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THE SOIL STRUCTURE CHANGES UNDER VARYING COMPOST DOSAGE

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The influence of different application of grape marc compost on the soil structure and the water stability of soil aggregate were studied in the course of four-year experiment. The trial was carried out in a Velké Bílovice vineyard in the Czech Republic. The altitude of the locality is about 200 m above sea level, the long-term average annual precipitation is 550 mm, the long-term average annual temperature is 9.5°C. The soil is Haplic Chernozem, loamy textured. Three variants were established: Variant 1 – control, no compost, Variant 2–30 t of compost per ha, Variant 3–60 t of compost per ha. The compost from pomace, poultry droppings, mown grass and straw was made in an EWA aerobic fermentor in an intensive and controlled process in an enclosed space and shallow ploughed (0–0.15 m) into the soil every year after harvest. The results of the experiment were statistically processed by multifactorial analysis of variance and then by Tukey's test of simple contrasts. The highest values of structural coefficient and water stability of soil aggregate were found in the variant with the highest dosage of compost. It was found that the application of grape pomace compost to the soil had a positive effect both on the soil structure and the water stability of soil aggregates.

Key words: vineyard, compost, water stability of soil aggregates, structure

Composting is a traditional method of utilizing organic waste. Various materials must be composted to obtain well-balanced properties in the final product – compost (suitable chemical and physical properties, supressed phytopathogens, a suitable level of humification etc.) (Moral *et al.* 2009). Use of organic soil supplements is a traditional agricultural practice for improving physical and chemical soil properties, soil structure, temperature and moisture conditions as well as nutrient content, which are beneficial to plant growth (Renčo 2013). Šimanský and Tobiašová (2013) confirmed that NPK fertilisers had a negative effect on soil organic matter stability. Intensity of fertilisation affected the changes in quantity and quality of soil organic matter; therefore it is very important to pay attention to the quantity and quality of organic matter in productive vineyards.

Soil structure is an important feature of agrosystem sustainability because of its involvement in many biological and physical soil processes. Good structure favours gas and water transfer in soils, germination, and crop rooting, while reducing susceptibility to erosion. Organic matter controls aggregate stability in loam soils. Intensive farming can lead to a decrease in soil organic matter content. In areas where livestock has disappeared, the recycling of composted urban organic waste on agricultural soils may represent a valuable source of organic matter for restoring soil organic matter content. Both immature and mature compost increased aggregate stability via different mechanisms (Annabi *et al.* 2007).

Organic material is a significant factor influencing aggregate stability as the quantity and characteristics can be influenced by farming methods. In many agricultural systems fresh organic matter is

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Figure 1. Map of the Czech Republic – sampling site

periodically returned to the soil in the form of crop residue. However, the quality of this organic matter input varies (Abiven 2009). Also according to Šoltysová and Danilovič (2011) the content of organic matter in the soil is significantly affected by soil tillage.

Brown and Cotton (2011) evaluated the advantages of applying compost to farmed land. They found that, after application of compost, the content of soil organic carbon increased three-fold and microbial activity in the soil doubled.

Annabi *et al.* (2011) compared the effectiveness of repeated application of municipal compost and manure on silty loam soil which had a low stability of soil aggregate. It was found that, in the majority of cases, the application of municipal organic waste had a more positive effect on aggregate stability than the application of manure. The authors state that such compost can be used to increase the soil´s resistance to water erosion.

According to Duog *et al.* (2012), the effect of applying compost varies according to both the type of soil and the type of compost used (production materials, maturity).

The aim of this paper was to evaluate influence of different compost doses on the soil structure and water stability of soil aggregates.

MATERIAL AND METHODS

The trial was carried out during 2012–2015 in South Moravian locations within the maize-growing production area and the Velké Bílovice vineyards – Úlehle locality (Figure 1). The altitude of the locality is about 200 m above sea level, the long-term average annual precipitations is 550 mm, the long-term average annual temperature is 9.5°C, climatic region is very warm and dry. The soil is Haplic Chernozem, loamy textured. The plot is situated on flatland.

The soil characteristics – average values of available nutrients: total nitrogen 0.14%, phosphorus 110 mg/kg, potassium 403 mg/kg in dry matter; dry matter %; organic carbon 0.92%; humic to fulvic acids ratio (HA/FA) 0.55; pH_{KCl} 7.5. In agreement with bulk density (1.30 g/cm^3) the soil isn´t compacted, porosity (51%) and air content (26% vol.) are high.

The following variants in form of inter-row were set for the experiment:

Variant 1 – control, no compost,
Variant 2–30 t of compost/ha,
Variant 3–60 t of compost/ha.

The compost from pomace, poultry droppings, mown grass and straw was made in an EWA aerobic fermentor in an intensive and controlled process in an enclosed space. The fermentation process took 14 days, followed by a maturing process on an open compost heap for 40 days. The compost characteristics – average values of total nutrients: nitrogen 1.95%, phosphorus 4.75 g/kg, potassium 16.52 g/kg in dry matter; dry matter 33.28%; carbon to nitrogen ratio (C/N) 20; pH 8.35.

The compost was evenly applied and shallow ploughed (0–0.15 m) into the soil after harvest.

Soil samples were taken in spring (at the beginning of the growing season) and in autumn (at the end of the growing season). In all cases, soil samples were taken at two depths, i. e. 0–0.15 m and 0.15–0.30 m in three replications.

Values of water stability of soil aggregates (WSA) were estimated using the wet sieve analysis method (Kandeler 1996). WSA is expressed as the percentage of water stable aggregates in the total amount of aggregates after subtracting the proportion of sand. Soil samples were taken in three repetitions.

The soil structure and its properties in the experimental locality were determined by sieving of dry soil (Javorský *et al.* 1987). Samples on sieves with the average mesh size of 0.25; 0.5; 2.5; 10 and 20 mm. Each structural fraction was weighed separately and converted to a percent value. For the evaluation itself, structure coefficient (SC) was calculated, which expressed the relationship between agronomically valuable (0.25–10 mm) and less valuable structural elements (>10 and <0.25 mm) (Procházková *et al.* 2004). Soil samples were taken in three repetitions.

The results of the experiment were statistically processed using multi-factor analysis of variance and Tukey's test of simple contrasts. The statistical analysis was performed using the Statistica 12 program.

RESULTS AND DISCUSSION

Soil structure is one of the most important soil properties and depends on the ability of soil particles to aggregate or disaggregate and create structural aggregates.

For the actual evaluation of soil structure, the SC was calculated. SC value less than 1 indicates poor soil structure. The bigger the coefficient, the better the soil structure (Hraško *et al.* 1962). According to the results obtained (Figure 2), there was an increase in SC in the variant where compost was applied, in comparison with the control variant without compost. The highest SC values were found in the variants with a higher dosage of compost (var. 3). Compared with the control variant, this increase was statistically confirmed. (Table 1, 2). SC exceeded a

T a b l e 1

Analysis of variance in SC (years 2012–2015)

Effect	d.f.	Mean square
Year	3	0.20^{+}
Variant	2	0.32^{++}
Year × depth	3	0.14^{+}
Error	6	0.03

$^{+}P = 0.05$; $^{++}P = 0.01$

T a b l e 2

Tukey´s HSD test of SC

Variant	Average
1	0.71^{a}
2	0.91^{ab}
3	1.10

Note: average values indicated by various letters are statistically different ($P < 0.05$)

T a b l e 3

Analysis of variance of WSA (years 2013–2015)

Effect	d.f.	Mean square
Year	2	540.72^{+++}
Variant	2	225.65^{+++}
Year × depth	2	150.80^{+++}
Error	40	13.17

$^{+++}P = 0.001$

T a b l e 4

Tukey´s HSD test of WSA

Variant	Average
1	22.93^{b}
2	27.11^{a}
3	29.97^{a}

Note: average values indicated by various letters are statistically different ($P < 0.05$)

value of 1, indicating an improvement from poor soil structure to good.

According to Cercioglu (2017) manure and compost application increased porosity, structure stability index, field capacity, wilting point, and water availability while reducing bulk density and particle density of soil in comparison with the control. These organic inputs also had a positive effect on grain yield. Baiano and Morra (2017) consider that biowaste compost could be effective in improving soil structure and long-term C sequestration.

Soil structure, which shows a varying resistance to disintegration in water (also called WSA), may be used in studies of soil condition. WSA depends on soil type, content of organic matter, biological activity of soil, the way the soil is worked, and other factors. WSA has a close relationship to soil structure.

Figure 3 shows the average WSA values. Here it is evident that, after application of compost, a significant WSA improvement occurred in variants 2 and 3 in comparison with the control variant (Table 3, 4). The highest WSA value was achieved in variant 3 with the higher dosage of compost.

Various authors agree on the positive influence that the application of organic matter has on WSA, especially compost (Angin *et al.* 2013; Arthur *et al.* 2010; Zhang *et al.* 2014). In their experiments, Babalola *et al.* (2012) found that two years after the application of compost there was a 15.7% improvement in aggregate stability. Also, according to Kroulík *et al.* (2010) organic matter showed a positive effect on soil fertility, increased the stability of soil aggregates and improved soil structure.

Compost should be evaluated primarily on its effect on soil. The effect of compost on the physical-chemical characteristics of soil must particularly be stressed. Mainly due to its humus matter content, compost assists the formation of stable soil structure, which improves water retention and aeration of the soil (Habart 2005). Compost also acts as a binding agent for soil particles, thus making the soil more resistant to erosion and increasing its ability to retain water (Stratton *et al.* 1995). Besides supporting biological activity in the soil, compost influences the formation of soil aggregate and the infiltration capability of the soil (Avnimelech & Kohen 1998). Badalíková and Bartlová (2011) state that the application of compost reduces soil compaction, i.e. the bulk density of soil, although this takes longer than e.g. an improvement in soil aggregate stability.

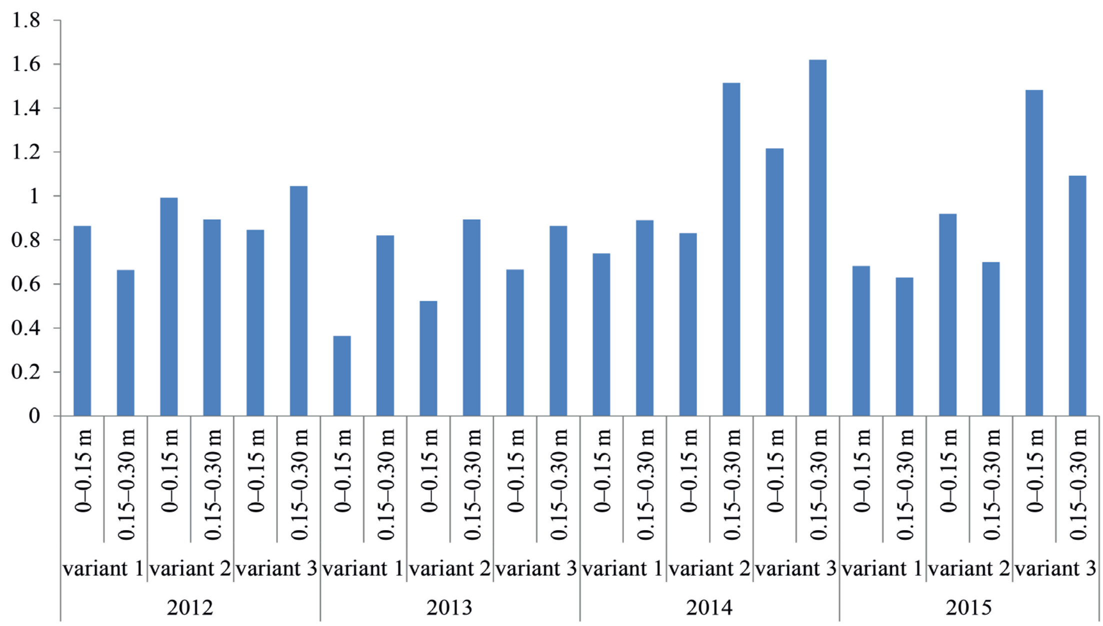

Figure 2. Average values of structure coefficient in years 2012–2015

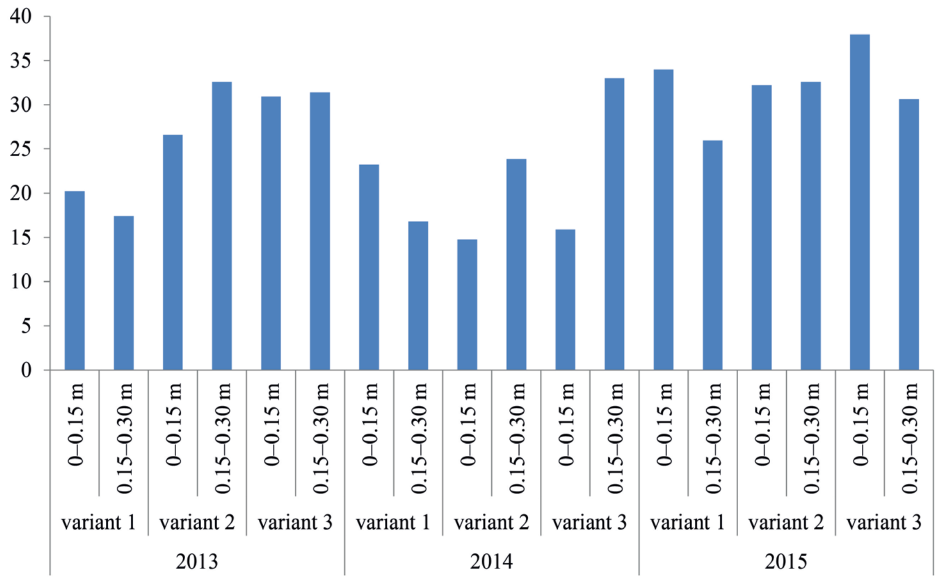

Figure 3. Average values of water stability of soil aggregates [%] in years 2013–2015

CONCLUSIONS

The results obtained after a 4-years application of pomace compost to the soil show the positive influence of the use of organic matter on the soil structure and water stability of soil aggregates. The application of compost led to a significant increase in soil structure and water stability of soil aggregate. The highest values of structural coefficient and water stability of soil aggregate were found in the variant with the highest dosage of compost, although an improvement in values was also evident in the variant with the lower dosage of compost, especially in terms of water stability of soil aggregate. Organic matter in soil is therefore important in terms of improving the fertility of soil and its resistance to degradation factors.

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