*Journal of Applied Horticulture, 10(1): 77-80, 2008*

# Comparison of conventional fertilization and vermicompost use for basil cultivation

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## Abstract

The effect of conventional fertilization was compared with a vermicompost that was mixed with substrate for sweet basil (*Ocimum basilicum* L.) in a greenhouse experiment. The study was conducted in a completely randomized block design with 4 replications. Eight treatments were compared: a control treatment of a substrate mixture (T0: with no vermicompost added), five treatments with increasing percentages of vermicompost added to the substrate mixture (H1 to H5), and two treatments using two application rates of a chemical fertilizer (F1 and F2). Both fertilizer and vermicompost presented very low levels of heavy metals, which assured agronomical suitability. Vermicompost from SS-MSW (Source-Separated Municipal Solid Waste) and slaughterhouse sludge, presented significant value as soil conditioner and biofertilizer and produced increased levels of C and N ($P<0.05$). The phosphorus addition by vermicompost was high, with a decrease of zinc absorption by plants and potential contamination risk. Mixtures including more than 50% of the vermicompost and the highest rate of fertilizer showed statistically significant differences for dry weight, leaf length, plant survival and P-Zn antagonism ($P<0.05$).

**Key words**: Fertilization, vermicompost, *Ocimum basilicum* L., basil

## Introduction

There is a controversy concerning the use of inorganic and organic fertilizers. Inorganic fertilizers are easy to manage and hygienic, but organic ones present the advantage of lower costs and environmental benefits (Ghosh, 2004). Environmental problems related with heavy metal contamination should be considered, as organic manures are generated by urban and industrial developments (Marbán *et al.*, 1999). Organic wastes of a different nature and environmental risks are generated as consequence of such activities, and their recycling can offer an ecological solution for waste treatment and disposal, and could be an efficient and economic alternative for conventional waste disposal procedures (Govil, 2001).

Composting is a biological process that produces a stable organic matter, free of pathogens and toxins: "*compost*" (Polo, 1997). Usually, in agriculture, the most important restrictive factors to use composts as soil amendments have been human pathogenic content, the presence of heavy metals, nutrient excesses, high salt concentrations, organic pollutants and immaturity (Madrid *et al.*, 2000). Vermicomposts, which are produced by the fragmentation of organic wastes by earthworms, have a fine particulate structure and contain nutrients in forms that are readily available for plant uptake. In greenhouse trials, they have shown to enhance growth of different seedlings and cultivations (Atiyeh *et al.* 2000). After the thermophilic stage of composting, the material is inoculated with earthworms and a commercial biofertilizer (vermicompost) is obtained as the final result. The organic matter of this biofertilizer contains a high percentage of humic and fulvic acids and a beneficial microbial load. Vermicompost incorporation increases soil aggregation, structure, water retention, cation exchange capacity, and releases nutrients required by plants, in a balanced way. It adsorbs pollutants such as heavy metals due to its high adsorption capacity and protects soil from erosion (Movahedi and Cook, 2000). It also contains phytohormones such as indolacetic and gibberellic acid, together with other biologically active substances (Ruiz *et al.*, 1999) and as a consequence of the high microbial load contributes to the protection of roots from bacterial and parasitic nematode attacks. Enough evidence exists to ensure that human pathogens do not survive the vermicomposting process (Eastman *et al.*, 2001), but special attention should be paid to heavy metal contents, since they could be dangerous in the food chain.

Sweet basil (*Ocimum basilicum* L.) is grown commercially as a cultivated herb plant in many parts of the world, and used both as a fresh and a dried food spice, for the commercial production of essential oil and in traditional medicine. Research has also shown that it may be a good indicator of the adverse effect of various environmental signals to plants, including high concentrations of trace metals in composts (Zheljazkov and Warman, 2003).

In the present study, soil and plant characterstics were evaluated with biofertilizer (vermicompost) and inorganic fertilization for basil cultivation.

## Materials and methods

The urban solid wastes from Chivilcoy town were classified, by manual separation for the inert materials (glass, plastic, cardboard and metals), from the organic ones. These urban organic residues, also denominated SS-MSW: Source-Separated Municipal Solid Waste (Zheljazkov and Warman, 2004), were mixed with reduced fat slaughterhouse sludge prior to being composted. When the first thermophilic stage was finished, the material was inoculated with earthworms (*Eisenia andrei*).

Sweet basil was sown in conventional 60 x 30 cm trays. After twenty days, 3-4 cm plants were transplanted to 1 kg pots. Substrate (peat) was sterilized with methyl bromide and mixed with different quantities of vermicompost. Three plants per pot were left in each pot, and the study was conducted in greenhouse conditions, with pots moisture maintained near field capacity.

The experiment was conducted in a completely random block design with 4 replications for each treatment. In the experiment, eight treatments were compared: a control treatment of a substrate mixture (T0: with no vermicompost added), five treatments with increasing percentages of vermicompost added to the substrate mixture (H1 to H5), and two treatments using two application rates of a chemical fertilizer (F1 and F2). Treatments were: T0: substrate mixture (peat without vermicompost), H1: 95 % mixture + 5% vermicompost, H2: 90 % mixture + 10% vermicompost, H3: 80 % mixture + 20% vermicompost, H4: 50 % mixture + 50% vermicompost, H5: 100 % vermicompost, F1: substrate + chemical fertilizer: 3 g KEMIRA NPK 12-5-11 per pot, F2: substrate + chemical fertilizer: 30 g of KEMIRA NPK 12-5-11 per pot.

Agronomic variables that were evaluated in substrate mixture were: pH: water extraction 1: 2.5, total organic carbon (%C): Walkley –Black technique (Nelson and Sommers, 1982), total nitrogen (%N): microKjeldahl procedure; available phosphorus (P, mg $kg^{-1}$): Bray 1 method (Bray and Kurtz, 1945); electrical conductivity (EC, dS $m^{-1}$): saturation extract. (Rhoades, 1996).

Heavy metals, cadmium (Cd), lead (Pb), zinc (Zn), nickel (Ni), copper (Cu), chromium (Cr) and mercury (Hg) were quantified in both the fertilizer and vermicompost with an aqua regia extraction and quantified by ICP Baird 2070 (Page, 1982).

The greenhouse study was concluded when the basil reached the commercial pre-bloom stage. Plant variables considered were dry matter weight and leaf size. Phosphorus (%P) and zinc (Zn mg $kg^{-1}$) concentrations were measured in leaves. Data were statistically analysed for ANOVA using Statistix 4.0 software.

## Results and discussion

The composition of the vermicompost was: 1.2 %N, 184 mg $kg^{-1}$ P-Bray, and K 1.1 $cmol_c$ $kg^{-1}$, and the fertilizer contained: 12.8% N, 4.5% $P_2O_5$ and 11.3 % K. Toxic metals, Cd, Pb, Zn, Ni, Cu, Cr and Hg, were evaluated in chemical fertilizer and biofertilizer; both compounds had lower levels of inorganic toxics than the maximum acceptable concentrations for biosolids of high quality according to the United States Environmental Protection Agency (US-EPA), and did not present limitations for European Union (EU). Fig. 1 shows the comparison between levels of metals and soil quality criteria for Argentine Law 24051, to remark the agricultural suitability of the materials.

Total organic carbon was associated to the highest rate of vermicomposts (50 and 100%), with a statistically significant difference from the control ($P < 0.05$). The inorganic fertilizers did not show any variation in the total organic carbon content. The total nitrogen levels also increased (Fig. 2) and H4, H5, F1 and F2 differed significantly from the control ($P < 0.05$). The C/N relationship was nearly 10/1 in all treatments. This relationship indicated that the vermicompost could be considered mature for use, without causing any nitrogen problems in the crop (Madrid *et al.*, 2000). Stability is an important property of compost as its application as soil conditioner or part of a growing medium requires a stable product characterized by odour, water content, pH and other parameters (Eggen, 2001). The results agree with those presented by Smith *et al.* (1999), about beneficial effect of composted materials in increasing soil carbon and nitrogen content.

The evolution of Bray-available phosphorus with higher rates of vermicompost showed a great increase, with particularly large values in H5 (800 mg $kg^{-1}$), such levels could cause contamination and nutritional imbalance in plants (Fig. 3).

The pH values were nearly neutral for the control and all doses of vermicompost, while those for inorganic fertilizers F1 and F2 were 5.6 and 5.3, respectively. Electrical conductivity values were higher in vermicompost (H4 and H5) and maximum in fertilizer (F2), with statistically significant differences ($P<0.05$) compared with control (T0).The elevated electric conductivity values indicated importance of contents of soluble salts, which could increase the osmotic pressure in the system and produce nutritional problems that could be associated with damage and death of plants. Zheljazkov and Warman (2003) also recorded the same tendency of increasing pH and EC of the growth medium with an increased addition of vermicompost.

Results of plant analysis are shown in Table 1. Dry matter yield weights of basil plants showed a significant decrease ($P < 0.05$) between the control (T0) and the higher rates of the vermicompost and fertilizer (H4, H5, F2), and growth of plants was similar for the rest of the treatments (H1, H2, H3 and F1) , with non significant differences ($P < 0.05$).

The size of the basil leaf is very important for commercial use. The treatment H2 (10 % vermicompost) produced the greatest leaf length (10.74 cm) followed by H1 and H3. These three treatments behaved as a statistically homogeneous group. The treatments producing lower leaf sizes were H4 and H5 (50 and 100 % vermicompost added).

The percentage survival of plants was in general 100%, but amending the soil with 100% of vermicompost and the highest rate of the fertilizer produced significant plant mortality.

The treatment that had adverse effects on growth, measured as reduction in dry weight and reduced development of the leaf and plant mortality, occurred when the vermicompost was used more than 50% and with highest rate of fertilizer, that could have a phytotoxic effect.

Table 1. Effect of different treatments on plant characterstics

| Treatment | Dry weight (g) | Leaf length (cm) | Survival (%) | P (%) | Zn (mg $kg^{-1}$) |
|---|---|---|---|---|---|
| T0 | 3.16b | 8.43b | 100b | 0.38a | 152.2b |
| H1 | 2.94b | 9.55c | 100b | 0.44a | 138.2b |
| H2 | 3.90b | 10.74c | 100b | 0.50b | 153.6b |
| H3 | 3.86b | 8.96c | 100b | 0.51b | 119.6ab |
| H4 | 1.55a | 6.19a | 100b | 0.53b | 72.2ab |
| H5 | 0.38a | 4.20a | 65a | 0.55b | 44.0a |
| F1 | 3.40b | 8.49 b | 100b | 0.38a | 159.2b |
| F2 | 1.41a | 8.41b | 65a | 0.38a | 277.0b |

Column values followed by the same letter are not significantly different at $P<0.05$

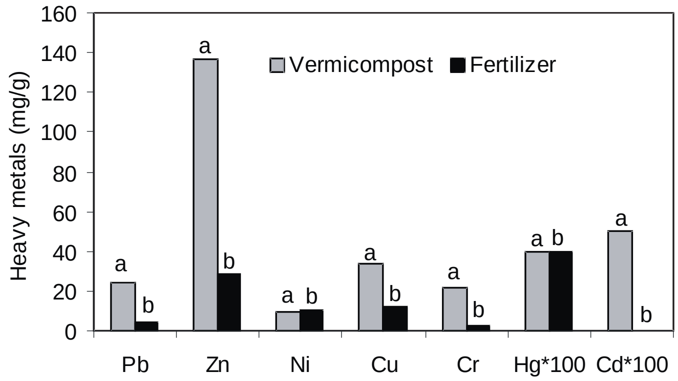


Fig. 1. Heavy metals in fertilizer and vermicompost compared to argentinian soil quality criteria (SQ criteria). Different characters designate statistical significant differences ( $P \leq 0.05$)

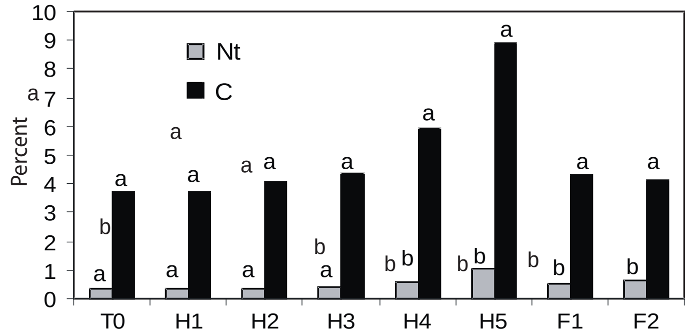


Fig. 2. Evaluation of C and N for all treatments. Different characters designate statistical significant differences ( $P \leq 0.05$)

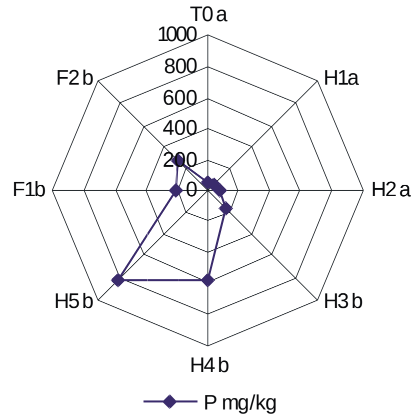


Fig. 3. P evaluation for all treatments. Different characters designate statistical significant differences ( $P<0.05$)

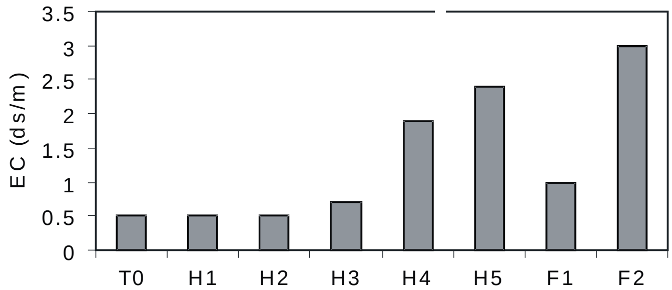


Fig. 4. Evaluation of electrical conductivity for all treatments. Different characters designate statistical significant differences ( $P<0.05$)

The P content of basil leaf varied from 0.386 % P in T0 to 0.550 % P in H5. The inverse situation was observed with the Zn content, which decreased with the rate of vermicompost application. Zn levels varied between 152.2 mg $kg^{-1}$ of Zn in T0 to 44.0 mg $kg^{-1}$ of Zn in H5 (Table 1). The antagonism between P and Zn is a well-known interaction. As the content of P increased in the media, a decrease in the absorption and transport of the Zn from the roots could take place, and in some cases, it could cause nutritional problems and yield decrease (Malavolta, 1994). An antagonism P-Zn was manifested in treatments H3, H4 and H5.

Our results showed that vermicompost has agronomic value if used as an amendment, and also for leaf growth with commercial application, but possible negative effects must be kept in mind that could result from large doses, as well as in the case of fertilizers. Vermiculture to process organic waste and generate fertilizer can be a useful tool to promote sustainable development on a local scale in Latin-American cities (Spiaggi *et al.*, 2001). As it was proposed by EPA (2001), we followed key factors contributing to vermicompost project success: comparison with other scientific research; comparative tests with different application rates of vermicompost, fertilizer and control plots; and a good trial design with statistically comprable results.

Zheljazkov and Warman (2004) reported that mature composts could be safely used as soil conditioners for agricultural crops, as addition of compost reduced bioavailability and transfer factors for micronutrients as Cu and Zn. It had also been demonstrated that soil amendment with compost is an effective non-chemical, environment-friendly means to prevent or to reduce the damage caused by *Fusarium oxysporum* f. sp. *basilici* that causes wilt in sweet basil plants (Zheljazkov and Warman, 2003).

A relevant agronomic application could be the exploitation of integrated nutrition. Jeyabal and Kuppuswamy (2001) showed that the integrated application of vermicompost, fertilizer N, *Azospirillum* and phosphobacteria increased rice yield by 15.9% over application with N fertilizer alone.

Fortuna *et al.* (2003) also suggested that it could play a role in optimizing nutrient availability and potential carbon sequestration in an agroecosystem. They reported a comparison of compost and chemical fertilizer, for corn–corn–soybean–wheat rotation compared to continuous corn. Compost applications over 6 years increased the resistant pool of C by 30% and the slow pool of C by 10%. The compost treatment contained 14% greater soil organic C than the fertilizer management. Proper management of nutrients from compost, cover crops and rotations can maintain soil fertility and increase C sequestration.

Vermicompost was as useful as fertilizer to obtain a product with commercial value. Both materials presented low toxic metals content, and the maturity of vermicompost was appropriated (C/N relationship was near 10). The restrictive factors for large rates of both materials were soluble salts content, which increased electrical conductivity, and produced plant mortality and P-Zn antagonism in plant. Vermicompost acted as organic amendment which presented a significant increase in C and N levels. It should be taken into account that the application of vermicompost could hardly increase the amounts of available phosphorus, with a risk of nutritional imbalance and potential environmental problems. Mixture including more than 50% of the vermicompost and the highest rate of fertilizer showed statistically significant differences for dry weight, leaf length, plant survival and P-Zn antagonism ($P<0.05$).

## References

Atiyeh, R.M., S. Subler, C.A. Edwards, G. Bachman, J. D. Metzger and W. Shuster, 2000. Effects of vermicomposts and composts on plant growth in horticultural container media and soil. *Pedobiologia*, 44: 79-590.

Bray, R.H. and L.T. Kurtz, 1945. Determination of total, organic and available forms of phosphorus in soils. *Soil Sci.,* 59: 39-45.

Eastman, B.R., P.N. Kane, C.A. Edwards and L. Trytrek, 2001. The effectiveness of vermiculture in human pathogen reduction for USEPA biosolids stabilization. *Compost Science and Utilization.,* 9: 38-49.

Eggen,T. and O. Vethe, 2001. Stability indices for different composts. *Compost Science and Utilization*, 9: 19-26.

EPA (Environmental Protection Agency). 2001. Vermicompost to improve agricultural soils. www.epa.nsw.gov.au/waste.

Fortuna, A., R. Harwood, K. Kizilkaya and E.A. Paul, 2003. Optimizing nutrient availability and potential carbon sequestration in an agroecosystem. *Soil Biology & Biochemistry*, 35: 1005-1013

Govil, A. 2001. Biotechnological approaches for waste treatment. *Standards India*, 15(9): 5-9.

Ghosh, C. 2004. Integrated vermi-pisciculture— an alternative option for recycling of solid municipal waste in rural India. *Bioresource Technology,* 93: 71-75.

Jeyabal, A. and G. Kuppuswamy, 2001. Recycling of organic wastes for the production of vermicompost and its response in rice-legume cropping system and soil fertility. *European Journal of Agronomy*, 15: 153-170

Madrid, F., J.M. Murillo, R. López and F. Goatherd, 2000. Use of urea to correct immature urban composts for agricultural purposes. *Commun. Soil Sci. Plant Analysis*, 31(15&16): 2635-2649.

Malavolta, E. 1994. Relationship between the match and the agronomic zinc. *Informaciones INPOFOS*, 15: 5-7.

Marbán, L., L. Giuffré, S. Ratto and A. Agostini, 1999. Contaminación con metales en un suelo de la cuenca del río Reconquista. *Ecología Austral*, 9: 15-19.

Movahedi, N. and H.F. Cook, 2000. Influence of municipal waste compost amendment on soil water and evaporation. *Commun. Soil Sci. Pl. Anal.,* 31: 3147-3161.

Nelson, D.W. and L.E. Sommers, 1982. Total carbon, organic carbon and organic matter. In: *Methods of soil analysis*. Page A.L. (Ed). Part 2. American Society of Agronomy, USA, Agronomy 9: 539-579

Page, L. 1982. *Methods of soil analysis*. Chemical and microbiological properties. American Society of Agronomy, Soil Science Society of America, Madison, Wisconsin. 1159p.

Polo, A. 1997. *Residuos orgánicos urbanos*. Consejo Superior de Investigaciones Científicas. Centro de Edafología y Biología Aplicada del Segura, España. 181p.

Rhoades, J.D. 1996. Salinity: Electrical Conductivity and Total dissolved Solids. In DL. Sparks *et al.* (ed.) *Methods of soil analysis. Part 3. Chemical methods*. SSSA and ASA, Madison, WI. p417-435.

Ruiz, A., N. Garcés and F. Guridi, 1999. Propiedades de vermicompost obtenidos en Cuba. *14 Congreso Latinoamericano de Ciencia del Suelo.* Pucón, Chile. Actas: 410.

Smith, C.J., W.J. Bond and W. Wang, 1999. Vermicompost to improve Agricultural Soils. CSIRO *Land and Water Technical Report*, 23.

Spiaggi, E., R. Biasatti and M. Guillén, 2001. Urban Agriculture and local sustainable development: evaluation and monitoring tools. *www.ruaf.org/conference/methods/papers/background/Spiaggi%2520Biassatti%2520and%2520Guillen*

Zheljazkov, V. and P.R. Warman, 2003. Application of high Cu compost to Swiss chard and basil. *The Science of the Total Environment*, 302: 13-26

Zheljazkov, V. and P.R. Warman, 2004. Phytoavailability and fractionation of copper, manganese, and zinc in soil following application of two composts to four crops. *Environmental Pollution*, 131: 187-195.