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Comparative Studies of Sewage Sludge, Urban Compost and FYM on Yield and Quality of Tomato (*Lycopersicon esculentum* Mill.) Fruit

P Kavitha , A Ravi Chandra Reddy and K Jeevan Rao
Department of Soil Science and Agricultural Chemistry, College of Agriculture ,
Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad 500 030, Andhra Pradesh

ABSTRACT

Effect of sewage sludge, urban compost and FYM @ 0, 20 and 40 t ha^{-1} on yield and quality of fruit (ascorbic acid, total soluble solids, protein content and heavy metal content *viz.,* Zn, Cu, Ni, Cr, Pb and Cd) in tomato during kharif season of 2003 under green house condition was studied. Results showed that the addition of sewage sludge and urban compost @ 40 t ha^{-1} did not show any detrimental effect on the yield and quality parameters *viz.,* TSS, ascorbic acid and protein content, although it increased the heavy metal content in tomato fruit. However, the concentrations of heavy metals were below the safe limits. Increasing levels of fertilizers from zero fertilizer application to 100 per cent recommended dose of fertilizers (RDF) as well as manure (0 to 40 t ha^{-1}) addition significantly increased the yield and quality parameters. Among the manures, the sewage sludge was superior in increasing the yield and quality parameters. Combined application of manures and fertilizers increased the yield and quality parameters. Among all the combinations, the highest yield and quality parameters were obtained with sewage sludge @40 t ha^{-1} along with 100 per cent RDF, closely followed by sewage sludge @40 t ha^{-1} along with 75 per cent RDF.

Key words : FYM, Sewage Sludge, Tomato, Urban Compost, Yield and Quality of Fruit.

The recycling of organic wastes for increasing soil fertility has gained importance in recent years due to high cost of fertilizers and reduced availability of organic manures. Sewage sludge and urban compost are rich in organic matter and plant nutrients (Jeevan Rao and Shantaram ,1996 ; Khankhane and Yadav, 2003). Thus, these are the potential resources for soil amelioration and crop production. Although a plethora of information is available on the effect of conventional soil organic inputs on the quality parameters in vegetables (Bachav and Sabale 1996; Rafi *et al.,* 2002), little is known about sewage sludge and urban compost in this respect. Hence, present studies were conducted to know the effect of sewage sludge, urban compost and FYM alone or in combination with fertilizers on yield and quality of fruit in tomato under green house experiment.

MATERIAL AND METHODS

Sewage sludge was collected from municipal sewage treatment plant, Amberpet, Hyderabad. Urban compost was collected from "SELCO International Composting Unit", Gandhamguda, Ranga Reddy district while FYM was collected from Dairy Farm, College of Veterinary Science, Rajendranagar, Hyderabad. The initial characteristics such as organic carbon (Walkley and Black, 1934), heavy metal status (Lindsay and Norwell 1978), available and total nutrients were analyzed as per the standard procedures. Table 1 represents the characteristics of sewage sludge, urban compost and FYM.

A pot experiment was conducted during kharif, 2003 on sandy loam soil at green house, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Rajendranagar, Hyderabad. The initial characteristics of experimental soil were 196.3, 21.16, 305.3 available N, P205 and K2O kg ha^{-1}, respectively, while 2.98, 2.76, 0.902,0.301 , 0.153 mg kg^{-1} and traces for Zn, Cu, Pb, Ni, Cr and Cd respectively. The four main treatments *viz.,* 0, 50, 75 and 100 per cent recommended dose of fertilizer (RDF) and seven sub treatments viz., two levels (20 and 40 t ha^{-1}) of each sewage sludge (SS), urban compost (UC), FYM and control (without manure) and combinations of fertilizer levels along with organic manurial levels, thus, total of 28 treatments, each replicated thrice was in completely randomized design. The soil in each of the pots was thoroughly mixed with required quantities of organic manure needed as per the treatments at 10 days before transplanting. Soil was maintained in moist condition by adding water up to transplanting. Thirty days old seedlings were planted @ 3 seedlings per pot on 10th July 2003. After 10

Table 1. Initial characteristics of sewage sludge, urban compost and FYM

Character	Sewage sludge	Urban compost	FYM
Physico- chemical properties			
pH	6.58	7.12	7.67
EC (dSm-1).	2.12	1.52	0.96
OC (%)	36.70	22.46	10.49
Total major nutrient status (%)			
N	1.92	0.92	0.56
P	0.82	0.34	0.18
K	0.68	0.56	0.52
Total micronutrient and heavy metal status (mg kg^{-1})			
Fe	6131	3250	1567
Mn	786	210	171
Cu	352	88.75	29.56
Zn	436	81.96	41.58
Cd	62.91	19.52	tr
Ni	67.83	12.24	6.62
Cr	95.50	58.33	2.36
Co	35.83	5.83	5.53
Pb	119	54	tr
DTPA extractable micronutrients and heavy metals (mg kg^{-1})			
Fe	213	102	58.82
Mn	29.36	14.23	7.86
Cu	19.32	5.36	5.36
Zn	28.86	10.15	5.12
Cd	1.56	0.58	tr
Ni	10.61	1.42	0.91
Cr	6.20	2.15	0.23
Co	3.12	0.18	0.20
Pb	4.21	5.62	tr

days, two plants were removed and incorporated in the same pot. Only one plant was maintained in each pot. The RDF applied to tomato crop was 150, 60 and 60 kg ha^{-1} of N, P2O5 and K2O, respectively. Nitrogen, phosphorus and potassium were applied through Urea, SSP and MOP, respectively. Phosphorus and potassium were applied as basal whereas nitrogen was applied in three equal splits *viz.,* as basal, at flowering and at fruit formation. At maturity, the yield of the tomato fruits from each pot was recorded. Fresh fruit samples were analyzed for the vitamin C and TSS (Total Soluble Solids) as per the procedures out lined by Ranganna, 1986, while the dried pieces of fruit samples were ground in Willey mill and were analyzed for the protein content using the procedure (multiplying the corresponding nitrogen content (%) with a factor 6.25) outlined in AOAC 1980) and the contents of heavy metals as per the procedures outlined by Lindsay and Norwell (1978). The data were subjected to statistical analysis (CRD-two way factorial) as per the procedures outlined by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Yield

The data revealed that there were significant increases in the fresh fruit yield with increasing levels of fertilizers from zero fertilizer application to 100 percent RDF (Table 2). The increase of tomato fruit yield in 100 per cent RDF over zero fertilizer application was 45.18 per cent. This may be due to increase in the availability of nutrients for plant absorption by the direct application of chemical fertilizers. Similar results were reported by Hanumanthappa and Shivaraj (2003) with the application of 100 per cent NPK in sesamum.

Table 2. Yeld and quality parameters of tomato fruit at harvest as influenced by different treatments.

Treatments	Fresh fruit yield (g pot^{-1})					Protein content (%)				
Main / Sub	Fertilizer levels (% RDF)					Fertilizer levels (% RDF)				
	0	50	75	100	Mean	0	50	75	100	Mean
Control	401	495	596	663	539	13.50	14.75	15.06	15.75	14.77
SS @ 20 t ha^{-1}	562	930	1032	1068	898	15.38	16.88	17.06	17.25	16.64
SS @ 40 t ha^{-1}	712	1110	1123	1142	1022	15.88	17.38	17.63	17.75	17.16
UC @ 20 t ha^{-1}	448	670	758	863	685	13.94	15.88	16.13	16.31	15.56
UC @ 40 t ha^{-1}	540	880	982	1034	859	15.00	16.63	16.81	17.06	16.38
FYM @ 20 t ha^{-1}	452	688	780	873	698	14.00	16.00	16.25	16.44	15.67
FYM @ 40 t ha^{-1}	550	910	1001	1049	878	15.13	16.75	16.94	17.19	16.50
Mean	524	812	896	956		14.69	16.32	16.55	16.82	
		S.Ed±	CD (0.05)			S.Ed±	CD (0.05)			
F		5	10			0.10	0.20			
T		6	13			0.14	0.27			
FXT		13	26			0.27	NS			

Treatments	Ascorbic acid (mg 100 g^{-1})					Total soluble solids (%)				
Main / Sub	Fertilizer levels (% RDF)					Fertilizer levels (% RDF)				
	0	50	75	100	Mean	0	50	75	100	Mean
Control	18.23	18.61	18.91	19.63	18.85	4.10	4.28	4.30	4.32	4.25
SS @ 20 t ha^{-1}	19.42	21.31	21.63	21.92	21.07	4.21	4.43	4.46	4.50	4.40
SS @ 40 t ha^{-1}	20.91	22.34	22.62	22.92	22.20	4.48	4.58	4.59	4.61	4.57
UC @ 20 t ha^{-1}	18.92	20.81	21.21	21.32	20.57	4.29	4.38	4.40	4.42	4.37
UC @ 40 t ha^{-1}	19.61	21.63	21.83	21.92	21.25	4.39	4.45	4.49	4.50	4.46
FYM @ 20 t ha^{-1}	19.13	20.64	21.21	21.41	20.60	4.30	4.40	4.42	4.48	4.40
FYM @ 40 t ha^{-1}	19.92	21.56	21.82	21.92	21.31	4.40	4.46	4.50	4.52	4.47
Mean	19.45	20.99	21.32	21.58		4.31	4.43	4.45	4.48	
		S.Ed±	CD (0.05)				S.Ed±	CD (0.05)		
F		0.07	0.15				0.02	0.04		
T		0.15	0.30				0.02	0.06		
FXT		0.30	NS				0.06	NS		

F : Fertilizers
T : Treatments
F x T : Fertilizers x Treatments

Table 3. Heavy metal content (mg kg^{-1}) of tomato fruit at harvest as influenced by different treatments.

Treatments	Zn					Cu					Pb				
Main	Fertilizer levels (% RDF)					Fertilizer levels (% RDF)					Fertilizer levels (% RDF)				
Sub	0	50	75	100	Mean	0	50	75	100	Mean	0	50	75	100	Mean
Control	13.12	15.62	17.51	20.81	16.77	3.51	4.18	4.32	4.59	4.15	0.201	0.431	0.581	0.741	0.489
SS @ 20 t ha^{-1}	21.23	30.14	33.62	36.42	30.35	4.53	5.08	5.18	5.36	5.04	0.873	1.342	1.362	1.490	1.267
SS @ 40 t ha^{-1}	25.13	42.62	45.12	46.32	39.80	4.88	5.54	5.61	5.78	5.45	1.151	1.720	1.781	1.810	1.616
UC @ 20 t ha^{-1}	18.32	23.14	25.23	28.12	23.70	4.11	4.68	4.71	4.88	4.60	0.552	1.180	1.112	1.396	1.060
UC @ 40 t ha^{-1}	21.42	29.12	31.23	34.21	29.00	4.32	5.01	5.08	5.13	4.89	0.751	1.261	1.312	1.412	1.184
FYM @ 20 t ha^{-1}	19.62	25.21	26.32	38.21	27.34	4.19	4.78	4.83	4.91	4.68	0.242	0.458	0.601	0.783	0.521
FYM @ 40 t ha^{-1}	22.12	32.64	35.21	36.12	31.52	4.46	5.06	5.10	5.23	4.96	0.461	0.672	0.762	0.812	0.677
Mean	20.14	28.36	30.61	34.32		4.29	4.90	4.98	5.13		0.604	1.009	1.073	1.206	
		S.Ed±	CD (0.05)				S.Ed±	CD (0.05)				S.Ed±	CD (0.05)		
F		0.17	0.34				0.03	0.05				0.01	0.01		
T		0.23	0.45				0.03	0.07				0.01	0.02		
FXT		0.45	0.90				0.07	0.14				0.02	0.04		

Treatments	Ni					Cr					Cd				
Main	Fertilizer levels (% RDF)					Fertilizer levels (% RDF)					Fertilizer levels (% RDF)				
Sub	0	50	75	100	Mean	0	50	75	100	Mean	0	50	75	100	Mean
Control	0.192	0.401	0.562	0.682	0.459	0.010	0.023	0.036	0.048	0.029	tr	tr	tr	tr	tr
SS @ 20 t ha^{-1}	0.883	1.360	1.512	1.561	1.329	0.083	0.108	0.113	0.118	0.106	0.011	0.019	0.023	0.027	0.020
SS @ 40 t ha^{-1}	1.070	1.680	1.712	1.742	1.551	0.103	0.121	0.128	0.131	0.121	0.023	0.032	0.041	0.046	0.036
UC @ 20 t ha^{-1}	0.691	0.921	0.981	1.068	0.915	0.031	0.056	0.059	0.060	0.052	0.003	0.006	0.008	0.010	0.007
UC @ 40 t ha^{-1}	0.912	1.102	1.230	1.381	1.156	0.036	0.079	0.081	0.083	0.070	0.004	0.018	0.019	0.012	0.013
FYM @ 20 t ha^{-1}	0.612	0.731	0.812	0.892	0.762	0.019	0.031	0.036	0.048	0.034	tr	tr	tr	tr	tr
FYM @ 40 t ha^{-1}	0.781	0.991	1.121	1.263	1.039	0.020	0.041	0.052	0.062	0.044	tr	tr	tr	tr	tr
Mean	0.734	1.027	1.133	1.227		0.043	0.066	0.072	0.079		0.006	0.011	0.013	0.014	
		S.Ed±	CD (0.05)				S.Ed±	CD (0.05)				S.Ed±	CD (0.05)		
F		0.01	0.01				0.0004	0.0009				0.00	0.00		
T		0.01	0.02				0.0006	0.0012				0.00	0.00		
FXT		0.02	0.04				0.0012	0.0024				0.00	0.001		

Application of organic manures significantly increased the yield over control. There was significant increase in the yield with increasing levels of manure application up to 40 t ha^{-1}. Among manures, the highest yield was obtained with sewage sludge application @ 40 t ha^{-1}. At 40 t ha^{-1} level increase in tomato fruit yield with sewage sludge over FYM was 14.09 per cent. Sewage sludge application was superior to FYM and urban compost because sewage sludge contains higher concentrations of nutrients than FYM and urban compost (Table 1). Similarly, the sewage sludge application proved to be superior in increasing the yield than FYM and biogas slurry in tomato and brinjal under pot culture conditions (Khankhane and Yadav ,2003). The direct and residual effects of organic manures on yield might be due to the release of nutrients through mineralization, good aggregation and improved soil physical conditions (Laxminarayana, 2006).

Interaction effects of different manures and fertilizers on yield were significant. Combined application of manures and fertilizers significantly increased the mean fruit yield than applied alone. Of all the combinations, sewage sludge combinations were superior in increasing yield. Among all the treatments sewage sludge application @ 40 t ha^{-1} along with 100 per cent RDF resulted in the highest mean fruit yield (1142 g pot^{-1}) but, it was on par with 75 and 50 per cent RDF at the same level of sludge application. The effect of sludge coupled with higher dose of inorganic fertilizer in increasing the yield of vegetables was also reported by Paulraj and Sreeramulu (1994).

Quality Parameters

Similar to yield, the quality parameters significantly increased with increase in fertilizer application and also due to manure application (Table 2). The increase in the quality parameters at 100 per cent RDF over zero fertilizer application was 9.87, 12.66 and 3.79 per cent for ascorbic acid, protein content and TSS, respectively .Among manures, the highest quality parameters were obtained with sewage sludge applied @ 40 t ha^{-1} followed by sewage sludge applied at 20 t ha^{-1}. The increase in quality parameters in treatment with sewage sludge @ 40 t ha^{-1} over FYM applied @ 40 t ha^{-1} was 4.00, 3.85 and 2.19 per cent for ascorbic acid, protein content and TSS, respectively.

Interaction effect was not significant for the quality parameters of tomato fruits. However, there was gradual increase in quality parameters with increased levels of application of manure from 0 to 40 t ha^{-1} in combination with increased levels of fertilizer *viz.,* from 0 to 100 per cent RDF. The highest quality parameters were recorded in treatment with sewage sludge applied @ 40 t ha^{-1} along with 100 per cent RDF followed by sewage sludge @ 40 t ha^{-1} with 75 per cent RDF level. The decreasing order of quality parameters with different organic manures was: sewage sludge > urban compost > FYM. The increase in protein content with fertilizer application, manure application and combined application may be due to the high content of nitrogen. The increase in ascorbic acid content was due to that Zn is a part of enzyme ascorbic acid oxidase. Higher Zn content leads to higher ascorbic acid content. Fe being an essential component of many respiratory enzymes, which would convert the reserve food materials to soluble simple sugars, this would be the possible reason for increased TSS content of fruits. Similar conclusions were also drawn by Mahendran and Kumar (1996) in cabbage. Combined application of manures and fertilizers resulted in higher content of protein, TSS and ascorbic acid in tomato fruits than individual application (Rafi *et al.,* 2002).

The contents of heavy metals (Zn, Cu, Ni, Cr and Cd) in the fruit also significantly increased with increase in fertilizer application and due to manure application (Table 3) .Among manure treatments, two levels of sewage sludge i.e., 20 and 40 t ha^{-1} showed significantly higher concentrations of all above said heavy metals than urban compost and FYM @ 40 t ha^{-1}. This was due to high heavy metal contents in sewage sludge when compared with urban compost and FYM (Table 1). Cadmium concentrations were observed in sewage sludge and urban compost treatments only. Control and FYM treatments showed negligible quantity of Cd (only traces). This was due to the absence of Cd in FYM and initial soil. Interaction effect was significant for all the above said heavy metals content in the fruit. Sewage sludge application along with 100 per cent RDF resulted in the highest concentration of heavy metals by fruits closely followed by 75 and 50 per cent levels of RDF with the same level of sludge application. However, the concentrations were within the permissible limit of 50, 30, 2.5 and 1.5 mg kg^{-1} for Zn, Cu, Pb and Cd as prescribed by Indian PFA act (1954), 2.0 mg kg^{-1} for Ni and Cr as suggested by Chapman (1975)

The results showed that the addition of sewage sludge and urban compost @ 40 t ha^{-1} did not show any detrimental effect on the yield and quality parameters *viz.,* TSS, ascorbic acid and protein content, although increased the heavy metal content in tomato fruit . However, the concentrations were below the safe limits. Among the manures, the sewage sludge was superior in increasing the yield and quality parameters. Combined application of manures and fertilizers increased the mean yield and quality parameters. Among all the combinations, the highest yield and quality parameters were obtained with sewage sludge @ 40 t ha^{-1} along with 100 per cent RDF, closely followed by sewage sludge @ 40 t ha^{-1} along with 75 per cent RDF.

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