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Analysis of nutritional status of pepper plants grown on sandy soil under different rates of compost and P fertilization

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Phosphorus nutrient is important nutrient of all plants, because it enters into bioprocesses within plant tissues. A field successive experiment was carried out employing sandy soil to clarify the effect of combination rates of compost and P fertilization on nutritional status of leaves and fruits of pepper plant. Two rates of compost (10 and 15 ton fed^{-1}) were added with four rates of P fertilization (0, 30, 45 and Kg P_2O_5 fed^{-1}). Under both the lower and higher compost rate, values of N, P and K uptake in leaf and fruit were increased by increasing P fertilization rate. The maximum N, P and K uptake of leaf and fruit (104.4 and 209.5, 16.02 and 28.42 and 184.2 and 227.3 mg plant^{-1},mg plant^{-1}, respectively) occurred under the higher rate of compost (15 ton fed^{-1}) and P fertilization rate (60 kg P_2O_5 fed^{-1}). As well as, the higher rate of applied compost and P fertilization, significantly increased Fe, Mn and Zn uptake in both leaf and fruit pepper plants. Under the 1st rate of applied compost, P application up to (60 kg P_2O_5 fed^{-1}) increased Fe, Zn and Mn uptake of leaf to maximum levels (3.167, 1.052 and 0.092 mg plant^{-1}, respectively), as well as of fruit to maximum levels (5.230, 2.729 and 0.155 mg plant^{-1}, respectively). The increasing trend of these micronutrients, lasted until fourth rate (60 kg P_2O_5fed^{-1}), which may suggest a tendency to accumulate of micronutrients in pepper fruit more than in pepper leaf, particularly under high P supplemental. The net effect of interaction between compost and P fertilization rates that the highest values of nutrients available content in soil i.e.: 96.39, 71.34, 78.81, 54.80 and 3.040 mg/kg of N, P, K, Fe and Zn, respectively, were due to the higher compost rate combined with fourth rate of P application (60 kg P_2O_5 fed^{-1}); as for soil available Mn the highest value (12.12 mg kg^{-1}) was under the higher compost rate (15 ton fed^{-1}) combined with third rate of P application (45 kg P_2O_5 fed^{-1})

Keywords: Pepper plants, Compost, P fertilization, Nutrients uptake, Nutrients available

INTRODUCTION

Composting can be defined as being the breakdown of organic materials by large numbers of microorganisms in a moist, warm, aerated environment, leading to the production of carbon dioxide, water, minerals and a stabilized organic matter (Diaz et al. 2002). Composting is the biochemical degradation of organic materials to a sanitary, nuisance-free, humus-like material. Composting has been defined as a controlled-microbial aerobic decomposition process with the formation of stabilized organic materials that may be used as soil conditions and/or organic fertilizers (Negro et al. 1999).Taalab and Aziz (2004) reported that available nitrogen and potassium in field plots that received organic materials was higher than those treated with chemical fertilizer. The rate of increases in the mean availability of potassium in plots treated with farmyard manure, tomato compost and farmyard manure combined with tomato compost were 23, 36 and 38% as compared with chemical fertilizer treatment, respectively. Taalab et al. (2003) studied the effect of farmyard manure and chicken manure on onion plant at Wady El-Mollak, Ismailia Governorate. Application of farmyard manure combined with chicken manure gave the highest extractable Fe, Mn and Zn particularly at 5-10cm depth as compared with control. The supply of P to the crops is influenced by soil P and P application as well as by soil and environmental conditions that affect P phyto availability and root growth. Roots absorb P ions from the soil solution. The ability of the plant to absorb P will depend on the concentration of P ions in the soil solution at the root surface and the area of absorbing surface in contact with the solution. Mass flow and diffusion govern the movement of P ions in soil, with diffusion being of primary importance (Grant et al. 2005). In highly P fertilized soils, the P concentration in soil solution is high (>1 ppm) and the depletion zone is readily replenished, but the replenishment is slow when soil solution P is low especially for soil solid phase with a low buffer capacity (Morel, 2002).The aim of this paper was study the effects of compost and P fertilization rates on nutritional status of pepper plants grown on sandy soil.

MATERIALS AND METHODS

A field trial was conducted on a loamy sand soil at Ismailia Agriculture Research Station, by cultivating pepper (*Capsicum annum* L., cv Markony) plants in the summer season of 2015. The experiment was carried out in a randomized complete block design, with three replicates.Plant residue of wheat collected from the Ismailia Agriculture Research Station farm, were cut and chopped into pieces of 3-4cm length and piled in 10 equal layers making up a heap of 1.5× 2 m area and a height of 2 m. Each layer in the heap was mixed thoroughly to attain good aeration, moistened with water to about 60% of water holding capacity and received 50 kg of poultry manure to activate the decomposition process. The floor of the heap as well as heap sides and top were covered with plastic sheets and left to decay. The pile was turned every 15 days from the top and sides into the center to enhance the aerobic decay process. Additional water was sprayed during the turning process to keep moisture content at almost 60% of water holding capacity. The plant residues were supposed to be satisfactorily decomposed under such conditions after 95 days. The main chemical analyses of the wheat residue before subjecting to decay and compost of the mature heap are presented in Tables (1 and 2), respectively. The field of experiment was sampled before pepper planting to determine physical and chemical properties according to the standard procedures outlined by Cottenie[7] are scheduled in Table (3)

The compost was added by through mixing with the surface soil layer in a 10and 15 ton fed^{-1}, which combined with four P fertilization rates (0, 30, 45 and 60 kg P_2O_5 fed^{-1}).One N and K fertilization rate (100 Kg N and 48 kg K_2Ofed^{-1}) in the form of ammonium nitrate and potassium sulfate, respectively. Plant samples were dried at 65 C° for 48 hrs to be then ground and wet digested using H_2SO_4: H_2O_2 method described by Cotteine (1980). The digests were then subjected to measurement of N using micro Kjeldahl method; P was assayed using molybdenum blue method while K was evaluated by flame photometer and Ca as well as Fe, Mn and Zn were determined using atomic absorption spectrophotometer (Chapman and Pratt, 1961).

Table (1): Chemical properties of the wheat straw used.

Plant residue	Organic carbon	C/N ratio	N	P	K	Fe	Zn	Mn
	%		g kg^{-1}			mg kg^{-1}		
Straw	56.5	94.2:1	0.6	0.082	0.600	506.0	46.0	33.0

Table (2): Chemical properties of the compost.

	pH*	Organic carbon	C/N ratio	N	P	K	Fe	Zn	Mn
		%		$g\ kg^{-1}$			$mg\ kg^{-1}$		
Compost	6.50	22	20:1	1.10	1.40	2.30	1800.8	288	300

***** (1:2.5) compost: water suspension

Table (3): Some physical and chemical properties of the soil used.

Soil property	Value	Soil property	Value
Particle size distribution %		**pH (1:2.5 soil suspension)**	7.70
Coarse sand	69.9	**EC ($dS\ m^{-1}$), soil paste extract**	1.26
Fine sand	14.2		
Silt	5.7	**Soluble ions ($mmol\ L^{-1}$)**	
Clay	10.2	**Ca^{++}**	6.12
Texture	Loamy sand	**Mg^{++}**	4.60
$CaCO_3$ %	1.90	**Na^{+}**	1.94
Saturation percent %	23.30	**K^{+}**	0.12
Organic matter%	0.01	**CO_3^{--}**	nd
Available N ($mg\ kg^{-1}$)	10.1	**HCO_3^{-}**	2.20
Available P ($mg\ kg^{-1}$)	1.4	**Cl^{-}**	4.98
		SO_4^{--}	5.60
Available K ($mg\ kg^{-1}$)	80.5	**CEC ($cmol\ kg^{-1}$)**	7.00

nd: not detected.

RESULTS AND DISCUSSION

Regarding the main effect of compost on nutrients uptake in pepper plant, obtained data (Table, 4) show that compost application at the higher rate significantly increased N, P and K uptake in pepper leaf and fruit. Abou El-Naga et al. (1996) reported that organic residues led to a significant positive response for uptake of N, P and K. Availability of N, P and K nutrients increased with increasing the levels applied of organic manure so these nutrients increased in pepper plants. Regarding the main effect of P fertilization rates on nutrients uptake in pepper tissues, obtained data (Table, 4) indicate that increasing the rate of applied P consistently significantly increased N, P and K uptake of leaf and fruit pepper plant, reaching their maximum values by high rate of P fertilization (60 kg P_2O_5 fed^{-1}). It is clear that at least, the effect of the highest P rate was always significant.

As the interaction effect between compost and P fertilization rates was concerned, obtained results (Table, 5) show that under both the lower and higher compost rate, values of N uptake in leaf and fruit were increased by increasing P fertilization rate. The N uptake values in pepper leaf and fruit steadily increased as the rate of applied P increased showing average values of 66.49 and 183.3 mg $plant^{-1}$respectively, under higher compost rate as compared with lower applied compost rate (average values of 49.62 and 138.6 mg $plant^{-1}$, respectively). The maximum N uptake of leaf and fruit (104.4 and 209.5 mg $plant^{-1}$, respectively) occurred under the higher rate of compost (15 ton fed^{-1}) and P fertilization rate (60 kg P_2O_5 fed^{-1}). Alabi (2006**)** found that increasing the rates of applied P increased significantly the nutrient elements (N, P and K) uptake of pepper plant with increasing the rates of applied poultry droppings. Under both lower and higher compost rate, significant increases in P uptake of leaf and fruit occurred under increasing P fertilization rate applied. P uptake values in pepper leaf and fruit steadily increased as the rate of applied P increased showing average values of 9.811 and 22.65 mg $plant^{-1}$, respectively, under higher compost rate as compared with lower applied compost rate (average values of 6.806 and 16.74 mg $plant^{-1}$, respectively). The maximum P uptake of leaf and fruit (16.02 and 28.42 mg $plant^{-1}$, respectively) occurred under the higher rate of compost (15 ton fed^{-1}) and P fertilization rate(60 kg P_2O_5 fed^{-1}).

Table (4): Main effect of compost and P fertilization rates on N, P and K uptake in leaf and fruit of pepper plants at the maturity stage.

Compost ton fed^{-1}	Leaf			fruit		
	Nutrients uptake (mg $plant^{-1}$)					
	N	P	K	N	P	K
10	34.81	6.551	107.1	140.6	17.71	136.6
15	73.89	8.892	129.8	157.0	18.71	160.9
Mean	54.35	7.721	118.4	148.8	18.21	148.7
L.S.D.$_{0.05}$	9.001	0.300	8.06	4.130	9.50	7.090
P_2O_5 kg fed^{-1}						
0	28.59	3.133	72.43	139.1	14.16	143.8
30	44.47	10.86	89.68	152.4	20.38	155.0
45	71.70	10.74	154.5	173.1	21.58	167.5
60	72.25	13.69	164.2	181.3	23.38	178.4
Mean	54.25	9.606	120.2	161.5	19.87	161.2
L.S.D.$_{0.05}$	5.205	0.031	3.711	7.001	1.067	8.109

Table (5): **Interaction effect of compost and P fertilization rate N, P and K uptake in leaf and fruit of pepper at the maturity stage.**

Compost ton fed^{-1}	P_2O_5 kg fed^{-1}	Leaf			fruit		
		Nutrients uptake (mg $plant^{-1}$)					
		N	P	K	N	P	K
10	**0**	19.36	1.537	68.78	124.9	13.68	121.6
	30	32.09	5.680	88.71	133.2	17.19	124.1
	45	57.47	8.429	121.6	142.4	17.82	152.1
	60	89.57	11.58	157.0	153.8	18.3	160.6
Mean		49.62	6.806	109.0	138.6	16.74	139.6
15	**0**	24.25	4.360	76.15	163.5	14.65	127.8
	30	34.80	5.664	90.48	173.7	22.41	183.9
	45	102.5	13.20	175.9	186.5	25.11	189.2
	60	104.4	16.02	184.2	209.5	28.42	227.3
mean		66.49	9.811	131.7	183.3	22.65	182.1
L.S.D.$_{0.05}$		4.120	0.630	7.430	3.710	1.120	2.661

Table (6): Main effect of compost and P fertilization rate on Fe, Zn and Mn uptake in pepper plants at the maturity stage

Compost $tonfed^{-1}$	Leaf			Fruit		
	Nutrients uptake (mg $plant^{-1}$)					
	Fe	Zn	Mn	Fe	Zn	Mn
10	2.283	0.777	0.067	3.363	1.821	0.097
15	2.848	0.979	0.083	3.760	2.074	0.105
mean	2.565	0.878	0.075	3.561	1.947	0.101
L.S.D$_{0.05}$	0.528	0.012	0.010	0.260	0.114	0.003
P_2O_5 kg fed^{-1}						
0	1.552	0.570	0.044	3.330	1.870	0.093
30	1.973	0.687	0.057	3.831	2.113	0.105
45	3.346	1.094	0.101	3.912	2.131	0.111
60	3.522	1.160	0.102	4.385	2.332	0.130
mean	2.598	0.878	0.076	3.864	2.111	0.110
L.S.D$_{0.05}$	0.285	0.223	0.010	0.133	0.390	0.039

Table (7): Interaction effect between compost and P fertilization rate on Fe, Zn and Mn uptake in pepper plants at the vegetative stage.

Compost tonfed^{-1}	P_2O_5 kg fed^{-1}	Leaf			Fruit		
		Nutrients uptake(mg plant^{-1})					
		Fe	Zn	Mn	Fe	Zn	Mn
10	**0**	1.403	0.508	0.041	3.071	1.730	0.086
	30	1.998	0.675	0.052	3.177	1.764	0.090
	45	2.705	0.898	0.088	4.423	2.466	0.119
	60	3.167	1.052	0.092	5.230	2.729	0.155
Mean		2.318	0.783	0.068	3.980	2.172	0.113
15	**0**	1.707	0.606	0.046	3.351	2.014	0.095
	30	1.946	0.698	0.059	4.426	2.488	0.127
	45	4.013	1.354	0.116	3.400	1.768	0.097
	60	3.892	1.270	0.113	3.500	1.893	0.105
Mean		2.890	0.982	0.084	3.744	2.041	0.106
L.S.D$_{0.05}$		0.571	0.446	0.038	0.715	0.073	0.038

Table (8): Effect of compost and P fertilization rate on nutrients availability in sandy soil cultivated with pepper.

Compost ton fed^{-1}	P_2O_5 kg fed^{-1}	Available nutrients content (mg kg^{-1})					
		N	P	K	Fe	Zn	Mn
10	**0**	56.45	59.35	53.47	35.43	1.347	8.530
	30	59.43	63.81	64.58	48.06	1.843	8.580
	45	71.23	67.48	67.35	48.70	2.010	10.82
	60	71.90	68.83	67.92	51.50	2.810	10.18
Mean		64.75	64.87	63.33	45.92	2.000	9.527
15	**0**	63.84	68.11	61.80	44.36	1.800	8.740
	30	89.74	68.83	70.64	48.66	1.800	9.630
	45	95.00	70.56	72.23	52.90	2.710	12.12
	60	96.39	71.34	78.81	54.80	3.040	11.19
Mean		86.24	69.71	70.87	50.18	2.337	10.42
L.S.D. $_{0.05}$		11.70	2.325	5.316	4.112	0.217	1.470

Pazhanivelan, et al. (2006) reported that increasing P uptake when compost was enriched by rock phosphate due to inducing the solubility of P and thereby its availability to crop. Under both the lower and higher compost rates, significant increases in K uptake of leaf and fruit took place under increasing P fertilization rate. K uptake values in pepperleaf and fruit steadily increased as the rate of applied P increased showing average values of 131.7 and 182.1 mg plant^{-1}, respectively, under higher compost rate as compared with lower applied compost rate (average values 109.0 and 139.6 mg plant^{-1}, respectively). The maximum K uptake of leaf and fruit (184.2 and 227.3 mg plant^{-1}, respectively) occurred under the higher rate of compost (15 ton fed^{-1}) and P fertilization rate (60 kg P_2O_5 fed^{-1}). Alabi (2006) found that increasing the rates of applied P and poultry droppings increased significantly N, P and K uptake of pepper plant.

Regarding the main effect of compost rate on Fe, Zn and Mn uptake (mg plant^{-1}) in pepper plants, obtained results (Table,) show that the higher rate of applied compost, significantly increased Fe, Mn and Zn uptake in both leaf and fruit, probably because adding the source of such nutrients via the added compost. Ibrahim et al. (1988) reported that increasing uptake of micronutrients such as Fe, Mn and Zn by addition of organic residues, could be due to the production of acids and chelating materials through decomposition of such residues that are expected to play a vital role in defining the net status of nutrients especially the micronutrients in growth media. Regarding the main effect of P fertilization rate on Fe, Zn and Mn uptake in pepper plant, obtained data (Table,6) show that increasing the rate of added P led to an increasing trend in Fe, Zn and Mn uptake either in leaf or fruit of pepper. P fertilization rate (60 kg P_2O_5 fed^{-1}) produced either significant increase of Fe, Zn and Mn uptake of leaf and fruit. Alabi (2006) reported that Fe, Mn and Zn uptake of pepper plants were increased by increasing the rate of P application

Regarding the interaction effect between compost and P fertilization rate on Fe, Zn and Mn uptake (mg $plant^{-1}$) of pepper plants, obtained results (Table, 7) show that under the 1st rate of applied compost, P application up to (60 kg $P_2O_5fed^{-1}$) increased Fe, Zn and Mn uptake of leaf to maximum levels (3.167, 1.052 and 0.092 mg $plant^{-1}$, respectively), as well as of fruit to maximum levels (5.230, 2.729 and 0.155 mg $plant^{-1}$, respectively). The increasing trend of these micronutrients, lasted until fourth rate (60 kg $P_2O_5fed^{-1}$), which may suggest a tendency to accumulate of micronutrients in pepper fruit more than in pepper leaf, particularly under high P supplemental. Alabi (2006) obtained increments in Fe, Zn and Mn uptake in pepper plants with addition of the high rate of P fertilization with high rate of poultry droppings. Under higher rate of compost, third rate of P fertilization (45 kg P_2O_5 fed^{-1}) increased Fe, Zn and Mn uptake of leaf to maximum levels (4.013, 1.354 and 0.119 mg $plant^{-1}$, respectively). Second rate of P fertilization (30 kg P_2O_5 fed^{-1}) was enough to maximize the nutrients uptake in pepper fruit. Regarding the effect of between added compost and P fertilization rate on available content of N, P, K, Fe, Mn and Zn (mg kg^{-1}) under pepper cultivated in sandy soil, obtained results (Table, 8) show that under the lower compost rate (10 $tonfed^{-1}$), the high level of P fertilization (60 kg P_2O_5 fed^{-1}) maximized available N, P, K, Fe, Mn and Zn content in soil surpassing that of the lower rates insignificantly for N, P, K and Fe but significantly for Zn and Mn. Under the higher compost rate (15 ton fed^{-1}), P application rate of 60 kg $P_2O_5fed^{-1}$ maximized all content of the tested available nutrients insignificantly of N but significantly for the other nutrients.

CONCLUSION

Finally, it may be concluded that the net effect of interaction reveals that the highest values of nutrients available content in soil i.e.: 96.39, 71.34, 78.81, 54.80 and 3.040 mg/kg of N, P, K, Fe and Zn, respectively, were due to the higher compost rate combined with fourth rate of P application (60 kg $P_2O_5fed^{-1}$); as for soil available Mn the highest value (12.12 mg kg^{-1}) was under the higher compost rate (15 ton fed^{-1}) combined with third rate of P application (45 kg P_2O_5 fed^{-1}).

CONFLICT OF INTEREST

The present study was performed in absence of any conflict of interest.

AUTHOR CONTRIBUTIONS

Abd El-Rheem Kh. M. designed and performed the experiments and also wrote the manuscript. All authors read and approved the final version.

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