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# Changes in chemical properties of sawdust and blood powder mixture during vermicomposting and the effects on the growth and chemical composition of cucumber

Fereshteh Najjari, Somayeh Ghasemi*

*Department of Soil Science, Yazd University, 89168-69511, Yazd, Iran*

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ABSTRACT

The aim of this study was to convert sawdust (SD) amended with blood powder (BP) into vermicompost and evaluates their effects on the growth and nutrition of cucumber. BP was mixed with SD in different proportions i.e., 5% and 10%BP along with control and allowed to pass through earthworm guts during 4 months. The vermicomposting caused a decrease in organic C (22.5–41.2%) and C:N ratio (42.4–57.8%), while increase in electrical conductivity (18.2–94.7%) and total N content (45.2–71.8%). Addition of BP with SD yielded vermicomposts which have significantly higher nutrients as compared to SD vermicompost. Application of SD + 5% BP vermicompost increased concentration of N, P, Fe, Zn and Cu in the leaves of cucumber. The results obtained indicated that mixing of 5%BP with SD was probably the optimum condition to obtain the best quality vermicompost which was demonstrated by enhanced nutrients uptake and growth of cucumber.

## 1. Introduction

Each year approximately 40 Mt organic waste is produced worldwide (Kumar et al., 2013). Management of these wastes has become one of the serious global problems, as unprofessional disposal of waste can adversely affect both the human health and environment by causing acrid odor, ground water contamination and soil pollution (Ekhuemelo et al., 2017).

Sawdust (SD) is one of the major underutilized by-products from sawmilling operations. The generation of wood wastes in sawmill is an unavoidable, hence a great efforts are directed towards utilization of such waste (Ekhuemelo et al., 2017). Application of SD in agriculture will be the most convenient method of disposal compared to several available alternatives (Tran, 2005) but, agricultural scientists have been reluctant to accept SD as a desirable form of organic matter to use as a mulch or soil amendment because of some of the problems which could arise when added to the soil. Its slow rate of decomposition, which may or may not be a disadvantage, and its temporary nitrogen (N) fixation have been the principal objections to its use. The very low value of SD as a source of readily available plant nutrients is a known disadvantage (El Halim and El Baroudy, 2014).

One of the useful methods for processing the organic wastes is recycling to organic fertilizer. As a result of this process, in addition to health and environmental problems reduction, considerable amount of organic fertilizer is produced (Londhe and Bhosale, 2015). Thus, in recent years, vermicomposting and composting have turned out to be promising way out for safe disposal of organic waste (Punde and Ganorkar, 2012). Vermicomposting is a technique of biodegradation or stabilization of organic waste (natural/anthropogenic) by using earthworms and microorganisms (Kumar et al., 2013). Several epigeic earthworms, e.g., *Eisenia foetida*, *Eudrilus eugeniae*, *Perionyx excavatus* and *Lumbricus rubellus* have been identified as detritus feeders and can be used potentially to minimize the anthropogenic wastes from different sources (Garg et al., 2006; Nayak et al., 2013; Suthar, 2007, 2009). However, *E. foetida* is the most common and favored earthworm species for vermicomposting of organic wastes due to its wide tolerance of environmental conditions e.g., pH, temperature and moisture content (Garg et al., 2006; Kumar et al., 2013; Suthar, 2007, 2009).

The effective use of the earthworms in organic waste management requires a detailed understanding of the effect of the substrate physicochemical properties. Several studies indicate that the activities of earthworms are influenced by quality of food (Tiunov and Scheu, 2004). To provide proper nutrition for earthworms during vermicomposting, carbon (C) and N must be present in the substrates at the optimal ratio. Sawdust is a carbonaceous organic substance which has a very high C:N ratio (typically C:N in sawdust is 300:1) (Tran, 2005). The conversion of this waste into a readily usable form can be indicated by the decline of its C:N ratio. Vermicomposting by mixing of high C:N

* Corresponding author.
*E-mail address:* s.ghasemi@yazd.ac.ir (S. Ghasemi).

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ratio materials with low C:N ratio materials have been studied by many researchers (Nayak et al., 2013; Suthar, 2009), to obtain a starting substrate with suitable C:N ratio. There is a scarcity of information regarding the combination of blood powder (BP) as a rich source of N, and SD for the production of vermicompost under optimal condition. Blood powder is a by-product of slaughterhouses and is used as a high-nitrogen organic fertilizer (Ciavatta et al., 1997) and a protein source in animal diets (Beski et al., 2015). Blood can be collected during the slaughter of various livestock species (cow, chickens, etc.) under a wide range of conditions. Blood is a highly perishable product and must be processed as soon as possible after slaughter. It is usually processes into a fine dry powder form, making it easily water soluble and one of the fastest acting organic fertilizers. Blood powder is also available worldwide, but like other animal products its sale and utilization are regulated in some countries for certain species for safety reasons (Fombad et al., 2004).

We hypothesized that since BP can reduce the C:N ratio in SD, the decomposition rate of SD mixed with BP using *E. foetida* can consequently be affected and hence, that would influence the growth and nutritional status of plant. Therefore, the objectives of this study were to investigate i) the effect of different quantities of BP on chemical characteristics of SD vermicompost and ii) The effect of produced vermicomposts on the growth and chemical composition of cucumber.

## 2. Materials and methods

### 2.1. Preparation of vermicompost

The fine SD was obtained locally by collecting from sawmills and BP (Table 1) was prepared from commercial BP producer factory of Fasaran located at 45 km north of Isfahan, Iran. The BP products of this factory are made from pure cattle's blood by spray-drying method. BP is stored before use in a cool and dry place. In this experiment, BP was mixed with SD in two different proportions i.e., 5% and 10% BP along with control. All beddings were kept for 4 weeks prior to experimentation and subsequently partially decomposed under anaerobic conditions. Appropriate moisture (75%) was maintained along this period by periodic sprinkling of an adequate quantity of water. After initial thermal stabilization of composting beds, approximately 4000 g of partially decomposed materials (80% moisture content) was placed in beds (40 cm × 27 cm × 15 cm). The earthworms, *E. foetida*, were added into these beds. The number of earthworms introduced initially was 200 per bed (ca. 150 g), including juveniles and adults. All beds were covered with lids perforated for aeration, and maintained in the laboratory at 25 ± 2 °C for a period of 4 months. The experiment was conducted following complete randomized design with three replications.

**Table 1**
Some properties of blood powder and soil used in the experiments.

| Parameter | Blood powder | Soil |
|---|---|---|
| pH | 6.4 | 7.5 |
| EC (dS $m^{-1}$) | 9.20 | 4.18[a] |
| Organic C (%) | 42.0 | 0.68 |
| Total N (%) | 13.10 | 0.08 |
| Available P (g $kg^{-1}$) | 2.70 | 0.017 |
| Available K (g $kg^{-1}$) | 8.78 | 0.096 |
| Fe (mg $kg^{-1}$) | 2600 | 3.02 |
| Zn (mg $kg^{-1}$) | 12.81 | 0.47 |
| Cu (mg $kg^{-1}$) | 5.50 | 0.24 |
| Mn (mg $kg^{-1}$) | 12.42 | 2.48 |

[a] Electrical conductivity of soil saturation extract.

### 2.2. Chemical analysis

The chemical parameters of bedding material and final vermicomposts were analyzed by using standard methods. The pH and EC was recorded from a suspension of the material in double-distilled water, in the ratio of 1:10 (w:v), after one hour of incubation. Total N was determined by Kjeldal digestion method (Bremner and Mulvancey, 1982) and organic C was analyzed by wet digestion procedures (Nelson and Sommers, 1982). Available P was measured using the method described by Anderson and Ingram (Olsen et al., 1954) and K was determined after extracting the sample using ammonium acetate (Simard, 1993). Analyses of Fe, Zn, Cu and Mn (acid digest) were carried out with an atomic absorption spectrophotometer (Model 3400, Perkin Elmer, Wellesley, MA).

### 2.3. Plant cultivation

Seeds of cucumber (*Cucumis sativus* L. Datis) were surface-sterilized in a 1% aqueous solution of Na-hypochlorite for 10 min, rinsed with distilled water and germinated on moist filter paper in an incubator at 28 °C. Uniformly-sized seedlings were transferred to polyethylene pots, 17.2 cm diameter and 17 cm depth, containing mineral soil (Table 1) substituted with 5% (by weight) of vermicomposts prepared from SD, SD + 5%BP and SD + 10%BP. Additional pots with no vermicompost were also prepared as control treatment. The experiment was conducted in a greenhouse with 60 ± 5% relative humidity at 25/20 °C day/night temperature and average midday photosynthetic photon flux density of 390 μmol $m^{-2}s^{-1}$. Each treatment was run with three replicates under the same conditions.

Plants were harvested approximately 60 days after seeding and divided into shoot and roots. Root and shoot dry weight and number of flowers were determined for each pot. Chlorophyll content was determined in 80% acetone extract. After centrifugation (8000*g*, 20 min) the absorbance was read spectrophotometrically at 663 and 645 nm. Total chlorophyll concentration was calculated according to Arnon (1949).

Shoot N concentration was measured using Autotech (Model 300) (Bremmer and Mulvaney, 1982). Analyses of Fe, Zn, Cu and Mn were carried out with an atomic absorption spectrophotometer (Model 3400, Perkin Elmer, Wellesley, MA). The concentrations of K and P in plant extracts were analyzed by flame photometer and spectrophotometer, respectively.

### 2.4. Statistical analysis

All statistical analyses were conducted using SPSS statistics 20. Differences among chemical characteristics of vermibeds during vermicomposting process were tested by two-way analysis of variance (ANOVA) with time and vermibed type as the two factors. For the plant growth bioassays, one-way ANOVA was used to determine significant differences in plant growth and nutrition among the different vermicomposts. Means were compared using Duncan's multiple range test at $P < 0.05$.

## 3. Results and discussion

### 3.1. Chemical changes during vermicomposting

Data indicated that chemical characteristics of the raw materials and their produced vermicomposts differed significantly (Tables 2 and 3). A slight decrease in pH was recorded in all vermibeds during vermicomposting (Table 3). pH ranged between 6.7 (SD + 10%BP) and 7.5 (SD) in vermicomposted materials, lower than initial levels. Slightly decreased pH values of vermicomposts compared to initial organic materials might be due to mineralization of N and P, microbial decomposition of organic materials into intermediate organic acids, fulvic