Scientific Papers. Series B, Horticulture. Vol. LXII, 2018
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

POSSIBILITIES FOR SMALL-SCALE COMPOSTING OF HORTICULTURAL PLANT WASTES

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Abstract

The aim of the study was to investigate the possibilities for composting in a small suburban farm, where also vineyards, orchards and vegetable crops are grown. The experiment was carried out in the period 2016-2017 in the experimental field on University of Forestry - Sofia. In the spring of 2016 were selected plant wastes from viticulture and horticulture and were built two compost piles – one only with plant residues (grape vine canes, fruit twigs and grass windrow) and one with rabbit manure,(grape vine canes, fruit twigs and grass windrow+ rabbit manure). In the autumn of 2016 was built a compost pile only with plant residues from vegetable field (frostbitten tomato and pepper stems and fresh leek residues). During composting period it was monitored the temperature regime in the compost piles. They achieved high temperature (60 and above 60 °C). The active phase of composting, in the three compost piles lasted for about a month. At the beginning and after the 6 months period were measured pH and C/N ratio in the compost piles and changes were established. After the 6 months period the C/N ratio was below 20/1, which is an indicator of mature compost. The pH in the spring piles dropped to 7.5-7.6 while the autumn pile remained alkaline - 8.4.

Key words: *composting, grape vine canes, fruit twigs, rabbit manure, vegetable residues.*

INTRODUCTION

Composting is a natural process of decomposition of organic waste using microorganisms and under strictly controlled conditions, at the end of the process to give a stable humus-like organic product called compost. (Misra R.V. et al., 2003).

Organic waste from agriculture - from pruning, harvesting, manure, etc. can be transformed into material that is used to improve soil structure and provide nutrients. (Misra R.V. et al., 2003; Román P. et al., 2015)

Most of these materials can easily be harvested on each farm. In the presence of animals, it is well that plant waste materials to be composted are not those used as fodder (Inckel M. et al., 2005; Schuchardt F., 2005).

When testing various combinations of plant residues from tomatoes, cucumbers, eggplants and pepper (composted alone or with olive tree branches and vine rods), it has been found that the compost piles made by mixing vegetable crops with twigs or grapes rods have developed high temperatures and the composting process has been beneficial (Maniadakis K. et al., 2004).

In aerobic composting, one of the most used methods is the ordering layers by layers of the various materials for the construction of the compost piles, alternating layers of carbon and layers of nitrogen material, the different authors indicating a different thickness of the layers. (Misra R.V. et al., 2003; Inckel M. et al., 2005).

Aerobic composting is a dynamic process. Several main factors are favoring composting processes: temperature, pH, oxygen level and C/N ratios.

These factors are a key point in building sustainable practices for organic waste management (Maheshwari D.K. et al., 2014).

Studies on the carbon, nitrogen, pH content are key to tracking composting processes (López-González et al., 2013).

When testing a different initial ratio C/N of 20/1, 30/1 and 40/1, compost with an initial C/N ratio of 30/1 has developed the highest maximum temperature (63.5°C) (Azim K. et al., 2014).

To determine if the compost is mature, ie. whether it is ready for use, different methods are available. Changes in temperature, pH, C/N ratio, microorganisms are observed. The C/N ratio gradually decreases and when it reaches less than 20, the temperature also decreases (Karadag D. et al., 2013).

Many authors point out that the C/N ratio can be taken as an indicator of maturation of compost (Goyal S. et al., 2005). Other authors have the opposite view because of the variety of materials that can be composted - with their structure and accessibility.

Others point out that the ratio is not important, but rather how much it decreases during the composting process. Ratio C/N=12 is indicated for the ideal but also a C/N=15-20 ratio is also acceptable (Estévez-Schvarz et al., 2012).

The aim of the study was to investigate the possibilities for composting in a small suburban farm, where also vineyards, orchards and vegetable crops are grown.

MATERIALS AND METHODS

The experiment was carried out in the period 2016-2017 in the experimental field on University of Forestry - Sofia.

In the spring of 2016 were selected plant wastes from viticulture and horticulture and rabbit manure. In the autumn of 2016 were selected plant residues from vegetable field.

Three compost piles were built from the crushed plant materials - two in the spring and one in the autumn:

- V1 - a combination of grape vine canes, fruit twigs and grass windrow;
- V2 - a combination of grape vine canes, fruit twigs and grass windrow + rabbit manure;
- V3 - a combination of frostbitten tomato and pepper stems and fresh leek residues.

It was made a pre-preparation of the starting materials - they were shredded into smaller part by garden shredder. Shredded material contained finely divided particles and larger ones. Larger parts were also inserted into the compost piles to aid natural aeration inside the pile.

To individual compost piles were incorporated starters - materials, making it easier to start the microbiological processes in the compost piles (large waste from last year's compost of plant waste and a thin layer of soil).

The first compost uses a combination of brown materials in a ratio of 2.4/1 (grape vine canes/fruit twigs). To them was added a grass windrow as a green material. The weight ratio of brown/green materials was 1.6/1 (brown/green).

The second one also uses a combination of the above-mentioned brown materials at a ratio of 2.2/1 (grape vine canes/fruit twigs). A combination of green materials was added to them - a grass windrow and a rabbit manure in a ratio of 1.1/1. The total weight ratio between brown and green materials is 1.8/1.

The compost bundle in autumn is dominated by green materials in order to develop a higher temperature in the compost bundle under conditions of low air temperatures.

During composting period it was monitored the temperature regime in the compost piles. With compost thermometers in the middle of the compost pile. The temperature was measured at noon hours.

Laboratory analyzes of the content of C, N, K, P, Mg, in starting materialsand in mature compost to track changes in compost and to establish its quality.

Calculate the ratio of C/N in the starting materials and in mature compost.

The data have been statistically processed and interpreted.

RESULTS AND DISCUSSIONS

The selection of waste materials is based on two criteria: to be available in sufficient quantity and not to be used in animal husbandry (such as bedding or fodder). Manure samples were taken for analysis from all groups of animals that are kept.

The total weight of materials used to build the first compost pile was 59,500 kg and for the second compost pile was 56,050 kg.

The total weight of the materials used to build the third compost pile was 218 kg.

Together with the preparation of the composting materials were taken samples to analyze the content of chemical elements. (Tables 1 and 2).

Table 1. Available plant waste and their chemical characteristics

Type of material	Season	Chemical elements				
		C %	N %	P mg/kg	K mg/kg	Mg mg/kg
Grape vine canes	Sping	26.56	0.753	1.02	4631	1176
Fruit twigs	Sping	25.09	0.670	0.89	2856	725
Corn leaves	Autumn	26.93	0.973	52.92	5619	1057
*Grass windrow	Sping/ Autumn	26.01	3.355	3.62	30622	2807
Tomato stems frostbitten	Autumn	24.11	2.225	301.28	3671	5150
Pepper stems frostbitten	Autumn	25.15	2.454	127.60	5796	7322
Fresh leek residues	Autumn	18.46	1.737	138.43	27490	3201

* Note: grass windrow can be used for composting and for fodder.

The C/N ratio was highest in the waste material from fruit (37.45) and grape vine canes (35.27), as they are carbon materials and the grass windrow had the lowest ratio (7.75), since it was high in total nitrogen. The remaining three macroelements were also the highest in grass windrow (P 3.62 mg/kg; K 30622 mg/kg; Mg 2807 mg/kg).

The rabbit manure had the highest nitrogen content (3.92%) compared to other manure, and the other chemical elements in it were also high in content.

Horse manure was low in nitrogen (1%) and respectively low C/N ratio (44.50%), probably due to the rough feed fed to the horses.

Table 2. Available animal waste and their chemical characteristics

Type of material	Season	pH (H_2O)	Chemical elements			
			C %	N %	P mg/kg	K mg/kg
Horse manure	All year round	7.55	44.50	1.00	0.68	1.45
Cattle manure	All year round	7.45	35.56	2.08	0.88	0.65
Pig manure	All year round	8.02	37.24	3.38	2.31	1.17
Mixed manure (sheep and goat)	All year round	7.30	37.78	2.70	2.77	4.26
Rabbit manure	All year round	8.05	40.46	3.92	2.56	3.24

Meteorological conditions during composting period were characterized by precipitation during the first and second ten days of June (06-08 and 13-15.06.2016), with the sum of precipitation being 49.4 and 23.1 l/m^2 respectively. Rainfall was also reported in July, but they were not heavy (Figure 1).

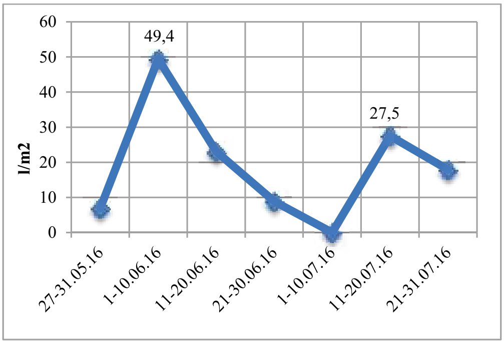

Figure 1. Amount of rainfall in l/m^2 at ten-day periods

Wet periods also led to a decrease in the average daily temperature at the end of May and in the first ten days of June (Figure 2). The precipitations recorded in the second ten days did not lead to a decrease in the air temperature (Figure 2).

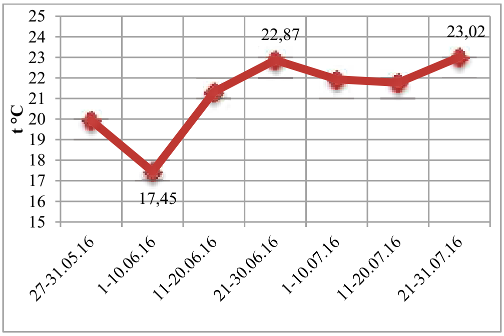

Figure 2. Average daily temperature at ten days periods

Weather conditions affected the temperature of the compost piles. The temperature graph of the spring compost piles shows several peaks, which outlined the turning of the compost from an initial mesophilic to a thermophilic and then again into the mesophilic phase (Figure 3).

Composte pile V1 continuously passes from thermophilic to mesophilic phase after about 25 days, and after 27 days the temperature steadily dropped below 30°C.

The thermophilic phase in compost V2 passes after about 21 days, and after 24 days it dropped permanently below 30°C.

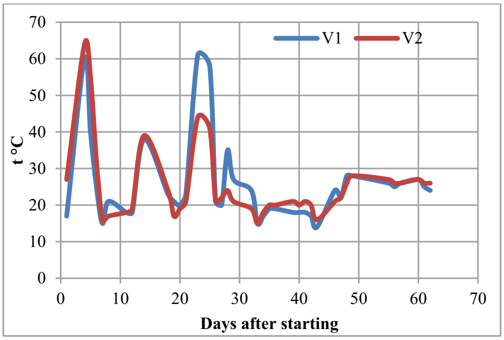

Figure 3. Dynamics of temperature in compost piles

The fall compost was built in the second half of November. The weather conditions were appropriate - sunny weather without precipitation and positive temperatures. During the first ten days of December, the air temperature dropped several times below zero, creating a risk of cooling the compost (Figure 4)

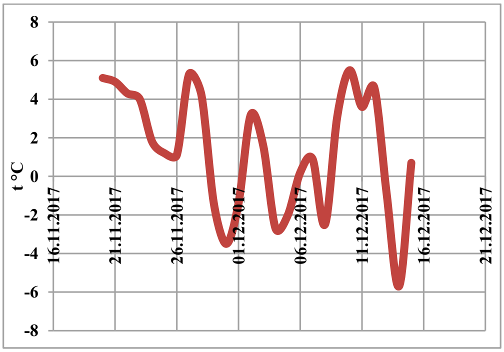

Figure 4. Average daily air temperature for the period 20.11.-15.12.2017

The temperature graph of the autumn compost pile showed that the compost was self-heating well and reached a high temperature of 61°C.
The temperature curve clearly indicates that the compost passed through the mesophilic and thermophilic phases (Figure 5).
With the fall of the compost temperature near 10°C, which coincided with the negative temperatures during the first ten days of December, there was a danger of a permanent cooling of the compost bundle. But the followed favorable daytime temperatures, along with the large mass of plant mass, helped to pass through (Figure 5).

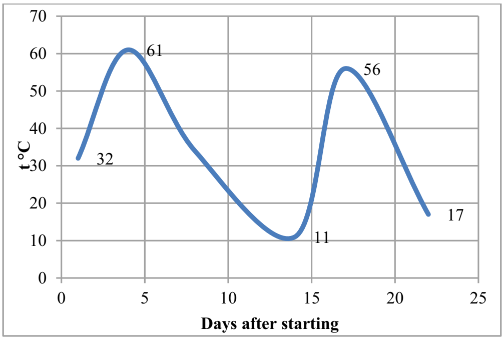

Figure 5. Changing the temperature in compost pile V3, bild in autumn

The last ten days of December, along with the fall of the snow, the temperature of the compost has dropped permanently and the temperature measuring has been stopped (Figure 5).

Table 3. Chemical composition of mature compost

Variants	pH (H_2O)	Chemical elements				
		C (%)	N (%)	P mg/kg	K mg/kg	Mg mg/kg
V1	7.6	16.33	1,028	2311	4970	2451
V2	7.5	12.65	1,005	2636	4434	2518
V3	8.3	4.86	1,070	2029	3592	2301

At the end of May 2017, were taken samples from the three compost piles for chemical analysis and tracking of composting processes (Table 3).
The highest level of pH is compost V3. The content of phosphorus, potassium and magnesium had lower values than the other two composts. Compost V1 had the highest C and K content, while compost V2 had the highest P content, which may be due to the presence of rabbit fertilizer in the compost. In the calculations of the ratio C/N at the beginning and end of the composting were found differences in the ratio C/Nin the three compost piles.
There is a decrease in the C/N ratio, and for spring compost pilesV1 and V2, this ratio has changed in the range of 11-13:1, while in autumn compost (V3) which at the beginning of the composting process is low , at the end of composting is reduced to about 4.5:1.
At this compost, all the basic materials showed low C/N ratios, where brown materials were virtually absent (Figure 6)

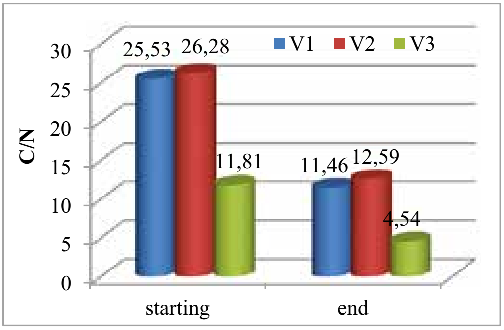

Figure 6. The C/N ratio of the compost piles at the beginning of the composting process and in the mature compost

A ratio of less than 20:1 at the end of composting is considered to be an indicator of mature compost (Hartz T.K. et al., 1996).

The obtained amounts of the three compost cups are as follows:

From V1 (compost 1) 17 kg of compost was sieved, from V2 (compost 2) 19.5 kg of compost was sieved and from V3 (compost 3) 72.5 kg of compost was sieved.

Visually, at the first two composts, there was more waste from vine branches and fruit rods, although the composting process was one year, while the third compost produced better composting of vegetable waste for only 6 months.

CONCLUSIONS

Small urban farms have the possibility of small-scale composting of plant and animal waste. The starting of the compost piles can be done seasonally and year-round, with sufficient waste materials.

In the spring, brown waste is in sufficient quantity, while the green is in short supply, especially if it is also used for fodder. In the presence of animals, then manure can also be used for green material. Rabbit manure is a good alternative to livestock manure.

In autumn, when cleaning the areas, there is a sufficient amount of plant waste that can be composted. In non-animal farming, there is no shortage of planting waste for autumn composting when we have a favorable mix of vegetable and food crops.

ACKNOWLEDGEMENTS

This research work was funded by Project № 14/19.01.2016: „Comparative study of different types of compost for composting phases, compost quality and application methods", to the Research Sector of the University of Forestry. The financial support for participation in the conference is under Project BG05M2OP001-2.009-0034 „Support for the Development of Scientific Capacity at the University of Forestry", funded by the Operational Program „Science and Education for Smart Growth" (2014-2020).

REFERENCES

Azim K., Ouyahia K., Amellouk A., Perissol C., Thami Alami I., Soudi B., 2014. Dynamic composting optimization through C/N ratio variation as a start-up parameter, Proceedings of the 4th ISOFAR Scientific Conference. 'Building Organic Bridges', at the Organic World Congress 2014, 13-15 Oct., Istanbul, Turkey.

Estévez-Schvarz I., Seoane-Labandeira S., Núñez-Delgado A., López-Mosquera M E., 2012. Production and Characterization of Compost Made from Garden and Other Waste. Pol. J. Environ. Stud. Vol. 21, No 4, 855-864.

Goyal S., Dhull S.K., Kapoor K.K., 2005. Chemical and biological changes during composting of different organic wastes and assessment of compost maturity. Bioresource technology, 96 (14), 1584-1591.

Hartz T.K., Costa F.J., Schrader W.L., 1996. Suitability of Composted Green Wastefor Horticultural Uses. Hortscience 31 (6): 961-964.

Inckel M.P., de Smet T., Tersmette Veldkamp T., 2005. The preparation and use of compost. Agrodok 8, Agromisa Foundation, Wageningen.

Karadag D., Özkaya B., Ölmez E., Nissilä M.E., Çakmakçı M., Yıldız Ş., Puhakka J.A., 2013. Profiling of bacterial community in a full-scale aerobic composting plant. International Biodeterioration & Biodegradation Vol. 77, 85-90.

López-González, Juan A., López M.J., Vargas-García M.C., Suárez-Estrella F., Jurado M., Moreno J., 2013.Tracking organic matter and microbiota dynamics during the stages of lignocellulosic waste composting. Bioresource Technology, Volume 146, Pages 574-584.

Maheshwari D.K., Dheeman S., Agarwal M., 2014. Decomposition of Organic Materials into High Value Compost for Sustainable Crop Productivity. Composting for Sustainable Agriculture. Sustainable Development and Biodiversity, Volume 3, 245-267.

Maniadakis K., Lasaridi K., Manios Y., Kyriacou M., Manios T., 2004. Integrated Waste Management through Producers and Consumers Education: Composting of Vegetable Crop Residues for Reuse in

Cultivation Journal of environmental science and health, Part B-Pesticides, Food Contaminants, and Agricultural Wastes, Vol. B 39, No. 1, 169-183.
Misra R.V., Royand Hiraoka R.N., 2003. On-Farm Composting Methods. Food and agriculture organization of the united nations Rome, land and water discussion paper 2 http://www.fao.org/docrep/007/y5104e/y5104e05.htm
Román P., Martínez M.M., Pantoja A., 2015. Farmer´s Compost Handbook Experiences in Latin America Authors Food and Agriculture Organization of the United Nations Regional Office for Latin America and the Caribbean Santiago.
Schuchardt F., 2005. Composting of Organic Waste. Environmental Biotechnology. Concepts and Applications, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 333-354.