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Vermicomposting Leachate (Worm Tea) as Liquid Fertilizer for Maize (*Zea mays* L.) Forage Production

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Abstract: We investigated how dilution of vermicompost Leachate combined with different concentrations of NPK triple 17 fertilizer and polyoxyethylene tridecyl alcohol as dispersant and polyethylene nonylphenol as adherent to increase efficiency of fertilizer uptake, affected maize plant development. The vermicomposting leachate with pH 7.8 and electrolytic conductivity 2.6 dS m^{-1}, contained 834 mg K^{+} L^{-1}, 247 mg NO_3^{-1} L^{-1} and 168 mg PO_4^{3-} L^{-1}, was free of pathogens and resulted in a 65% germination index. Vermicompost Leachate diluted to 50% and mixed with 170 g L^{-1} NPK resulted in the best maize plant development while the dispersant and adherent had no significant effect. It was found that vermicompost leachate stimulated plant development when diluted, but fertilization with NPK was required for maximum growth.

Key words: Vermicompost leachate, maize growth, liquid fertilizer, forage production, optimization

INTRODUCTION

Tropical regions face a shortage of fertilizer inputs principally nitrogen, which is the most crucial nutrient limiting the yields of cereals (Pal and Shehu, 2001). Much attention has been paid in recent years to manage different organic waste resources at low-input as well as eco-friendly basis (Suthar, 2007). Vermicompost utilizing earthworms, is a biotechnological process that transform energy-rich and complex organic substances into stabilized humus-like product (Benitez *et al*., 2000), through interactions between earthworms and microorganisms (Arancon *et al*., 2005). Vermicomposting has been successfully used for composting different types of wastes, such as municipal and industrial sludges (Edwards and Bohlen, 1996; Elvira *et al*., 1998). In the vermicomposting process, the bed filled with composted wastes and bedding materials containing the earthworm populations is provides with a leachate drainage and collection system, which allowed the environmental impact of leachate. Leachate from vermicomposting operations is often regarded as beneficial in the sense that when collected it can be used a liquid fertiliser, often called worm tea (Warburton and Pillai-McGarry, 2002). Has been reported that worm tea contained certain concentrations of plant nutrients making it useful as a liquid fertilising medium, if used with care. When the leachate was tested using a cress seed bioassay it was found to inhibit seed germination and growth to some degree. Therefore, if used as fertilising for sensitive plants, the leachate would need to be diluted to ensure minimal plant damage (Frederickson, 2002). However, this leachate dilution also decrease the NPK concentration necessary for plant nutrition. The commercial formulations for liquid fertilizers used certain chemical compounds such as polivinil alcohol as adherent and sorbitol as dispersant (Eibner *et al*., 1984) for promotion the nutrient utilization for plants. Arancon *et al*. (2005) suggested that the major contribution that vermicompost might have been the addition of plant growth regulators, such as humic acids and plant growth regulators adsorbed onto the humic acids. Humic acids are molecules that regulate many process of plant development included macro and micro nutrients adsorption (Atiyeh *et al*., 2002) and Maize (*Zea mays* L.) cultivation in the tropics and subtropics is becoming more

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widespread because of its adaptability to the existing cropping pattern and high yield potential in these climates (Karim *et al.*, 2000). An question is if the vermicompost leachate contain the necessary amounts of humic acids for promotion a better mineral adsorption for maize plants nutrition. Therefore the objective of present investigation was determined the best levels of NPK, adherent and dispersant additions at vermicompost leachate for obtained a liquid fertilizer for maize plants.

MATERIALS AND METHODS

The study was carried out in Tuxtla Gutiérrez, Chiapas, Mexico (lat. 16°45'0'' N, long. 93°7'0'' W). During the months of May to June 2006.

Vermicomposting leachate: For obtained the vermicomposting leachate, was construct eight individual experimental blocks of beds. The blocks of beds were constructed out of breeze blocks with a damp-proof course membrane protruding (5 cm) out from the breeze block at the top of the beds to help prevent earthworm migration. Each individual bed was 1.5 m wide by 6.6 m long and beds were around 1 m deep. The dimensions of each Block were 1.5 m wide by 25 m long. Total bed area available for research was 400 m^2. Each bed was filled with composted cow manure/maize straw bedding material (approximately 0.5 m deep) to contain the earthworm populations. Cow manure was composted thermophilically for two months while mechanically turning it over every 15 days. The composted cow manure, adjusted to 80% moisture content, was placed in beds. Earthworms (Eisenia fetida) were added (25 g earthworms kg^{-1} of cow manure or 2.5 kg earthworms m^{-2} for bed) and left to vermicompost for two months.

Each bed contained a leachate drainage and collection system. Leachate from each bed was allowed to collect in a separate holding (200 L) for sampling, before being pumped into a central collection tank (1500 L). Leachate samples were taken for analysis from central collection tank.

Phytotoxicity test on vermicompost leachate: Cress seed bioassay test. The germination index for cress (*Lepidium sativum*) was determined by placing a layer of vermicompost leachate in a Petri dish and covering it with a filter paper. Water was added until the filter paper was completely submerged and seeds of cress were placed on the filter paper and Numbers of seeds germinating was measured after incubating the covered Petri dishes in the dark at 28°C for 4 days (Mathur *et al.*, 1993a, b).

The pH was measured in vermicompost leachate using a 716 DMS Titrino pH meter (Metrohm Ltd. CH.-9101 Herisau, Switzerland) fitted with a glass electrode (Thomas, 1996). Total C was determined by oxidation with potassium dichromate and titration of excess dichromate with ammonium ferrosulfate (Kalembasa and Jenkinson, 1973). Total N was measured by the Kjeldhal method using concentrated H_2SO_4, K_2SO_4 and HgO to digest the sample (Bremner, 1996). The concentration of NH_4^+ was determined by distillation with magnesium oxide (MgO) (Bremner and Keeney, 1966) and NO_2^- and NO_3^- colorimetrically (APHA AWWA WPCF, 1989).

Cation Exchange Capacity (CEC) was measured with the barium acetate method (pH 8.1) (Sumner and Miller, 1996). Production of CO_2 was determined over a 4 day period (Bartha and Pramer, 1965), by trapping evolved CO_2 in 1 M NaOH and determined the residual NaOH by titration with 0.1 M HCl. Electrolytic conductivity (EC) was determined in the vermicompost leachate (Rhoades *et al.*, 1989).

A dry sub-sample of 1 g was treated with 20 mL 0.1 M NaOH (1:20 w/v), shaken for 4 h, centrifuged at 8000 x g for 15 min and the supernatants divided into two equal parts. An aliquot of supernatant was analyzed for oxidizable total C considered and this part was considered as the total extractable C (EXC); the other aliquot was adjusted to pH 2 by adding 95% H_2SO_4, incubated at 4°C for 24 h and then centrifuged at 8000 x g for 15 min. The supernatant was considered the fulvic (FA) fraction and the coagulated precipitate the humic (HA) fraction. The former was analyzed for total C subtracted from the C content of EXC fraction to calculate the C content of the HA fraction (García *et al.*, 1993; Sánchez-Monedero *et al.*, 1996).

The vermicompost leachate was analyzed for total and faecal coliforms (*Escherichia coli*), *Salmonella* sp. and *Shigella* spp. (1999). *Salmonella* and *Shigella* were determined by serial dilution. A sub-sample of 10 mL vermicompost leachate was added to 90 mL 1% peptone solution under sterile conditions and 10^{-1}, 10^{-2} and 10^{-3} dilutions were made with sterile 0.8% NaCl solution and A 100 μL aliquot was plated on two selective media Salmonella-Shigella agar and sulfite-bismuth agar. The second medium is highly specific for Salmonella. The colonies were identified by form and color (USEPA, 1999). For the measurement of total and faecal coliforms (*E. coli*), a 100 μL aliquot of each serial dilution was incubated in lactose broth for at 35°C for 24 h and total coliforms were counted. The faecal coliforms were differentiated from the rest of the coliforms by incubating a 100 μL aliquot of each serial dilution in *E. coli* medium at 44°C. Gas

Table 1: Orthogonal experimental design L_9 (3^4) done in triplicate to investigate the effect of different concentrations of NPK, adherent, dispersant and vermicomposting leachate on leaves number and maize plant height (cm) (*Zea mays*) genotype v-534 grown in greenhouse for 16, 34, 42, 56 and 70 Days after Soaking (DAS) of the maize seeds

					No. of leaves				Plant height (cm)			
Treatment	NPK (g L^{-1})	Adherent (g L^{-1})	Dispersant (g L^{-1})	Leachate (ml L^{-1})	34	42	56	70	34	42	56	70
					(DAS)				(DAS)			
1	170	0	0	0	7.0a	6.5c	6.4c	7.7b	107b	135b	165d	180d
2	170	1	2	500	6.8a	6.8ab	7.0a	7.6b	111a	139a	177b	190cd
3	170	2	3	1000	6.7a	6.2d	6.6b	7.0d	109a	138a	180a	198c
4	160	0	2	1000	6.3a	6.7ab	6.7b	7.4bc	102c	130c	172b	194c
5	160	1	3	0	6.8a	6.7ab	6.7b	7.7b	104c	133c	176b	199b
6	160	2	0	500	6.8a	6.9b	7.0a	8.0a	108a	139a	188c	213a
7	140	0	3	500	6.8a	7.2a	6.9ab	7.4bc	107b	142a	188c	214a
8	140	1	0	1000	6.9a	6.2d	6.9ab	6.9d	108a	134b	179a	205b
9	140	2	2	0	6.5a	7.3a	6.4c	7.4bc	100d	133c	179a	211a

[a]Adherent = Polyethylenic nonyl phenol as adherent (Surfafer Quimia S.A) dispersant = Polyoxyethylenic tridecilic alcohol (Surfacid, Quimia S.A), DAS = Days after Soaking

production in each assay was considered as positive after 48 h. Results were confirmed by plating on Eosin Methylene Blue (EMB) agar, incubating for 24 h and examining for typical coliform colonies (USEPA, 1999).

For the bioassay, 90 maize plants were planted to cylindrical black plastic bags (length 60 cm, ⌀ 50 cm, one plantlet per bag) filled with the different mixtures. Nine treatments with different mixtures of NPK, adherent, dispersant and vermicompost leachate were used (Table 1). Plants were grown under black knitted shade cloth (60%) without temperature control and grouped in plots 7 m long and 2.1 m wide each containing 30 plants spaced at a distance of 70 cm. The plots were separated 1.8 m from each other. The center five plants were analyzed for growth and nitrogen, phosphorus and potassium in leaves. The plots were arranged in a randomized complete block design in triplicate. All treatments were drip irrigated with tap water ranging from 1 to 2 dm^3 per plant per day depending of soil conditions and crop maturity.

Experimental design: An orthogonal experimental design of L_9 (3^4) with ten repetitions was used to investigate the effect of NPK concentration (0, 1 or 2 g $plant^{-1}$), adherent (0, 1 or 2 g $plant^{-1}$), dispersant (0, 10^3 cfu mL^{-1} y 10^5 cfu mL^{-1}) and vermicompost leachate (VL) (0, 5 y 10% v/v) on plant height, stem diameter, leaves number, wet weight stem plus leaves, dry weight roots from plants (Table 1) (Ross, 1989). The symbol L_a (b^c) is used to represent the orthogonal array where a is the number of experimental runs, b the number of levels for each factor or variable and c the number of factors investigated.

Statistical analyses: The Statgraphics Plus for Windows (1999) was used to analyse data with the Taguchi robust design (L_9 (3^4) (orthogonal array) and the $3^{(K-p)}$ Box-Behnken design using a confidential limit of 5%. The linear and quadratic values of all factors and the interactions between them were tested for. The percent contribution was calculated to determine the portion that each significant factor and/or interaction contributed to the total variation (Ross, 1989). The percent contribution is a function of the sums of squares for each significant item and indicates the relative power of a factor and/or interaction to reduce variation. If the factor and/or interaction levels are controlled then the total variation can be reduced by the amount indicated by the percent contribution.

RESULTS AND DISCUSSION

Characteristics of the vermicompost leachate: The vermicomposting leachate characteristics (mean of samples collected every 8 weeks) were: pH mean for all blocks was 7.8±0.1, 256.0±20.8 of electrical conductivity (μS cm^{-1}), 128.3±42.2 suspended solids (mg L^{-1}); Na (mg L^{-1}) 46.0±12.2, NH_4 (mg L^{-1}) 0.0, K (mg L^{-1}) 834±71.1, Mg (mg L^{-1}) 58.6±9.2, Ca (mg L^{-1}) 83.7±13.0, Cl (mg L^{-1}) 130.0±2.2, NO_3 (mg L^{-1}) 247.0±43.2, PO_4 (mg L^{-1}) 168.0±11.4, SO_4 (mg L^{-1}) 46.9±12.7. Humic to fulvic acid ratio (HA/FA) was 1.6. The electrical conductivity of vermicomposting leachate was also low compared with compost leachate, suggesting a much lower level of dissolved salts. Finally, the vermicomposting leachate contained much higher concentrations of nitrate and phosphorus and this suggests that it could have good fertilizing properties if used undiluted in agriculture.

In the phytotoxicity test on vermicompost leachate, the cress seed bioassay test effectuated in each block indicated that root elongation (% of control) was 68±10%, germination was 92±12 (% of control) and germination index was 65±7%. These results indicated that the leachate while not completely safe to plants (Germination index = 100%). The Germination index was mostly above 70% and could be used in diluted form, for fertilizing growing plants.

Table 2: Orthogonal experimental design L_9 (3^4) done in triplicate to investigate the effect of different concentrations of NPK, adherent, dispersant and vermicomposting leachate on stem diameter of maize plants (*Zea mays*) genotype v-534 grown in greenhouse for 16, 34, 42, 56 and 70 days after soaking (DAS) of the maize seeds, shoot dry and fresh weight (g) and concentration of nitrogen (N), potassium (K) (mg g^{-1} dry plant weight) and phosphorus after 70 DAS

	Stem diameter r(mm)				Shoot weight				
	37	42	56	70	Dry	Fresh	K	N	P
Treatment	(DAS)				(g)		(mg g^{-1} dry wt.)		
1^{a}	18.3^{ab}	20.1^{a}	18.8^{a}	18.0^{a}	54^{bc}	132^{c}	10.9^{a}	1.7^{bc}	2.1^{a}
2	19.0^{a}	19.8^{a}	19.8^{a}	19.0^{a}	64^{abc}	147^{b}	9.5^{b}	3.0^{a}	2.6^{a}
3	18.1^{a}	19.8^{a}	18.8^{a}	17.9^{a}	52^{bc}	117^{cd}	9.8^{b}	2.0^{b}	0.3^{b}
4	18.3^{a}	19.9^{a}	18.7^{a}	18.1^{a}	46^{c}	104^{d}	8.0^{c}	1.2^{cd}	1.4^{ab}
5	187.^{a}	20.2^{a}	19.2^{a}	18.2^{a}	66^{ab}	150^{b}	7.4^{cd}	1.0^{d}	0.2^{b}
6	19.2^{a}	21.0^{a}	20.1^{a}	19.0^{a}	71^{a}	161^{a}	6.9^{de}	1.0^{d}	0.1b
7	18.4^{a}	20.3^{a}	19.4^{a}	18.4^{a}	64^{abc}	149^{b}	6.7^{de}	0.8^{d}	0.1^{b}
8	18.6^{a}	20.8^{a}	20.2^{a}	19.6^{a}	68^{ab}	158^{a}	6.4^{de}	0.8^{d}	0.1^{b}
9	17.3^{a}	21.0^{a}	18.8^{a}	18.0^{a}	51^{bc}	119^{d}	6.4^{de}	1.0^{d}	0.2^{b}

[a]Legends to the treatments can be found in Table 1, [b]Values with the same letter(s) are not significantly different ($p<0.05$)

The microbial assays for faecal coliforms (*Escherichia coli*), *Salmonella* sp. and *Shigella* spp. was indicated that vermicompost leachate is free of these pathogenic microorganism. This suggests that the leachate from the waste and earthworm casts was being treated by microbial action as it passed through the bedding and this material was therefore acting as a biofilter (Frederickson, 1998).

Maize development and NPK uptake: The number of leaves was similar for all treatments after 34 days and showed little increase over time (Table 1). After 70 days, the number of leaves varied between 6.9 and 8.0 and was significantly affected by treatment ($p<0.05$). The plant height nearly doubled between day 34 and 70, while treatment had a significant effect on plant height ($p<0.05$). The tallest plants were found for treatments 6, 7 and 9 and the lowest for treatments 1 and 2 (Table 1). Stem diameter was not affected by treatment and did not significantly change between day 34 and 70 (Table 2). The fresh and dry shoot weight was significantly affected by treatment with the largest values found in treatment 6 and the lowest in treatment 4 ($p<0.05$). The N, P and K content of the maize plant was significantly affected by treatment with the largest values found in treatments 1, 2 and 3, i.e., those amended with the largest amount of NPK, and the lowest in treatments 7, 8 and 9, i.e., amended with the lowest amount of NPK ($p<0.05$). The P concentration in the maize plants was similar to those reported in maize shoots after spraying them with P at the four, five and seven-leaf stages (Leach and Hameleers, 2001).

The NPK fertilizer explained 35.9% of the variation found between the treatments for stem height, whereas vermicompost leachate explained 14.3% (Table 3). The NPK fertilizer explained 5.2% and vermicompost leachate 5.8% of the variation found between the treatments for stem diameter, while NPK explained 24.9% and vermicompost leachate 44.4% of the variation for the number of leaves (Table 3). The NPK was the factor that most explained N, P and K concentration in maize leaves, while vermicompost leachate had no significant effect (Table 3). The importance of NPK fertilizer on crop yields is well known (Olness *et al.*, 2002). Vermicompost leachate was the second most important factor affecting maize growth, but it had no significant effect on the macro-nutrient content of the plant, i.e., N, P and K uptake. It appears that certain components in the vermicompost leachate, such as humic acids and plant growth regulators, stimulated plant growth (Arancon *et al.*, 2003; Atiyeh *et al.*, 2002). It has been reported that humic acids increase the number of roots thereby stimulating nutrient uptake and plant development (Alvarez and Grigera, 2005). The vermicompost leachate also contains micronutrients, that might stimulate plant growth.

The overall mean of the stem height was 200 cm, it was 18.5 mm for the stem diameter and 7.5 for the number of leaves (Table 4). The best combination to obtain maximum stem height and stem diameter was 170 g NPK L^{-1} (level 3) mixed with 500 mL vermicompost leachate L^{-1} (level 2) (Table 5). With these levels, the increase in stem height was 19.3 cm compared to the grand average and the stem was 1.4 mm thicker. The best combination to obtain a maximum number of leaves was 160 g NPK L^{-1} plus 500 mL vermicompost leachate L^{-1} and with these 0.6 more leaves were obtained per plant than the grand average. No dispersant or adherent was required to improve plant development. The overall mean N, P and K concentration in the leaves was 1.4, 0.9 and 8.0 mg g^{-1} dry matter, respectively. The largest concentration of N and P in the leaves was found when 140 g NPK L^{-1} was mixed with 500 mL vermicompost leachate L^{-1}, while the largest K when 140 g NPK L^{-1} was applied (Table 5).

This low efficiency is attributed to N losses through volatilization, denitrification and leaching from the soil-plant system when macro nutrients are applied in a solid

Table 3: ANOVA analysis using all factors with a significant effect on stem height, stem diameter, leaves number, nitrogen, phosphorus and potassium in leaves ($p<0.05$)

Factor	SS[a]	DF[b]	CV[c]	F-value	Percentage
Stem height					
NPK	2022	2	1011	10.11	35.9
Adherent	686	2	343	3.43	1.6
Dispersant	152	2	76	0.76	0.9
Vermicompost leachate	416	2	208	2.08	14.3
All other	1800	18	100		47.3
Total	5076	26			100.0
Stem diameter (mm)					
NPK	0.6	2	0.31	0.31	5.2
Adherent	3.0	2	1.51	1.51	1.8
Dispersant	2.3	2	1.17	1.17	1.3
Vermicompost leachate	2.5	2	1.24	1.24	5.8
All other	18.0	18	1.00		85.9
Total	34.5	26			100.0
Leaves number					
NPK	0.99	2	0.49	11.35	24.9
Adherent	0.04	2	0.02	0.44	1.4
Dispersant	0.11	2	0.06	1.28	0.7
Vermicompost leachate	1.69	2	0.85	19.43	44.4
All other	0.79	18	0.04		28.6
Total	3.63	26			100.0
Nitrogen					
NPK	10.1	2	5.1	160.7	74.0
Adherent	0.9	2	0.4	13.6	5.0
Dispersant	1.3	2	0.7	20.9	1.3
Vermicompost leachate	0.7	2	0.7	11.3	4.8
All other	0.6	18	0.03		6.0
Total	13.6	26			100.0
Phosphorus					
NPK	9.7	2	4.8	66.2	42.8
Adherent	3.6	2	1.8	24.9	15.7
Dispersant	6.7	2	3.3	45.6	29.3
Vermicompost leachate	0.9	2	0.5	0.6	3.7
All other	1.3	18	0.07		8.5
Total	32.3	26			100.0
Potassium					
NPK	59.05	2	29.50	26.40	67.40
Adherent	3.90	2	1.90	1.70	1.90
Dispersant	0.02	2	0.01	0.00	-2.63
Vermicompost leachate	1.20	2	0.59	0.53	-1.24
All other	20.20	18	1.12		34.50
Total	84.40	26			100.00

[a]SS: Sum of Squares, [b]DF: Degree of Freedom, [c]CV: Coefficient of variance

Table 4: Stem height, stem diameter and leaves number ($p<0.05$) in maize plants (*Zea mays*) genotype v-534 grown in greenhouse added with different concentrations of components (Level 1, 2 and 3)

	Stem height with overall mean 200.3			Stem diameter with overall mean 18.5			No. of leaves with overall mean 7.5		
Factor	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
NPK	189.0	202.0	210.0	18.3	18.4	18.7	7.4	7.7	7.2
Adherent	207.3	198.0	195.7	18.2	18.9	18.3	7.5	7.4	7.5
Dispersant	203.7	198.3	199.0	18.9	18.4	18.2	7.5	7.5	7.4
Vermicompost leachate	196.3	205.7	199.0	18.1	18.8	18.5	7.6	7.7	7.1
	Nitrogen with overall mean 1.4			Phosphorus with overall mean 0.87			Potassium with overall mean 7.9		
Factor	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
NPK	2.2	1.0	0.9	1.7	0.7	0.2	10.0	7.4	6.5
Adherent	1.2	1.6	1.3	1.2	1.0	0.4	8.5	7.8	7.7
Dispersant	1.2	1.7	1.3	0.9	1.4	0.2	8.0	7.9	7.9
Vermicompost leachate	1.2	1.6	1.3	0.9	1.1	0.6	8.2	7.7	8.1

Table 5: Optimum levels and contribution of NPK, adherent, dispersant and vermicompost leachate on maize plants cultivated in the greenhouse

	Stem height		Stem diameter		No. of leaves	
Factor	Best level	Contribution	Best level	Contribution	Best level	Contribution
NPK	3	9.7	3	2.20	2	0.25
Adherent	1	2.0	1	0.47	1	0.04
Dispersant	1	2.3	1	0.40	1	0.07
Vermicompost leachate	2	5.3	2	0.33	2	0.22
Total		219.7		19.87		8.03
Grand average		200.3		18.47		7.45
Improvement		19.3		1.40		0.58
	Nitrogen		Phosphorus		Potassium	
Factor	Best level	Contribution	Best level	Contribution	Best level	Contribution
NPK	1	0.8	1	0.8	1	2.00
Adherent	2	0.2	1	0.4	1	0.05
Dispersant	2	0.3	2	0.4	1	0.03
Vermicompost leachate	2	0.2	2	0.2	1	0.21
Total		3.0		2.8		10.80
Grand average		1.4		0.9		7.90
Improvement		1.6		1.9		2.80

form (Alvarez and Grigera, 2005). Evidence exists to show that higher P concentrations in soil can result in increased P losses to natural waters and they are known to contribute to accelerated eutrophication of lakes and rivers.

The fertilizer Triple 17 (NPK) contains 170-175 g N L^{-1} in the form of ammonium, nitrate and organic N, 170-172 g P L^{-1} mostly as P_2O_5 and 170-173 g K L^{-1} as K_2O. Triple 17 thus provides the major elements required for plant growth but when mixed with vermicompost leachate the latter will provide microelements and the humic and fulvic acids in it will stimulate the absorption of the micro-elements by the cultivated maize plants. For The vermicompost leachate had to be diluted 50% to 500 ml L^{-1} to obtain maximum plant growth. This could be related to the effect that the high salt content of the vermicompost leachate had on N, P and K uptake. It has been shown that P uptake decreases when the salinity increased (Irshad *et al*., 2002). The uptake of K also decreases when salinity increases, but K can be substituted with Ca, Mg and Na so that the plant is not stressed by the lack of this element (Rabie and Kumazawa, 1988). The effect on N uptake, however, is not that clear as Luque and Bingham (1981) reported that excesses of salt decreased N uptake by plants, while Khalil *et al*. (1967) reported an increase in the concentrations of N in maize and cotton when the salt content of the soil increased. The vermicompost leachate also contains large amounts of humic acid that might have affected plant growth. Sánchez-Conde and Ortega (1968) reported that the assimilation of N and P increased when amended with liquid humic acid while the uptake of K decreased. Pilanali and Kaplan (2003) reported that N, P and K contents in leaves of strawberry plants were not affected by the form in which humic acids were applied, i.e., solid or liquid, but addition of high concentrations rates inhibited nutrient uptake. They attributed this to an increased application of auxin and gibberellin-like substances in the humic acids which inhibit N, P and K uptake. The effect of the vermicompost leachate on concentrations of N and P in maize plants was small and even negative for K after 70 days (Table 3). It remained to be investigated how the vermicompost leachate affected the N, P and K content of the younger plants. The effect of N, P or K fertilizer is often most outspoken at the onset of plant growth (Mubarak *et al*., 2003).

CONCLUSION

It was concluded that vermicompost leachate can be used as liquid fertilizer for the cultivation of maize when diluted to 50% and mixed with 160-170 g L^{-1} of NPK triple 17 fertilizer. Apart from micro-elements, vermicompost leachate also contains humic and fulvic acids that promote growth of maize plants.

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