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Vermicompost Leachate and Vermiwash Enhance French Dwarf Bean Yield

H. Ayyobi, E. Hassanpour, S. Alaqemand, S. Fathi, J. A. Olfati, and Gh. Peyvast

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Vermicompost has beneficial effects on plant growth. However, vermicompost increases electrical conductivity in soil due to increased salinity associated with continued usage. An experiment was conducted to determine effects of 0 and 7 Mt·ha\(^{-1}\) of cow manure vermicompost, 7 Mt·ha\(^{-1}\) of vermicompost leachate, or vermicompost leachate with vermiwash and a no-fertilization control on French dwarf bean (Phaseolus vulgaris L.) yield and development. Type of vermi-fertilizer affected all measured characteristics except individual pod fresh and dry weights. Plants treated with vermiwash had the tallest plants, longest pods, number of pods per plant, number of lateral branches, and number of pods, but the highest plant dry weight and longest internodes were from plants treated with vermicompost leachate. Vermiwash combined with vermicompost leachate negatively affected vegetative characteristics and yield. With leaching, the negative effects of vermicompost related to high electrical conductivity decreased and continuous application of this material may be possible. Vermicompost leachate and vermiwash can be used as fertilizer for sustainable bean cultivation.

Keywords Phaseolus vulgaris, Fertilizer, Farming, Iran, Organic, Sustainable agriculture.

If appropriate amounts of fertilizers are not applied during production, physiological symptoms of deficiency can occur in French dwarf bean (Phaseolus vulgaris L.; Olfati et al., 2012; Takahashi, 1981). Most producers use synthetic fertilizers because they are easy to transport, quickly available to plants, and produce high yields. However, with succeeding crops, quantities of chemical fertilizers must be increased because of low soil fertility (Thy and Buntha, 2005). Organic fertilizers have beneficial effects on soil structure and nutrient availability, help maintain yield and quality, and are less costly than synthetic fertilizers (Olfati et al., 2012; Thy and Buntha, 2005).

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Large amounts of organic wastes—that is, biosolids, animal manures, and household wastes—are produced in Iran. These wastes may be used in production of vegetables or to restore soil fertility (Benton and Wester, 1998; Krogman et al., 1997), because they contain large quantities of nitrogen (N), phosphorous (P), and potassium (K; Elliot and Dempsey, 1991). Thermophilic composting is biological aerobic decomposition of organic residues in which labile organic matter is degraded to CO$_2$, H$_2$O, NH$_3$, inorganic nutrients, and stable organic material containing humic-like substances (Senesi, 1989). Compost is homogenous, retains most of its original nutrients, and has reduced levels of organic contaminants because they are degraded before use (Ndewga et al., 2000); it can be applied to increase soil organic matter and nutrients, which can be released upon decomposition; improve soil structure; and increase cation exchange capacity. However, thermophilic composting is generally time consuming, requiring frequent mixing with possible loss of nutrients.

Certain species of earthworms can fragment organic material residuals into finer particles by passing them through a grinding gizzard (Ndewga and Thompson, 2001). Additionally, earthworms reduce populations of human pathogens, an effect obtained in traditional composting by increasing temperature (Contreras-Ramos et al., 2004). There is evidence that earthworms produce plant hormones in their secretions (Suthar, 2010a, 2010b). Earthworm-processed material casts contain nutrients in forms easily available to plants (Suthar, 2008, 2009, 2010a, 2010b; Suthar and Singh, 2008; Taylor et al., 2003).

Greenhouse and field studies have examined the effects of vermicompost on cereals and legumes (Chan and Griffiths, 1988), vegetables (Atiyeh et al., 1999; Edwards and Burrows, 1988; Peyvast, Olfati, Madeni, and Forghani, 2008; Peyvast, Olfati, Madeni, Forghani, and Samizadeh, 2008; Subler et al., 1998; Wilson and Carlile, 1989), ornamental and flowering plants (Edwards and Burrows, 1988), and field crops (Buckerfield and Webster, 1998; Mba, 1996). Most of these investigations confirmed that vermicomposts have beneficial effects on plant growth. Vermicomposts, used as soil additives or as components of greenhouse bedding plant container media, improve seed germination, enhance seedling growth and development, and increase overall plant productivity (Atiyeh et al., 2000). Szczech (1999) suggested that chemical factors in vermicompost had no direct inhibiting effects on soil-borne fungi but that bacteria and fungi in the vermicompost were antagonistic to *Fusarium oxysporum* Schlecht.

The final vermicomposting product has high electrical conductivity (EC), which increases soil salinity with continued usage. To reduce EC, vermicompost leachate and vermivash have been developed. Vermiwash may contain cytokinins, auxin, amino acid, vitamins, and enzymes possibly derived from microbes associated with earthworms (Suthar, 2010a). There is a demand
for naturally derived agro-chemicals for sustainable farming systems, and organic production disallows use of synthetic chemicals. There is no comprehensive study concerning the impact of vermiwash and vermicompost leachate on French dwarf bean. This project was undertaken to determine the effects of vermicomposted cow manure and the leachate residue with vermiwash on growth and yield of French dwarf bean.

MATERIALS AND METHODS

The experiment was conducted in a research field at the University of Guilan Campus, Agriculture Faculty, Rasht, Iran (altitude 7 m below mean sea level, 37°16'N, 51°3'E), from Apr. to Sept. 2012. The soil was a loam, pH 7.44, containing total N (1%), total C (1.08%), and there was 4600, 1700, and 4000 mg·kg⁻¹ of Ca, P, and K, respectively, in soil dry matter, with an EC of 0.1 ds·cm⁻¹. The soil was prepared by plowing and disking. Local cultivar seed of bean were sown on 15 Apr. with a distance of 0.5 × 0.15 m between rows and plants. Each plot area was 4 m² containing 50 plants.

Earthworms (Eisenia fetida; 25 g earthworms·kg⁻¹ of cattle manure or 2.5 kg earthworms/m² per bed) were added and vermicomposted for 2 months (Peyvast, Olfati, Madeni, and Forghani, 2008; Peyvast, Olfati, Madeni, Forghani, and Samizadeh, 2008). The vermicompost had a water content of 380 g·kg⁻¹, pH 6.82; total C content of 23.8% dry matter (DM) and a total N content of 1.5% DM. The vermicompost (100 kg) was flushed with 50 L of water and leachate (vermiwash) collected.

A completely randomized design with three replications was used. Treatments included 0 and 7 Mt·ha⁻¹ of cow manure vermicompost or leachate vermicompost; 7 Mt·ha⁻¹ of leachate vermicompost with vermiwash and a no-fertilizer control where vermicompost and leachate vermicompost treatment spread over beds; and vermiwash applied four times to plants at a 7-day interval with the first application one month after seed sowing.

At harvest total yield, number of pods per plant, pod weight, number of lateral branches per plant, percentage dry matter of pod and plant, internode length, number of nodes, pod length, and plant height were determined. Chopped pods and plants were placed in a forced air drying oven at 75°C for 48 h to determine dry matter. Data were subjected to analysis of variance (ANOVA) in SAS (ver. 9.1, SAS Institute, Inc., Cary, NC). Means were separated using Tukey’s test.

RESULTS AND DISCUSSION

Fertilizer type affected all measured characteristics except individual pod fresh and dry weight (Tables 1 and 2). Pod fresh weight averaged 4.62 g and
Table 1: ANOVA table of effects of different vermicompost usage on plant height, pod length, pod fresh and dry weight, and number of nodes.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Plant height</th>
<th>Pod length</th>
<th>Pod fresh weight</th>
<th>Pod dry weight</th>
<th>Number of nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rep.</td>
<td>2</td>
<td>70.65**</td>
<td>1.88*</td>
<td>2.23**</td>
<td>0.07 ns</td>
<td>0.64**</td>
</tr>
<tr>
<td>Treatment</td>
<td>3</td>
<td>22.2*</td>
<td>1.05*</td>
<td>1.16 ns</td>
<td>0.06 ns</td>
<td>0.18*</td>
</tr>
<tr>
<td>Error</td>
<td>6</td>
<td>3.62</td>
<td>0.2</td>
<td>0.28</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>CV (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ns, *, **Nonsignificant or significant at $P \leq 0.01$ and $P \leq 0.04$, respectively.

Table 2: ANOVA table of effects of different vermicompost usage on number of lateral branches, plant dry weight, internode length, number of pods, and total yield.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Number of lateral branches</th>
<th>Plant dry weight</th>
<th>Internode length</th>
<th>Number of pods</th>
<th>Total yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rep.</td>
<td>2</td>
<td>0.65**</td>
<td>6.05**</td>
<td>0.09**</td>
<td>12*</td>
<td>156.6**</td>
</tr>
<tr>
<td>Treatment</td>
<td>3</td>
<td>1.58**</td>
<td>4.55**</td>
<td>2.29**</td>
<td>93.11**</td>
<td>160.24**</td>
</tr>
<tr>
<td>Error</td>
<td>6</td>
<td>0.02</td>
<td>0.23</td>
<td>0.001</td>
<td>1.78</td>
<td>13.35</td>
</tr>
<tr>
<td>CV (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ns, *, **Nonsignificant or significant at $P \leq 0.01$ and $P \leq 0.04$, respectively.

pod dry weight percentage averaged 0.93%. Plants treated with vermiwash had the tallest plants, longest pods, most pods per plant, most lateral branches, and greatest number of pods; highest plant dry weight and longest internodes were from plants treated with vermicompost leachate (Tables 3 and 4); differences between plants treated with vermicompost leachate and vermiwash were not different. Vermiwash combined with vermicompost leachate negatively affected vegetative characteristics and yield (Table 2).

Organic fertilizers beneficially effect soil structure and nutrient availability; they maintain quantity and quality of yield and can be less costly than synthetic fertilizers (Olfati et al., 2012; Thy and Buntha, 2005). Application of organic fertilizers may help alleviate soil erosion (Shahvali and Abedi, 2006), and saline and sodium problems as a result of excessive chemical fertilization and irrigation (Allahyari et al., 2008). Use of sustainable organic materials can increase fertility without negative effects on human health and environment. Vermicompost (Gutiierrez-Miceli et al., 2007; Peyvast, Olfati, Madeni, and Forghani, 2008; Peyvast, Olfati, Madeni, Forghani, and Samizadeh, 2008) and vermiwash (Suthar, 2010b) have been proposed as organic fertilizers, but there are no reports about combined application of vermiwash and vermicompost.
Table 3: Effect of treatment on plant height, pod length, pod fresh and dry weight, and number of nodes.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height</th>
<th>Pod length</th>
<th>Pod fresh weight</th>
<th>Pod dry weight</th>
<th>Number of nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 Mt-ha⁻¹ vermicompost</td>
<td>47.28ab</td>
<td>10.18a</td>
<td>5.1a</td>
<td>1.03a</td>
<td>7.77ab</td>
</tr>
<tr>
<td>Vermiwash prepared from 7 Mt-ha⁻¹ vermicompost</td>
<td>48.21a</td>
<td>9.7ab</td>
<td>4.57a</td>
<td>0.91a</td>
<td>7.87a</td>
</tr>
<tr>
<td>7 Mt-ha⁻¹ vermicompost leachate</td>
<td>46.86ab</td>
<td>10.07ab</td>
<td>5.05a</td>
<td>1.02a</td>
<td>7.8a</td>
</tr>
<tr>
<td>7 Mt-ha⁻¹ vermicompost leachate + vermiwash</td>
<td>42.13b</td>
<td>8.87b</td>
<td>3.76a</td>
<td>0.74a</td>
<td>7.33b</td>
</tr>
</tbody>
</table>

Values in columns followed by the same letter are not significantly different, \( P < 0.05 \), Tukey’s test.

Table 4: Effect of treatment on number of lateral branches, plant dry weight, internode length, number of pods, and total yield.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of lateral branches</th>
<th>Plant dry weight</th>
<th>Internode length</th>
<th>Number of pods</th>
<th>Total yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 Mt-ha⁻¹ vermicompost</td>
<td>7.93a</td>
<td>14.62a</td>
<td>7.06a</td>
<td>29.33a</td>
<td>26.52ab</td>
</tr>
<tr>
<td>Vermiwash prepared from 7 Mt-ha⁻¹ vermicompost</td>
<td>8.47a</td>
<td>14.68a</td>
<td>7.13a</td>
<td>30.33a</td>
<td>25.93ab</td>
</tr>
<tr>
<td>7 Mt-ha⁻¹ vermicompost leachate</td>
<td>8.03a</td>
<td>15.42a</td>
<td>7.1a</td>
<td>29.67a</td>
<td>28.05a</td>
</tr>
<tr>
<td>7 Mt-ha⁻¹ vermicompost leachate + vermiwash</td>
<td>6.77b</td>
<td>12.55b</td>
<td>5.35b</td>
<td>18.67b</td>
<td>12.33b</td>
</tr>
</tbody>
</table>

Values in columns followed by the same letter are not significantly different, \( P < 0.01 \), Tukey’s test.

leachate on vegetables. Most investigations confirmed that vermicomposts are beneficial to plant growth (Atiyeh et al., 1999; Buckerfield and Webster, 1998; Chan and Griffiths, 1988; Edwards and Burrows, 1988; Mba, 1996; Peyvast, Olfati, Madeni, and Forghani, 2008; Peyvast, Olfati, Madeni, Forghani, and Samizadeh, 2008; Subler et al., 1998; Wilson and Carlile, 1989).

Vermicompost leachate contains slightly higher amounts of sodium (Na); vermiwash contains high potassium (K), which, as a primary nutrient, is needed in high amounts for plant growth (Gutierrez-Miceli et al., 2007). Quaik and Ibrahim (2013) reported that for mung bean (Vigna radiate L.), using leached vermicompost and vermiwash, germination was higher in 10% vermiwash than in treatment with 10% vermicompost leachate.
The main problem that can arise from excessive vermicompost application is plant toxicity due to high salt content. With leaching, the negative effects of vermicompost related to high EC (Gutierrez-Miceli et al., 2007) decreased and continuous application of this material may be possible. The vermicompost leachate and vermiwash can be used as organic fertilizer for sustainable bean cultivation.

REFERENCES


