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Evaluation of the Chemical Composition of Manures from Different Organic Wastes and their Potential for Supply of Nutrients to Tomato in a Tropical Ultisol

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ABSTRACT

Manures (sewage sludge, swine, rabbit and poultry manures) from four farm or homestead wastes were analyzed for their chemical composition and were compared with NPK fertilizer for their ability to supply nutrient elements to tomato plants under field conditions.

The organic manures varied considerably in their initial content of nutrient elements, their effects on soil pH and in their release of nutrients for tomato absorption. NPK fertilizer appeared more efficient than the organic manures in supplying N, P and K, at least in the short run, while the organic manures had an advantage in the supply of other macro- and micro-nutrient elements not contained in NPK fertilizer. There were variabilities in the efficiency of supply or uptake of the elements contained in the various manures.

Under the conditions of the experiment, the recommendable manure rates at which tomato gave good growth were 10 t ha^{-1} for swine manure, 20 t ha^{-1} for sewage, a range of 10 to 20 t ha^{-1} for rabbit and poultry manures, and a combination of 100 kg N, 40 kg P and 100 kg K ha^{-1} ($N_{100}P_{40}K_{100}$ kg ha^{-1} rate) for NPK fertilizer. A high rate of 30 t ha^{-1} did not produce a further advantage in tomato growth for any manure source.

INTRODUCTION

Farmers in West Africa commonly keep livestock as well as growing crops. Consequently a lot of wastes are produced from animal houses. Similarly, large quantities of urban wastes including sewage sludge are produced. Often these wastes accumulate, posing a disposal problem and constituting an ecological hazard, but they can be composted and used profitably for fertilizing premium crops like vegetables. With the present high cost of fertilizers, the use of farmyard and homestead sources of organic manure is becoming more popular with the resource-poor farmers. The more common organic manures from these wastes which were identified for the study were sewage sludge, poultry, pig and rabbit manures.

Information is lacking on the chemical composition of these manures obtained locally and on their nutrient supplying power under cropping conditions. Yet it is commonly recognized that the chemical composition of manures and their ability to release the nutrients for crop absorption are of great importance when developing recommendations for rates of manure application. This investigation was, therefore, aimed at studying the chemical composition of the manures from these farm and homestead wastes to gain information on their potential fertilizer value. The relative efficiency of the manure application at various rates compared with inorganic NPK fertilizer in supplying nutrient elements to tomato under field conditions was also studied.

MATERIALS AND METHODS

The organic manures used for the study were sewage sludge, swine, rabbit and poultry manures. The swine and rabbit manures were, in each case, a mixture of dung, urine and litter-bedding collected from the manure pits of the faculty of Veterinary Medicine, University of Nigeria, Nsukka, Nigeria. Sewage sludge was collected from the University's sewage collection pit. The poultry manure used was from the deep litter system from a commercial unit at Obimo, near Nsukka, and was a mixture of poultry droppings and sawdust. The manures were collected at two periods of the year, the first in April and the second in August 1987. They were separately analyzed for their nutrient composition. Field evaluation of nutrient supply for tomato crops was from the April collection.

The experiment consisted of five manurial treatments viz; NPK fertilizer and swine, sewage sludge, rabbit and poultry manures at four rates each. The four rates of organic manure were 0, 10, 20 and 30 t ha^{-1} calculated on a dry weight basis. The NPK fertilizer, mixed immediately before application from urea, single superphosphate and muriate of potash, was applied according to the following rates: $N_0P_0K_0$, $N_{150}P_{20}K_{50}$ (i.e. 50, 20, 50 kg ha^{-1} of N, P and K, respectively), $N_{100}P_{40}K_{100}$ and $N_{150}P_{60}K_{150}$. The experimental design was a randomized complete block and there were three replications.

The experiment was conducted in a tropical Ultisol at Nsukka, Nigeria, located at 447 m above sea level, and at latitude 06° 52′N and longitude 07° 24′E. The Ultisol constitutes over 70% of the agricultural lands of south eastern Nigeria. After land preparation, a composite soil sample was taken to a depth of 18 cm for physical and chemical analyses. Tomato, *Lycopersicon esculentum* Mill, cv Rossol VFN, seedlings were transplanted into the field plots at the 5-week old stage, 16 days after the organic manures were applied to the appropriate plots. The NPK-fertilizer was applied to the appropriate plots in two equal parts, one at 10 days from transplanting and the other at 24 days after transplanting. Hoe weeding was done twice in all plots at 38 and 60 days after planting. Soil samples for determination of the effect of manuring on pH were taken from each plot 52 days after organic manure application, which was 26 days from the day of application of the first dose of NPK treatment or 12 days from the day of the last dose given to NPK plots.

Laboratory analyses of the soil, organic manures and tomato leaves

The composite soil sample collected from the site was analyzed for pH, N, NH_4^+, NO_3^-, organic matter, P, K, Ca, Mg, Zn, Cu, Na, Al and Fe using the methods outlined in the Official Methods of Analysis of the Association of Official Analytical Chemists (A.O.A.C. methods, 1970). At 72 days after planting (DAP), when the tomato plants had attained maximum vegetative growth, destructive harvest was made for evaluation of dry matter partition to plant organs. Also a sample of the 5th-leaf from the stem apex was obtained from each plot, dried, milled and used for chemical analysis. Similarly the various organic manure samples were analyzed for their chemical composition. In all cases total N was determined by the modified Kjeldahl method and elemental P by the micro Kjeldahl method, both as outlined in the A.O.A.C. Methods (1970). Determinations of ammonium-N and nitrate-N were by the procedures of Bremner (1965). Determination of metals (K, Ca, Mg, Na, Zn, Cu, Fe and Al) was by the atomic absorption method as outlined in the A.O.A.C. Methods (1970). Statistical analysis of data was by the standard procedure for a randomized complete block design as outlined by Steel & Torrie (1960).

RESULTS

The soil was, texturally, a sandy loam and the contents of the major elements were generally low (Table 1). Aluminium content was relatively high and this was reflected in the low soil pH.

Organic matter was highest in rabbit manure followed by poultry manure for manures collected in April, but for the August collection, it was highest with poultry manure (Table 2). Sewage sludge had, remarkably, the highest content of ammonium and nitrate nitrogen followed by swine manure but swine manure had always the highest total N followed by sewage sludge. Ammonium-N was usually higher than nitrate-N in the manures. Sewage

TABLE 1

Mechanical and chemical properties of the tropical Ultisol at Nsukka on which the experiment was conducted.

Mechanical properties	
Coarse sand (%)	57.6
Fine sand (%)	18.4
Clay (%)	21.8
Silt (%)	2.2
Textural class	Sandy loam
Chemical properties	
Soil pH (1:2.5, soil:water)	4.6
Organic matter (%)	3.09
NO_3-N (ppm)	30.99
NH_4-N (ppm)	65.20
Total N (%)	0.08
Total P (ppm)	57.50
Exchangeable cations meq per 100 g soil	
Ca	0.54
K	0.17
Mg	0.46
Na	0.15
Al	1.36
Base saturation (%)	58.00

sludge was generally low in P, K, and Ca, but markedly high in Mg, Zn and Cu while poultry manure was particularly high in Ca, Na and Fe. Swine manure was always high in P and Ca.

Rabbit and poultry manures, on average, significantly raised the soil pH compared to where sewage sludge and NPK fertilizer were applied (Table 3). Increasing rates of NPK and sewage sludge did not have any significant effects on soil pH. Except for sewage sludge and the lower rates of swine manure, applied manure increased soil pH compared to the control plots. At 10 or 20 t ha^{-1}, poultry manure plots had significantly higher pH than sewage sludge, swine manure and the corresponding NPK fertilizer rate plots, but not more than the rabbit manure plots. At 30 t ha^{-1}, rabbit and swine manures gave higher soil pH than sewage sludge and the corresponding $N_{150}P_{60}K_{150}$ kg ha^{-1} fertilizer rate.

Significantly higher levels of leaf and stem dry matter were observed with the application of rabbit manure or NPK fertilizer, on average, than swine and sewage sludge applications (Table 4). Rabbit manure gave the highest total dry matter of plant tops followed by NPK fertilizer and then poultry manure. The highest dry matter of tops was obtained at 10 t ha^{-1} with swine manure, at 20 t ha^{-1} with sewage, while with rabbit and poultry manures the highest dry matter of tops appeared to occur within the range of 10 to 20 t ha^{-1} of manure application. A high rate of 30 t ha^{-1} did not show additional benefits

TABLE 2

Chemical composition of the more commonly available organic manure types collected at two different periods.

Manure sources	Dry matter	Organic matter	Total N	NH_4-N µg/g	NO_3-N µg/g	C/N	P	K	Ca	Mg	Na	Fe	Zn	Cu	Al
	—— % ——					—— % ——								—— µg ——	
April collection															
Swine manure	60.90	68.10	1.62	316.22	218.76	24.38	2.06	1.08	2.76	0.95	0.15	1.18	272.09	43.06	1990
Sewage sludge	66.79	64.48	1.52	763.87	582.44	24.61	0.46	0.12	1.15	1.10	0.07	1.24	646.65	119.34	1333
Rabbit manure	73.40	81.54	1.22	227.99	102.45	38.77	1.41	1.22	2.50	0.60	0.55	1.46	295.90	33.23	1102
Poultry manure	88.10	99.2	1.41	137.61	188.59	31.77	1.33	1.61	6.25	0.86	1.88	2.47	332.91	31.93	1880
August collection															
Swine manure	68.90	58.44	1.70	336.42	225.54	19.94	1.51	0.74	2.29	0.78	0.11	1.30	232.39	33.99	1190
Sewage sludge	55.80	59.82	1.49	752.71	570.94	23.29	0.48	0.13	1.10	0.90	0.60	1.20	599.02	116.31	1278
Rabbit manure	72.80	57.41	1.00	209.14	35.59	33.30	1.06	0.65	4.19	0.50	0.15	1.80	173.93	24.17	1269
Poultry manure	66.50	92.00	1.34	115.99	36.50	39.85	1.23	0.90	4.06	0.60	0.17	2.20	253.32	30.93	2028

TABLE 3

Effect of organic manure sources and rates on soil pH.

Manure sources	Manure rates				
	0	10	20	30	Mean
Swine manure	4.67	4.87	4.43	5.53	4.88
Sewage sludge	4.67	4.70	4.50	4.43	4.58
Rabbit manure	4.67	5.03	5.37	5.57	5.16
Poultry manure	4.67	5.57	5.97	5.17	5.35
NPK* fertilizer	4.67	4.87	4.73	4.70	4.74
Mean	4.67	5.01	5.00	5.08	4.94

$LSD_{0.05}$ for 2 manure sources = 0.28
$LSD_{0.05}$ for 2 manure rates = 0.25
$LSD_{0.05}$ for same or diff. manure sources at same or diff. rates = 0.55

*NPK rates were 0-0-0; 50-20-50; 100-40-100; 150-60-150 elemental N, P, K (kg h^{-1}), corresponding to 0, 10, 20 and 30 t ha^{-1} manure rates.

in improving growth with any manure type.

The difference in leaf N did not attain statistical significance (Table 5). Poultry and rabbit manures gave higher leaf P than sewage sludge, on average, and at the 10 t ha^{-1} rate. Application of poultry and rabbit manures always have higher leaf P than the control plots. Poultry manure application gave a higher average leaf K than sewage sludge and swine manure, while rabbit manure gave a higher value than sewage sludge. Except for swine and sewage sludge at rates of 10 and 20 t ha^{-1}, applied manure or NPK fertilizer gave higher leaf K than the control plots. At 20 t ha^{-1}, poultry manure treatment accumulated greater K in tomato leaf than sewage sludge, swine and poultry manures. NPK fertilizer application resulted in lower leaf Ca than poultry manure. Similarly, NPK fertilizer treatment resulted in lower leaf Mg compared to swine, rabbit and poultry manures, while sewage sludge gave a lower value than swine manure. Cases where swine and poultry manures were applied have higher leaf Mg than the control plots.

There were no consistently significant effects of the manures and NPK fertilizer on leaf Fe and Cu (Table 6). Zinc accumulation in tomato leaf was significantly higher with poultry and rabbit manures compared with swine manure. A higher quantity of Zn was accumulated at 20 or 30 t ha^{-1} of rabbit or poultry manure than with the control plots. On average, sewage sludge treatment resulted in higher leaf Al than application of swine manure only.

The manure rates at which tomato growth appeared best were 10 t ha^{-1} for swine manure, 20 t ha^{-1} for sewage sludge and 10 to 20 t ha^{-1} for rabbit and poultry manures, while for NPK fertilizer, $N_{100}P_{40}K_{100}$ appeared optimum (Table 7). At the highest tomato growth with each manure, leaf N was highest with rabbit manure followed by NPK and sewage sludge treatments, while

TABLE 4

Effect of manure sources and rates on tomato leaf and stem fractions and on total dry matter of tops (g plant^{-1}) at 72 DAP.

Manure sources	Manure rates				
	0	10	20	30	Mean
Leaf dry matter (g plant^{-1})					
Swine manure	42.9	65.2	58.3	49.3	53.9
Sewage sludge	42.9	45.1	65.6	54.9	51.1
Rabbit manure	42.9	67.2	78.3	71.9	65.2
Poultry manure	42.9	58.5	63.5	58.6	55.9
NPK* fertilizer	42.9	68.7	76.4	53.8	60.5
Stem dry matter (g plant^{-1})					
Swine manure	20.8	27.0	26.6	20.3	23.9
Sewage sludge	20.8	30.9	24.2	21.4	24.3
Rabbit manure	20.8	28.4	33.1	30.8	28.3
Poultry manure	20.8	26.7	26.7	28.0	25.4
NPK* fertilizer	20.8	24.8	35.3	24.2	26.3
Total dry matter of tops (g plant^{-1})					
Swine manure	63.7	92.2	85.0	70.6	77.9
Sewage sludge	63.7	76.0	96.5	78.8	78.8
Rabbit manure	63.7	95.6	112.0	102.6	93.5
Poultry manure	63.7	85.2	90.2	86.6	81.4
NPK* fertilizer	63.7	93.5	111.6	78.1	86.7

	Leaf	*Stem*	*Total*
LSD for 2 manure source means	7.8	3.8	10.9
LSD for 2 manure rates means	6.9	3.4	9.8
LSD for 2 means of same or diff. manure sources at same or diff. rates	N.S.	7.7	N.S.

*NPK rates were 0-0-0; 50-20-50; 100-40-100; 150-60-150 elemental N, P, K (kg h^{-1}), corresponding to 0, 10, 20 and 30 t ha^{-1} manure rates;
N.S. = not significant.
Dap = days after planting.

leaf P and K were highest with poultry manure followed by rabbit manure or NPK fertilizer.

Results of the linear regression and correlation analysis of the elements in the 5th leaf against the total amount in the manures applied have been summarized in Table 8. The P, K, Ca, Mg, Cu and Zn accumulated in the 5th leaf mostly correlated significantly with the total amounts of these elements contained in swine and sewage manures. Except for P, this situation was also true with rabbit manure. With poultry manure, similar significant correlations were established in the cases of Mg and Zn concentrations in the leaf with the

TABLE 5

Effect of manure sources and rates on the macro-nutrient concentrations (%) in tomato 5th leaf at 72 days after planting.

Manure sources	Manure rate (t ha^{-1})				
	0	10	20	30	Mean
Nitrogen (N)					
Swine manure	4.60	4.66	4.79	4.77	4.71
Sewage sludge	4.60	4.76	4.87	4.85	4.77
Rabbit manure	4.60	4.97	4.67	4.69	4.73
Poultry manure	4.60	4.63	5.06	5.08	4.84
NPK*	4.60	4.62	4.88	4.86	4.74
Phosphorus (P)					
Swine manure	0.33	0.41	0.47	0.54	0.44
Sewage sludge	0.33	0.34	0.42	0.46	0.39
Rabbit manure	0.33	0.47	0.49	0.52	0.45
Poultry manure	0.33	0.50	0.51	0.50	0.46
NPK*	0.33	0.47	0.47	0.47	0.42
Potassium (K)					
Swine manure	3.20	3.35	3.70	4.38	3.66
Sewage sludge	3.20	3.22	3.60	4.07	3.52
Rabbit manure	3.20	4.07	4.15	4.76	4.04
Poultry manure	3.20	4.68	5.00	4.21	4.27
NPK*	3.20	4.16	4.63	4.18	4.04
Calcium (Ca)					
Swine manure	1.37	1.56	1.56	1.68	1.54
Sewage sludge	1.37	1.49	1.53	1.84	1.56
Rabbit manure	1.37	1.64	1.75	1.88	1.66
Poultry manure	1.37	1.76	2.08	1.72	1.73
NPK*	1.37	1.38	1.41	1.54	1.43
Magnesium (Mg)					
Swine manure	0.41	0.55	0.63	0.71	0.57
Sewage sludge	0.41	0.55	0.49	0.54	0.46
Rabbit manure	0.41	0.53	0.56	0.59	0.52
Poultry manure	0.41	0.48	0.60	0.60	0.52
NPK*	0.41	0.41	0.47	0.42	0.43

	N	P	K	Ca	Mg
LSD for 2 manure source means	N.S	0.05	0.38	0.25	0.06
LSD for 2 means of same or diff. manure sources at same or diff. rates	N.S.	0.11	0.75	N.S.	0.11

*NPK rates were 0-0-0; 50-20-50; 100-40-100; 150-60-150 elemental N, P, K (kg ha^{-1}), corresponding to 0, 10, 20, 30 t ha^{-1} manure rates
N.S. = not significant.

TABLE 7

Manure rates and the corresponding N, P and K concentrations in tomato 5th leaf at which growth was best for each manure source.

Manure source	Manure rates (t h^{-1})	N, P, K (%) in tomato 5th leaf		
		N	P	K
Swine manure	10	4.66	0.41	3.35
Sewage manure	20	4.86	0.42	3.60
Rabbit manure	10–20	4.97	0.49	4.15
Poultry manure	10–20	4.63	0.50	4.68
NPK	100–40–100	4.88	0.46	3.99
Mean		4.80	0.46	3.99
Quoted acceptable range*		4.0–5.5	0.40–0.65	3.0–6.0

*Bergmann & Bergmann (1985)

between tomato leaf N and the amount of N applied as manures.

The nutrient concentration in the 5th-leaf is usually a good index of the nutrient uptake by tomato (Sobulo *et al.*, 1975). The efficiency in the supply of the nutrients by the manures or fertilizer for tomato absorption was estimated as:

$$\text{Efficiency} = \frac{\text{elemental concentration in tomato fifth leaf}}{\text{total elemental content in manure or fertilizer applied}}$$

and the following orders in the efficiency of supply of the different elements the manures and fertilizer were obtained:

N: NPK > rabbit > poultry > sewage > swine manures
P: NPK > sewage > poultry > rabbit > swine manures
P: NPK > rabbit > poultry > swine > sewage manures
Ca: sewage > rabbit > swine > poultry manures
Mg: rabbit > swine > poultry > sewage manures
Cu: poultry > rabbit > swine > sewage manures
Zn: rabbit > poultry > swine > sewage manures
Fe: sewage > swine > rabbit > poultry manures

DISCUSSION

There was a high variability in the concentration of elements in the different organic manures as was also demonstrated in a review by Page (1974). The type and condition of the animal and the type of feed consumed (Phillips,

TABLE 8

Linear regression equation (Y = a + bX) and correlation coefficients (r) of elemental concentration in tomato 5th leaf against the total amount of individual nutrients contained in different manures.

Nutrient elements	Manure sources			
	Swine manure	Sewage sludge	Rabbit manure	Poultry manure
N	$\hat{Y}=4.61+0.004X^{N.S.}$ $r = 0.914^{NS}$	$\hat{Y}=4.74+0.0005X^{N.S.}$ $r = 0886^{NS}$	$\hat{Y}=4.75-0.0002X^{N.S.}$ $r = -0.200^{NS}$	$\hat{Y}=4.75+0.0001X^{N.S.}$ $r = -0.889^{NS}$
P	$\hat{Y}=0.334+0.0003X^{*}$ $r = 0.999^{**}$	$\hat{Y}=0.317+0.001X^{*}$ $r = 0.964^{*}$	$\hat{Y}=0.364+0.0004X^{N.S.}$ $r = 0.904^{NS}$	$\hat{Y}=0.382+0.0004X^{N.S.}$ $r = 0.773^{NS}$
K	$\hat{Y}=3.074+0.0036X^{*}$ $r = 0.956^{*}$	$\hat{Y}=3.074+0.0249X^{N.S.}$ $r = 0.944^{*}$	$\hat{Y}=3.331+0.0039X^{*}$ $r = 0.957^{*}$	$\hat{Y}=3.770+0.0024X^{N.S.}$ $r = 0.551^{NS}$
Ca	$\hat{Y}=1.403+0.0003X^{N.S.}$ $r = 0.937^{*}$	$\hat{Y}=1.340+0.0013X^{N.S.}$ $r = 0.935^{*}$	$\hat{Y}=1.414+0.0007X^{*}$ $r = 0.977^{*}$	$\hat{Y}=1.520+0.0002X^{N.S.}$ $r = 0.619^{NS}$
Mg	$\hat{Y}=0.428+0.001X^{*}$ $r = 0.989^{**}$	$\hat{Y}=0.392+0.0004X^{*}$ $r = 0.949^{*}$	$\hat{Y}=0.437+0.001X^{N.S.}$ $r = 0.933^{*}$	$\hat{Y}=0.419+0.001X^{*}$ $r = 0.948^{*}$
Fe	$\hat{Y}=0.096+0.0001X^{*}$ $r = 0.956^{*}$	$\hat{Y}=0.107+0.0002X^{N.S.}$ $r = 0.310^{NS}$	$\hat{Y}=0.101+0.0001X^{N.S.}$ $r = 0.868^{NS}$	$\hat{Y}=0.108+0.00001X^{N.S.}$ $r = 0.406^{NS}$
Cu	$\hat{Y}=63.679+14.742X^{*}$ $r = 0.949^{*}$	$\hat{Y}=62.522+18.80X^{N.S.}$ $r = 0.938^{*}$	$\hat{Y}=7.179+65.512X^{*}$ $r = 0.965^{*}$	$\hat{Y}=73.629+59.007X^{N.S.}$ $r = 0.643^{NS}$
Zn	$\hat{Y}=15.859+0.299X^{**}$ $r = 0.991^{**}$	$\hat{Y}=15.543+0.290X^{*}$ $r = 0.973^{**}$	$\hat{Y}=15.956+0.527X^{*}$ $r = 0.985^{**}$	$\hat{Y}=15.870+0.462X^{**}$ $r = 0.999^{**}$

$\hat{Y}$ = Estimated elemental concentrations +in 5th leaf (%) or ppm (for Cu and Zn)
X = Amount of the nutrient element in the manure (k/ha); r = Correlation coefficient
* = Significant at P = 0.05; ** = Significant at P = 0.01; N.S. = Non-significant.

1977) and handling (Heleman, 1967), together with the proportion of the litter content, usually contribute to the variabilities. The low P and K concentrations in sewage sludge could be attributed to the food habit of the people from whom the excrements were derived. The variability in the organic matter content of the manures partly depended on the type of feed consumed by the animal, the proportion of the litter component of the original waste and on the type of litter. The extent of the improvement of soil physical characteristics derived from organic manure application (Mbagwu & Ekwealor, 1990) is dependent on the proportion and nature of the organic matter content of the manure.

Based on elemental concentrations in the manures, the quantities of nutrient elements applied as manure were quite high compared to the situation with NPK fertilizer. For example, based on the application of 20 t ha^{-1}, the total amount of N was at least 114% and that of P 133% higher with any of the organic manures compared to NPK fertilizer at $N_{100}P_{40}K_{100}$ rate. Sewage sludge was notably low in P and K and, therefore, could need supplementation for those elements. Swine, rabbit and poultry manures contained at least 116% higher K than the NPK fertilizer. The potential fertilizer values for the various manures could be high if the nutrient elements they contain could be made readily available. However, the high elemental contents of the manures were not always proportionately reflected in their concentration in the leaf or in the total dry matter of tops. Apparently a great proportion of the elements were still held in organic forms and were only slowly released and made available for absorption by the tomato plants.

That swine manure required only 10 t ha^{-1} to give satisfactory growth of tomato was essentially due, in general, to its high content of nutrient elements. Sewage sludge required up to 20 t ha^{-1}, probably due to its low content of P and K. Sewage sludge and swine manure were particularly high in ammonium-N and this would not lend them to application at rather high rates of up to 30 t ha^{-1}, especially to sensitive crops.

Increase or decrease in soil pH depends on the type of organic manure and its chemistry. For example, poultry, rabbit and swine manures in this study increased soil pH, confirming the view expressed by Artkinson *et al.* (1958), Page (1966), Heathcote (1969) and Wahab & Lugo-Lopez (1980) that the use of organic manure increased soil pH. This was due to the high Ca content in the manures, deriving essentially from the type of ration on which the animals were fed. Sewage sludge on the other hand, with its low Ca and high NH_4-N contents, depressed the soil pH by 0.24 units supporting the report by Abd-Elnaim *et al.* (1982) that application of sewage effluent decreased soil pH.

Following the recommendation by Bergmann & Bergmann (1985) on the nutrient requirements of tomato, N concentration in the 5th leaf was generally satisfactory, while P and K were within the lower limits for sewage and swine manure plots. The leaf Ca appeared, generally, sub-optimal. The manures were generally less efficient in supplying N, P and K nutrient elements compared with the NPK fertilizer. This was probably due to the fact that much of the elements were still held in combination in organic forms in the manures, although the extent would vary amongst the manure types. For example, the sum of the ammonium and nitrate N constitutes less than 1% of the total N in each of the manures. However, the supply of Zn, Mg and Ca were clear advantages associated with the organic manures compared to NPK fertilizer.

It was possible in many cases to predict the nutrient element availability to the tomato plant by correlation analysis and fitting a linear regression equation based on the quantity of the elements in the manure and that in the 5th leaf. However, in other cases, this was not possible presumably because of the variability in the release of the elements from combination in the manures for tomato absorption. It could be assumed that manures which release their nutrients less readily may have more residual benefits. However, for a quicker release of nutrients to a short duration determinate field grown tomato, sewage sludge, in particular, appeared to need more composting or supplementation with P and K.

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Distribution of Saprophytic Fungi Antagonistic to *Fusarium Culmorum* in Two Differently Cultivated Field Soils, with Special Emphasis on the Genus *Fusarium*

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ABSTRACT

The purposes of the present study were to search for antagonistic fungi to control seed-borne diseases of cereals caused by *Fusarium culmorum* (W.G.Sm) Sacc. and to use these results to compare the distribution of non-pathogenic *Fusarium* spp. and other fungi antagonistic to *Fusarium culmorum* in soil and on straw particles in an organically and a conventionally cultivated field. The organic farm had been cultivated according to the principles of Steiner (1963) since 1952. The sites were similar with respect to climatic conditions, soil type and vegetation. There was no difference in the total number of antagonistic fungi isolated from the two differently cultivated fields, but the results for *Fusarium* spp. showed effects of the actual crop as well as the cropping system. Soil sampling over a three year period at the organically cultivated farm in two crops — winter wheat or a mixture of grass and clover — showed almost twice as many species of *Fusarium* in the mixed crop compared to monoculture. In mixed crop fields, the percentage of *F. culmorum* in relation to total isolations of fusaria was 20% in the organically cultivated field compared with 45% in the conventionally cultivated field. These results indicate that pathogenic fusaria may be suppressed by antagonistic fusaria to a larger extent in the organically cultivated field than in the conventionally cultivated field. In accordance with this, a higher number of antagonistic fusaria was found in the organically farmed field (14) compared to three in the conventionally farmed field. This was partly a result of a higher number of isolated fusaria and a higher number of different species of *Fusarium* in the organically cultivated soil (total number of non-pathogenic fusaria was 10 in the conventionally cultivated field and 56 in the organically cultivated field). However, it also seems to reflect an enrichment of fusaria with antagonistic properties towards F. culmorum. Thus, the occurrence of F. culmorum was 1.7 times higher in the organically cultivated field while the occurrence of its antagonists was 4.6 times higher in the organically compared with the conventionally cultivated field.