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EVALUATION OF COMPOST INFLUENCE ON SOIL WATER RETENTION

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Abstract

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The experiment was focused on evaluation of influence of compost application on soil water retention. Soil retention is a major soil water property that governs soil functioning as a ecosystem. Soil moisture forms a major buffer against flooding, and water capacity in subsoil is a major factor for plant growth. The effects of changes in soil water retention depend on the proportions of the textural components and the amount of organic carbon present in the soil. During seasons of 2009 and 2010, experiments at two sites of different soil conditions prepared by addition of compost doses of 50 and 100 t.ha^{-1} were carried out. Changes of humidity were continuously monitored and recorded by soil moisture sensors. Results showed that application of compost of above mentioned doses positively affected water retention of the soil. Organic matter, applied at the above mentioned amount has a positive effect on soil moisture retention, regardless of possible influence of soil type, grassing and amount of rainfalls. Outcomes of experiment become bases for recommended compost doses as well as for technical proposal of compost application processes.

compost, soil moisture, water retention of the soil

To ensure effective production of permanent sustainable development of agriculture systems, minimizing negative effects on environment, especially on sources of water and soil fund is necessary. That means, among others, to hinder soil degradation leading to nutrient losses and organic matters losses linked with rapid reduction of biologic productivity and soil quality. One of the causes of such degradation is soil's lower ability to retain water. An ability of soil organic matter to bind water has become an important theme for research in the past years. Decrease of organic compounds in soil followed by decrease in quantity of soil' s fauna and flora species and consequently lower water retention of the landscape is considered to be one of the main European soil problems (CÍLEK, 2010).

It is a matter of common knowledge that in terms of soil moisture retention and nutrients, humus plays a significant role as an important component of soil. The decrease of farm manure application and development of a great number of biologically decomposable waste during farming offers an option of effective usage of produced compost. Its applications onto exposure soils in appropriate doses can significantly mitigate and reduce impacts of surface flow on agricultural land resources.

HALL (1977) proved that soil's retentive ability correlates positively with soil organic matter content and negatively with soil density. THOMPSON *et al.* (2008) stated that infiltration ability of sandy loam or loam soil linearly increased by adding a mixture of compost and sand or compost alone compared to the soil without compost.

An implementation of organic matter into soil creates a mixture of soil aggregates and residues of plant tissues. These parts are gradually decomposing. The decomposition process takes a different speed than usual maturing of soil surface layers. Due to temperature and humidity changes, strain in stalky parts occurs. DUVIGNEAUD (1988) and other authors consider processes, in which pores and micro pores form as the basic condition of soil's retentive ability. Such phenomenon is externally expressed as increasing soil's sorptive ability. The high retentive ability of forest soil can serve as an example.

An increase of retentive ability is also explained by humus properties. Huge area of humus internal specific surface binds a great deal of ions and water and increases the absorption capacity of the soil. This property is illustrated by comparing retentive abilities of humus, sand and mineral soil. One kilogram of humus can retain up to three kilograms of water which is six times more than mineral soil can retain and fifteen times more than dry sand can do (POŠTULKA, 2007).

MEIER, PLOEGER, VOGTMANN (2003) state that an increase of humus content by 0.2% causes increase of utilizable water capacity by 0.5% and pore volume by 1% on average. Technology of compost production and its application lead to soil properties improvement due to mature composts' stable and high proportion of organic matter (BADALÍKOVÁ, 2009).

An impact of soil forming factors is also important. The most fertile soils have proportion of capillary pores to non-capillary ones in well balanced condition (50:50) and contain large quantity of various animal, bacterial and other organic species. Soil's natural soaking ability is affected by its biodiversity given by presence of sufficient number of bacterial and other species in soil (ROUS *et al.*, 2004). The retention is also affected by volume of macro-pores (crannies, air-holes) through which water penetrates into the deeper layers. Low retention of arable soil with insufficient content of organic matter is related to poor occurrence of useful animals and lack of cracks in soil caused by deep-rooted plants (POŠTULKA, 2007).

In order to reach above mentioned synergistic effects, it is necessary to apply high doses of organic matter. KASPEROVÁ, JANDOVÁ *et al.* (2006) state that in terms of increasing soil's soaking ability, only addition of compost of doses higher than 50 $t.ha^{-1}$ are considered to be effective.

MATULA (2004), SEDLÁČKOVÁ (2006), WEINDORF (2006) and others confirm that amount of organic matter in soil added in doses of 80–150 $t.ha^{-1}$ has a significant influence on the soil profile porosity and increases soil retention ability.

The aim of experiments was to assess effects of various doses of composts on soil humidity retention of agriculture lands. Experiments were carried out at the Department of Horticultural Machinery, Faculty of Horticulture, Mendel University, Brno, during the period of 2009–2010.

MATERIAL A METHODS

1. Experimental plots

For experiments, two plots of the following locations have been chosen: plot belonging to Horticultural Faculty in Lednice and plot in the village of Topolná (district of Uherské Hradiště). On the experimental areas, small land parcels experiment were established of the size of each plot 4 × 5m (20 m^2). The data on both areas are provided in the following Table I.

2. Types of Treatment

The soil tillage on both experimental plots was done in autumn by means of mouldboard ploughs

I: *Characteristics of the experimental plots*

Plot	LEDNICE	TOPOLNÁ
Trial establishement	28th March 2009	1st April 2009
Start of measurement	5th May 2009	7th May 2009
End of measurement	23rd November 2009	23rd November 2009
Altitude	176	220
Geographic coordinates	48°47'46.242"N, 16°47'52.315"E	49°7'18.964"N, 17°32'38.619"E
Soil typ	Black soil	fluvial gley soil
Soil sort	clay loam	clay
Sloping	0°	up to 3°

II: *Type of Treatment*

Treatment	Applied dose of compost [$kg.m^{-2}$]	Applied dose of compost [$t.ha^{-1}$]
Reference Treatment	0	0
Treatment 1	5	50
Treatment 2	10	100

Qualitative features of used compost	Humidity [%]	Organic compound [%]	N_2 [%]	C:N [-]	pH [-]	Density [$kg.m^{-3}$]
2009	32	24.4	1.4	21:1	7.7	395
2010	34	26.0	1.6	18:1	7.0	425

in depth of 0.3 m. Following operations consisted in layering and placement of compost doses (50 and 100 t.ha^{-1}). After the compost was plought in, the plot surface was modified by means of rotary cultivator into depth of 0.15 m. The qualitative features of compost and doses of treatment are shown in the following Table II.

3. Determination of soil density

Soil's density was measured after applying the compost and just before the measurement started, for orientation assessment of the effect of applied compost. Soil samples were taken by means of Kopecky cylinder from the depths of 0,1–0,2–0,3 m.

4. Soil moisture observation

The figures of soil moisture depending on various doses of compost were measured by means of soil moisture meter VIRRIB placed at the depth of 0.3 m. The soil moisture measurements were recorded daily during vegetation, at regular one-hour intervals, with use of the unit record VIRRIBLOGGER, Measurements were provided with 6 sensors during the period of May to November.

5. Results evaluation

The value of average daily soil moisture was calculated from data collected throughout the measured period and graphically recorded. The graphs were, for better clarity, processed in monthly courses and supplemented with amounts of rainfalls and its terms. Responses of the soil environment and differences of the soil moisture could be read from provided data.

RESULTS AND DISCUSSION

The results of determination of soil density are provided in the following Tables III and IV.

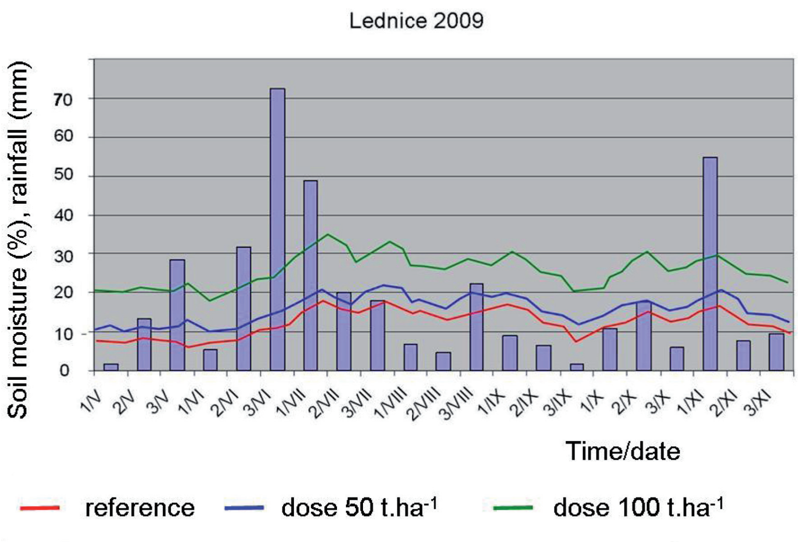
Decline of soil density with increasing dose of applied compost is evident. It indicates legitimacy of the assumption that compost, added into soil,

III: *The soil density*

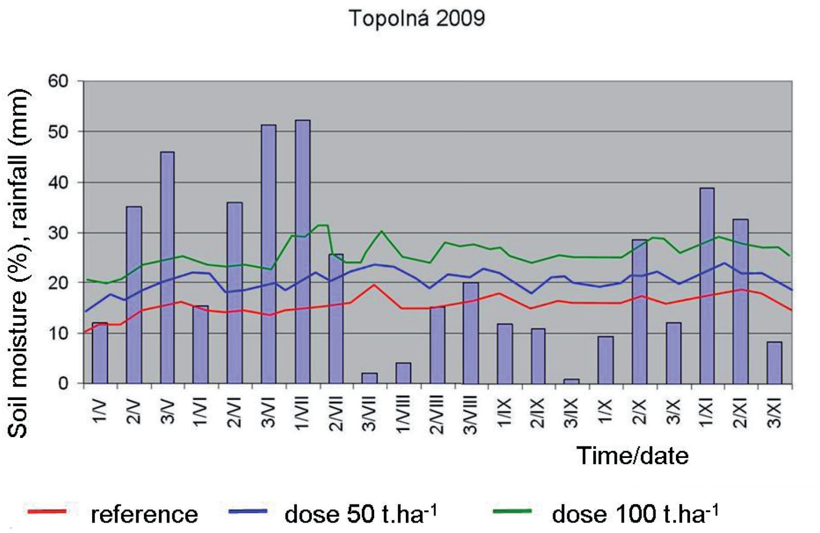
Area LEDNICE	Density [g.cm^{-3}]			
	Depth 0.1 m	Depth 0.2 m	Depth 0.3 m	Average
Reference Treatment	1.38	1.39	1.43	1.40
Treatment 1	1.35	1.37	1.40	1.37
Treatment 2	1.29	1.30	1.34	1.31

IV: *The soil density*

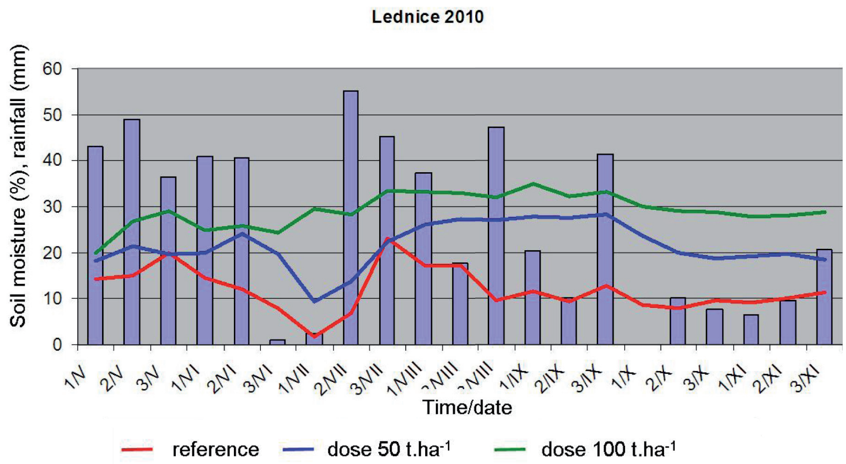
Area TOPOLNÁ	Density [g.cm^{-3}]			
	Depth 0.1 m	Depth 0,2 m	Depth 0,3 m	Average
Reference Treatment	1.41	1.47	1.49	1.46
Treatment 1	1.38	1.43	1.43	1.42
Treatment 2	1.35	1.38	1.41	1.38



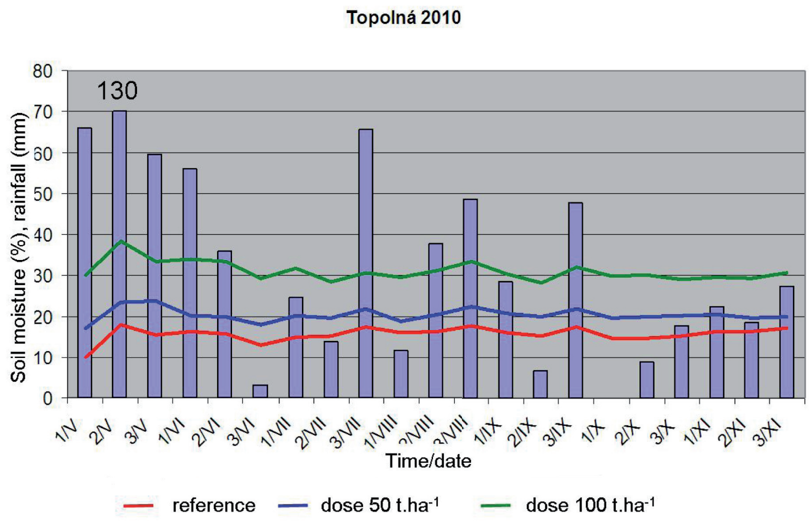
1: *The course of soil moisture at the plot of Lednice*
Note: soil moisture and rainfall have on the y axe the same scale



2: *The course of soil moisture at the plot of Topolná*



3: *The course of soil moisture at the plot of Lednice*



4: *The course of soil moisture at the plot of Topolná* positively effects the soil structure also in a short term period (MEIER, 2003; WEINDORF, 2006). These measurements are to be considered as a directory information with respect to the fact that no mechanical means were working on the plot and the soil samples were taken two months after the compost was applied. The density was influenced only by natural settling down of the soils in this case.

Graphs 1 and 2 show soil moisture ratio in assessed treatments at both plots, together with course of rainfalls in 2009.

The Graphs 3 and 4 show soil moisture ratio in assessed treatments of both plots, together with course of rainfalls in 2010.

The 2009 Treatment

The curves in the graphs 1 and 2 show evidence of markedly higher soil moisture sufficiently supplied with medium (50 t.ha^{-1}) and high (100 t.ha^{-1}) compost dose.

At the area of Lednice, the curves show evidence of the same or similar course of moisture decrease. This fact can be explained by good homogeneity of the light clay sand soil (loamy sand, sandy loam) profile which enables good soaking ability across the horizon (MATULA, ARZHAD, 1997; THOMPSON *et al.*, 2008). Higher maintain of the soil moisture gained at treatment 2 (up to 15–18%) and treatment 1 (up to 2–4%) compared to the reference treatment could be read from the presented chart.

The Topolná plot shows smaller absolute differences in humidity retention of observed treatments, ranging between 7–10%. The reason for differences can be explained by diverse soil type of the plot whose heavy loamy soil reduces its infiltration capacity, resulting in lower retention of the profile.

The curves for the observed variants on both plots are alike, showing an increase in soil moisture due to rainfall and its fast decline onto retention ability level. With respect to the progress of climatic conditions in 2009, when low level of rainfalls occurred, an effect of compost application was perceptible after rainfalls over 10 mm.

The 2010 Treatment

Curves in the Graph 3 and 4 displaying amount and terms of rainfalls show that observations were affected by outstanding and frequent rainfalls in the 2010.

Both treatments at the Lednice plot proved a great change of moisture. The treatment 2 showed maximum moisture differences of 22–27% and the treatment 1 maximum of 10–20% of the moisture content. The Graph also showed that the high soil moisture throughout the vegetation season influenced the observation in some degree. It was evident especially in the periods of 2/V–3/V and in 2/VII–3/VII period where a response of the soil was significantly biased. The treatment 1 (50 t.ha^{-1}) results sporadically over lapped with the reference treatment. An influence of organic matter was in some cases eliminated by high natural soil moisture content. At the same time, the results of the treatment 2 (100 t.ha^{-1}) showed longer retention of higher values of moisture, similarly as in 2009. The higher values of soil moisture caused by application doses higher then 50 t.ha^{-1} were stated by WEINDORF *et al.* (2006).

The changes in soil moisture were definitely influenced by enormous amount of rainfall in period V. and VI. (total rainfall of 340 mm represented a multiple of a long-term average) also at the Topolná plot. The curves showed a balanced course of moisture throughout the period. Maximum differences, compared to the reference treatment, reached 12–20% in treatment 2, and did not get over 4% in the treatment 1.

The comparison of results, gained during both years enabled to assess an effect of location onto the dynamics of moisture decrease. The Loamy soil at the Lednice area showed a considerable moisture decrease during time between rainfalls. Such effect was due to soil higher infiltration ability (NOZDROVICKÝ, HALAJ, 1998). In heavy clayish soil with lower infiltration ability at the Topolná plot such changes did not appear. The greater moisture decline was caused by evaporation. Similar reason of lower infiltration ability in heavy soil were stated by THOMPSON *et al.* (2008).

The results gained in this research will be further utilized for determination of the effect of compost on increasing field water capacity of individual soil types, for setting up of recommended dosage of compost leading to recovery of retention ability, as well as for technical processes proposals related with compost application.

CONCLUSION

This work was dealing with assessment of impact of application of compost into soil in order to retain soil moisture. The compost was applied in doses of 50 and 100 t.ha$^{-1,}$ on two plots of different soil conditions, at the 2009 and 2010 seasons. The changes in moisture were continuously measured by means of moisture sensors. The results prove that the soil on the plot with the dose of compost of 100 t.ha^{-1} showed increase of the humidity. Organic matter, applied at the above mentioned amount has a positive effect on soil moisture retention, regardless of possible influence of soil type, grassing and amount of rainfalls. Outcomes of experiment become bases for recommended compost doses as well as for technical proposal of compost application processes.

The article follows the research project NAZV No. QH 81200 “Optimization of water regime in the country and increase of country retention ability by means of application of composts from biology decomposable wastes on arable land and sustainable grass stands”.

SUMMARY

This work deals with assessing the impact of application of compost into soil in order to retain soil moisture. The compost was applied in doses of 50 and 100 $t.ha^{-1}$ respectively, on two plots of different soil conditions, in seasons of 2009 and 2010. The changes of soil moisture were continuously measured by moisture sensors. The results showed that application of compost of above mentioned dosages positively affected soil moisture retention. The results enabled to evaluate changes in moisture in course of time as well as differences between observed treatments.

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