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Article · August 2022

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Pak. J. Bot., 54(1): DOI: http://dx.doi.org/10.30848/PJB2022-1(34)

INTEGRATED NUTRIENT MANAGEMENT IN BANANA: COMPARATIVE ROLE OF FYM AND COMPOSTED PRESSMUD FOR THE IMPROVEMENT OF SOIL PROPERTIES

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Abstract

Banana crop requires high nutrient supply for optimal production and economic benefits. Low crop yields are due to the low fertility of the soil, which can be improved with the addition of organic and inorganic sources of nutrients. This study evaluated the role of FYM and pressmud in improving the soil properties of the banana field. A field experiment involving the use of organic and inorganic sources of nutrients was laid out in a split-plot design. The organic sources i.e. control, FYM and composted pressmud (CPM), each at 20 t ha^{-1} constituted the major split and mineral fertilizer treatments (full N, N+1/2P, N+3/4P, N+P, N+P+K and 1.25 NP) as sub-split. The fertilizer rates were based on the recommended rates of N, P_2O_5 and K_2O (500-250-500 kg ha^{-1}). Each treatment received a blanket application of $ZnSO_4$ at 10 kg ha^{-1}. Banana (Cv. Dwarf Cavendish) was grown for one cropping cycle. Soil samples were secured from each treatment after the banana harvest and included a composite sample before conducting the experiment. The results showed that the increased fertilizer rates did not increase soil EC, pH, OM, soil macro and micro-nutrients. FYM improved the fertility of surface soil by increasing organic matter (49.2%), Olsen P (45.2%), NH_4OAc-K (3.9%), and DTPA-Cu (16.4%), Fe (61.8%), Mn (17.5%), and Zn (44.5%) over control and was superior over CPM. However, the later requires extended use to establish its beneficial effect on soil properties with particular reference to EC. Banana flourishes well on soils with very low salt content. FYM or CPM, in both cases the values decreased with the increase in soil depth.

Key words: Soil properties, FYM, CPM, Organic matter, Banana crop.

Introduction

Intensive farming and harvesting high crop yields may lead to depletion of soil organic matter and nutrients unless appropriately replenished through manures and fertilizers. The application of chemical fertilizers increases the yield of several crops. However, the system may not sustain for a more extended period without balanced nutrition. This is especially true for heavy feeder crops like banana, which requires a large quantity of plant nutrients in the form of N, P and K fertilizers (Yao *et al*., 2009) and manures. Potassium (K), nitrogen (N), magnesium (Mg), phosphorus (P), followed by zinc (Zn) and manganese (Mn), are most important for optimum yield of banana (Ozbek & Damsman, 1978; Martin- Prevel, 1977). Banana is an important crop of Sindh province of Pakistan where it was grown on 27,000 ha, the average yield being 5.21 t ha^{-1} (Anon., 2018). Various studies on banana have shown the average yield as 26 to 29.3 t ha^{-1} for district Hyderabad, Sindh (Abro *et al*., 2008; Memon *et al*., 2010) against a potential yield of 60-80 t ha^{-1} (Memon *et al*., 2010). Among other things, poor soil fertility with 100% soils deficient in N, 80-90% in P and 25-30% in K (Anon., 2001; Akhtar *et al*., 2003; Rajput *et al*., 2015) and frequently less than 0.5% organic matter (Abbas *et al*., 2012) contribute substantially to lower crop yields. Under the declining nutrient supply capacity of soils, it becomes necessary to properly apply organic and mineral nutrients for sustaining high banana yields. The balanced application of organic and inorganic amendments increases fertilizer efficiency and provides expensive NPK fertilizers (Jan & Noor, 2007). Banana growers commonly use N and P fertilizers, with some using K fertilizers and FYM also. Abro *et al*., (2008) and Memon *et al*., (2010) reported that banana growers of Sindh practiced FYM application between 9-13 t ha^{-1}. Pressmud, another organic source, is rich in NPK (20.0, 13.5 and 9.4 g kg^{-1}), micronutrients and organic matter (Memon *et al*., 2012a) content. It can be used alone or with mineral fertilizers for their beneficial use in an environment-friendly way (Ziauddin, 2009; Ansari and Hazarika, 2009; Jeyabaskaran & Mustaffa, 2010) and the improvement in quality (Bhalerao *et al*., 2009; Rajput *et al*., 2017) of banana. Few research studies related to the effect of organic manures and their combined application with FYM, green manure, and pressmud on the response of banana crop (Ghulam *et al*., 2010; Adriano *et al*., 2012; Vanilarasu and Balarkrishnamurlly, 2014). Balanced fertilizer application is a vital factor to improve banana yield and soil environment under the continuous banana cropping system. Under the combined use of mineral fertilizers and organic amendments, this study was planned to compare the role of FYM and pressmud in improving soil properties under the subtropical environment of Sindh, Pakistan.

Materials and Methods

A field study was carried out at Asim Agriculture Farm, Tando Soomro, Sindh, Pakistan to investigate the comparative role of FYM and CPM for the improvement of soil properties under banana cultivation. The mean annual rainfall during study period was 215 mm, temperature 38^{o}C and soil was alluvial with flat topography. The experiment was designed under split-plot arrangment with organic amendments (control, FYM and CMP at 20 t h^{-1}) as major split. Mineral fertilizer treatments (N (500 kg ha^{-1}), N+1/2P (500+125 kg ha^{-1}), N+3/4P (500+188 kg ha^{-1}), N+P (500+250 kg ha^{-1}), N+P+K (500+250+500 kg ha^{-1}) and

1.25 NP (625+313 kg ha^{-1}) were assigned to sub-split. Application of mineral form of nutrients was based on the recommended rates (i.e. 500:250:500 kg N: P_2O_5:K_2O ha^{-1} yr^{-1}) as given by Bhatti *et al*., (1995) and was continuously applied for 8 months from March to November (except June). Zinc was applied in the form of $ZnSO_4$ at 10 kg ha^{-1} in March. FYM and CPM were incorporated (11 kg $plant^{-1}$) during winter season after the harvest of banana fruit before mineral fertilizer application. Well rotten FYM was collected from local area and prepared CPM from Matiari Sugar Mills, Maitari. The CPM was prepared from sugar industry based pressmud, boiler ash and spentwash with former 10 times more than the later ones.

Composite soil samples representing 0-15, 15-30, 30-45 and 45-60 cm were collected from each treatment and replication before and after one fruiting cycle of banana harvest. Soil samples were air dried, roots and other materials were removed, and passed from 2mm mesh sieve. EC and pH of samples was analysed in 1:2 soil-water extracts. Soil texture (Bouyoucos, 1962), organic matter, and lime (Jackson, 1958) were tested as per details under standard soil test methods. Total N (Bremner, 1965), Olsen P (Olsen *et al*., 1954; Murphy & Riley, 1962), NH_4OAc-K) and DTPA extractable micronutrients i.e., Cu, Fe, Mn and Zn (Lindsay & Norvell, 1978) were determined as per details under Estefan *et al*., (2013). Samples of FYM and CPM were also determined by standard methods (Lindsay & Norvell, 1978: Estefan *et al*., 2013). Statistical analysis of the data was carried out by analysis of variance test using split-plot design. The comparison of means for those significant was performed by least significant difference ($LSD_{0.05}$) test by applying Statistix 8.1 (Anon., 2005).

Results and Discussion

Properties of experimental soil: The soil was generally silty clay loam throughout the profile, except the lower horizon of 60-90 cm soil which was heavy in texture. EC and pH of the surface soil was 0.338 dS m^{-1} and 7.71, respectively. The $CaCO_3$ content depicted calcareousness (11.30%). The surface soil was adequate in Olsen P (12.27 mg kg^{-1}), NH_4OAc-K (163 mg kg^{-1}), Cu (3.88 mg kg^{-1}), Fe (6.59 mg kg^{-1}), and Mn (8.64 mg kg^{-1}) but low in Zn (0.29 mg kg^{-1}) and organic matter content (0.68%). All metioned parameters decreased with the depth of soil as described under Table 1.

Composition of organic amendments: Total N content of both FYM and CPM (2.07 and 2.15 %) was more or less similar but differed in P and K content. Total P (1.30%) and K (1.31%) content of FYM was same, but relatively higher P (1.76%) and lower K (0.83%) content was noted in CPM. In case of micronutrients, Cu, Fe and Zn contents of CPM (79.4, 848 and 48.5 mg kg^{-1}) were higher than that in FYM (40.2, 895 and 46.8 mg kg^{-1}). Total Mn content of FYM (464 mg kg^{-1}) was higher than that in CPM (341 mg kg^{-1}) as given under Table 2. The C:N ratio of FYM was higher (20.82 %) as compared to CPM (15.2 %).

Comparative role of FYM and CPM on soil properties under banana cultivation: Statistical analysis in the form of F values and significance from analysis of variance table for soil properties i.e., EC, pH, organic matter, Kjeldahl's N, Olsen P, NH_4OAc-K and DTPA-Cu, Fe, Mn and Zn at different soil depths have been presented in (Table 3).

EC, pH and organic matter: The data related to EC, pH and organic matter content has been presented in Fig. 1. Electrical conductivity generally increased with the rate of inorganic fertilizer at all soil depths. The EC values increased from 0.53 dS m^{-1} in treatments applied with N to 0.61 dS m^{-1} where either NPK or 1.25 NPK was applied, corresponding to 13.1% increase in surface soil. The lower soil depths experienced 19.7, 14.3 and 12.27% increase in EC values (Fig. 1a). In case of organic amendments, it increased from 0.55 dS m^{-1} in control to 0.61 dS m^{-1} under CPM. While, the values under FYM treatments were lower (0.58 dS m^{-1}) and much less (i.e. 0.40 dS m^{-1}) at lower soil depths (Fig. 1b). The values remained within the non-saline category (< 2 dSm^{-1}) in all treatments after the application of either mineral fertilizer, FYM or even CPM. Fertilizer application did not show any significant increase in pH of surface soil, however, with the increase in soil depth, the effect became more and more significant as the rate of fertilizer increased (Fig. 1c). In case of organic amendments, FYM (7.86) applied surface soils had pH similar to that in control (7.9), but CPM applied ones were slightly at upper hand (Fig. 1d). There was slight increase in pH to lower soil depths. All pH values were in the moderately alkaline range and remained within this range at all soil depths. The organic matter content of the of surface soil increased from 0.67% in N applied treatment to 0.92% in NPK treatment. Application of NPK or 1.25 NP performed similarly (Fig. 1e). In case of organic amendments, the contents of surface soil increased from 0.59% in control to 1.01% in CPM. In all the cases, organic matter content decreased with the depth of soil (Fig. 1f). The increase in organic matter content by organic amendments was more than that under mineral fertilizer application. It was prominent at sub-surface under FYM applied treatments and at surface with CPM application. Generally, Pakistani soils are low (0.5 to 1 %) (Sarwar *et al*., 2011) in organic matter. Local research related to organic amendments and even mineral fertilization on soil properties of banana crop in Sindh, Pakistan is scanty. Wiebel *et al*., (1994) reported pH and EC values of 8.68 and 0.98 dS m^{-1} in NPK (492-156-325 kg ha^{-1} $year^{-1}$) applied treatments. Mughal (2002) analyzed soil properties of district Shaheed Benazirabad and showed that the majority of soils were non-saline, alkaline in reaction with pH from 7.2 to 8.2 and 7.4 to 8.2, organic matter content from 0.49% to 1.53% and 0.41% to 1.16%, corresponding to surface and sub-surface soil depths. Our results were also very closely in line with widely held research works (Bhalerao *et al*., 2010; Ghulam *et al*., 2010; Adriano *et al*., 2012, Vanilarasu & Balakrishmanurthy, 2014 and Zhong *et al*., 2014). Aziz *et al*., (2012) reported EC value of 0.287 dS m^{-1} and organic carbon of 0.85% and pH of 7.05 under FYM incorporated treatments. Wahba (2007) showed improvement in soil organic matter content as a result of compost application rich in humic acid. Aziz *et al*., (2012) showed that there was no change in pH, and EC but the organic matter contents were higher in FYM, followed by pressmud and poulty manure applied treatments. Studies by Liu *et al*., (2010) showed that integration of organic sources with inorganic fertilizer generally increase soil organic carbon. The outcome of Singh *et al*., (2015) was exactly in line with the results of this study, that pressmud relatively increases the EC of soil compared to that by FYM.

Table 1. Properties of experimental soil under banana cultivation.

S. No.	Soil depth (cm)	Electrical conductivity (dS m^{-1})	pH	$CaCO_3$ (%)	Organic matter (%)	Olsen P	NH_4OAc extractable K	DTPA extractable Cu	DTPA extractable Fe	DTPA extractable Mn	DTPA extractable Zn	Textural class
						(mg kg^{-1})						
1.	0-15	0.338	7.71	11.30	0.68	12.27	163	3.88	6.59	8.64	0.29	Silty clay loam
2.	15-30	0.275	7.67	11.32	0.52	10.25	123	3.42	5.25	5.88	0.22	Clay loam
3.	30-45	0.266	7.7	11.06	0.43	1.85	124	2.62	3.22	3.75	0.14	Silty clay loam
4.	45-60	0.269	7.67	10.55	0.27	1.03	110	2.07	2.07	2.24	0.09	Silty clay loam
5.	60-90	0.188	7.56	10.02	0.18	0.88	80	0.83	1.55	1.42	0.05	clay

Table 2. Composition of farmyard manure (FYM) and composted pressmud (CPM).

Waste	N	P	K	Cu	Fe	Mn	Zn	C:N Ratio
	%			mgkg^{-1}				
FYM	2.07	1.30	1.31	40.2	895	464	46.8	20.8
CPM	2.15	1.76	0.83	79.4	848	341	48.5	15.2

Table 3. F-values and significance from analysis of variance for soil properties under banana cultivation.

Parameters	Depths (cm)	F-values FT	F-values OA	F-values FT x OA	$LSD^{0.05}$ FT	$LSD^{0.05}$ OA	$LSD^{0.05}$ FT x OA
EC	0-15	4.27	7.40	7.04	0.062	0.459	0.134
	15-30	7.46	1.35	3.03	0.077	0.095	0.167
	30-45	3.85	19.33	2.27	0.076	0.045	0.164
	45-60	15.58	8.40	2.29	0.074	0.081	0.159
pH	0-15	1.45	7.42	1.35	0.257	0.178	0.554
	15-30	30.94	56.80	3.50	0.079	0.066	0.172
	30-45	44.69	100.61	8.90	0.092	0.053	0.198
	45-60	3.36	3.92	2.69	0.208	0.104	0.448
OM	0-15	1.83	12.42	1.05	NS	0.297	NS
	15-30	19.83	96.88	2.87	0.081	0.096	0.173
	30-45	6.68	6.08	0.98	0.115	0.143	NS
	45-60	8.76	5.86	1.25	0.088	0.116	NS
N	0-15	2.80	0.37	0.32	0.017	NS	NS
	15-30	1.37	1.03	0.66	0.017	NS	NS
	30-45	3.82	0.91	0.60	0.014	NS	NS
	45-60	3.45	8.27	0.74	6.763	3.811	NS
P	0-15	33.51	47.20	3.68	5.241	4.189	11.29
	15-30	25.21	15.41	1.12	2.346	2.7164	NS
	30-45	0.89	6.05	2.11	NS	1.7043	3.846
	45-60	3.65	5.96	0.53	0.489	0.2513	NS
K	0-15	2.06	0.02	0.50	NS	NS	NS
	15-30	0.13	0.2	1.10	NS	NS	NS
	30-45	1.84	0.00	1.31	NS	NS	NS
	45-60	1.51	1.78	0.44	NS	NS	NS
Cu	0-15	1.07	54.86	0.22	NS	0.471	NS
	15-30	1.41	4.96	0.47	NS	0.930	NS
	30-45	1.70	6.95	0.20	NS	0.341	NS
	45-60	2.37	1.65	1.12	0.4967	NS	NS
Fe	0-15	0.63	54.45	0.95	NS	4.461	NS
	15-30	0.63	54.45	0.95	NS	4.461	NS
	30-45	0.73	20.13	1.12	NS	2.831	NS
	45-60	2.40	2.89	0.44	NS	NS	NS
Mn	0-15	2.60	11.15	0.19	3.392	1.436	NS
	15-30	2.52	9.63	0.54	2.019	0.854	NS
	30-45	6.01	9.06	0.86	1.917	0.788	NS
	45-60	4.15	1.10	0.64	1.624	NS	NS
Zn	0-15	0.97	28.56	0.20	NS	0.249	NS
	15-30	0.97	28.52	0.20	NS	0.249	NS
	30-45	1.20	16.83	0.60	NS	0.294	NS
	45-60	4.49	12.38	1.36	0.244	0.249	NS

FT Fertilizer treatments, OA Organic amendments, NS non-significant

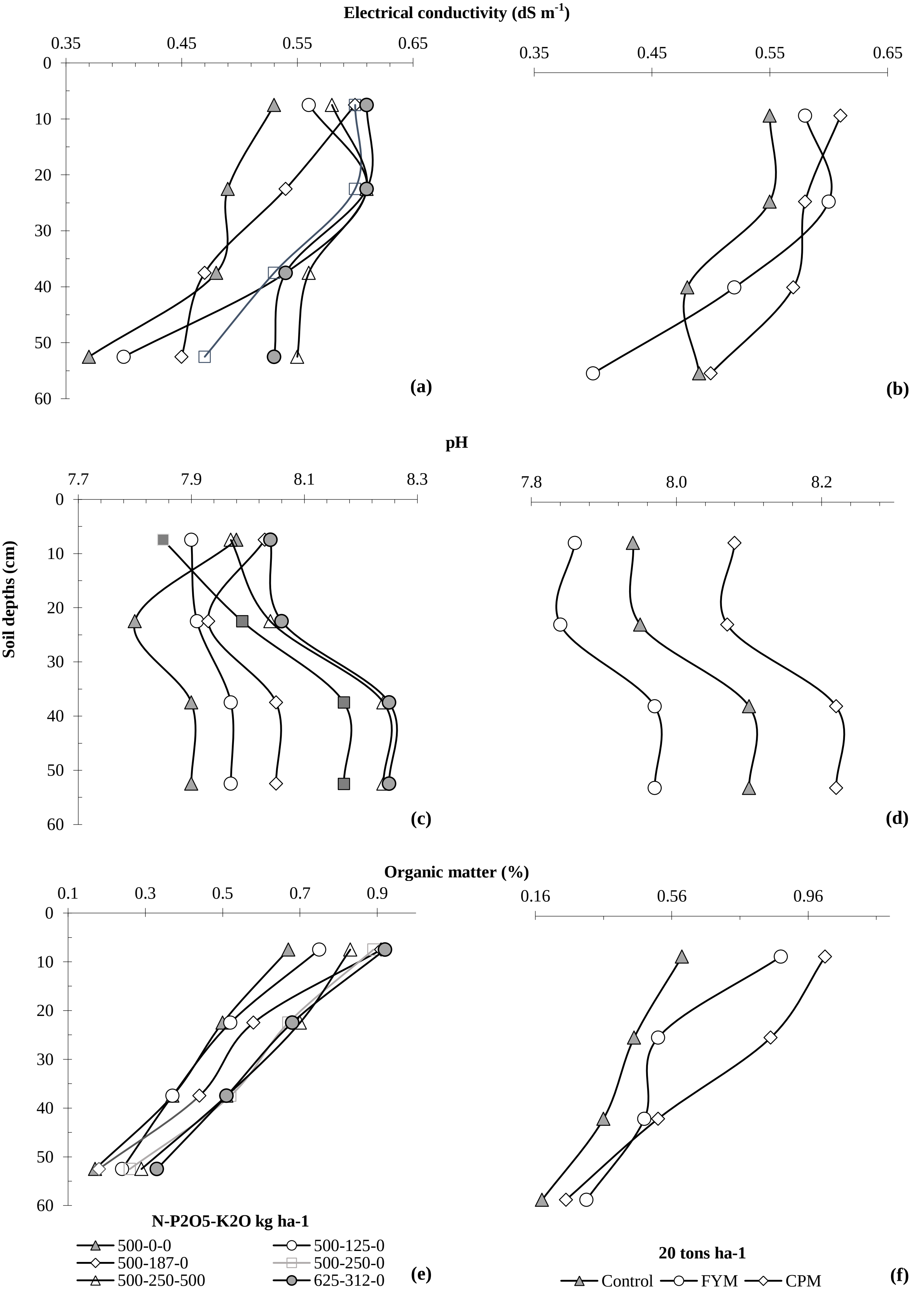

Fig. 1. Effect of mineral fertilizer (N-P_2O_5-$K_2$0 kg ha^{-1}) and organic amendments (control, FYM and CPM) on soil EC (a, b), pH (c, d) and organic matter (e, f) content at various depths under banana cultivation.

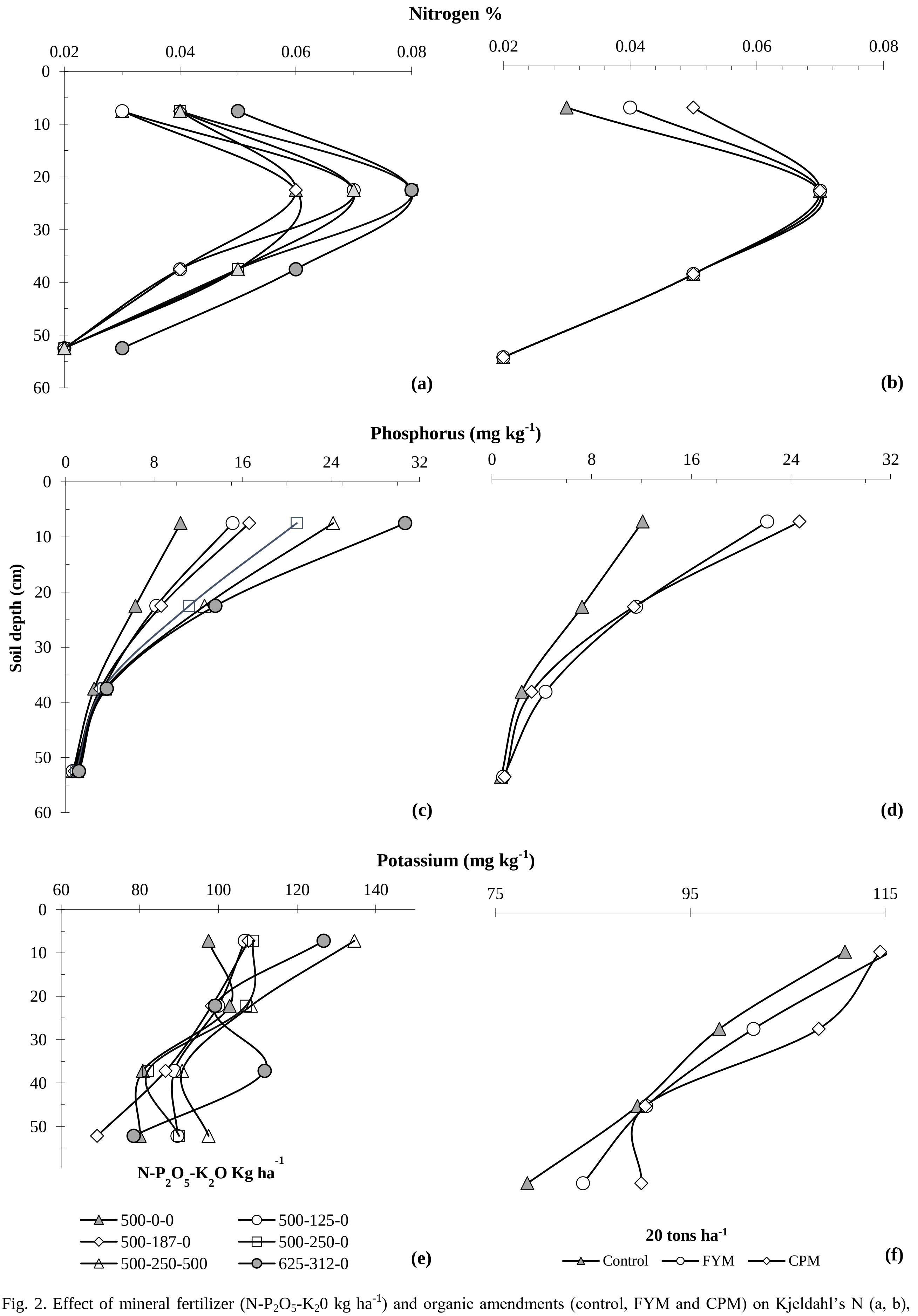

Fig. 2. Effect of mineral fertilizer (N-P_2O_5-$K_2$0 kg ha^{-1}) and organic amendments (control, FYM and CPM) on Kjeldahl's N (a, b), Olsen P (c, d) and NH_4OAc-K (e, f) content at various depths under banana cultivation.

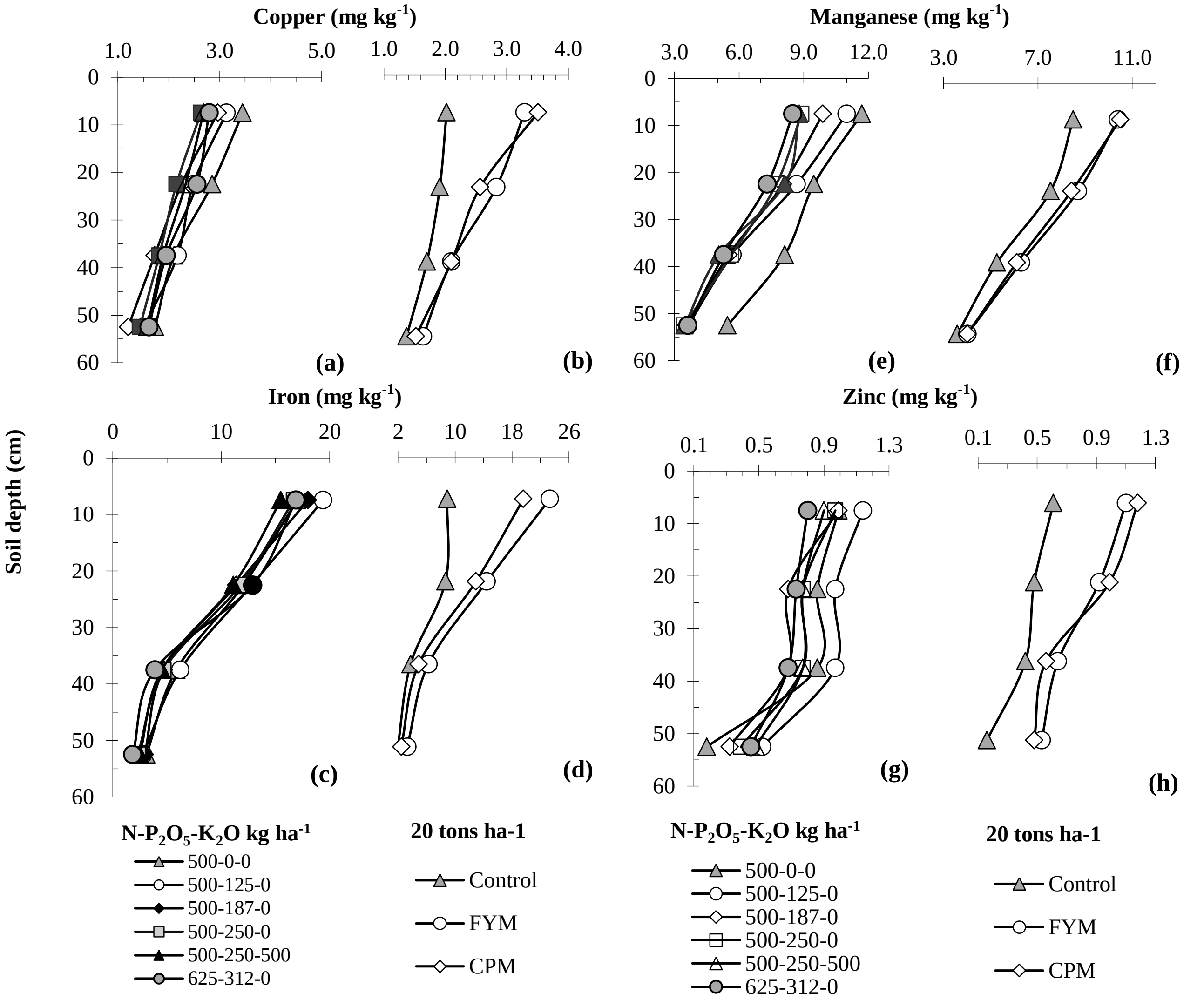

Fig. 3. Effect of mineral fertilizer (N-P_2O_5-K_20 kg ha^{-1}) and organic amendments (control, FYM and CPM) on DTPA extracatable Cu (a, b), Fe (c, d), Mn (e, f) and Zn (g, h) at various depths under banana cultivation.

Soil macronutrients: The data pertaining to total N, Olsen P and NH_4OAc-K content has been presented in Fig. 2. The data showed that mineral fertilizer and organic amendments did not differ significantly from each other in total N content at all soil depths, as all treatments received uniform rate of N. However, in both cases, sub-surface soil had more N, than surface or lower depths (Fig. 2a and 2b). Application of mineral fertilizer improved Olsen P of surface soil from 10.4 mg kg^{-1} in treatments applied with N only to 30.7 mg kg^{-1} in treatments applied with 1.25 NP. The values generally decreased with the depth of soil (Fig. 2c). Addition of organic amendments increased soil surface Olsen P from 12.1 mg kg^{-1} in control to 22.1 mg kg^{-1} in FYM and 25 mg kg^{-1} in CPM applied treatments (Fig. 2d). The available P content decreased with the depth of soil. Inorganic fertilizer application showed increase in NH_4OAc-K in soil. The NH_4OAc-K values increased from 97.5 mg kg^{-1} in N applied treatments to 134.6 mg kg^{-1} in NPK applied treatments of surface soil. Same treatments increased the values at each soil depths, however, the values increased from surface to lower depths (Fig. 2e). In case of organic amendments, available K increased from 110.9 mg kg^{-1} in control to same value of 115.6 mg kg^{-1} by both FYM and CPM of surface soil (Fig. 2f). Overall, it was noted that a soil residual K was not enough to show significant increase over all treatments except NPK. Our results were in line with the studies by Wiebel *et al*., (1994). They reported that available P (37 mg kg^{-1}) and K (79 mg kg^{-1}) experienced a rise when higher NPK (492-156-32 kg ha^{-1} yr^{-1}) rates were used over the lower ones (169-68-21 kg ha^{-1} yr^{-1}). Improved NPK fertilization (544-227-494 kg ha^{-1} yr^{-1}) in banana was beneficial and increased total N (0.085%), P (9.55 mg kg^{-1}) and K (0.53 me 100 g^{-1}) compared to lower rates practiced by farmers (Memon *et al*., 2010). There are no particular studies comparing FYM and composted pressmud, particularly under banana cultivation, however, there are different forms of organic sources applied on different crops such as secondary products of organic origin from sugar industry i.e. spentwash (Kaloi *et al*., 2017). These studies show that these amendments with mineral fertilizer also improved soil organic matter (65%), N (20%), P (25%) and K (230%) over full NP treatment alone.

Soil micronutrients: Micronutrient contents (Fig. 3) decreased with the increasing level of mineral fertilizer application DTPA extractable Cu, Fe, Mn and Zn contents of surface soil decreased from 3.45, 17.0, 11.7 and 0.99 mg kg^{-1} in treatments applied with N only to to 2.79, 16.9, 8.50 and 0.80 mg kg^{-1}, respectively to treatments where either NPK or 1.25 NPK was applied. This trend was similar at all other soil depths and the values decreased from surface to lower soil depths (Fig. 3a, c, e, g). In case of organic amendments, control plots had minimum Cu, Fe, Mn and Zn (2.02, 8.9, 8.58 and 0.61 mg kg^{-1}) contents of surface soil. Among two amendments i.e., FYM and CPM treated plots, the former had relatively higher values of Cu, Fe, Mn and Zn (3.29, 23.3, 10.4 and 1.10 mg kg^{-1}) over the later ones (Fig. 3b, d, f, h). The depth-wise trend shows a decrease all micronutrient content from surface to subsurface. Early research reports related to micronutrient assessment (Memon *et al*., 1988-89) and Memon (1998) reported that available Cu, Fe and Mn were adequate in various districts i.e. Hyderabad, Badin, Mirpurkhas, Sanghar and Shaheed Benazeerabad, Sindh, Pakistan except Zn which was deficient in 60% soil of Hyderabad and 90% in Sanghar. This is in confirmation with other studies, where the Zn deficiency had further increased (Memon *et al*., 2012b). Pressumd was superior over FYM with regard to NPK contents when tested on maize. FYM had relatiavely more K than N but very minor quantity of P. On the other hand, pressmud had more N and more or less equal amounts of P and K (Memon *et al*., 2012a). Results of this study report that FYM had relatively higher quantities of Cu, Fe, Mn and Zn over CPM. FYM has potential to make changes in soil properties and manage soils better (Damatto *et al*., 2006).

Conclusion

Organic sources of nutrients have potential to increase nutrient contents and manage soils. In this study two organic sources FYM and CPM were applied to enhance nutrient contents and soil health under banana cultivation. Research related to soil properties as a result of FYM and CPM is negligible. This study suggestes that use of organic sources of nutrients can vary soil properties and improve soil health better. FYM had and edge over CPM, that is, in addition to organic matter content, Kjeldhal's N, Olsen P and NH_4OAc-K, it improved DTPA-extractable Cu, Fe, Mn and Zn contents of the soil. The effect of CPM was slightly higher in case of EC of the soil. Banana typically grows well under low salt content, therefore, there is need to plan longterm studies on the use of CPM and establish its beneficial role on soil properties.

Acknowledgement

This work on 'Integrated Nutrient Management in Banana' was carried out in a project funded by Agriculture Department, Government of Sindh, Pakistan. Thanks to Mr. Imdad Nizamani of Asim Farm, Tando Soomro for providing experimental area and other facilities. The help from Matiari Sugar Mills, Matari regarding pressmud for banana experimentation is also appreciated.

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(Received for publication 25 April 2020)