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Growth, Mineral Nutrition and Selected Soil Properties of Lowland Rice, as Affected by Soil Application of Organic Wastes and Phosphorus

M. Maftoun*[1], and F. Moshiri[1]

ABSTRACT

Lack of adequate organic matter (OM) in the agricultural soils of Iran is responsible for the poor physical condition of these soils. Thus, increasing soil OM is very important. On the other hand, the eutrophication of surface water caused by continuous use of phosphorus (P) fertilizer has created an interest in the combined use of organic wastes and P fertilizer. Hence, the present study was undertaken to study the effects of several levels of municipal waste compost (MWC), poultry manure (PM) and P on the growth and elemental composition of lowland rice (*Oryza sativa* L.) and on selected soil chemical characteristics. There was a consistent increase in the shoot dry weight as the levels of MWC, PM or P increased. However, rice shoot growth was stimulated more by MWC than by PM and the enhancing effect of P on shoot growth was greater in MWC-treated plants than that of PM. Shoot P concentration increased with increasing levels of MWC, PM and P, whereas nitrogen (N) concentration was only affected significantly by the two organic wastes. Iron (Fe) and zinc (Zn) concentration was suppressed by P supply in PM-amended soil and was not affected by MWC treatment. Rice seedlings treated with either of the biosolids accumulated more Fe, Zn, chloride (Cl) and sodium (Na) but less manganese (Mn) than the control plants. Furthermore, rice plants grown on MWC-amended soil contained higher Fe and Mn and lower Cl and Na than those grown on PM-treated soil. In the present study, lead (Pb) and cadmium (Cd) concentrations did not follow a definite pattern with either of the organic wastes, whereas they increased with P application. Post-harvest soil sample analysis indicated that soil addition of MWC and PM increased concentrations of soluble salt, OM, N, $NaHCO_3$-soluble P and DTPA-extractable Fe, Mn, Cu, and Pb.

Keywords: Calcareous soil, DTPA-extractable heavy metals, Municipal compost, Poultry manure, Soluble salts.

INTRODUCTION

In arid and semi-arid regions of Iran, the distinct feature of most cultivated soils is relatively low organic matter (OM) content and, generally, these soils have poor physical characteristics. Consequently, soil application of organic wastes to supply at least a part of the plant nutrient requirement and improve the physical properties of soil is highly important. Moreover, the continuous use of phosphorus (P) fertilizers during the past two or three decades has resulted in the build-up of excessive P in many cultivated soils and, thus, has induced eutrophication in downstream surface waters due to the elevated vated concentrations of P in surface runoff (Correll, 1998). This, along with the substantial increase in the price of P fertilizers demonstrates an urgent need in the integrated use of organic wastes and P fertilizers. Abdel-Ghaffar (1982) believes that in arid and semi-arid regions of the world, the two most important factors limiting crop production are water and OM. Numerous experiments have indicated that soil application of organic manure will improve its

[1] Department of Soil Science, College of Agriculture, Shiraz University, Shiraz, Islamic Republic of Iran.
[*] Corresponding author, e-mail: mmaftoon@hotmail.com

physical properties (Oades, 1984; Mbagwu 1989; Tisdale and Oades, 1992; Andraski *et al.,* 2003; Soda *et al.*, 2006; Adeli *et al.*, 2007), chemical characteristics (Warren and Fonteno, 1993; Kingery *et al.*, 1994; Maftoun *et al.*, 2004; Soda *et al.*, 2006; Adeli *et al.,* 2007) and fertility status (Pratt *et al.,* 1976; Cabral *et al.,* 1998; Lithourgidis *et al.*, 2007).

The response of paddy rice to P fertilization has been reported by several research workers (Singh and Singh, 1980; Sharma and Mishra, 1985; Swarup and Chhillar, 1986). Mongia *et al.* (1998) reported that, in acid sulfate soils, lowland rice was more responsive to P when the source was rock phosphate comparised with superphosphates. DeDatta *et al.* (1988) observed that the rice grain yield response to P varied greatly from site to site in the Philippines. They noted that at the IRRI site there was no response to P fertilization whereas, at other sites, an appreciable response to P application was observed.

Although research with organic manure as a fertilizer has demonstrated different effects on crop production, the major drawbacks encountered with long term use of organic wastes to soils are the pollution of ground and surface waters due to the leaching and runoff of nutrients, accumulation of excessive soluble salts and the build up of certain trace elements. Despite the above mentioned shortcomings, land application of organic wastes is the most practical means of managing the large amounts of biosolids. Furthermore, the integrated use of organic materials with mineral fertilizers can improve crop productivity and sustain soil health, quality, and fertility. A number of greenhouse and field experiments have been conducted regarding the effects of organic manure alone (Dawe *et al.*, 2003; Li *et al.*, 2003) or in combination with inorganic fertilizers (Subbian and Kumaraswamy, 2000; Reddy *et al.*, 2001; Prasad *et al.*, 2002) on the growth and chemical composition of crops. Khoshgoftarmanesh and Kalbasi (2002) reported that soil application of 150 and 300 t ha^{-1} of municipal waste leachate (MWL) increased the straw and grain yields of rice (*Oryza sativa* L.), whereas 600 t ha^{-1} decreased grain yield. They believe that MWL is a good source of plant nutrients and OM for rice and, thus, it may be used as liquid fertilizer especially in the calcareous soils of Iran. Satyanaryana *et al.* (2002) observed that addition of 10 t farmyard manure ha^{-1} along with N, P and K inorganic fertilizer produced the highest grain yield in rice.

Since there is no report available regarding the response of lowland rice to soil application of organic wastes and P fertilizer on the highly calcareous soils of Iran, the present experiment was undertaken to determine the effects of several rates of poultry manure (PM), municipal waste compost (MWC) and P on the growth and mineral composition of rice and to evaluate the impacts of PM and MWC on some soil chemical properties.

MATERIALS AND METHODS

The experiment was conducted in pots, each containing 2 kg air-dried alluvial calcareous silty clay loam (Fine, mixed, thermic, Calcic Haploxeralfs). The main physical and chemical properties of the soil are given elsewhere (Maftoun *et al.*, 2004). Treatments consisted of four rates of MWC (0, 10, 20, and 40 g kg^{-1}), five levels of PM (0, 10, 20, 30, and 40 g kg^{-1}) and three P rates (0, 25, and 50 mg kg^{-1} as KH_2PO_4). The experiment was arranged in a factorial manner in a completely randomized design with three replicates. Some selected chemical characteristics of the two organic wastes are shown in Table 1.

Ten seeds of rice var. Ghasrodashti were sown in each pot and seedlings were thinned to 4 after three weeks. Three cm standing water was then maintained in each pot. The aerial parts of the plants were harvested after 11 weeks, rinsed with distilled water, dried at 65°C for 48 hours and weighed. The shoots were ground to pass a 40-mesh screen and dry-ashed at 500°C and analyzed for N by the micro-Kjeldahl method, P by colorimetry, Na by flame photometer, Fe, Mn,

Table1. Physical and chemical properties of the soil.

Soil property	Quantity
Clay (%)	35
Silt (%)	52
Sand (%)	13
pH (saturated paste)	7.7
EC_e (dS m^{-1})	0.8
CEC ($cmol_c$ kg^{-1})	25
OM (%)	0.8
Total N (%)	0.06
CCE (%)	34
$NaHCO_3$-P (mg kg^{-1})	9
DTPA-Fe (mg kg^{-1})	3.1
DTPA-Zn (mg kg^{-1})	1.4
DTPA-Mn (mg kg^{-1})	14
DTPA-Cu (mg kg^{-1})	2
Cation concentration in saturation extract ($mmol_c$ L^{-1})	
Ca^{2+}	3.1
Mg^{2+}	1.1
K^+	0.53
Na^+	3.9
Anion concentration in saturation extract ($mmol_c$ L^{-1})	
Cl^{-1}	5.0
HCO_3^-	2.6
SO_4^{-2}	2.8

Zn, Cu, Cd, Pb by atomic absorption spectrophotometer and Cl by the method outlined by Chapman and Pratt (1961).

At the end of the experiment, triplicate soil samples were taken from each pot following shoot and root removal and analyzed for OM, total N, $NaHCO_3$-extractable P, DTPA-extractable Fe, Mn, Zn, Cd, and Pb, and electrical conductivity (EC_e). All data were subjected to analysis of variance and mean comparisons were made by Duncan's Multiple Range Test by using MSTATC software.

RESULTS AND DISCUSSION

The influence of soil application of MWC, PM and P on the shoot dry weight is shown in Table 2. Phosphorus fertilization increased shoot dry yield in MWC-and PM-treated rice. The beneficial effects of the addition of P on rice growth have been reported by others (Bhattacharyya and Chatterjee, 1978; Sharma and Tripathi, 1999; Pheav *et al.*, 2003; Sahrawat *et al.*, 2003). Simatupang (2000) has observed that high concentrations of $NaHCO_3$-extractable P in the first season resulted in the highest rice yields. Rice yield of a second crop decreased and remained constant at this level throughout the fourth crop. Slaton *et al.* (2002) showed that broadcast application of P fertilizers to the soil surface between seeding and active tillering were equally effective in increasing rice yields and optimizing P uptake on P deficient alkaline soils. In the present study, it seems that the enhancing effect of P on rice growth was greater with MWC than that of PM and was more pronounced at lower levels of PM. For instance, with 10 g PM kg^{-1}, addition of 50 mg P kg^{-1} increased shoot dry weight by 68% when compared to control, whereas with 40 g PM kg^{-1}, and with the same P level, the increase was 39%. There was a rather consistent increase in the shoot dry weight as the levels of either of the biosolids increased. In general, rice growth was stimulated more by MWC than by PM. Satyanara *et al.* (2002) noted that application of farmyard manure increased grain and straw yields, tiller number and 1000-grain weight. Eneji *et al.* (2002) stated that although rice growth increased following soil addition of organic manures, the possible

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Table2. Effect of municipal waste compost (MWC), poultry manure (PM), and P on the rice shoot dry weight (g pot^{-1}).

Organic waste	Rate ($g\ kg^{-1}$)	P rate ($mg\ kg^{-1}$) 0	25	50	Mean
MWC	0	3.73 c*	5.23 d	7.23 c	5.39 d
	10	8.01 b	9.20 c	10.40 b	9.20 c
	20	9.80 a	11.70 b	15.90 a	12.41 b
	40	11.00 a	14.60 a	16.40 a	14.00 a
	Mean	8.14 C	10.18 B	12.50 A	
PM	0	4.03 d	5.03 d	7.03 d	5.36 d
	10	6.47 c	8.10 c	10.87 c	8.48 c
	20	8.13 b	10.17 b	11.80 b	10.03 b
	30	9.70 a	11.13 a	13.10 a	11.29 a
	40	9.40 a	11.10 a	13.10 a	11.22 a
	Mean	7.55 C	9.09 B	11.19 A	

* Mean each organic waste, means followed by the same letters in each column and each row (capital letter) are not significantly different at $p \leq 0.05$.

risk of a build-up of trace elements in the environment should not be overlooked, especially if high levels of organic waste are applied. Das *et al.* (2002) reported that application of 50% vermicompost and 50% NPK fertilizers produced the maximum straw and grain yields in rice. Chattopadhyay *et al.* (1992) noted that rice performance was greater in the compost plus P treatment than application of P alone.

Despite the moderate sensitivity of rice to soil salinity, the apparently high tolerance of this cultivar to salt stress in the present study (Table 8) might suggest that the adverse effects of soil salinity were probably alleviated by the constant water logging. Papadopoulos and Rendig (1983) reported that, even at a high salinity level, plant growth could still be maintained if enough moisture was supplied to crops.

Due to the higher total P content of PM as compared to MWC, the concentration of P in PM-treated rice shoots was higher than in MWC-treated plants (Table 3). The phosphorus concentration significantly increased with increasing MWS, PM and P rates. However, total P uptake by rice in MWC- and PM-treated soil was almost the same and was significantly affected by P fertilization. An increase in P concentration and uptake by rice due to P and organic waste addition has been reported by others (Singh and Singh, 1980; Selviranganathan and Selvavaseelan, 1997; Mongia *et al.*, 1998). In our study, the stimulating effect of P supply on the concentration and uptake of P declined with PM treatment. For instance, the addition of 50 mg P kg^{-1} alone increased P concentration and P uptake by 21 and 111%, respectively, whereas with the same P level and 40 g PM kg^{-1} soil those increases were 2.86 and 44%, respectively.

The relationship between N concentration in the rice shoot and MWC and PM levels was evaluated by regression analysis and the following prediction equations were obtained:

$Y= 1.865+0.422\ MWC \quad R^2=0.875^{**}$ (1

$Y= 1.981+0.489\ PM \quad R^2=0.910^{**}$ (2

Where Y is the N concentration in g kg^{-1}. Increasing WMC and PM rates significantly increased shoot N concentration. Moreover, rice plants treated with PM contained higher N than those treated with MWC. These findings are in agreement with those reported by Chattopadhyay *et al.* (1992). However, Phongpan and Mosier (2003) indicated that organic manure did not significantly change the N accumulation in rice. In the present experiment, N uptake increased significantly as the levels of P, MWC, and PM increased (Table 4). However, rice seedlings grown on

Table3. Effect of municipal waste compost (MWC), poultry manure (PM), and P application on the P concentration and uptake by the rice shoots.

Organic waste	Rate ($g\ kg^{-1}$)	P rate ($mg\ kg^{-1}$) 0	25	50	Mean
MWC		P concentration ($mg\ pot^{-1}$)			
	0	1.76 c*	1.94 b	2.22 b	1.97 b
	10	1.71 c	1.78 c	1.92 c	1.80 c
	20	1.89 b	1.93 b	2.20 b	2.01 b
	40	2.06 a	2.38 a	2.70 a	2.38 a
	Mean	1.85 C	2.01 B	2.26 A	
PM	0	1.76 c	1.94 c	2.13 d	1.94 d
	10	1.83 c	2.01 c	2.21 d	2.02 d
	20	2.26 b	2.49 b	2.65 c	2.47 c
	30	2.66 a	3.05 a	3.29 a	3.00 a
	40	2.79 a	2.98 a	2.87 b	2.88 b
	Mean	2.26 A	2.49 B	2.63 C	
		P uptake ($mg\ pot^{-1}$)			
MWC	0	6.5 d	10.1 d	16.1 d	
	10	13.6 c	16.4 c	19.9 c	10.9 d
	20	18.4 ab	22.5 b	34.8 b	16.6 c
	40	22.7 a	34.8 a	44.2 a	25.3 b
	Mean	15.3 C	20.9 B	28.8 A	33.9 a
PM	0	7.1 d	9.8 d	15.0 e	10.6 e
	10	11.8 c	16.3 c	24.0 d	17.4 d
	20	18.4 b	25.3 b	31.2 c	25.0 c
	30	25.9 a	33.6 a	43.0 a	34.2 a
	40	26.2 a	33.2 a	37.7 b	32.4 b
	Mean	17.9 C	23.6 B	30.2 A	

* For each organic waste and each growth parameter, means followed by the same letters in each column and each row (capital letter) are not significantly different at $p \leq 0.05$.

MWC-treated soil contained higher N that those raised on PM-amended soil. For instance, increasing MWC and PM levels from 0 to 4% increased mean N uptake by 360 and 282%, respectively. This was in contrast to our findings with N concentration. The greater rice shoot growth stimulation by MWC as compared to that by PM was probably responsible for such behavior. Furthermore, the enhancing effect of P on N uptake was greater in the MWC treatment than in the PM treatment.

The effects of P, MWC and PM applications on the Fe and Zn concentrations are shown in Table 5. Mean Fe and Zn concentrations decreased significantly with P addition to PM-enriched soil but were not affected in MWC-treated plants. The suppressing effects of P on Zn concentrations might be due to a dilution effect (Loneragan *et al.*, 1979), binding Zn to the cell wall (Youngdahl *et al.*, 1977), enhancement of Zn adsorption (Saeed and Fox, 1979), interference in Zn translocation from roots to tops (Terman *et al.*, 1972), and reduction of VAM infection on roots (Singh *et al.,* 1986). Proposed mechanisms for P interference on Fe absorption include immobilization of soil Fe (Mandal and Haldar, 1980), inhibition of Fe uptake by roots and of its transport from root to shoots (Elliott and Lauchli, 1985) and inactivation of plant Fe (De Kock *et al.*, 1979). There was a consistent increase in Fe and Zn concentrations with increasing MWC and PM levels. However, plants treated with MWC generally accumulated more Fe and Zn than those treated with PM.

In the present work the following regression equations were obtained between Mn concentration and applied MWC and PM:

$$Y= 254–7.06\,X_1+0.138\,X_1^2 \quad R^2=0.772^{**} \quad (3$$

$$Y= 263–1.05\,X_2 \quad R^2=0.540^{**} \quad (4$$

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Where Y is the Mn concentration (μ g^{-1}) and X_1 and X_2 are the MWC and PM levels, respectively, both in g kg^{-1}. The manganese concentration declined with increasing MWC and PM rates. However, the depressing effect of MWC on Mn absorption was greater compared with that of PM. For instance, Mn concentration decreased by 28%

Table4. Effect of municipal waste compost (MWC), poultry manure (PM), and P application on the N uptake by rice shoots (mg pot^{-1}).

Organic waste	Rate (g kg^{-1})	P rate (mg kg^{-1}) 0	25	50	Mean
		N uptake			
MWC	0	69 c*	107 c	157 c	111 d
	10	147 c	237 b	232 c	205 c
	20	242 b	275 b	426 b	314 b
	40	414 a	521 a	597 a	511 a
	Mean	218 C	285 B	396 A	
PM	0	78 c	108 c	158 c	115 d
	10	131 c	221 b	259 b	204 c
	20	236 b	254 b	336 b	275 b
	30	354 a	394 a	482 a	410 a
	40	367 a	436 a	517 a	440 a
	Mean	233 C	283 B	350 A	

* For each organic waste, means followed by the same letters in each column and each row (capital letter) are not significantly different at p≤0.05.

Table5. Effect of municipal waste compost (MWC), poultry manure (PM), and P application on the Fe and Zn concentrations in rice shoots.

Organic waste	Rate (g kg^{-1})	P rate (mg kg^{-1}) 0	25	50	Mean
		Fe concentration (μg g^{-1})			
MWC	0	52 c*	75 b	63 b	64 c
	10	64 c	77 b	71 b	71 b
	20	92 b	79 b	87 ab	86 ab
	30	128 a	94 a	102 a	108 a
	Mean	84 A	81 A	81A	
PM	0	53 c	73 b	64 c	63 d
	10	98 b	87 ab	69 c	85 c
	20	95 b	82 ab	62 c	80 c
	30	108 b	95 a	85 b	96 b
	40	151 a	80 b	103 a	111 a
	Mean	101 A	84 B	76 C	
		Zn concentration (μg g^{-1})			
MWC	0	25.8 c*	24.3 c	23.8 c	24.6 c
	10	37.4 b	36.5 b	35.1 b	36.3 b
	20	42.4 a	39.5 b	38.0 b	40.0 ab
	40	44.2 a	43.4 a	43.0 a	43.5 a
	Mean	37.5 A	35.9 A	35.0 A	
PM	0	26.3 c	25.3 b	24.5 a	25.4 c
	10	31.5 b	30.8 a	25.8 a	29.4 b
	20	35.9 b	28.8 a	25.9 a	30.2 b
	30	36.1 b	32.3 a	27.1 a	31.8 ab
	40	42.0 a	32.3 a	25.2 a	33.2 a
	Mean	34.4 A	29.9 AB	25.7 B	

* For each organic waste and each growth parameter, means followed by the same letters in each column and each row (capital letter) are not significantly different at p≤0.05.

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with soil addition of 40 g MWC kg^{-1} whereas, for the same level of PM, the reduction was 18%. Phosphorus fertilization caused a significant increase in the mean Pb and Cd concentrations (Table 6). Moreover, the first increment of MWC induced a significant increase in the mean Pb concentration; higher rates resulted in little further response. In general, the accumulation of Pb and Cd did not follow any definite pattern with either biosolids, while they increased by P addition probably as a result of the presence of Cd and Pb in superphosphate as impurities (Tables 6).

In the present work, Na and Cl concentrations increased sharply with an increase in MWC and PM rates (Table 7). However, shoot contained considerably lower Na than Cl and rice plants raised on PM-amended soil generally accumulated higher Na and Cl than those grown on MWC-treated soil, which could be attributable to the higher EC of PM. Gates *et al.* (1967) and Hu and Schmidhalter (1997) reported that, although both Na^+ and Cl^- are readily absorbed by plant roots, most Cl^- ions are transported to the shoot, whereas a greater portion of Na^+ ions is accumulated in the root.

Table 6. Effect of municipal waste compost (MWC), poultry manure (PM), and P application on the Pb and Cd concentrations in rice shoots.

Organic waste	Rate (g kg^{-1})	P rate (mg kg^{-1}) 0	25	50	Mean
		Pb concentration (μg g^{-1})			
MWC	0	0.46 b*	2.09 b	4.26 b	2.27 b
	10	3.76 a	4.63 a	5.91 ab	4.77 a
	20	4.53 a	4.56 a	5.59 b	4.89 a
	40	4.11 a	4.31 a	6.86 a	5.09 a
	Mean	3.21 C	3.90 B	5.61 A	
PM	0	0.51 c	2.51 c	3.99 b	2.34 c
	10	0.64 c	0.64 d	1.56 c	0.95 d
	20	1.08 cd	1.14 d	2.11 c	1.44 d
	30	3.38 b	4.34 b	6.40 a	4.70 b
	40	4.58 a	5.50 a	6.66 a	5.58 a
	Mean	2.04 C	2.83 B	4.14 A	
		Cd concentration (μg g^{-1})			
MWC	0	0.49 b*	0.94 a	1.37 a	0.93 a
	10	0.89 a	0.84 a	1.24 ab	0.99 a
	20	0.59 b	1.10 a	1.07 b	0.92 a
	40	0.70 ab	0.94 a	1.27 ab	0.97 a
	Mean	0.67 C	0.95 B	1.24 A	
PM	0	0.64 a	0.60 b	1.39 b	0.87 bc
	10	0.74 a	0.94 ab	1.17 b	0.95 bc
	20	0.65 a	1.02 a	1.32 b	0.99 bc
	30	0.95 a	1.02 a	1.44 ab	1.14 ab
	40	0.82 a	1.25 a	1.74 a	1.27 a
	Mean	0.76 C	0.97 B	1.41 A	

* For each organic waste and each growth parameter, means followed by the same letters in each column and each row (capital letter) are not significantly different at p≤0.05.

Soil application of MWC and PM significantly increased selected soil chemical characteristics (Table 8). Furthermore, MWC-treated soil contained higher DTPA-extractable Zn and Pb and lower $NaHCO_3$-P and DTPA-soluble Fe and Mn than did PM-amended soil. For instance, the addition of 40 g MWC kg^{-1} caused a 88, 188, 143, and 105% increases in Zn, Pb, Fe and P, respectively, while those increases with the same

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Table 7. Effect of municipal waste compost (MWC), poultry manure (PM), and P application on the Cl and Na concentrations in rice shoots.

Organic waste	Rate (g kg^{-1})	Cl concentration (mg g^{-1})	Na concentration (mg g^{-1})
MWC	0	4.62 b*	1.93 d
	10	4.93 ab	2.12 c
	20	4.97 ab	2.26 b
	40	5.35 a	2.34 a
PM	0	4.63 c	1.92 c
	10	4.88 c	2.14 c
	20	5.45 b	2.19 bc
	30	5.77 ab	2.26 b
	40	5.93 a	3.46 a

* For each organic waste, means followed by the same letters in each column are not significantly different at p≤0.05.

Table 8. Effect of MWC, and PM on some chemical soil properties.

Levels of organic waste (g kg^{-1})	ECe (dSm^{-1})	OM (g kg^{-1})	Total N (g kg^{-1})	Na-HCO_3-P (mg kg^{-1})	DTPA-extractable heavy metals (mg kg^{-1}) Fe	Mn	Zn	Cu	Pb
				MWC					
0	0.80 d*	13 d	1.21 b	21.1 c	2.10 c	11 c	1.11 d	3.60 d	0.400 d
10	1.80 c	15 c	1.42 b	35 b	4.41 b	11 bc	2.63 c	6.31 c	0.750 c
20	2.71 b	17 b	1.70 ab	40 a	4.93 a	12 b	3.70 b	7.25 b	1.075 b
40	4.62 a	22 a	2.33 a	43 a	5.10 a	13 a	6.68 a	10.20 a	1.150 a
				PM					
0	1.00 e	13 d	1.10 d	24 e	2.10 d	12 d	1.10 c	4.10 c	0.380 e
10	1.61 d	15 c	1.40 cd	88 d	5.82 c	15 c	2.20 b	6.26 b	0.525 d
20	2.23 c	16 c	1.71 bc	153 c	6.73 b	15 c	3.10 b	7.20 b	0.700 c
30	3.00 b	19 b	2.0 ab	200 b	7.80 a	17 b	4.20 a	7.63 b	0.925 b
40	4.00 a	22 a	2.31 a	238 a	7.80 a	18 a	4.10 a	10.55 a	1.050 a

* For each organic waste, means followed by the same letters in each column are not significantly different at p≤0.05.

level of PM were 73, 176, 271, and 892%. However, the two biosolids showed a similar effect on other soil parameters (Table 8). An increase in the chemical properties of soil treated with MWC and PM has been reported by others (Bevacqua and Mellano, 1994; Wood *et al.*, 1996; Wen *et al.*, 1997; El-Shakweer *et al.*, 1998; Eneji *et al.*, 2001; Zhang *et al.*, 2006). Mohammad and Mazahreh (2003) Reported that application of wastewater treatment increased EC, soil P, K, Fe and Mn and had no significant effect on Zn, Cu, Pb, and Cd. Khoshgoftarmanesh and Kalbasi (2002) observed that addition of municipal waste leachate to a calcareous soil increased OM, N, P, K and DTPA-extractable Fe, Zn, Mn, Cu, Pb, Ni and Cr. Kingery *et al.* (1994) concluded that long-term litter application has altered soil chemical properties and could create the potential for adverse environmental impacts.

CONCLUSION

Our results clearly indicate that integrated use of MWC and PM with P fertilizer improved the growth rate and chemical composition of lowland rice grown in a highly calcareous soil. However, the continuous use of organic wastes on cultivated soils may lead to the accumulation of heavy metals, N, and

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P in excess of crop removal, hence causing a nutrient imbalance in the soil. However, the soil used in our study had a high pH, CEC and CCE and so, the build-up of heavy metals was negligible. On the other hand, improper and/or long-term, addition of organic wastes might lead to the accumulation of soluble salts in the soil and, thus, a leaching fraction might be needed to leach out the excess salts beneath the root zone. Elevated concentration of P in PM-amended soil can cause eutrophication of surface water (Correll 1998; Chardon *et al.*, 2007). Land application of organic wastes, however, offers the most practical means for managing the large amounts of these biosolids produced. For this reason, the proper management of organic wastes and periodic monitoring of soil fertility and productivity parameters and environment quality are needed to ensure successful, safe and long term use of biosolids on agricultural lands.

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تأثیر کاربرد خاکی ضایعات آلی و فسفر بر رشد، تغذیه معدنی برنج و بعضی از خصوصیات خاک

م. مفتون، و ف. مشیری

چکیده

نبود ماده آلی در خاکهای کشاورزی ایران سبب بروز شرایط فیزیکی نامطلوب این خاکها شده است. بنابراین افزایش ماده آلی حایز اهمیت می‌باشد. از طرفی بهپروردگی آبهای سطحی ناشی از مصرف مدام کودهای فسفردار باعث شده که کاربرد توأم ضایعات آلی و کود فسفردار مورد توجه قرار گیرد. بنابراین در این آزمایش، تأثیر چند سطح کمپوست شهری، کود ماکیان و فسفر بر رشد و ترکیب شیمیایی برنج و برخی ویژگیهای شیمیایی خاک مورد بررسی قرار گرفت. با افزایش مقدار کمپوست شهری، کود ماکیان و فسفر، رشد شاخسار برنج افزایش یافت. با وجود آن اثر مثبت کمپوست شهری از کود ماکیان زیادتر بوده و تأثیر فسفر بر افزایش وزن خشک شاخسار برنج تیمار شده با کمپوست شهری در مقایسه با کود ماکیان بیشتر مشهود بود. غلظت فسفر در شاخسار با افزایش سطوح کمپوست شهری، کود ماکیان و فسفر زیاد گردید حال آنکه غلظت نیتروژن فقط تحت تأثیر دو کود آلی قرار گرفت. میزان آهن و روی در اندام هوایی برنج فقط با اضافه‌کردن فسفر به خاک تیمار شده با کود ماکیان کاهش نشان داد. انباشتگی آهن، روی کلر و سدیم در شاخسار نهالهای برنج با کاربرد دو ضایع آلی در مقایسه با شاهد بیشتر بوده حال آنکه روند معکوسی در رابطه با غلظت منگنز مشاهده شد. همچنین کاربرد کمپوست شهری در مقایسه با کود ماکیان با افزایش بیشتر میزان آهن و منگنز و افزایش کمتر غلظت سدیم و کلر در برنج همراه بود. در این آزمایش تغییر غلظت سرب و کادمیوم با کاربرد دو ماده آلی از روند مشخصی پیروی نکرد حال آنکه با مصرف فسفر، زیاد شد. نتایج تجزیه خاک پس از برداشت گیاه نشان داد که با مصرف کمپوست شهری و کود ماکیان، غلظت نمکهای محصول، ماده آلی نیتروژن، فسفر محلول در بیکربنات سدیم و آهن، منگنز مس و سرب عصاره‌گیری شده با دی تی پی آ زیاد شده است.

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