An integrated crop-vermiculiculture system for treating organic waste on formland

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Outline:

1. Introduction

2. System design

3. Experimental design

4. Results and discussion
   4.1 Organic waste treatment and recycling
   4.2 The effect of soil improvement and crop growth
   4.3 System output

5. Conclusion
Humans produce more and more organic waste every day. *household garbage, agricultural waste, sludge, etc*

How to properly dispose of these organic wastes has become the focus of much research. *landfills, fermentation, farmland use, etc*

Using earthworms to process organic waste is a relatively new technology. *simper, less investment, better treatment effect, etc*

However, using earthworms to process organic wastes has been limited to specially adapted places. *earthworm farms, do not use on site, etc*
So we introduce an integrated crop-vermiculture system for treating organic waste on farmland using earthworms.

Through vermiculture, this system disposes of organic waste and produces organic fertilizer. At the same time, nutrients in the organic waste can be used by the agricultural plants on site.

We evaluate the effectiveness of this model in terms of organic waste treatment, system production, and soil improvement relative to conventional agriculture.
2. System design

The model basically consists of alternating bands of crop plant ridges and worm farming troughs.

In Fig.
- **a** is 0.5 meters wide crop planting band with winter wheat-summer maize rotation which has higher density than conventional agriculture.
- **b** is worm farming trough with 0.8 meters wide, 0.2 meters deep, organic waste is treated while breeding earthworm (*Eisenia fetida*).
2. System design

Fig. Field photographs of the integrated crop-vermiculuture system
3. Experimental design

We conducted plot experiments with a total of four treatments:

- dung (NF)
- sludge (WN)
- mushroom residue (MGZ)
- conventional cultivation (CK)

In accordance with the requirements of the design, dung, sludge, and mushroom residues were placed in their respective troughs.

The CK treatment served as a control and included no earthworm breeding troughs. Following local crop rotation practices.
4. Results and discussion: **Organic waste treatment and recycling**

4.1 Organic waste treatment and recycling
4. Results and discussion: **Organic waste treatment and recycling**

Effect of organic waste treatment and organic fertilizer output

**Fig. Annual inputs and outputs of organic waste, dung (NF), sludge (WN), and mushroom residue (MGZ)**

Model is effective at disposing of organic waste, while capacity varied significantly with organic waste type (P < 0.05). This may be related to properties of the organic waste itself, such as the C/N ratio.
The nitrogen, phosphorus, potassium, and organic matter content of organic fertilizer produced by vermiculture

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total-N (N) %</th>
<th>Total-P (P₂O₅) %</th>
<th>Total-K (K₂O) %</th>
<th>Total nutrient %</th>
<th>Organic matter %</th>
</tr>
</thead>
<tbody>
<tr>
<td>NF</td>
<td>1.49</td>
<td>1.51</td>
<td>1.29</td>
<td>4.29a</td>
<td>37.09a</td>
</tr>
<tr>
<td>WN</td>
<td>1.22</td>
<td>3.31</td>
<td>1.14</td>
<td>5.67b</td>
<td>37.79a</td>
</tr>
<tr>
<td>MGZ</td>
<td>0.69</td>
<td>0.65</td>
<td>1.51</td>
<td>2.85c</td>
<td>34.28b</td>
</tr>
<tr>
<td>National standard</td>
<td></td>
<td></td>
<td></td>
<td>4.00d</td>
<td>30.00c</td>
</tr>
</tbody>
</table>

Different letters in the same column indicate significant differences at $p=0.05$ based on the least-significant difference (LSD) test method.

The total nutrient content and organic matter content of the fertilizer produced in the NF and WN treatments comply with the Chinese national standards for agricultural organic fertilizer.
4. Results and discussion: **The effect of soil improvement and crop growth**

4.2 The effect of soil improvement and crop growth
4. Results and discussion: **The effect of soil improvement and crop growth**

**Soil bulk density**

![Graph showing soil bulk density](image)

**Fig. Soil bulk density after each harvest**

There was **no significant different** between the treatments and conventional agriculture for the same period.
4. Results and discussion: The effect of soil improvement and crop growth

Soil nutrient content

Fig. Soil total-N during various stages of crop growth

Fig. Soil alkaline-N during various stages of crop growth

Fig. Soil Olsen-P during various stages of crop growth

Fig. Soil available-K during various stages of crop growth
4. Results and discussion: **The effect of soil improvement and crop growth**

Soil nutrient content

These results indicate that while the model avoids fertilizer inputs in the planting process, **the soil nutrient which are important to crop growth, did not decrease rapidly.**

Furthermore, use of higher nutrient content organic waste in this model would in turn improve soil nutrient contents.
4. Results and discussion: The effect of soil improvement and crop growth

Soil heavy metal content

![Soil DTPA-Zn after each harvest](image1)

![Soil DTPA-Cu after each harvest](image2)

Fig. Soil DTPA-Zn after each harvest

Fig. Soil DTPA-Cu after each harvest

Sludge treatment resulted in DTPA-Zn levels significantly higher than levels under conventional agriculture, while the other treatments had no significant effect on DTPA-Zn levels. DTPA-Cu levels were not significantly affected by the treatments.
4. Results and discussion: **The effect of soil improvement and crop growth**

The impact on plant height and leaf area

The treatments did not have a significant effect on plant height or leaf area for a given sampling stage, but over time, plant height in the MGZ treatment did show a downward trend relative to the other treatments.
4. Results and discussion: **System output**

4.3 **System output**
4. Results and discussion: **System output**

Crop yield and quality

**Table. Yield and 1000-Kernel Weight (TKW)**

<table>
<thead>
<tr>
<th></th>
<th>2008 corn</th>
<th></th>
<th>2009 wheat</th>
<th></th>
<th>2009 corn</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yield kg/ha</td>
<td>TKW g</td>
<td>Yield kg/ha</td>
<td>TKW g</td>
<td>Yield kg/ha</td>
<td>TKW g</td>
</tr>
<tr>
<td>NF</td>
<td>10290a</td>
<td>299.04a</td>
<td>4380a</td>
<td>41.01a</td>
<td>10650a</td>
<td>311.30a</td>
</tr>
<tr>
<td>WN</td>
<td>10,020ab</td>
<td>322.98a</td>
<td>3930a</td>
<td>39.65a</td>
<td>10385a</td>
<td>310.92a</td>
</tr>
<tr>
<td>MGZ</td>
<td>8865b</td>
<td>252.03ab</td>
<td>4395a</td>
<td>42.07a</td>
<td>8355b</td>
<td>289.43b</td>
</tr>
<tr>
<td>CK</td>
<td>6480c</td>
<td>228.43b</td>
<td>7290b</td>
<td>35.12b</td>
<td>7770b</td>
<td>292.52ab</td>
</tr>
</tbody>
</table>

_Different letters in the same column indicate significant differences between treatments based on the LSD test method (p=0.05)._
## Crop yield and quality

### Table. N, P, K, and crude protein content in the harvested grain

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Sampling period and crop</th>
<th>2008 corn</th>
<th>2009 wheat</th>
<th>2009 corn</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total-N %</strong></td>
<td>NF</td>
<td>1.2181a</td>
<td>2.1454ab</td>
<td>1.3660a</td>
</tr>
<tr>
<td></td>
<td>WN</td>
<td>1.2120a</td>
<td>2.2408a</td>
<td>1.3227a</td>
</tr>
<tr>
<td></td>
<td>MGZ</td>
<td>1.2460b</td>
<td>2.0396b</td>
<td>1.2631b</td>
</tr>
<tr>
<td></td>
<td>CK</td>
<td>0.9895c</td>
<td>2.1696ab</td>
<td>1.1923c</td>
</tr>
<tr>
<td><strong>Total-P %</strong></td>
<td>NF</td>
<td>0.3895a</td>
<td>0.4385a</td>
<td>0.3430a</td>
</tr>
<tr>
<td></td>
<td>WN</td>
<td>0.3880a</td>
<td>0.4374a</td>
<td>0.3160a</td>
</tr>
<tr>
<td></td>
<td>MGZ</td>
<td>0.3092a</td>
<td>0.3850a</td>
<td>0.3226a</td>
</tr>
<tr>
<td></td>
<td>CK</td>
<td>0.3462a</td>
<td>0.3997a</td>
<td>0.3585a</td>
</tr>
<tr>
<td><strong>Total-K %</strong></td>
<td>NF</td>
<td>1.8227a</td>
<td>2.1341a</td>
<td>2.0722a</td>
</tr>
<tr>
<td></td>
<td>WN</td>
<td>2.2984b</td>
<td>2.9941a</td>
<td>1.9078a</td>
</tr>
<tr>
<td></td>
<td>MGZ</td>
<td>1.9327a</td>
<td>2.2618a</td>
<td>1.8332a</td>
</tr>
<tr>
<td></td>
<td>CK</td>
<td>1.7219a</td>
<td>2.8836a</td>
<td>1.9193a</td>
</tr>
<tr>
<td><strong>Crude protein %</strong></td>
<td>NF</td>
<td>8.3559a</td>
<td>13.8519a</td>
<td>8.6997a</td>
</tr>
<tr>
<td></td>
<td>WN</td>
<td>8.1730a</td>
<td>14.1416a</td>
<td>8.6303a</td>
</tr>
<tr>
<td></td>
<td>MGZ</td>
<td>8.1761a</td>
<td>13.8221a</td>
<td>7.8980b</td>
</tr>
<tr>
<td></td>
<td>CK</td>
<td>6.6984b</td>
<td>14.0491a</td>
<td>8.0331b</td>
</tr>
</tbody>
</table>

However, in all treatments, the TKW, and grain nitrogen, phosphorus, potassium, and protein contents were better than those under conventional agriculture.

Different letters in the same column indicate significant differences between treatments based on the LSD test method (p=0.05).
### Table. Cu and Zn content in the harvested grain

<table>
<thead>
<tr>
<th></th>
<th>NF</th>
<th>WN</th>
<th>MGZ</th>
<th>CK</th>
<th>National standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cu content</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mg/kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008 corn</td>
<td>3.25A</td>
<td>3.28A</td>
<td>3.19A</td>
<td>3.31A</td>
<td>10</td>
</tr>
<tr>
<td>2009 wheat</td>
<td>2.43A</td>
<td>3.23A</td>
<td>3.63A</td>
<td>3.32A</td>
<td>10</td>
</tr>
<tr>
<td>2009 corn</td>
<td>4.02A</td>
<td>4.26A</td>
<td>3.23A</td>
<td>3.95A</td>
<td>10</td>
</tr>
<tr>
<td><strong>Zn content</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mg/kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008 corn</td>
<td>18.46A</td>
<td>39.01aA</td>
<td>12.90A</td>
<td>13.23A</td>
<td>50</td>
</tr>
<tr>
<td>2009 wheat</td>
<td>25.63aA</td>
<td>37.78aA</td>
<td>33.34aA</td>
<td>11.04A</td>
<td>50</td>
</tr>
<tr>
<td>2009 corn</td>
<td>19.49A</td>
<td>35.23aA</td>
<td>26.79A</td>
<td>22.47A</td>
<td>50</td>
</tr>
</tbody>
</table>

*a*: significant difference between the treatment and CK at the 0.05 level.

*A*: significant difference between the treatment and national standards at the 0.05 level.

There were no significant differences in Cu content. However, Zn content was significantly higher in the WN treatment than in the CK, and in 2009, all of the treatments had significantly higher wheat grain Zn content.
Earthworm harvest and Cu and Zn content

These results indicate that by using this model to treat organic waste, earthworms can also be farmed at the same time. The annual yield was significantly higher in NF and WN than in MGZ.
4. Results and discussion: System output

Earthworm harvest and Cu and Zn content

The Cu content was significantly higher in earthworms raised on sludge than in those raised on dung or mushroom residue. The Zn content of earthworms raised on dung, sludge, and mushroom residue was varied significantly with waste type.
5. Conclusion

We have already conducted 1.5 years of research, the results show that the social and economic benefits of the corn/wheat-vermiculture system are greater than those of the traditional corn/wheat cropping pattern.

(1) The crop-vermiculture system is an effective method of waste processing, although the waste treatment capacity and nutrient content vary with the type of organic waste used.

(2) The crop-vermiculture system attained a higher corn yield than the traditional method, but half the wheat yield of the traditional method. However, the quaintly of grain were better than in the traditional method.

(3) In the harvest season, we can obtain not only corn or wheat, but also earthworms and organic fertilizer, with zero chemical fertilizer input and a reduction in mechanical cultivation. Revenue can be increased.

(4) Although we did not use urea or other fertilizers in this system, earthworm activity certainly improved the soil physical structure and maintained or increased soil nutrients.

(5) Treatment with sludge, which has a high heavy metal content, resulted in a slight enrichment of soil Zn content; Zn levels were also higher in grain and worms with sludge treatment.
In conclusion, we found the crop-vermiculture system of processing organic waste to be feasible and effective at treating, transforming, and using organic waste. The system can provide larger outputs and good economic benefits, improve the physical properties of soil and soil fertility. All results were greatly affected by the type of organic waste used, with the order of treatment effect from greatest to least being dung > sludge > mushroom residue.
Thank you!!