Południowo-wschodni Oddział Polskiego Towarzystwa Inżynierii Ekologicznej z siedzibą w Rzeszowie
Polskie Towarzystwo Gleboznawcze, Oddział w Rzeszowie
Zeszyty Naukowe

Zeszyt 6 rok 2005*

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COMPOSTED GREEN WASTE AS A FEEDSTOCK FOR EISENIA FETIDA: EFFECTS OF COMPOST AGE ON BIOLOGICAL INDICES

PRZEKOMPOSTOWANE ODPADY ROŚLINNE JAKO POKARM DLA EISENIA FETIDA: WPŁYW WIEKU KOMPOSTU NA WSKAŹNIKI BIOLOGICZNE

Niniejsza praca ocenia proces kompostowania koszonej trawy i ścinków żywopłotów z udziałem dżdżownic. Została przeprowadzona w Preston (Anglia), z wykorzystaniem specjalnie przygotowanej 50-cio tonowej pryzmy świeżych, rozdrobnionych odpadów roślinnych. Pryzma miała 2 metry wysokości i została założona w czerwcu 2002. Przez okres 2 miesięcy pobierano z niej próbki i karmiono nimi dżdżownice (Eisenia fetida), w celu oceny przydatności kompostu (w różnym wieku) jako pokarmu dla dżdżownic. Wykazano, że prędkość rozwoju dżdżownic nie zależała od wieku kompostu, którym były żywione, ale wskaźniki ich dojrzewania i zdolności reprodukcyjne były większe w przypadku materiału, pobranego we wcześniejszych stadiach dojrzewania kompostu.

I. INTRODUCTION

The process of composting has been known to and utilised by Man for millennia and involves the actions of a suite of aerobic micro-organisms, that degrade organic matter to obtain the nutrients they require. The process is assisted by creating heaps (windrows) of appropriate material. During the process, high (thermophilic) temperatures in excess of 50^{o}C are reached and oxygen uptake and carbon dioxide production are rapid. High temperatures above 60^{o}C bring about the death of most microbes including potential pathogens. Microbial metabolism gives rise to by-products which affect the compost pH. After as little as 10 days a heap can lose up to 40% of mass through these processes. Addition of oxygen throughout the process through turning of the heap or forced aeration will ensure that the microbes work most effectively. However, if the compost isn't turned

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and becomes compacted or too wet, anaerobic microorganisms can take over. After degradation of the more volatile solids, even lignin and cellulose will be softened as humification occurs. Finally over a period of months the darkened material will become chemically stabilised forming the "finished compost". This phase takes place at low temperatures [2].

Use of naturally occurring micro-organisms in aerobic composting of organic materials is becoming less of an experimental process and more of a major consideration in mainstream waste management. The European Union's Directive [5] on the landfill of waste requires a reduction in the landfill of biodegradable municipal waste in the UK to 75% of 1995 amounts by 2010, 50% by 2013 and 35% by 2020 therefore the processing of organic wastes, including green waste, has increased enormously as these can often contribute significant volumes to the waste stream.

Vermicomposting is the processing of organic matter using appropriate species of earthworms. Such species form the litter dwelling ecological category [3] and are typified by *Eisenia fetida* (Savigny 1826) [7], also known colloquially as the brandling or tiger worm. This is the species promoted by many "vermi-technology" companies. It is extremely fecund and under optimal conditions will grow and reproduce very rapidly as vermicomposting proceeds [4,7]. It should be noted that "vermicomposting" is a very different process to aerobic composting. The products of vermicomposting are thought to have a good texture, having passed through the worm gut, and there is evidence that they contain plant growth hormones and therefore be of great use to horticulture [1]. Very few authors have sought to combine the effects of both aerobic composting and vermicomposting [6].

The major aim of this work was to collect material from an aerobic windrow and assess its utilisation by earthworms over a period of months, following any changes in earthworm production brought about by the length of the composting process.

II. MATERIALS AND METHODS

A dedicated windrow for this project was constructed at Clifton Marsh Landfill Site (CMLS), Preston (National Grid Reference SD 470286) during June 2002. This windrow was composed of shredded green waste (grass cuttings and hedge prunings) collected from Civic Amenity Sites. Windrow dimensions were approximately 50 tonnes fresh material, with a height of no less than 2 m. The windrow was situated on hard-standing.

Over a period of eight weeks, during June to August 2002, samples were taken from three random points along the single, dedicated windrow. The three points were selected by taking a sample of the windrow material from points approximately equidistant from each other, along the horizontal length of the windrow at approximately half the height of the windrow (approx. 1 m) and at a depth of approximately 1 m. The first sample (week zero) was collected on 13th June and samples were then collected at weeks 1–4, 6 and finally 8 (August 8th). During this period the windrow was not turned.

Standard laboratory preparation of samples (mixing and removal of coarse woody material) for chemical analyses were undertaken [8]. Analyses measured moisture content, % loss on ignition, pH, conductance, conductivity, particle size ratio, ammonia, potassium and various metals (nickel, zinc, cadmium, chromium, lead, copper). Part of the mixed, sieved sample was bagged, sealed, marked for identification and frozen for future use. This

occurred on all sampling dates). All material was kept frozen until 16th October when the earthworm experiment was begun.

Seven treatments were set up, representing each stage at which the material had been collected from the windrow; initial and weeks 1, 2, 3, 4, 6 and 8. Plastic containers (600 ml) were provided with 150 g of defrosted compost. The species of earthworm used for growth was *E. fetida* obtained from stock sources at UCLAN. Four juvenile animals were put into each container (mean individual mass 0.12 g). These were then sealed with perforated lids, given identification codes and stored in a temperature-controlled incubator at 18°C. There were five replicates per treatment. Sampling of all pots took place every two weeks over a period of 10 weeks. At each sampling, the compost was thoroughly searched for worms and each found was individually weighed and its sexual condition was assessed. After maturity was recorded for worms, the compost was then searched again for earthworm cocoons. All cocoons were incubated in Petri dishes containing a moistened filter paper at 18°C.

III. RESULTS

Results from the growth trial are shown in Figure 1. The age of the compost had no significant effect ($p>0.05$) on *E. fetida* growth (standard error bars are not shown for reasons of clarity). Maturity was first achieved after a period of 4 weeks (fig. 2) by worms fed with compost of all ages. In addition, maturity of all animals in 3 of the treatments was recorded after 6 weeks (initial, week 1 and week 3 composts) (fig. 2). As with maturation, the first cocoons were collected after 4 weeks. Numbers produced in all treatments peaked at sampling week 6 and declined thereafter. A general decreasing trend in number of cocoons produced and age of compost was recorded (fig. 3). Cocoon hatching success was 75–80 percent regardless of compost age. On average 2.57 hatchlings emerged from each cocoon (week 6 data).

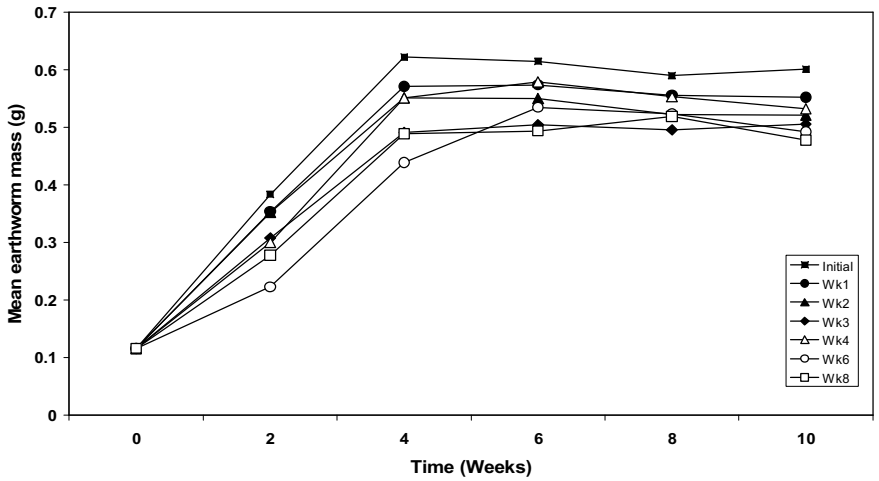

Fig. 1. Growth of *Eisenia fetida* related to duration of feed (green waste) composting
Rys. 1. Rozwój Eisenia fetida w zależności od czasu kompostowania odpadów zielonych

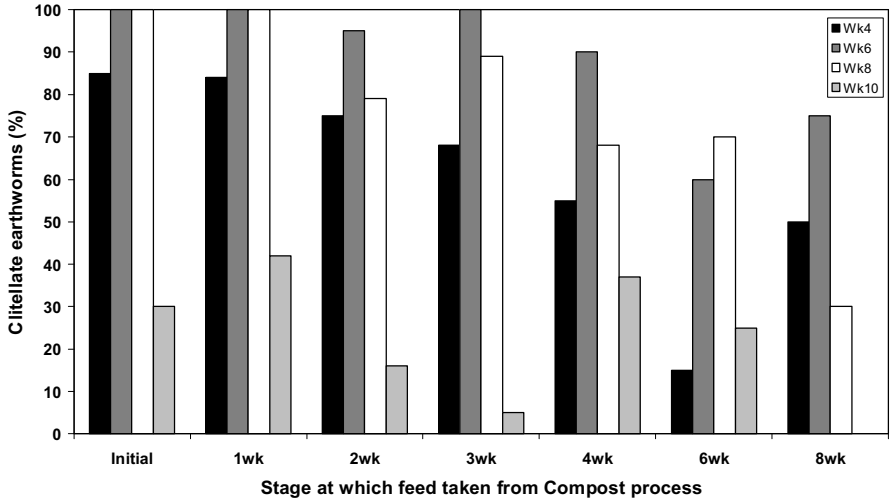

Fig. 2. Percentage of clitellate *Eisenia fetida* related to duration of feed composting
Rys.2. Udział procentowy osobników dojrzałych Eisenia fetida w zależności od czasu kompostowania odpadów zielonych

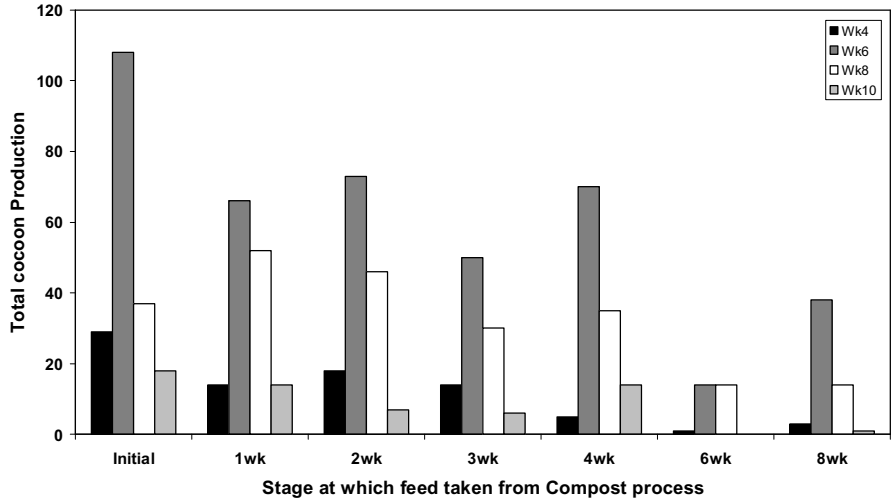

Fig. 3. *Eisenia fetida* cocoon production related to duration of feed composting
Rys. 3. Produkcja kokonów Eisenia fetida w zależności od długości kompostowania pokarmu (odpadów)

IV. DISCUSSION

Results suggest that the material produced from the composting of green waste will sustain the growth, maturation and reproduction of the earthworm *E. fetida*. The age of the compost does not appear to have a significant effect on growth of this species, which contrasts with the findings of Frederickson et al. [6]. These authors, using the closely related *E. andrei* found that increased age of compost led to a significantly decreased growth rate. Reproductive rate and rate of maturation were however, found to be restricted by compost age. This is most likely due to the action of micro-organisms, reducing the compost content of volatile solids over time.

If composted green waste is to be used as a feedstock for vermiculture, then the amount of composting that takes place is critical. To obtain maximum growth, rates and maximum reproductive output of worms the "pre-composting" phase needs to be kept to a minimum of e.g. 1 to 2 weeks. Nevertheless, this pre-treatment may be critical to allow the more rapid action of earthworms. This is an area that is worthy of further research.

ACKNOWLEDGEMENTS

LWS Lancashire Environmental Fund for funding the composting trial and Mr. Ian Stephenson for access to the windrow at CMLS.

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