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Soil physical and Physico- Chemical Properties as Influenced by Integrated Nutrient Management Practices in Maize-Maize Cropping System

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ABSTRACT

A field experiment was conducted to evaluate the integrated use of organic and inorganic source of nutrients on soil physical and physico-chemical properties in maize-maize cropping system during *kharif* and *rabi* seasons of 2008 and 2009 at the irrigated upland farm of Tamil Nadu Agricultural University, Coimbatore. The experiment was laid out in randomized block design with three replications and ten treatments. The results revealed that application of 100 per cent RDF through poultry manure markedly improved the soil physical properties i.e., reduced the bulk density, increased the pore space, hydraulic conductivity, water aggregate stability and water holding capacity. Physico-chemical properties were improved *i.e.,* reduction in soil pH, EC and considerable built up in soil organic carbon content at the end of two year cropping sequence.

Key words: *Integrated nutrient management, Maize, Soil physical properties*

The soil physical properties play an important role in determining its suitability for crop production. Maintenance and improvement of soil quality in continuous cropping system is critical to sustain agricultural productivity and environmental quality for future generations (Reeves, 1998). Maize (*Zea mays L.*) is one of the most important cereal crop grown all over the globe as poor man's food and also as cattle and poultry feed. With the intention of achieving evergreen revolution, intensive research in maize has been started anticipating its importance for food and feed. It is well known that maize is an exhaustive crop and responds well to applied fertilizers. Though the continuous use of fertilizers had significantly improved the crop productivity, heavy fertilizer application on the same plot every year in continuous maize system will drain the soil fertility rapidly, reducing the available water content and water aggregate stability etc. The success of future agriculture depends upon sustainability of production systems. This has necessiated research on use of organic manures. It helps farmers to reduce inputs of commercial fertilizers, thereby increasing profit margin. But, the use of organic manure alone, cannot sustain the cropping system due to unavailability of required quantities and their relatively low nutrient content (Palm *et al,* 1997).

Thus, it has been realized that application of chemical fertilizers in conjunction with organic manures and bio fertilizers will sustain and maintain the productivity of soil. Therefore, it is necessary to compare various organic as well as biological sources of nutrients with chemical fertilizers in order to find out the most effective combination.

MATERIAL AND METHODS

Field experiments were conducted during *kharif* and *rabi* seasons of 2008 and 2009 at the irrigated upland farm of Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. The soil of the experimental field was sandy clay loam in texture, alkaline in reaction (pH 8.5), low in organic carbon (0.39%), E.C (0.50 dS m^{-1}). A composite soil sample was drawn from 0-30 cm depth of the experimental field initially and analyzed for physico-chemical properties. The results of the analysis revealed that the soil was sandy clay loam in texture, belonging to *Typic Ustropept*. Soil bulk density (1.44Mg m-3), Water holding capacity (42.00%), Hydraulic conductivity (2.50 cm hr^{-1}), Total porosity (45.90 m^3 100 m^{-3}), Aggregate stability (59.00%) Soil samples were drawn plot wise, immediately after harvest of each of the crop to assess soil fertility dynamics. The experiment was laid out in randomized block design, replicated thrice and the same layout was maintained during both the years of study. The experiment consisted of ten treatments comprising four treatments of different organic manures and their combinations *viz.*,100 per cent RDF through FYM, vermicompost and poultry manure and all the manures at 1/3, 1/3, 1/3 proportion. Four treatments were integrated i.e., 50 per cent RDF through organic manures and 50 per cent RDF through inorganic fertilizers. The remaining two treatments were 100 per cent RDF through inorganic fertilizers and control (without organics and inorganics).

Based on the equal N basis, required quantities of organic manures were incorporated into the soil ten days before sowing (Table 1). The applied manures also satisfied the P and K requirement of maize. Seed treatment was done with biofertilizers *viz., azospirillum* and *pseudomonas* to all the treatments except 100 per cent RDF through inorganic fertilizers treatment and control. All the organic and integrated treatments were sprayed with *panchagavya* at regular intervals. The recommended dose of fertilizer for maize is 150-75-75 kg N,P_2O_5,K_2O ha^{-1}. Fertilizer dose was calculated as per the treatment using Urea, Super Phosphate and Muriate of Potash. The treatments were imposed on test cultivar of maize CoH (M) 5. The data recorded on various parameters during the course of investigation and the summed up data were statistically analysed following the analysis of variance for randomized block design as suggested by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Soil physical properties

Bulk density

The bulk density of the soil was not significantly influenced by nutrient management practices. However, comparatively lower values of bulk density were recorded with 100 per cent RDF through poultry manure (T_5) and 100 per cent RDF through vermicompost (T_4) (Table 2). The higher bulk density was noticed in control plot (T_1). The reduction in bulk density in the first year is marginal and it was comparatively higher during the second year.

During *kharif* 2009, lower bulk densities were observed in 100 per cent RDF through poultry manure (T_5) and 100 per cent RDF through FYM (T_3), whereas in *rabi* season 2009, reduction in bulk density was observed in 100 per cent RDF through FYM (T_3) and 100 per cent RDF through poultry manure (T_5) which were closely related to 100 per cent RDF through vermicompost (T_4) (Table 3). Higher bulk density was observed in 100 per cent RDF (T_2) but it was lower than control treatment (T_1). It is due to poultry manure, which had long-term effects on soil physical properties and maintained a basic level of stability and physically prevented the close packing of the soil and thus decreased the bulk density and increased porosity as observed by Agbede *et al.* (2008).

Total porespace

The effect of nutrient management practices on total porespace was not significant in all the seasons. However, total porespace under the 100 per cent RDF through poultry manure (T_5) was higher followed by 100% RDF through vermicompost and 100 per cent RDF through FYM (T_3) during *kharif* and *rabi* seasons of 2008, whereas in *kharif* 2009, the 100% RDF through poultry manure (T_5) recorded the higher porespace followed by 100% RDF through FYM (T_3). During *rabi* 2009, 100% FYM (T_3) recorded higher pore space and the next best treatment was 100 per cent RDF through poultry manure followed by 100 per cent RDF through vermicompost (T_4). The 100 per cent recommended dose of fertilizer (T_2) and control plot (T_1) recorded the lower pore space per cent.

Hydraulic conductivity

Nutrient management practices did not influence significantly the hydraulic conductivity in all the seasons. Marginally higher values were recorded with 100 per cent RDF through poultry manure (T_5) (2.62 cm hr^{-1}) followed by 100 per cent RDF through vermicompost (T_4) and 100 per cent RDF through FYM (T_3) during *kharif* and *rabi* seasons of 2008. During *kharif* and *rabi* seasons of 2009, higher hydraulic conductivity (2.68 cm hr^{1} and 2.72 cm hr^{-1}) were recorded with 100 per cent RDF through poultry manure followed by 100 per cent RDF through vermicompost and 100 per cent RDF through 1/3 FYM, 1/3VC, 1/3PM (T_6). Addition of poultry manure increased the

Table 1. Nitrogen content of organic manures on dry weight basis.

S.No.	Organic manures	Nitogen (%)		Quantity on fresh weight basis (t ha^{-1}) added to supply recommended Nitrogen for maize(150 kg ha^{-1})	
		2008	2009	2008	2009
1.	FYM	0.60	0.50	25.00	30.00
2.	Vermicompost	1.74	1.81	8.62	8.28
3.	Poultry manure	2.74	2.27	5.47	6.60

Table 2. Effect of integrated nutrient management practices on soil physical properties -2008.

Treatments	Bulk density (Mgm^{-3})		Total porespace(%)		Hydraulic conductivity (cmhr^{-1})		Water aggregate Stability (%)		Water holding capacity(%)	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	1.44	1.44	45.90	45.70	2.48	2.46	59.02	58.70	42.00	39.50
T_2	1.43	1.42	46.12	47.25	2.51	2.51	63.41	63.32	44.00	43.52
T_3	1.41	1.39	48.13	49.00	2.59	2.62	64.85	65.01	46.75	48.50
T_4	1.40	1.38	48.65	49.00	2.60	2.63	65.73	68.00	46.50	48.26
T_5	1.39	1.38	48.93	50.20	2.62	2.65	66.44	68.20	48.00	49.20
T_6	1.40	1.39	47.84	49.25	2.61	2.64	64.33	65.10	46.75	47.25
T_7	1.41	1.40	46.70	47.50	2.58	2.63	64.55	66.00	47.00	47.50
T_8	1.42	1.40	46.73	48.90	2.60	2.62	65.28	67.50	47.00	47.00
T_9	1.41	1.39	46.85	48.00	2.61	2.63	65.47	68.00	47.50	48.00
T_{10}	1.42	1.39	46.66	47.50	2.59	2.62	65.08	65.90	46.00	46.75
SEd	0.08	0.07	2.88	2.91	0.15	0.15	3.94	4.00	0.31	0.32
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Effect of integrated nutrient management practices on soil physical properties -2009.

Treatments	Bulk density (Mgm^{-3})		Total porespace(%)		Hydraulic conductivity (cmhr^{-1})		Water aggregate Stability (%)		Water holding capacity(%)	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	1.43	1.44	45.25	43.50	2.40	2.35	62.05	53.56	38.00	36.75
T_2	1.40	1.39	47.50	47.00	2.58	2.50	64.51	64.30	43.00	41.50
T_3	1.35	1.33	51.82	53.00	2.66	2.69	68.03	69.20	48.00	48.50
T_4	1.37	1.34	51.86	52.50	2.67	2.71	69.59	71.50	48.50	49.00
T_5	1.35	1.33	52.23	52.82	2.69	2.72	70.77	72.00	49.25	50.00
T_6	1.36	1.35	50.65	51.50	2.66	2.70	68.23	70.00	47.50	49.00
T_7	1.37	1.36	49.73	50.00	2.66	2.71	67.45	69.70	47.00	47.25
T_8	1.36	1.35	49.48	50.75	2.67	2.70	68.00	71.40	47.50	48.00
T_9	1.36	1.34	51.29	52.00	2.68	2.71	69.12	71.20	48.00	48.50
T_{10}	1.37	1.35	50.48	51.50	2.66	2.69	67.91	69.10	47.75	48.25
SEd	0.08	0.08	3.02	3.04	0.16	0.16	4.13	4.17	0.41	0.47
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

hydraulic conductivity of the soil by modifying soil structure, proportion of macropores and aggregate stability. At the end of the second year, the increase in hydraulic conductivity is 8.8 per cent from the initial level.

Water aggregate stability

Nutrient management practices did not have any significant effect on water aggregates in all the seasons. Higher values (66.44% and 68.20 %) were recorded with 100 per cent RDF through poultry manure followed by 100 per cent RDF through vermicompost and 50 per cent RDF + 50 per cent RDF through poultry manure (T_9) during *kharif* and *rabi* seasons of 2008.

In *kharif* and *rabi* seasons of 2009 also this trend was unaltered and 100 per cent RDF through poultry manure (T_5) recorded the higher water stable aggregates (70.77% and 72.00%) followed by 100 percent RDF through vermicompost and 50 per cent RDF + 50 per cent RDF through poultry manure (T_9). Lower values of water aggregate stability was recorded with control. increased the proportion of water stable aggregates and their mean diameter as reported by Mullins *et al*. (2002). Continuous addition of poultry manure alone or in combination with inorganic fertilizers stimulated the root growth and hence increased the population of microorganisms in the soil which in turn improved aggregate formation mainly by stabilization of microaggregates against disruption by organo-mineral complexes and polysaccharides. (Haynes and Beare, 1996).

Water holding capacity

During *kharif* and *rabi* seasons of 2008, improvement in water holding capacity (48.00 %) was observed with 100 per cent RDF through poultry manure (T_5). Application of 100 per cent RDF through vermicompost(T_4) and 100 per cent RDF through FYM (T_3) which did not differ significantly with each other in influencing water holding capacity during both the seasons.

During 2009 *kharif* and *rabi* seasons, 100 per cent RDF through poultry manure (T_5) was superior in recording higher water holding capacity (49.25%) and it was followed by 100 percent FYM treated plot and 100 per cent RDF through 1/3 FYM + 1/3 VC + 1/3 PM (T_6). Least water holding capacity was observed in control treatment (T_1). Organic matter is an important determinant of water holding capacity of soil. The increase in water retention is not due to organic matter itself but its effect on aggregation and aggregate size distribution (Darwish *et al*., 1995).

Soil physico - chemical properties

Soil pH

The soil pH values duing *kharif* and *rabi* seasons of 2008 were significantly influenced by the different nutrient management practices and the soil pH varies from 8.40 to 8.20 and 8.40 to 8.14. (Table 4). Application of 100 percent poultry manure (T_5) has shown lesser soil pH of 8.20 during *kharif* season and 8.14 during *rabi* season and it was closely followed by 100 per cent RDF through FYM (T_3) and 100 per cent RDF through vermicompost (T_4).During *kharif* and *rabi* seasons of 2009, soil pH followed the same trend as that was observed during 2008. Application of 100 per cent poultry manure (T_5) recorded the lower soil pH (8.10 and 7.90) followed by 100 per cent RDF through FYM (T_3) and 100 per cent RDF through vermicompost (T_4) (Table 5).

This could be ascribed to the acidifying effect of various organic acids (amino acid, glycino, cystein and humic acid), acid forming compounds and CO_2 that are released during the decomposition of organic manures (Natarajan, 2007). Among the organic manures, application of 100 per cent RDF through poultry manure to soil greatly reduced the soil pH (Ayoola and Makinde, 2009).

Soil EC

The different nutrient management practices significantly influenced the soil EC during both the years of study. Soil EC was reduced with the application of 100 percent poultry manure (T_5) *i.e* 0.43 and 0.41 during *kharif* and *rabi* seasons of 2008 and 0.40 and 0.36 during 2009 *kharif* and *rabi* seasons. It was closely followed by 100 per cent RDF through vermicompost (T_4) during both the years of study. The reduction in EC is due to leaching of salts by the organic acids released by the organic sources (Anand, 1992).

Soil Organic carbon

Soil organic carbon content was significantly influenced by different nutrient management practices. During *kharif* and *rabi*

Table 4. Effect of integrated nutrient management practices on soil physico - chemical properties -2008.

Treatments	pH		EC(dS m^{-1})		Organic carbon(%)	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	8.40	8.38	0.47	0.46	0.391	0.390
T_2	8.37	8.40	0.46	0.46	0.403	0.400
T_3	8.21	8.16	0.44	0.42	0.413	0.421
T_4	8.23	8.20	0.44	0.43	0.414	0.423
T_5	8.20	8.14	0.43	0.41	0.417	0.424
T_6	8.21	8.18	0.45	0.43	0.413	0.420
T_7	8.24	8.19	0.44	0.43	0.411	0.418
T_8	8.27	8.23	0.45	0.44	0.412	0.419
T_9	8.23	8.20	0.44	0.43	0.414	0.420
T_{10}	8.25	8.22	0.45	0.44	0.410	0.419
SEd	0.01	0.01	0.01	0.01	0.001	0.002
CD(P=0.05)	0.03	0.03	0.02	0.02	0.003	0.004

Table 5. Effect of integrated nutrient management practices on soil physico - chemical properties -2009.

Treatments	pH		EC(dS m^{-1})		Organic carbon(%)	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	8.49	8.48	0.44	0.43	0.386	0.385
T_2	8.48	8.47	0.45	0.44	0.402	0.400
T_3	8.12	8.00	0.41	0.38	0.422	0.430
T_4	8.16	8.10	0.40	0.37	0.424	0.431
T_5	8.10	7.90	0.40	0.36	0.426	0.432
T_6	8.15	8.08	0.41	0.38	0.422	0.426
T_7	8.18	8.12	0.41	0.37	0.421	0.423
T_8	8.19	8.15	0.42	0.40	0.423	0.427
T_9	8.17	8.14	0.42	0.39	0.424	0.430
T_{10}	8.20	8.15	0.42	040	0.422	0.426
SEd	0.02	0.02	0.01	0.01	0.002	0.002
CD(P=0.05)	0.04	0.04	0.02	0.02	0.004	0.005

seasons of 2008, the highest status of post harvest soil organic carbon of maize was recorded with the application of 100 per cent poultry manure (T_5) (0.417 and 0.424) which was on par with 50 per cent RDF + 50 per cent RDF through poultry manure (T_9) and 100 per cent RDF through vermicompost (T_4). (Table 4). The next best treatment was 100 per cent RDF through 1/3 FYM + 1/3 VC + 1/3 PM (T_6). The control treatment (T_1) recorded the least soil organic carbon content of 0.391 and 0.390 during *kharif* and *rabi* seasons, respectively.

During *kharif* season of 2009, the same trend was continued *i.e.* application of 100 per cent poultry manure (T_5) recorded significantly higher organic carbon content of 0.426 which was however comparable with 50 per cent RDF + 50 per cent RDF through poultry manure (T_9) and 100 per cent RDF through vermicompost (T_4) (Table 5). During *rabi* season also, T_5 treatment *i.e.* 100 percent poultry manure proved its superiority and recorded 0.432 per cent of organic carbon and it was on par with 100 per cent RDF through vermicompost (T_4).

The lowest status of post harvest soil organic carbon (0.386 and 0.384 during *kharif* and *rabi* seasons of 2009) was recorded with unmanured plot. Among the manures, application of 100 per cent RDF through poultry manure significantly increased the organic carbon content of the soil across the cropping season. At the end of the second year, the increase in organic carbon content compared to the initial value was 4.2 per cent with the application of 100 per cent RDF through poultry manure (T_5) and it is comparable to application of poultry manure in combination with 50 per cent RDF as inorganic fertilizers (T_9). Gradual build up of organic carbon in the soil is due to the influence of sources of nutrients on the addition of root biomass and other organic residues left after the harvest of each season crop. Since, the maize root carbon to soil organic carbon per cent was 1.5 times higher (Balubane, 1996).

Conclusion

Application of organic manures improved the soil physical properties at the end of two year cropping cycle compared to initial status. However, the difference between the treatments within a season was too small to exert significant difference. Among the manures, application of 100 per cent RDF through poultry manure reduced the bulk density, increased the pore space, hydraulic conductivity, water holding capacity and water aggregate stability of the soil. Maximum reduction in soil pH and EC was found in 100 per cent poultry manure applied plots. Gradual build up in soil organic carbon content was recorded with the addition of organic manures either alone or integrated with inorganic fertilizers, at the end of the two year cropping cycle compared to pre-experimental status.

LITERATURE CITED

Agbede T M, S O Ojeniyi and A J Adeyemo 2008 Effect of poultry manure on soil physical and chemical properties, growth and grain yield of sorghum in Southwest, Nigeria. *American – Eurasian Journal of Sustainable Agricultural,* 2(1): 72-77.

Anand S 1992 Effect of organic amendments on the nutrition and the yield of wetland rice and sodic soil reclamination. *Journal of Indian Society of Soil Science,* 40: 816-822.

Ayoola O T and E A Makinde 2007 Complementary organic and inorganic fertilizer application: Influence on growth and yield of cassava/maize/melon Intercrop with a relayed cowpea. *Austratian Journal of Basic N Applied Sciences.,* 1(3):187-192.

Balubane M 1996 Turnover of clay-associated organic nitrogen in the different aggregate size classes of cultivated silty loam. *Euripian Journal of Soil Science,* 47:285-291.

Darwish O H, N Persaud and D C Martens 1995 Effect of long-term application of animal manure on physical properties of three soils. Plant and Soil, 176: 289-295.

Haynes R J and M H Beare 1996 Aggregation and organic matter storage in mesothermal, humid soils. In: Advances in Soil Science : Structure and organic matter in agricultural soils, (eds) M. Caster and B.A. Stewart, C.R.C. Lewis Press Inc.

Natarajan S K 2007 Influence of organics on soil health and quality under rainfed coastal ecosystems of Tamil Nadu. *Journal of Ecobiol.,* 20(3): 263-268.

Palm C A, R J K Myers, S M Nandwa 1997 Combined use of organic and inorganic nutrition on plant disease resistance and its mechanism. *Plant nutrition and fertilizer Science,* 12(3): 445-450.

Panse V G and PV Sukhatme 1978 Statistical methods for Agricultural workers. Indian Council of Agricultural Research, New Delhi.

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