SURFACE WATER RUNOFF DURING RAINFALL AFTER COMPOST INCORPORATION INTO SOIL

Pavel KOVAŘÍČEK[1], Josef HŮLA[1], David HÁJEK[1], Marcela VLÁŠKOVÁ[1]

[1]*Research Institute of Agricultural Engineering, Prague, Czech Republic*

Abstract
The effect of compost application on soil hydraulic properties was evaluated in a field trial on a farm with ecological agriculture. A control treatment was without compost application during the trial while in a treatment with compost incorporation a dose of 12-18 t of dry matter/ha was applied every year after the forecrop harvest. Microplots for surface runoff collection were used to measure surface runoff during rainfalls, another method was the use of rainfall simulation by a rainfall simulator. Both measurement methods showed lower values of surface water runoff and higher values of water infiltration into soil in the treatment with every-year compost incorporation into soil compared to the control treatment. The results of the field trial confirmed a contribution of high-quality compost application to an increase in the infiltration capacity of soil during intense rainfalls.

Keywords*: surface runoff; water infiltration into soil; rainfall simulation.*

INTRODUCTION

A change in farming systems on land and technical anthropic activities in landscape underlie changes in the soil environment. Aboveground parts of plants are returned to the soil to a limited extent while humus content in the soil is often reduced and the soil structure is disturbed. Soil disaggregation is the most often caused by mechanical disturbance of the soil by farm machines and by a concurrent reduction in soil organic matter content. These soil processes decrease the infiltration rate of water into soil while surface water runoff and water erosion occur on slopes during intense rainfalls. Drought periods become more severe when the plants are lacking water lost through rapid surface runoff during rainfall. High-quality compost may be a suitable instrument supplying missing organic matter to the soil.

A decrease in the bulk density of soil at the depth of compost incorporation was reported *by Golabi et al. (2007)* and also by other authors *(Courtney & Mullen, 2008; Lynch et al., 2005)*. An improvement in the stability of soil aggregates after organic waste application to the soil was documented by *Rajeswari et al. (2007)*. High-quality soil organic matter has positive effects in conditions where the soil is exposed to the impacts of tractor passes *(Horn et al., 2006).*

Compost application can be a way of accelerating water infiltration into the soil during torrential rains. An increase in the water-holding capacity is also assumed. Both factors become more and more important under the current climate pattern when alternating dry and wet periods are being extended. The compost application to make up for organic compounds in the soil taken up for crop production and the effect on surface water runoff during rainfall are investigated in specific farming conditions in pilot trials.

The application of high compost doses (200-500 $t.ha^{-1}$) aimed to influence soil properties was reported by *Pagliali et al. (1981)*. *Thompson et al. (2008)* stated that the infiltration capacity of sandy-loam or loamy-sand soil increased linearly with the supply of a compost and sand mixture or of compost only compared to the soil not treated with compost.

The hypothesis of beneficial effects of compost incorporation on physical and hydrophysical properties of soil has been supported by results of many authors – *Boyle et al.(1989); Pagliali et al.(1981); Stoffela & Kahn (2001)*.

The aim of this study is to evaluate the effect of compost application on soil's hydraulic properties over three-years on a farm that employs ecological farming methods.

MATERIALS AND METHODS

In a pilot trial conducted on a farm with ecological agriculture and where conventional ploughing technology is used for soil tillage, the effect of compost application on soil hydraulic properties was evaluated. All agricultural practices in the trial were carried out in a direction of contour lines. The compost made from farmyard manure, slurry and grass hay from meadow maintenance and landscape maintenance produced in a farm composting plant was used for fertilization (Tab. 1).

Tab. 1 Quality characteristics of produced compost for fertilization on experimental plot (according to ČSN 46 5735)

Year	Moisture (% weight)	Burned component (% weight)	N - total (%)	Ratio C:N	pH
2012	64.18	41.52	2.37	8.76	8.67
2013	60.86	35.50	1.62	11.00	8.40
2014	42.90	39.90	1.88	10.80	8.41
2015	51.50	39.60	2.02	9.47	8.65

Two parcels of 150x60 m in size were delineated on a slightly sloping plot – a control treatment without compost application during the trial and a treatment with incorporated compost at a dose of 12-18 t dry matter/ha every year after the forecrop harvest.
In each experimental treatment 4 microplots for surface runoff collection were installed after the crop sowing (Fig. 1). The area of the microplot (0.5x0.4 m) for surface runoff collection was delimited by the steel sheet sides. The steel sheet sides were driven into the soil to a depth of 0.10 m and the side height above the ground surface was 0.05 m. Using a collector in the bottom part of the microplot, water was caught into a collection bottle during a runoff event. The collector was covered with a sheet metal so that the surface runoff from the measuring area would not be influenced by a rainfall caught in the collector. The collection of surface runoff by this method was described by *Bagarello & Ferro (2007) or Hudson et al. (1993)*. The rainfall total during a runoff event was read off on a rain gauge placed in each experimental treatment. It was checked under intense rainfall whether any surface water runoff had occurred. If it had, collection bottles were replaced by empty ones and the collected volume of water was weighed to the nearest ±5 g. In the course of the microplot installation the inclination of the microplot measuring area was measured with a digital clinometer (Tab. 2). Investigations were done in four farming years 2012-2016 when the crop rotation of oats, winter triticale, emmer wheat and spring barley was used.

Tab. 2 Average slope of the mini-collectors on the measuring surface during installation

Year	Variant	Slope - average (°)
2012	control	3.7
	compost	4.2
2013	control	3.2
	compost	3.0
2014	control	4.1
	compost	4.0
2015	control	3.8
	compost	3.2

In addition to the study of surface water runoff from the microplots measurements were done during rainfall simulation on a measuring area of 0.5 m^2 at rainfall intensity of 87.8 $mm.h^{-1}$ (1.46 $l.m^{-2}.min^{-1}$) and at constant water pressure of 100 kPa *(Kovaříček et al. 2008)*. Water flowing from the sprinkled measuring area was conducted to a vessel placed on a digital balance. The weight of cumulative runoff of surface water was logged in a PC at an interval of 5 s. Collected water from surface runoff is filtered, filtered soil is dried and from the dry weight of washed soil a unit soil loss ($g.m^{-2}.h^{-1}$) caused by water erosion is determined. Based on the known simulated rainfall intensity and surface runoff volume other derived indicators converted per unit area of 1 m^2 are calculated: cumulative rainfall, cumulative surface runoff and cumulative infiltration.

Fig. 1 A microplot for surface runoff collection installed after the crop sowing, a collector directing water runoff to a collection bottle is covered with a sheet metal

RESULTS AND DISCUSSION

Figs. 2–4 document the results of evaluation of surface runoff from microplots for surface runoff collection in runoff events during a pilot field trial conducted in three farming years. In the first year of investigation winter triticale was planted on an experimental parcel. The effect of compost application on soil hydraulic properties is expressed by cumulative surface runoff. Fig. 2 shows differences in surface water runoff between experimental treatments for different rainfall totals during the growing season of winter triticale. Very low values of surface water runoff were recorded in the 2013 autumn season, when most water was infiltrated into the soil during rainfalls. The reason was an increased occurrence of macropores in topsoil within a short period after ploughing. The beneficial effect of compost on water infiltration into soil was manifested at the end of April and after mid-May 2014 – on these dates after compost incorporation into soil the surface runoff of precipitation water was 5.5 times and 2.8 times lower, respectively, compared to the control treatment without compost application.

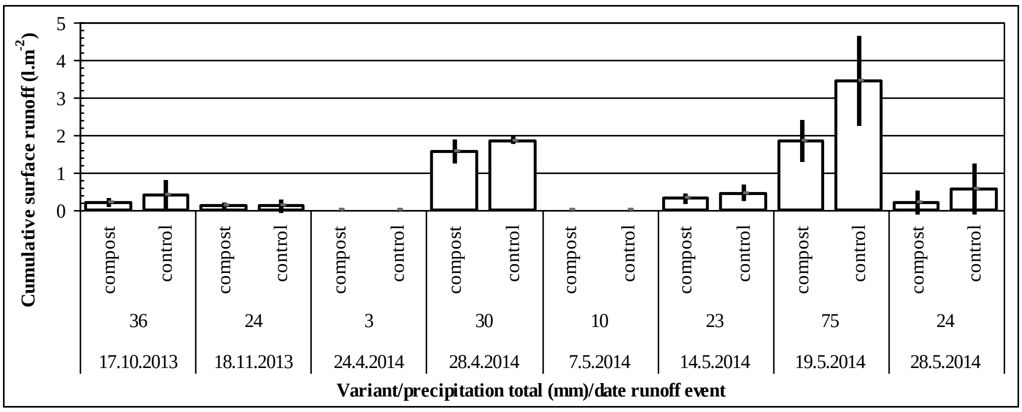

Fig. 2 Surface runoff – 2013-2014 – winter triticale

In the subsequent farming year winter emmer wheat was grown on an experimental parcel. The higher surface runoff of precipitation water occurred at intense rainfall in June 2015 (Fig. 3). On two dates of June 2015 the lower surface water runoff was observed in a treatment with compost incorporation in comparison with the control treatment without compost application.

In 2016 spring barley was sown on an experimental parcel. Surface water runoff occurred after more intense rainfalls in the second half of May and before mid-June 2016 (Fig. 4). Also on these dates surface water runoff was lower in the treatment with compost incorporation into soil. The infiltration capacity of soil during rainfalls is mainly influenced by the instantaneous porosity of soil and by soil moisture.

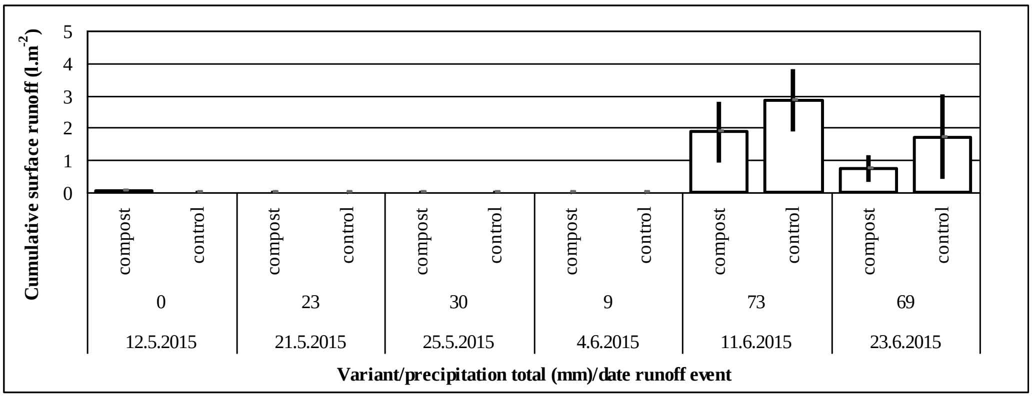

Fig. 3 Surface runoff in 2015 – emmer wheat

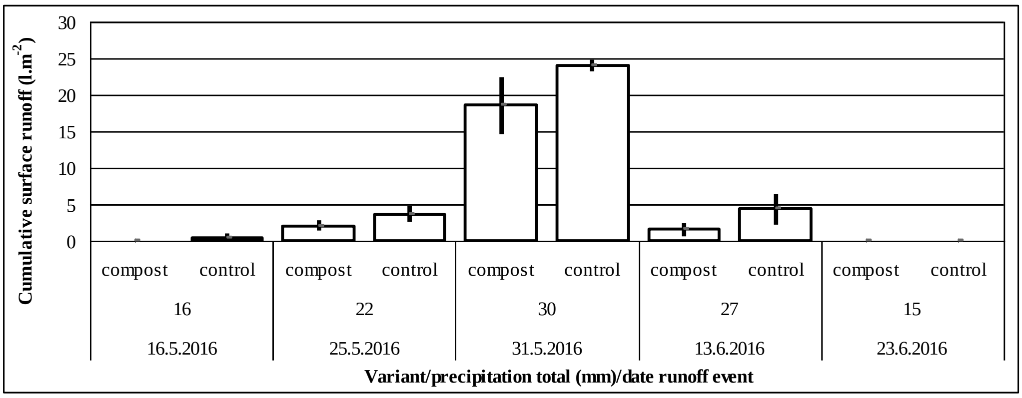

Fig. 4 Surface runoff in 2016 – spring barley

From the measurements when a rainfall simulator was used, results of measuring the surface runoff from a collection area of 0.5 m^2 are given in litres per hour (Fig. 5). Also these measurements indicated a beneficial effect of compost incorporated into soil – higher water infiltration into soil and lower surface water runoff were observed on the parcel with every-year compost incorporation.
The results of measurements of surface runoff during rainfalls and of measurements when rainfall simulation was used confirm a hypothesis that the application of high-quality compost is a contribution to an improvement in the infiltration capacity of soil during rainfall. A reduction in surface water runoff during intense rainfalls is also beneficial from the aspect of lowering a risk of water erosion of soil, which is very urgent in conditions of the CR. The seasonal data were evaluated using Statistica 12CZ software and evaluated at confidence level 0.95. The effect of compost on decreasing surface runoff could be confirmed ($p=0.046$) using Mann-Whitney U test using data from the whole tested period.

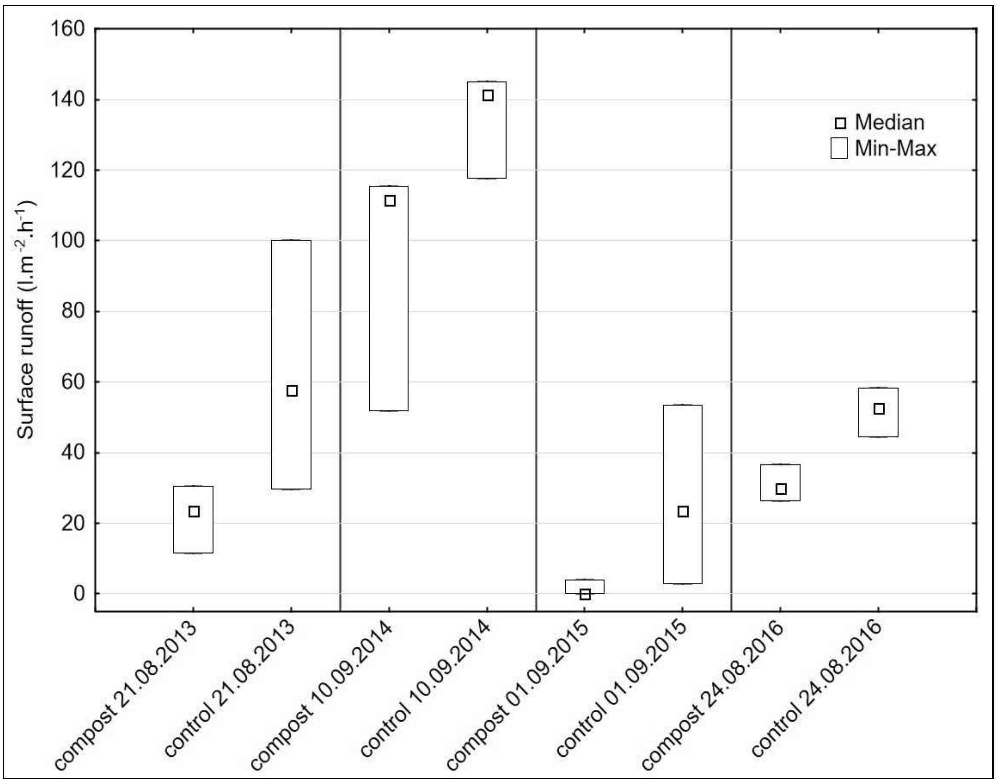

Fig. 5 Surface runoff in 2013-2016

Soil loss results from rainfall simulation are in Tab. 3.

Tab. 3 Soil loss at rainfall simulation (intensity 87.8 mm.h^{-1})

Year	Soil loss (g.m^{-2}.h^{-1}) Compost	Control
2013	2.64	43.39
2014	58.40	83.61
2015	0.10	13.10
2016	2.58	14.49

The results of evaluation of surface water runoff during rainfalls and rainfall simulation are consistent with the results of the authors who reported a positive effect of compost incorporation into soil on physical properties of soil and on water infiltration into soil *(Courtney & Mullen, 2008; Lynch et al., 2005)*. The results showing an improvement in the infiltration capacity of lighter soils after compost incorporation were also confirmed *(Thompson et al. 2008)*.
In an overall evaluation of results of this field trial it should be taken into account that the compost was applied every year at a dose of 12-18 t of dry matter/ha after the forecrop harvest. However, in agricultural practice the compost is not applied every year.

CONCLUSIONS

An evaluation of the effect of compost incorporation into soil in three consecutive farming years confirmed a beneficial effect of high-quality compost on the infiltration capacity of soil during rainfall and during rainfall simulation using a rainfall simulator. Besides the direct effect of incorporated compost on mechanical properties of soil a contribution of high-quality compost to an increase in the intensity of biological processes in soil can be assumed. The application of high-quality compost can become a component of soil productivity conservation by means of returning a part of produced plant biomass to the soil.

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Corresponding authors:
Ing. Pavel Kovaříček, CSc., Research Institute of Agricultural Engineering, p.r.i., Drnovská 507, 161 01 Prague 6-Ruzyně, Czech Republic, phone: +420233022236, +420601587191, e-mail: pavel.kovaricek@vuzt.cz