Valorisation of by-products from agriculture and nature management: opportunities for potting media, composting or as soil improver

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Short abstract

Composting is a technique to reduce organic-biological waste resulting in a soil improver contributing to a fertile soil. Despite the numerous advantages, on-farm composting and compost application are sparse in Flemish agriculture because of technical, logistic and legal constraints. Also, there is a shortage in lignocellulosic material due to the high demand for bioenergy production. At the same time, the nature conservation management sector exports biomass to maintain its ecosystems. As such, there is a potential win-win situation by composting the biomass from the nature sector. In this project we investigate the applications for sod-cuttings and choppered material from heathland management as a feedstock for potting media and a soil improver, both directly and after on-farm composting. The applied conceptual model takes into account the end-user adoption from the initial phase of the research process by multi-stakeholder participation. The tested materials were stable, they could be used as feedstock in potting media and as a soil improver (directly, after composting or after sieving).

Introduction

Current production and processing methods in agricultural and fisheries industries result in the production of by-products which are not always used for valuable applications in an efficient way. Nevertheless, possibilities to use these streams are often manifold: anaerobic digestion, combustion, feed production, extraction of valuable components, etc. Also composting might be a valuable technique which has several advantages: e.g. reducing organic-biological waste, better recycling of nutrients and materials, increasing crop productivity, improving soil quality in a biological and physico-chemical way, increasing the organic matter (OM) content of the soil, preventing erosion or avoiding nutrient leaching to the groundwater [1].

Composting is a natural process in which microorganisms convert fresh organic matter into a stable and humus-rich product under controlled aerobic conditions [2,3]. Through composting one can reuse part of the biomass to create and maintain a fertile, healthy soil. The composting microorganisms acquire a proper balance between the carbon-rich (brown) materials and the nitrogen-rich (green) materials to grow and break down the organic waste. Most agricultural waste is wet and has a high N content, e.g. crop residues, manure, grass clippings, fresh weeds, vegetable and fruit wastes. Therefore they need to be mixed with carbon-rich, structural materials such as straw, wood chips and bark. Because bioenergy production is increasing and is expected to increase exponentially in the near future [4], there is a shortage in the supply of carbon-rich feedstock for composting. This is one reason why composting is not often applied on farms, but there are several other institutional stumbling-blocks. Composts may vary significantly in physic-chemical and biological properties due to diversity and availability of feedstock materials and the composting circumstances. Also many questions about the cost efficiency, logistic and institutional limitations still remain.

The general goal of the research is to valorize by-products from agriculture and horticulture by the development of qualitative, economically feasible compost products with an added value for agriculture in Flanders. An opportunity to create a win-win situation is the cooperation with the nature conservation management sector. Management of nature conservation areas creates structural, carbon-rich by-products which are often difficult to valorize without pretreatment, but have a high potential as brown feedstock for composting.

Materials and methods

Because the classic science-driven research approach often neglects the investigation of aspects linked to end-user adoption, a conceptual model is followed that takes into account the end-user adoption from the initial phase of the research process [5]. This model uses intense multi-stakeholder participation to assess present and future market demand and improves public acceptance. Stakeholders from the supply/demand side and the processing industry are interviewed to identify the variety of by-products, quantity, availability, geographic location, current use and possible applications. Also the stumbling-blocks (technological, economical, legislative or logistic) of applying compost and the sector-specific requirements of the compost are assessed. Moreover, policy-makers are involved in the stakeholder meetings. Besides stakeholder participation, preliminary analyses give more information about the chemical properties and the opportunities for application.

Results and discussion

Through individual stakeholder interviews we selected two streams from the nature sector that seem to have adequate properties as brown feedstock material in the composting process: sod-cuttings and choppered material. **Sod-cutting** is considered the most suitable means of recreating degenerated heaths; it is highly effective at reducing nutrient pools [6,7,8]. The complete above-ground biomass, the O-horizon and part of the A-horizon are removed by specially developed sod-cutting machines. This work is very cost-intensive and produces a large amount of waste material [8,9,10]. **Choppering** is a recent technique that removes the above-ground biomass and the largest part of the O-layer, without affecting the A-horizon [11], hence resulting in less waste material [9]. The result is a bare soil with a thin layer of about 0.5 cm of organic material remaining. Choppered material contains less mineral soil particles but more N than sod-cuttings due to higher N-contents in the organic layer than in the A-horizon [12]. Moreover, the machine used is smaller and faster. For these reasons, choppering is more economical than sod-cutting and it is expected that its use will increase.

Following the individual stakeholder consultations, a larger multi-stakeholder meeting was held with the nature management sector, research institutions, sales market and policy-makers for two purposes: (1) to identify the constraints of on-farm composting of sod-cuttings and choppered material, and (2) to determine the chemical requirements of the sod-cuttings and choppered material for different applications.

(1) Constraints for on-farm composting of sod-cuttings and choppered material

1. A first important (logistic) constraint is the quantity, availability (seasonal or continuous) and geographic location of the materials. Sod-cutting occurs every 15-25 years, while choppering has to take place more often (about every 5 years). Each year, part of the heathland is managed between July and February. In 2008 there were about 23000 m³ sod-cuttings in the nature management areas of the Agency of Nature and Forest Management in Flanders [13]. Heathlands are located in the Campine area (Antwerp, Limburg and the northern part of Flemish Brabant). It is also useful to assess the (value of the) current applications so as to evaluate new, enhanced application opportunities. Nowadays, the sod-cuttings are either re-used in the nature area (e.g. as material to construct ditches) or removed by contractors. The final destination of the latter is mostly unknown because of the lack of supervision.
2. In case of on-farm composting, a second constraint is the purchase of specialized equipment such as a turning machine, tools to follow-up the process (thermometer, CO_2-meter), pile covers, etc. An alternative is to hire or share a turning machine with other farmers or nature managers.
3. A third important consideration is the time and work investment. The time investment is strongly dependent on the intensity of the composting. An intensive and controlled composting process needs a strict follow-up, regular turning and/or irrigation. Nevertheless, composting can often be organized to fit in the usual business operations [14].
4. Composting in Flanders has to meet a set of regulations on Flemish, Federal and European level. An important legislative barrier for on-farm composting are the stringent requirements when using external inputs. Also sod-cuttings are not allowed to use as a soil improver because the considered instability.

(2) Requirements for different applications based on sod-cuttings and choppered material

From the stakeholder participation we derived three possible applications of sod-cuttings and choppered materials: as feedstock for potting media and as material to improve soil quality either by direct application on the soil or as feedstock for compost. The expected requirements for each application are listed in Figure 1. To better meet the physico-chemical requirements the raw material could potentially be treated by e.g. sieving, grinding, natural decay (this is the natural decomposition of the material if placed on a pile) and composting.

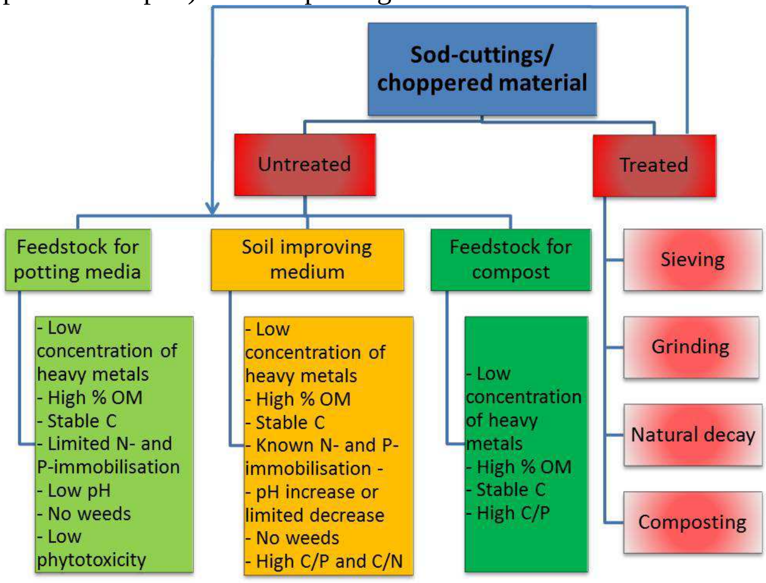

Figure 1. Application possibilities and their chemical requirements for sod-cutting and choppered material. OM = Organic Matter, C = Carbon, N = Nitrogen, P = phosphorus, pH = acidity degree

Eight samples of sod-cuttings and four samples of choppered material from different locations were tested for several parameters (Figure 1). pH-H_20 was between 4 and 6. Electrical conductivity was below 100 µS/cm (Table 1), which is in line with the norms for potting media and soil improvers.

The OM content was variable for the different samples, but in general the choppered material had a higher OM content (on dry-weight basis) than the sod-cuttings (Table 1). This is logical because choppering removes less soil particles. Half of the samples from the choppered material had an OM content above 50%, which is recommended for the mentioned applications. The other materials were sieved (5 mm), which caused an increase in the OM content in the fraction > 5 mm.

As mentioned above, the C:N ratio of the feedstock is very important. The C:N ratio was between 20 and 30 (Table 1) for all the tested materials, which indicates stability and a slow release or even immobilization of N. The carbon/phosphorus (C:P) ratio was very high (Table 1), which means that the materials have a low P content. This is a great advantage for application in agriculture. The tested materials did not exceed legal criteria for heavy metals (data not shown).

The materials were mixed with potting media and placed in a greenhouse (21°C) for three weeks to test for germination of potential weed seeds. Five of the eight choppered materials and three of the four sod-cuttings tested positive for weeds. This might be a problem for the application in potting media. However, because of the high temperatures, weed seeds are suppressed during composting [15,16]. Materials high in weed seeds should first be composted, but composting will result in other (and maybe less suited) chemical characteristics since other feedstock materials will be added in the process.

The materials with a high potential based on OM content were tested for immobilization of mineral N by adding 350 mg N/l followed by one week of incubation at 37°C. They all immobilized N (data not shown). Consequently, when those materials are directly applied to the soil in spring, crops will suffer a shortage of N. But when they are applied in autumn, the materials can capture N (e.g. from crop residues) and thus prevent leaching of N to the ground water. To compost these materials, other N-rich feedstock materials have to be added.

To evaluate the stability of the materials, the potential biodegradation was calculated after biochemical analysis of cell wall components: (hemicellulose + cellulose) / lignin. The values ranged between 1 and 2, which indicate stability. In comparison, different feedstock mixtures for composting had a value between 2.8 and 7.3 at the beginning of the composting process. Finished compost products had a value between 1.0 and 1.3 for stable composts and between 1.5 and 1.8 for less stable composts [17].

Table 1. Average and standard deviation of pH-H_2O, electrical conductivity (EC), percentage organic matter on dry-weight basis (OM/DM), C:P and C:N ratio for choppered material (n=4) and sod-cuttings (n=8)

	pH-H_2O	EC [µS/cm]	OM [%/DM]	C:P	C:N
Choppered material	5.0 ± 0.6	79.9 ± 41.9	45.8 ± 31.3	634.4 ± 245.7	31.2 ± 13.4
Sod-cuttings	4.7 ± 0.2	65.5 ± 30.2	18.6 ± 9.6	538.5 ± 152.2	22.4 ± 1.8

Conclusion and perspectives

In conclusion, the tested sod-cuttings and choppered material from heathland management in the Campine area in Flanders were stable materials: they had a low pH, low EC, high OM content, high C:N and C:P ratio, low concentration of heavy metals, low potential biodegration and they immobilized N. Therefore they could be used as feedstock in potting media (e.g. after composting to suppress weed seeds) and as soil improver (directly, after composting or sieving). Further research will be performed to test the on-farm composting of these materials (technical research) and the possibility to cooperate between the nature management and agricultural sector (socio-economical research).

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