AcademicPres

Available online at www.notulaebotanicae.ro

Print ISSN 0255-965X; Electronic ISSN 1842-4309

Not. Bot. Hort. Agrobot. Cluj 37 (2) 2009, 9-13

Notulae Botanicae Horti Agrobotanici Cluj-Napoca

Waste Recycling and Compost Benefits

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Abstract

Composting is commonly used to treat solid wastes prior to recycling or disposal. It reduces the amount of material to handle and has the potential to inactivate pathogens thermally. Using composts in agriculture to minimize organic wastes and to reduce the addition of fertilizers and fungicides in crop production is highly effective. The amendment compost may improve all physical properties. Bulk density, hydraulic conductivity, porosity, and, water retention capacity may be improved, and, the improvement is proportional to the compost rate. Increasing concern regarding food safety and environmental pollution, as well as legislative pressures in European countries to reduce the number of approved active pesticide ingredients, has generated an interest in compost and other biological control agents to prevent and control plant diseases. In that way there was reported that compost amendment may be advantageous by increasing the disease suppressive properties of the soil or of the potting mixture due to an increasing microbial activity and/or the presence of specific antagonists in compost.

Introduction

The European Landfill Directive (1999/31/EC) have a profound effect on how to collect and process biodegradable wastes. Article 5 of the Directive places strict limits on the amount of biodegradable municipal waste that can be disposed of to landfill in the future. Limiting amount of biodegradable waste going to landfill implies the diversion of this waste towards appropriate treatment options such as composting. Increasing legislation and higher environmental standards appear to have been responsible for encouraging the development of a new generation of composting facilities throughout Europe. Composting is an important element in sustainable waste management and could potentially have a vital role to play in meeting the obligations of the Landfill Directive (Slater and Frederickson, 2001).

Composting is an aerobic biological decomposition of organic solid substrates, with putrescible materials converted to a stabilised end-product, the compost, by microbial action. This process is in widespred use as a means of treating organic wastes including sewage sludge, animal and agricultural residues, and household refuse (Vallini *et al.*, 1984; Gasser, 1985). Through composting, organic matter undergoes partial mineralisation and, to a varying degree, transformation into humus-like substances (de Bertoldi *et al.*, 1983). Thus compost can be used directly in agriculture as an organic amendant to enhance soil tilth and fertility. According to a current trend in many other countries, composting is gaining particular consideration (Valdrighi *et al.*, 1996).

The application of organic wastes, and particularly composted municipal refuse and sewage sludge, could be a way of solving two problems, the waste disposal and the correction of the low organic matter content of any agricultural soils. Using waste in agriculture is an economical disposal of these materials, and it is interesting from an ecological point of view as it reduces negative effects on the environment (Aggelides and Londra, 2000). Efficient use of organic waste in agriculture requires an individual assessment waste products, and effects should be compared with natural variations due to climatic and soil type (Debosz *et al.*, 2002).

Compost has a high organic matter content. By incorporating compost into soil, Soil Organic Matter (SOM) is increased, making the soil healthier. The benefits of increasing SOM by adding compost are many and fall under four categories: biological, physical, chemical and environmental. With this paper some detail about waste recycling and compost benefits will be reviewed, such as: improvement of soil organic matter content and soil properties and antiphytopathogenic potential.

Improvement of soil organic matter content and soil properties

The modern concept of sustainability is based on the integration of three dimensions: the ecological dimension, the economic dimension and the socio-cultural dimension. The activities of our societies today must therefore be based on the goal that the ecological, economic and socio-cultural development of future generations has the same potential as today. For example, the consumption of natural resources by today's societies must not lead to deficiencies for future generations. In this context, besides the rate of consumption and the proposed availability of natural resources also demographic development and technical innovation potentials are important parameters for the adequate prognosis of a sustainable development (Hüttl and

Fussy, 2001). Current trends in European waste policy aim at reducing the deposition of biodegradable wastes in land-fill sites (Council Directive, 1999/31/EC). Only when residual organic materials cannot be used, they shall be disposed or utilized for energy production. In this context the recycling of these materials shall help to protect natural resources (Hüttl and Fussy, 2001).

Organic content is a key component of healthy soil and is critical to its properly functioning to support plant life naturally. Organic matter provides structure and a place for water, air, and biological life to exist in soil. A soil with insufficient organic matter may not hold adequately water or supply an environment for beneficial microbes. These soils become quickly dependent on high levels of watering and multiple fertilizer applications and pesticides to maintain the verdant appearance that our society expects.

Organic matter management means the application of residual organic matter such as compost or sewage sludge (biosolids) to improve soil properties or to accelerate pedogenesis. However, this soil treatment option must always aim at the improvement of at least one soil function (i.e. regulation function, transformation function, production function) and at the same time must not impair any of these soil functions (Hüttl and Fussy, 2001).

Compost has been proposed as a means of simultaneously diverting organic materials from landfills while producing a valuable product that improves tilth, organic matter content and nutrient supply of agricultural soils (Levy and Taylor, 2003). For these reasons, composting has been advocated as one component of sustainable agriculture (Arrougé *et al.*, 1999; Edwards *et al.*, 2000).

The continuous decomposition of organic matter in cultivated soils may lead to soil degradation with a consequence of inability to ensure a sustainable production (Aggelides and Londra, 2000). There is a very important link between soil properties and organic matter content. The alteration of the soil organic matter status should positively influence also a variety of other soil properties (Strauss, 2001) such as: soil aggregation or structure, infiltration and aeration, water holding capacity, humic substances content of soil (Pascual et al, 1999; Aggelides and Londra, 2000; Albiach *et al.*, 2001). Recycling of organic wastes within agriculture may help maintain soil fertility via effects on physical, chemical and biological properties (Debosz *et al.*, 2002). Compost application positively affects soil organic carbon (SOC), nitrogen supply and cause beneficial effects on soil humic substances (HS) properties (Weber *et al.*, 2007). Organic fertilizers can contribute to the improvement of the nutritional value of vegetable production (Pavla and Pokluda, 2008).

Kluge and Bolduan (2001) reported that several years experiments have shown that the so-called soil improving effects of compost application develop little by little. In contrast to the fertilization effect of the compost, which can be found with phosphorus, potassium and lime after few years, compost dosage change soil-physical and microbiological parameters only on a medium and long term scale. The bulk density of the soil usually decreases by supply of organic matter. Parameters of soil structure are influenced relatively efficient and also noticeably positive by regular compost dosage (Kluge and Bolduan, 2001).

Aggelides and Londra (2000) repported that the amendment compost improved all physical soil properties, and the improvement were proportional to the compost rate. Compost significantly reduced the bulk density of the soils ($P = 0.05$). The highest reduction was 19.7% and 16.7% for the 300 m^3 ha^{-1} compost addition rate in the amended loamy and clay soils, respectively (Tab. 1). The total porosity was improved by the use of compost (Tab. 1), the increase over soil alone being 11.0, 27.0 and 32.8% in the loamy soil, and 5.4, 8.5, and 9.9% ($P = 0.05$) in the clay soil, for the 75, 150 and 300 m^3 ha^{-1} rates. Also, there was a statistical-significant treatment effect ($P = 0.05$) upon the saturated hidraulic conductivities, *K*s, of the treated soils (Tab. 1). *K*s was increased by 32,5, 53,0 and 95,2% in the loamy soil and by 55,3, 97,4 and 168,4% in the clay soil for the rates 75, 150 and 300 m^3 ha^{-1}.

Tab. 1. Some physical properties of soils treated and untreated with the compost [a] (Aggelides *et al.*, 2000)

Soil mixtures [b]	Hydraulic conductivity ($m\ h^{-1}$)	Bulk density ($g\ cm^{-3}$)	Total porosity ($cm^3\ cm^{-3}$)
Loamy + c0	0.083	1.37	0.418
Loamy + c75	0.110	1.20	0.464
Loamy + c150	0.127	1.13	0.531
Loamy + c300	0.162	1.10	0.555
Clay + c0	0.038	1.12	0.585
Clay + c75	0.059	1.05	0.617
Clay + c150	0.075	0.98	0.635
Clay + c300	0.102	0.94	0.643

[a]The samples were taken in December 1995.
[b]c0, c75, c150, c300 represent compost addition rates of 0, 75, 150 and 300 m^3 ha^{-1}.

Strauss (2001), after a rainfall simulation, reported that the total soil losses of the treatment with compost application reduced to about 1/3 compared to the control treatment without compost.

The positive effects of compost on the water regime of soil are remarkable. The improved water binding contributes to a prevention of reduction of crop yield loss on dryness, particularly on light sandy soils (Kluge and Bolduan, 2001).

The addition of compost increase the water retention capacity of the soils. The experimentally determined soil water retention curves under different compost treatments of the loamy and clay soils were reported by Aggelides *et al.* (2000) (Figs. 1 and 2).

The addition of compost increased the water retention capacity of the soils in all treatments as any particular soil

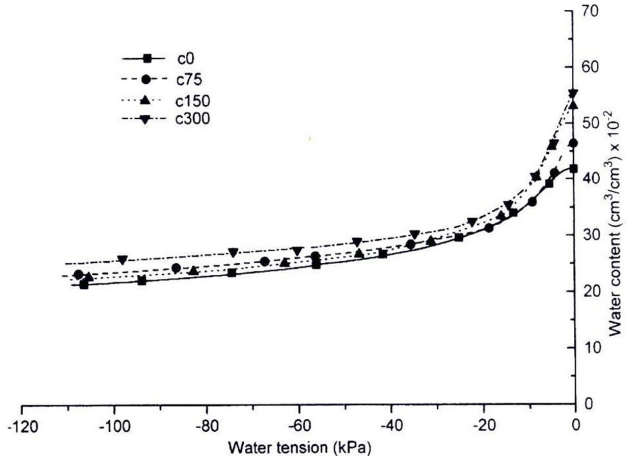

Fig. 1. Soil ware retention curves under the different treatments of loamy soil. Curves c0, c75, c150 and c300 correspond to the loamy soil amended with compost at rates of 0, 75, 150 and 300 m^3 ha^{-1} (Aggelides *et al.*, 2000).

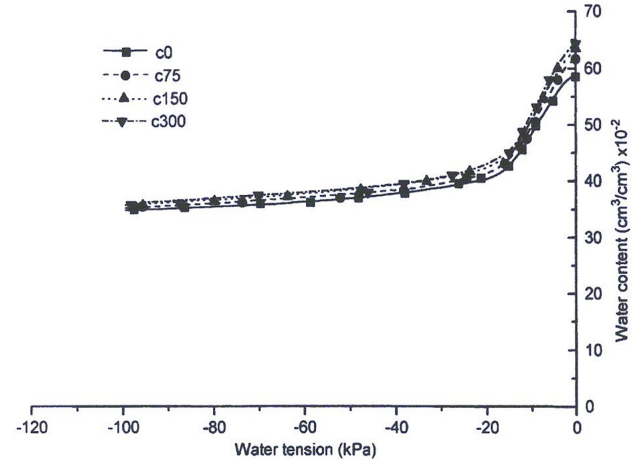

Fig. 2. Soil ware retention curves under the different treatments of clay soil. Curves c0, c75, c150 and c300 correspond to the clay soil amended with compost at rates of 0, 75, 150 and 300m^3 ha^{-1} (Aggelides *et al.*, 2000).

water content corresponded to a higher negative soil water tension. The retention capacity was higher in the soils amended with high compost rates than those in soils receiving low rates, except in the case of the curve belonging to the loamy soil amended with 75 m^3 ha^{-1} compost (Fig. 1). This curve, for the water contents between 0.365 and 0.305, overlapped the retention curve of the control treatment and for the water content lower than 0.280 overlapped the retention curve of the soil amended at the rate of 150 m^3 ha^{-1}. Perhaps, this was due to experimental error. The standard error of the data was 0.44, 3.13. For the clay soil the differences between the treatments were not statistically significant (P=0.05). The standard error of the data was 0.19, 1.28 (Aggelides *et al.*, 2000).

Compost application have a promoting effect on soil life and particularly soil microbiology. Along with the content of organic matter of soil the microbiological biomass in soil usually increases (Kluge and Bolduan, 2001). Guerrero *et al.* (2000) found increased bacteria and fungal populations and improved stability of soil aggregates when municipal solid waste compost was applied to brunt forest soils.

Antiphytopathogenic potential

Soil suppresiveness to diseases induced by soil-borne plant pathogens is the ability of a soil to reduce disease severity, even in the presence of a high inoculum density (Alabouvette, 1986). Soil suppresiveness may be induced by abiotic or biotic soil properties (Höper, 1995). Soils and potting media may have natural ability to reduce the incidence of plant diseases. This quality of such substrates is referred to disease suppression and may be achieved by either limiting growth or saprophytic survival of pathogen, expression of the disease, or both. Suppression is based mainly on interactions between the pathogen and some populations of the saprophytic microflora. Such interactions are influenced by the abiotic characteristics of the soil (Alabouvette, 1999). Microbial communities contribute to the suppression through all four principal mechanisms of biological control: competition, antibiosis, parasitism/predation and induced systemic resistance (Hoitink and Boehm, 1999).

The use of compost in the control of plant pathogens was already known and practiced in the early stages of agriculture, especially in China (Cook and Baker, 1983). The study of the mode of action of compost, especilly against soil-borne plant pathogens started only after 1945. Nevertheless, during the 1960s and 1970s increased intensification and specialization in agriculture were accompanied by a sharp decline in the research on compost. Only recently (after discovering the suppressiveness of certain bark compost against soil-borne plant pathogenic fungi), has grown the interest in putting these plant-protecting properties of composts into ation (Hoitink and Fahy, 1986).

Using composts in agriculture to minimize organic wastes and to reduce the addition of fertilizers and fungicides in crop production is highly effective (Trials *et al.*, 2006). Several studies reveal that composts can suppress plant diseases (e.g., Schueler *et al.*, 1989; Cronin *et al.*, 1996; Serra-Wittling *et al.*, 1996; Cotxarrera *et al.*, 2002, Pérez-Piqueres *et al.*, 2006). In the majority of these studies, suppressiveness of one type of compost has, however, been tested against a single or a few pathogens only, while in reality a host plant may face infection by multiple pathogens. Furthermore, compost is known as a product that varies considerably in chemical, physical and biotic composition, and, consequently, also in ability to supress soil-borne diseases (Termorshuizen *et al.*, 2006). Different plant pathogens were subject of the compost suppressiveness properties study (Tab. 2.).

A study to test a wide array of compost (18 compost made from different kinds of material combinations: gre-

Tab. 2. Pathogens reported to be sensitive to compost suppressiveness capacity

Pathogens	References
Pythium ultimum/beetroot and beans	Schueler *et al.*, 1989;
Rhizoctonia solani/peas	Schueler *et al.*, 1989;
Rhizoctonia solani/cucumber	Trillas *et al.*, 2006;
Rhizoctonia solani	Pérez-Piqueres *et al.*, 2006
Venturia inaequalis/apple	Cronin *et al.*, 1996
Fusarium oxysporum f. sp. *Lini*	Serra-Wittling *et al.*, 1996; Termorshuizen *et al.*, 2006;
Fusarium oxysporum f. sp. *Lycopersici*	Cotxarrera *et al.*, 2002
Verticillium dahliae/eggplant	Termorshuizen *et al.*, 2006; Gaag, van der *et al.*, 2007;
Rhizoctonia solani/cauliflower	Termorshuizen *et al.*, 2006;
Rhizoctonia solani/pine	Termorshuizen *et al.*, 2006;
Phytophtora nicotianae/tomato	Termorshuizen *et al.*, 2006; van der Gaag *et al.*, 2007;
Phytophtora cinnamomi/lupin	Termorshuizen *et al.*, 2006; van der Gaag *et al.*, 2007;
Cylindrocladium spathiphylli/spathiphyllum	Termorshuizen *et al.*, 2006;
Fusarium oxysporum/flax	

en waste, domestic biowaste, manure) was carried out by Termorshuizen *et al.* (2006). The objective was to select the characteristics which may be used to predict suppressiveness against one or mode diseases. In total, 120 bioassays were performed (6 pathosystems with 18 composts and 1 pathosystems – *Phytophthora nicotianae* on tomato – with 12 composts). Significant disease suppression was found in 65 (54%) cases and significant aggravation in 4 (3.3%) cases (Fisher's Protected LSD, $P<0.05$). The highest and most consistent disease suppression was found for *P. nicotianae* (compost/peat) and for *Fusarium oxysporum* (compost/soil) with medians of 71% and 64%, respectively. Significant disease suppression of *P. cinnamomi* and *Rhizoctonia solani*/pine was relatively infrequent, with median suppression of 6.5% and 4.7%, respectively. At least three composts induced a disease suppression >50% and one compost >70% for each pathosystem. Composts differed in their ability to suppress disease for different pathosystems. So, disease suppression can better be predicted based on compost mixes than on pure composts and should be focused on specific pathogens, given the variation in disease suppression between pathosystems (Termorshuizen *et al.*, 2006).

Schueler *et al.* (1989) reported the suppressiveness of biogenic waste compost (BWC), originating from separately collected organic household wastes, towards *Pythium ultimum*, compared with that of compost originating from bark and cattle manure. Water extracts of two sources of slurries of spent mushroom substrate (SMS) inhibited *in vitro* germination of conidia of the apple scab pathogen *Venturia inaequalis* by up to 98% relative to germination in water control. The microbial activity played a major role in the inhibition (Cronin *et al.*, 1996).

In summary, composting is an important element in sustainable waste management. Compost amendments maintain and enhance the fertility and productivity of agricultural soils, allowing a sustainable land use. Effective use of organic wastes for agricultural production requires that risks and benefits to be documented. Efficient use, however, requires an individual assessment of waste products, and effects should be compared with natural variation due to climate and soil type.

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