghum in rice-sorghum cropping system

Physical properties

Bulk Density

Data pertaining to bulk density of soil indicated non-significant influence by application of different INM treatments to preceding rice are presented in tables 3 and 4. Among the main plots, the mean bulk density values ranged from 1.26 to 1.35 Mg m^{-3} in 2020-21 and 1.24 to 1.34 Mg m^{-3} in 2021-22 at harvest stage of sorghum crop.

Integrated use of organics and inorganics to preceding rice crop, resulted in slight decrease in bulk density by succeeding sorghum in *rabi* than the treatments that had received only inorganics. T_1 which received no fertilizers recorded higher bulk density values when compared to all other treatments. Decrease in bulk density might be due to addition of root biomass which led to increase in the organic carbon content of the soil; the increased organic carbon content decreased the bulk density of soil (Puli *et al.*, 2017) [16]. Decrease in bulk density might be due to higher organic carbon content of the soil, more pore space and better soil aggregation (Singh *et al.*, 2006 [17]; Gathala *et al*., 2007) [18].

The mean highest bulk density was recorded in the treatment Control *i.e.*, (1.35 and 1.34 Mg m^{-3}) which received no fertilizers and lowest bulk density was recorded in the treatments receiving FYM *i.e.*, T_7- 100% RDF + 25% N through FYM (1.26 and 1.24 Mg m^{-3}) and T_4- 75% RDF + 25% N through FYM (1.27 and 1.25 Mg m^{-3}) during first and second year of the study, respectively.

Among the sub plots, bulk density decreased with increase in level of fertilizers from Control *i.e.*, S_1 (1.32 and 1.30 Mg m-

3) to S_3 (1.29 and 1.27 Mg m^{-3}) *i.e.*,100% RDF at harvest stage during 2020-21 and 2021-22 but the increase was not at a significant level and the interaction effect was also not significant.

Table 3: Residual effect of INM practices in preceding rice and NPK levels on soil physical properties at harvest stage of sorghum (*Rabi*, 2020-21)

	BD (Mg m^{-3})			Mean	WHC (%)			Mean	Porosity (%)			Mean	Aggregate stability (%)			Mean
	S1	S2	S3		S1	S2	S3		S1	S2	S3		S1	S2	S3	
T_1	1.36	1.35	1.34	1.35	39.73	41.43	42.72	41.29	38.42	39.60	41.28	39.77	30.54	32.16	32.84	31.85
T_2	1.34	1.32	1.31	1.32	40.56	42.43	43.25	42.08	39.07	40.52	42.35	40.65	31.25	33.64	34.17	33.02
T_3	1.34	1.31	1.30	1.32	40.82	42.65	43.90	42.46	39.55	40.64	42.72	40.97	32.72	34.15	34.56	33.81
T_4	1.29	1.27	1.26	1.27	43.64	45.86	46.52	45.34	43.06	43.76	44.73	43.85	37.92	39.18	40.14	39.08
T_5	1.32	1.30	1.29	1.30	41.26	43.31	44.23	42.93	40.63	41.82	43.69	42.05	34.25	36.35	36.73	35.78
T_6	1.31	1.29	1.28	1.29	42.24	44.23	45.19	43.89	41.78	42.48	44.15	42.80	36.42	38.47	39.18	38.02
T_7	1.28	1.26	1.25	1.26	44.36	46.25	47.43	46.01	43.38	44.42	45.54	44.45	37.27	39.54	40.69	39.17
T_8	1.32	1.28	1.29	1.30	41.53	43.92	44.64	43.36	41.16	42.26	44.07	42.50	34.78	36.83	37.85	36.49
T_9	1.3	1.27	1.26	1.28	42.62	44.51	45.76	44.30	42.15	42.86	44.28	43.10	36.94	38.82	39.65	38.47
Mean	1.32	1.30	1.29		41.86	43.84	44.85		41.02	42.04	43.65		34.68	36.57	37.31	
	SEm+	CD (p=0.05)	CV (%)		SEm+	CD (p=0.05)	CV (%)		SEm+	CD (p=0.05)	CV (%)		SEm+	CD (p=0.05)	CV (%)	
M	0.036	NS	7.51		1.55	NS	10.92		1.49	NS	10.61		1.73	NS	13.35	
S	0.015	NS	6.18		0.96	NS	9.68		0.75	NS	9.16		0.84	NS	11.05	
M X S	0.320	NS			2.16	NS			2.24	NS			2.52	NS		
S X M	0.348	NS			2.33	NS			2.11	NS			2.39	NS		

Table 4: Residual effect of INM practices in preceding rice and NPK levels on soil physical properties at harvest stage of sorghum (*Rabi*, 2021-22)

	BD (Mg m^{-3})			Mean	WHC (%)			Mean	Porosity (%)			Mean	Aggregate stability (%)			Mean
	S1	S2	S3		S1	S2	S3		S1	S2	S3		S1	S2	S3	
T_1	1.35	1.34	1.33	1.34	39.95	41.76	42.95	41.55	38.78	39.87	41.64	40.10	30.85	32.65	33.16	32.22
T_2	1.33	1.31	1.30	1.31	40.94	42.78	43.47	42.40	39.41	40.75	42.62	40.93	31.54	33.96	34.54	33.35
T_3	1.33	1.30	1.29	1.31	41.17	42.86	44.12	42.72	39.86	41.08	42.54	41.16	33.24	34.46	35.02	34.24
T_4	1.27	1.25	1.23	1.25	43.93	46.32	46.87	45.71	43.52	44.36	45.68	44.52	39.26	42.28	42.85	41.46
T_5	1.31	1.28	1.27	1.29	42.02	44.06	45.15	43.74	41.06	42.35	44.17	42.53	36.48	38.82	39.47	38.26
T_6	1.29	1.27	1.26	1.27	42.85	44.73	45.64	44.41	42.19	42.94	44.42	43.18	38.27	40.57	41.32	40.05
T_7	1.26	1.24	1.22	1.24	44.82	46.67	47.96	46.48	43.74	45.18	46.32	45.08	39.63	42.86	43.45	41.98
T_8	1.30	1.28	1.27	1.28	42.36	44.44	45.51	44.10	41.43	42.66	44.53	42.87	36.98	39.55	40.74	39.09
T_9	1.27	1.25	1.24	1.25	43.55	45.15	46.24	44.98	42.67	43.45	44.86	43.66	38.54	41.64	42.43	40.87
Mean	1.30	1.28	1.27		42.40	44.31	45.32		41.41	42.52	44.09		36.09	38.53	39.22	
	SEm+	CD (p=0.05)	CV (%)		SEm+	CD (p=0.05)	CV (%)		SEm+	CD (p=0.05)	CV (%)		SEm+	CD (p=0.05)	CV (%)	
M	0.036	NS	7.51		1.55	NS	10.86		1.49	NS	10.61		1.73	NS	12.77	
S	0.015	NS	6.18		0.94	NS	11.40		0.75	NS	9.16		0.84	NS	10.56	
M X S	0.320	NS			2.25	NS			2.24	NS			2.52	NS		
S X M	0.348	NS			2.62	NS			2.11	NS			2.39	NS		

Water holding capacity

The data presented in tables 3 and 4 indicated that, different nutrient management practices applied in *kharif* have not shown significant residual effect on water holding capacity of soil at harvest stage of sorghum crop and during both the years of study.

Combined application of organics along with inorganics in rice resulted in slight increase in water holding capacity of soil over control under sorghum when compared to all other treatments. The highest mean WHC values was recorded in the treatments receiving FYM *i.e.*, T_7- 100% RDF + 25% N through FYM (46.01% and 46.48%) and 75% RDF + 25% N through FYM (45.34% and 45.71%) and lowest was recorded in control (T_1- 41.29% and 41.55%) during first and second year of the study, respectively. The increase in WHC of soil after harvest of sorghum in treatments those received organic manures to preceding rice crop was evidently due to residual effect of organic sources. Sarwad *et al*. (2005) [19] observed significant reduction in bulk density and improved infiltration rate and WHC of the soil with the incorporation of green manure crop in a *rabi* sorghum-chickpea cropping sequence.

Irrespective of the treatments applied to preceding rice, the WHC of soil under succeeding sorghum increased with increasing level of NPK from S_1 *i.e.*, Control (41.86 and 42.40%) to S_3 *i.e.*,100% RDF (44.85% and 45.32%) during 2020-21 and 2021-22 but not at significant level. The results were in accordance with Puli *et al.* (2017) [17]. The interaction effect was found statistically not significant.

Porosity

Close perusal of data pertaining to porosity (Tables 3 and 4) of soil indicated that various INM treatments imposed during *kharif* did not show any significant influence on porosity of postharvest soil under sorghum during both the years of experimentation. Among the main plots, the mean porosity values ranged from 39.77% to 44.45% in 2020-21 and 40.10% to 45.08% in 2021-22 at harvest stage of sorghum crop.

However, application of FYM and green leaf manure along with inorganics in rice resulted in slight increase in porosity over control under sorghum when compared to all other treatments at harvest stage. T_1 (control) which received no fertilizers recorded in preceding rice crop recorded lower porosity values when compared to all other treatments.

Irrespective of the treatments applied to preceding rice, the porosity of soil under succeeding sorghum increased with increasing level of NPK from Control (S_1) to 100% RDF (S_3) during 2020-21 and 2021-22 but not at significant level. The interaction between nutrient management treatments and levels of RDF was not significant.

Aggregate stability

The data presented in tables 3 and 4 indicated that, different nutrient management practices applied in *kharif* have not shown significant residual effect on Aggregate stability at harvest stage of sorghum crop and during both the years of study.

Among the main plots, combined application of organics and inorganics in rice resulted in increase in Aggregate stability of soil over control under sorghum when compared to all other treatments. The highest percentage of Aggregate stability was recorded in the treatments receiving FYM *i.e.,*100% RDF + 25% N through FYM (39.17% and 41.98%) and 75% RDF + 25% N through FYM (39.08 and 41.46%) and the lowest percentage of Aggregate stability was recorded in Control *i.e.,* S_1 (31.85% and 32.22%) during first and second year of the study, respectively. This result is in accordance with Sandeepsingh and Jagpal Singh (2012) [20] who revealed that increase in the proportion of water stable macroaggregates (>2mm) due to FYM + inorganic fertilizer application which could be attributed to the input of additional organic residues and available C to the soils and increase in electrical conductivity as compared to inorganic fertilizer application alone and unfertilized control. The secretion of mucilaginous substances released from the applied FYM binds some of the microaggregates thereby enhancing the proportion of macroaggregates.

Irrespective of the treatments applied to preceding rice, the Aggregate stability of soil under succeeding sorghum increased with increasing level of NPK from Control (*i.e.,* S_1- 34.68% and 36.09%) to 100% RDF (*i.e.,* S_3- 37.31 and 39.22%) during 2020-21 and 2021-22 but not at significant level. The interaction effect was found statistically not significant.

Physico-chemical properties

Soil Reaction (pH)

Close perusal of data pertaining to soil reaction (pH) indicated that various INM treatments imposed during *kharif* did not show any significant influence on pH of postharvest soil under sorghum during both the years of experimentation (Table 5). Among the main plots, the mean pH values ranged from 6.98 to 7.28 in 2020-21 and 6.96 to 7.26 in 2021-22 at harvest stage of sorghum crop.

Integrated use of organics and inorganics to preceding rice crop, resulted in more reduction in pH by succeeding sorghum in *rabi* than the treatments that had not received organics and control (T_1). This could be due to the release of organic acids during the process of decomposition of the organic compounds. However, application of farmyard manure and green leaf manure along with inorganics in rice resulted in more reduction in pH over control under sorghum when compared to all other treatments at harvest stage of sorghum. T_1 which received no fertilizers recorded more pH values when compared to all other treatments.

Irrespective of the treatments applied to preceding rice, the soil pH under succeeding sorghum decreased with increasing level of NPK from Control (S_1) to 100% RDF (S_3) during both the years of study but not at significant level. The results were in accordance with Puli *et al.* (2017) [16]. Prasad *et al*. (2010) [21] also reported decrease in pH at harvest of maize crop due to continuous use of urea. The interaction between main plots and subplots was found non-significant.

Electrical Conductivity (EC)

Data pertaining to electrical conductivity (EC) of soil indicated nonsignificant influence by application of different INM treatments to preceding rice are presented in table 5. Among the main plots, the mean EC values ranged from 0.39 to 0.53 dS m^{-1} in 2020-21 and 0.43 to 0.56 dS m^{-1} in 2021-22 at harvest stage of sorghum crop.

Among all the treatments, the treatments that received organics in combination with inorganics in rice decreased the EC of the soil under sorghum compared to only inorganic treatments. Minimum EC values were recorded in control (T_1) during both the years of experimentation. Combined application of organics and inorganics reduced the EC of soil over complete inorganic treatments. Reduction of EC might be due to leaching of salts by the organic acids released by the organic sources (Sarwar *et al.*, 2008 [22] and Sankaramoorthy *et al.*, 2017) [23]. The findings were in consonance with the results reported by Sharma *et al.* (2007) [15].

Among the sub plots, EC increased with increase in level of fertilizer from Control (S_1) to 100% RDF (S_3) but the increase was not at a significant level and the interaction effect was also not significant.

Mairan *et al.* (2005) [24] concluded that there was decline in values of soil electrical conductivity of vertisol with crop residue incorporation over fertilizer application in long-term fertilizer experiment with sorghum-sunflower sequence. Khusbhoo *et al.*, 2016 [25] also recorded similar results *i.e*., the lowest EC values were reported in maize-wheat-greengram cropping system. It might be attributed that more organic matter provided by these crops which decreased the bulk density, an enhancement of soil porosity, aeration and permeability of soil thereby reducing soil salinity and reduced the EC values (Rathod *et al.*, 2003) [26].

Table 5: Residual effect of INM practices in preceding rice and NPK levels on soil physico-chemical properties at harvest stage of sorghum (*Rabi*, 2020-21 and 2021-22)

	***Rabi* (2020-21)**								***Rabi* (2021-22)**							
	pH			**Mean**	**EC (dS m^{-1})**				**pH**				**EC (dS m^{-1})**			**Mean**
	S1	**S2**	**S3**		**S1**	**S2**	**S3**		**S1**	**S2**	**S3**		**S1**	**S2**	**S3**	
T_1	7.31	7.29	7.24	7.28	0.36	0.39	0.41	0.39	7.28	7.27	7.22	7.26	0.41	0.43	0.44	0.43
T_2	7.23	7.17	7.13	7.18	0.53	0.55	0.58	0.55	7.21	7.15	7.12	7.16	0.54	0.57	0.59	0.57
T_3	7.26	7.20	7.16	7.21	0.54	0.57	0.59	0.57	7.23	7.18	7.14	7.18	0.56	0.59	0.61	0.59
T_4	7.12	7.05	6.99	7.05	0.45	0.48	0.50	0.48	7.09	7.03	6.96	7.03	0.47	0.51	0.54	0.51
T_5	7.16	7.08	7.03	7.09	0.42	0.45	0.48	0.45	7.13	7.07	7.01	7.07	0.44	0.48	0.51	0.48
T_6	7.14	7.07	7.01	7.07	0.43	0.46	0.49	0.46	7.11	7.05	6.98	7.05	0.45	0.49	0.52	0.49
T_7	7.06	6.97	6.90	6.98	0.50	0.53	0.55	0.53	7.04	6.95	6.88	6.96	0.52	0.56	0.59	0.56
T_8	7.11	7.02	6.96	7.03	0.48	0.50	0.53	0.50	7.08	6.99	6.94	7.00	0.50	0.54	0.56	0.53
T_9	7.17	7.08	6.94	7.01	0.49	0.51	0.54	0.51	7.07	6.97	6.91	6.98	0.51	0.53	0.57	0.54
Mean	7.17	7.10	7.04		0.47	0.49	0.52		7.14	7.07	7.02		0.49	0.52	0.55	
	SEm+	CD (p=0.05)	CV (%)		SEm+	CD (p=0.05)	CV (%)		SEm+	CD (p=0.05)	CV (%)		SEm+	CD (p=0.05)	CV (%)	
M	0.16	NS	6.90		0.038	NS	13.35		0.17	NS	7.27		0.038	NS	14.21	
S	0.12	NS	8.73		0.016	NS	11.93		0.12	NS	9.12		0.016	NS	12.64	
M X S	0.36	NS			0.040	NS			0.37	NS			0.051	NS		
S X M	0.31	NS			0.037	NS			0.33	NS			0.047	NS		

Conclusion

Integrated use of organics, inorganics and their combination did not show any marked difference in physical (water holding capacity, bulk density, porosity, Aggregate stability) and physico-chemical (pH, EC) properties of soil at harvest stage of rice and sorghum but they improve soil properties (physical and physico-chemical) over initial but the effect was not statistically significant during both the years of experimentation. Irrespective of the nutrient management practices adopted in preceding rice, the soil physical and physico-chemical properties under succeeding sorghum improved with increasing level of NPK from Control (S_1) to 100% RDF (S_3) during both the years of study but not at significant level.

References

1. Mishra JS, Subbarayudu B, Chapke RR, Seetharama N. Evaluation of Sorghum (*Sorghum bicolor*) cultivars in rice (*Oryza sativa*) fallows under zero tillage. Indian Journal of Agricultural Sciences. 2011;81(3):277-279.
2. Balasubramanian V, Hill JE. Direct seeding of rice in Asia: emerging issues and strategic research needs for the 21st century. International Rice Research Institute, Los Banos, Philippines, 2002, 15-42.
3. Mahajan G, Timsina J. Effect of nitrogen rates and weed control methods on weeds abundance and yield of direct-seeded rice. Archives of Agronomy and Soil Science. 2011;57:239-250.
4. Selvi D, Santhy P, Dakshinamoorthy M. Effect of inorganics alone and in combination with FYM on physical properties and productivity of Vertic Haplustepts under long-term fertilization. Journal of the Indian Society of Soil Science. 2005;53(3):302-307.
5. Sheeba S, Chellamuthu S. Effect of continuous cropping and fertilizer use on structural properties of *Vertic Ustropept* soil. Journal of Soils and Crops. 2002;12(1):17-21.
6. Talathi MS, Pinjari SS, Ranshur NJ, Bhondave TS, Suryawanshi JS. Integrated nutrient management in rice-maize crop sequence. International journal of agricultural sciences. 2009;5(2):563-567.
7. Ijaz Ahmad, Safdar Ali, Khalid Saifullah Khan, Fayyaz-Ulhassan, Kashif Bashir. Use of coal derived humic acid as soil conditioner to improve soil physical properties and wheat yield. International Journal of Plant and Soil Science. 2015;5(5):268-275.
8. Yaduvanshi NPS, Shrama 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):188-194.
9. Pattanayak SK, Mishra KN, Jena MK, Nayak RK. Evaluation of greenmanure crops fertilized with various phosphorus sources and their effect on subsequent rice crop. Journal of the Indian Society of Soil Science. 2001;49(2):285-291.
10. Yaduvanshi NPS. Effect of five years of rice-wheat cropping and NPK fertilizers use with and without organic and green manures on soil properties and crop yields in a reclaimed sodic soil. Journal of the Indian Society of Soil Science. 2001;49(4):714-719.
11. Smiciklas KD, Walker PM, Kelley TR. Utilization of compost (food, paper, landscape and manure) in row crop production. Department of Agriculture and Health Sciences, Illinois State University, USA, 2002.
12. Sarwar G, Schmeisky H, Hussain N, Muhammad S, Ibrahim M, Safdar E. Improvement of soil physical and chemical properties with compost application in rice-wheat cropping system. Pakistan Journal of Botany. 2009;40(1):275-282.
13. Kumar V, Singh AP. Long-term effect of green manuring and farm yard manure on yield and soil fertility status in rice-wheat cropping system. Journal of the Indian Society of Soil Science. 2010;58(4):409-412.
14. ElShouny MM, El-Shikha SA, El-Warth A. Impact of farm yard manure and some mineral fertilizers on some soil properties and its productivity of wheat. Journal of Agricultural Research. 2008;33(5):1249-1267.
15. Sharma M, Mishra B, Singh R. Long-term effect of fertilizers and manure on physical and chemical properties of Mollisol. Journal of the Indian Society of Soil Science. 2007;55(4):523-524.
16. Puli MR, Prasad PRK, Babu PR, Rao KLN, Subbaiah G, Jayalakshmi M. Residual Effect of Different Organics on Physico-Chemical Properties of Soil After Harvest of Maize in Rice Fallow Maize Cropping System. Trends in

Biosciences. 2017;10(44):9083-9086.
17. Singh RP, Yadav PK, Singh RK, Singh SN, Bisen MK, Singh J. Effect of chemical fertilizer, fym and biofertilizer on performance of rice and soil properties. Crop Research. 2006;32(3):283-285.
18. Gathala MK, Kanthaliya PC, Arvind V, Chahar MS. Effect of integrated nutrient management on soil properties and humus fractions in the long-term fertilizer experiments. Journal of Indian Society of Soil Science. 2007;55(3):360-363.
19. Sarwad IM, Guled MB, Gundlur SS. Influence of integrated nutrient supply system for rabi sorghum chickpea crop rotation on crop yields and soil properties. Karnataka Journal of Agricultural Sciences. 2005;18(3):673-679.
20. Sandeep singh, Jagpal singh. Effect of organic and inorganic nutrient sources on some properties and wheat yield. Journal of the Indian Society of Soil Science. 2012;60(3):237-240.
21. Prasad J, Karamkar 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):200-204.
22. Sarwar G, Hussain N, Schmeisky H, Suhammad S, Ibrahim M, Ahmad S. Efficiency of various organic residues for enhancing rice-wheat production under normal soil conditions. Pakistan Journal of Botany. 2008;40(5):2107-2113.
23. Sankaramoorthy, Alagappan, Venkitaswamy, Mariappan G. Impact of different sources of organic manures on soil physico-chemical properties, nutrient balance and yield of rice-greengram cropping sequence under organic farming. Agriculture update. 2017;12(7):2044-2066.
24. Mairan NR, Patil SG, Kachhave KG. Physico-chemical properties under sorghum-sunflower cropping sequence in Vertisols. Journal of Soils Crops. 2005;15(2):352-355.
25. Khusbhoo S, Jat HS, Meena MD, Madhu C, Mishra AK, Chaudhari SK. Long term impact of different cropping systems on soil quality under silty loam soils of Indo-Gangetic plains of India. Journal of Applied and Natural Science. 2016;8(2):584-587.
26. Rathod VE, Sagare BN, Ravankar HN, Sarap PA, Hadole SS. Efficacy of amendments for improvement in soil properties and yield of cotton grown in sodic vertisols of vidarbha using alkali water. Journal of soils and crops. 2003;13:176-178.