Valorization of Corn Sillage through Vermicomposting

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Abstract
In this study, corn sillage was converted to vermicompost and vermiwash through earthworm bio conversion. *Eisenia Fetida* earthworms loaded at a rate of 2.5 kg/m^2 were used as the vermicomposting media over a period of 30 days in a vermireactor. The corn sillage vermiwash and vermicompost produced were analysed for bio fertilizer nutritional composition. The vermicompost had a nitrogen, phosphorous and potassium (NPK) composition of 0.52-1.53%, 0.18-1.06% and 0.13-0.74% respectively, whilst the vermiwash had an NPK composition of 0.011-1.83%, 0.003-1.65% and 0.062-1.73% respectively. Bio conversion of corn sillage to vermi- products presents an opportunity to boost food security and at the same time resource recovery from waste.

Keywords: Bio fertilizers, corn sillage, NPK, vermicompost, vermiwash, waste management

1. Introduction
Vermicomposting (earthworm) technology presents an opportunity for organic waste management at the same time producing vermicompost and vermiwash which can be used as bio fertilizers in the agriculture industry (Mishra *et al*., 2014; Kapoor *et al*., 2015). Various waste such as municipal, industry and agriculture have been investigated for vermicompost production (Zambare *et al*., 2008; Sailila *et al*., 2010). Figure 1 shows typical vermicompost from organic waste.

Figure 1. Vermicompost from organic waste

Several earthworm types such as *Eisenia Foetida, Eudrilus Eugeniae, Lumbricus Rubellus, Lampito Mauritti, Octochaetus Surnensi, Drawida Willsi* and *Perionyx Excavatus* have been used in the production of vermicompost (Barik *et al*., 2015). During the vermicomposting process, a leachate called vermiwash is also produced; both vermicompost and vermiwash are applicable as bio fertilizers due to their rich composition in nitrogen, phosphorous and potassium as well as their potential to improve soil fertility and aeration (Esakkiammal *et al*., 2015; Kaur *et al*., 2015).
On the other hand, in Zimbabwe and other countries in the sub Sahara Africa, tons of corn sillage are produced at the end of each farming cycle and are usually burnt yet this can also be a source of raw material for the vermicomposting technology. This study focused on the investigation of the potential to produce vermicompost and vermiwash from corn sillage.

2. Materials and methods

2.1 Materials

Corn sillage was obtained from a nearby farm in Shamva, Zimbabwe. Eisenia Fetida earthworms were obtained from the local fisherman. Vermireactors were obtained from Full Cycle, South Africa. An AND moisture analyser was used for moisture content, ash content and volatile matter analysis. A Perkin Elmer model 3110 double beam atomic absorption spectrophotometer was used for the potassium composition determination. The pH was determined by a Hanna Instrument pH probe.

2.2 Methods

Vermicomposting was conducted in the vermireactor over a period of 30 days at standard conditions at a local farm in Shamva, Zimbabwe. Earthworms thrive best at temperatures between 10-32 °C (Nagavallemma *et al*., 2004). The vermireactor had 3 chambers which allowed the movement of earthworms to the next chamber once vermicomposting was done. Eisenia Fetida earthworms were stocked at a rate of 2.5 kg/m^2 in tea vermireactor. Vermiwash was also collected throughout the process.
The organic carbon content of the vermicompost was measured by oxidising a sample using nascent oxygen produced by reacting sulphuric acid and aqueous solution of potassium chromate. The residual potassium chromate is titrated with ferrous ammonium sulphate to determine the amount of organic carbon. The total nitrogen was measured using Kjeldahl digestion whilst potassium and the trace elements were measured using colometric methods. Physicochemical parameters were determined for both the vermicompost and the vermiwash.

3. Results and discussion

3.1 Corn sillage characteristics

The corn sillage had a moisture content of around 55% which was adequate to start the vermicomposting process. The ideal moisture content for vermicomposting process is reported to be optimal at 45-60% (Munroe, 2004). The corn sillage also had a pH of 6.5. The ideal pH for the vermicomposting process is 5-9 and in the event that the pH is too high, then calcium carbonate can be applied for its neutralization (Munroe, 2004).

3.2 Vermicompost from corn sillage

The conversion efficiency of the corn sillage to vermicompost was 60% and this was in line with the conversion efficiencies reported by Nagavallemma *et al*. (2004). The moisture content of the final vermicompost product was 35%. The vermicompost had micro and macro fertiliser nutrients as shown in Table 1. The nitrogen, phosphorous and potassium content (NPK) were 0.52-1.53%, 0.18-1.06% and 0.13-0.74%. The NPK results in this study compared very well with values reported by Aalok *et al*. (2009). The NPK content of the vermicompost can be further enhanced by adding rock phosphate (Barik *et al*., 2011). The vermicompost also contained trace elements required for plant growth and can be used from growing agricultural and horticulture crops at the planting stage as well as its growth.

Table 1. Nutrient composition of vermicompost from corn sillage

Nutrient	Composition (%)
Organic carbon (OC)	9.5-12.4
Total nitrogen (TN)	0.52-1.53
Phosphorous (P)	0.18-1.06
Potassium (K)	0.13-0.74
Calcium (Ca)	1.16-7.48
Magnesium (Mg)	0.092-0.561
Sodium (Na)	0.048-0.157
Zinc (Zn)	0.0037-0.150
Copper (Cu)	0.0021-0.004
Iron (Fe)	0.211-1.334
Manganese (Mn)	0.0112-0.204

3.2 Vermiwash from corn sillage

The vermiwash produced from the vermicomposting process of corn sillage had an average organic carbon of 5.3%. The nitrogen, phosphorous and potassium (NPK composition) was 0.011-1.83%, 0.003-1.65% and 0.062-1.73% respectively. The vermiwash also contained trace elements with calcium being the major trace nutrient with an average composition of 74.8%. The composition of the vermiwash from corn sillage is shown in Table 2. Ansari and Sukhraj (2010) reported almost similar results for vermiwash composition when they vermicomposted various organic waste.

Table 2. Vermiwash from corn sillage nutrient composition

Parameter	Nutrient composition
Organic carbon (OC)	1.58-8.95%
Nitrogen (N)	0.011-1.83%
Phosphorous (P)	0.003-1.65%
Potassium (K)	0.062-1.73%
Calcium (Ca)	62.9-86.7 ppm
Magnesium (Mg)	23.6-87.1 ppm
Copper (Cu)	11.6-14.5 ppm
Iron (Fe)	0.016-1.33 ppm
Manganese (Mn)	13.2-14.8 ppm

*ppm-parts per million

4. Conclusion

The sub Sahara Africa has plenty of corn sillage that can be vermicomposted to vermicompost and vermiwash bio fertilizers. The vermicompost had a nitrogen, phosphorous and potassium composition of 0.52-1.53%, 0.18-1.06% and 0.13-0.74% respectively, whilst the vermiwash had an NPK composition of 0.011-1.83%, 0.003-1.65% and 0.062-1.73% respectively. Corn sillage vermi products (vermicompost and vermiwash) are rich in nitrogen, phosphorous content and can be used for agricultural and horticultural crops.

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