# THE IMPACT OF MULCHING MATERIALS ON THE SOIL MOISTURE DYNAMICS IN CENTRAL EUROPEAN VINEYARDS

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***Abstract***
*This study discusses the evaluation of moisture changes in soil in the area of the vineyard intersection that is covered with different kinds of mulching materials. The experiment was based on four variants in which three kinds of covering materials were chosen to protect the soil surface – grain straw (var. A: the consumption of cover material - 12 t per ha$^{-1}$) and wood chips (var. B: the consumption of cover material - 40 t per ha$^{-1}$) and compost (var. D: the consumption of cover material - 20 t per ha$^{-1}$). The fourth control variant (C) was formed from a cultured spacing without intersection covering material. The soil moisture was measured all year round by using VIRRIB moisture meters located at a depth of 0.1-0.3 m. The measured data was recorded by using a VIRRIBLOGGER recording unit. Analysis of the results obtained confirms the positive effect of grain straw on higher soil moisture values. In this variant, in 2017, soil moisture was higher by 4.37 % and in 2018 by 10.37 % compared to the control variant. In overall, the highest soil moisture values, over a two-year period, were achieved with grain straw and wood chips.*

***Key words:*** *soil moisture; mulching; grain straw; wood chips; vineyard.*

## INTRODUCTION

The soil water containing dissolved mineral and organic substances and its efficient use are critical to the sustainable productivity of permanent crops under the context of climate change in typical semiarid regions (*Li et al., 2018*). Water shortage especially during reproductive stage can significantly reduce the yield and quality of fruit (*Li et al., 2016*). Therefore, in order to ensure sustainable production, new methods and procedures are being sought and used in intensive production areas, enabling maximum utilization and retention of natural rainfall in the soil profile. These include, for example, terracing, ridge tillage, changing the gradient, slope length, and roughness of slopes. Moreover, in recent years, increasingly, there have been also used the methods of mulching.

Mulching is referred to as the agronomic practice of leaving mulch on the soil surface for soil and water conservation and to favour plant growth (*Jordán et al., 2011*). The covering layer of mulch represents any material other than soil or living vegetation that performs the function of a permanent or semi-permanent protective cover over the soil surface *(Jordán et al., 2011*). Therefore, for the mulching purposes, there might be different kinds of materials, such as vegetative residues, biological geotextiles, gravel and crushed stones (*Jiménez et al., 2016*). Mulching has been shown to confer several beneficial effects. Furthermore, mulching allows improved infiltration capacity (*Wang et al., 2016*) and increases water intake and supplies of usable water in the soil *(Mulumba & Lal, 2008*). Experimental measurements shows that mulching positively influences the topsoil temperature for more optimal growth and development of the plant roots (*Dahiya, Ingwersen & Streck, 2007*) and to decrease evaporation (*Cerdà & Doerr, 2005*). Among these beneficial mulching effects, the reduction of water loss rates is one of the most significant and remarkable (*Díaz-Raviña et al., 2012; Prosdocimi et al., 2016*).
The aim of this work was to evaluate the different influence of mulching materials covering the soil, on the dynamics of changes within the soil moisture in the Central European vineyards.

## MATERIALS AND METHODS

### Experimental site

For experimental measurements, specific test site, in the south of the Czech Republic, was selected. This was wine-growing sub-region "Velke Pavlovice", the area of "Rakvice", the track / land called "Kozi Horky" (Latitude: 48°51′29″N, Longitude: 16°48′48″E). This site is in the corn production area, where the climate is very warm and dry, with an altitude of 164 meters above the sea level. The land has a flat surface. The average annual temperature in 2017 was 12.3 °C and the total rainfall was 480.0 mm. In 2018, the average annual temperature was 12.5 °C and the total rainfall was 512.8 mm. In terms of the amount of natural rainfall, it is a typical semiarid region, with an annual precipitation of around 450-550 mm.

The soils are classified as a pelic chernozem on very heavy substrates (clays, marshes, carpathian flysch and tertiary sediments), on a scale from heavy to very heavy with a lighter horizon, rarely gravely, with a tendency of moisture on the surface in the profile. Skimmer is classified from none up to 10 %. The slope of the land is up to 10 %.

At the beginning of the vegetation, the initial physical state of the soil was always detected at the site using "Kopecky physical cylinders", the samples were analysed using a valid methodology (*Jandák, 2003*). Samples were taken at five reps from each depth the resulting values are provided in Tab.1 and Tab.2.

**Tab. 1** Physical character of soil (at the beginning of vegetation in 2017)

| Soil depth (m) | Density ($g \cdot cm^{-3}$) | Porosity (%) | Volume | | Maximum capillary capacity | Minimal air capacity |
|---|---|---|---|---|---|---|
| | | | Water | Air | | |
| | | | (% volume) | | (% volume) | |
| 0–0.1 | 1.05 | 59.95 | 59.95 | 25.40 | 34.55 | 45.91 |
| 0.1–0.2 | 1.23 | 53.23 | 53.23 | 26.47 | 26.76 | 37.48 |
| 0.2–0.3 | 1.29 | 50.95 | 50.95 | 24.13 | 26.83 | 36.99 |
| Average | 1.19 | 54.71 | 54.71 | 25.33 | 29.38 | 40.13 |

**Tab. 2** Physical character of soil (at the beginning of vegetation in 2018)

| Soil depth (m) | Density ($g \cdot cm^{-3}$) | Porosity (%) | Volume | | Maximum capillary capacity | Minimal air capacity |
|---|---|---|---|---|---|---|
| | | | Water | Air | | |
| | | | (% volume) | | (% volume) | |
| 0–0.1 | 1.39 | 47.11 | 23.66 | 23.45 | 35.83 | 11.28 |
| 0.1–0.2 | 1.36 | 48.14 | 24.01 | 24.13 | 36.09 | 12.06 |
| 0.2–0.3 | 1.42 | 45.64 | 26.40 | 19.24 | 35.41 | 10.23 |
| Average | 1.39 | 46.96 | 24.69 | 22.27 | 35.78 | 11.19 |

### Character of the mulching materials and experiment variants

The experiment was based on four variants, for which three kinds of cover material were chosen to cover of soil cover by the layer of mulching material. The area of tested plots were 13.8 $m^2$ (2.3 x 6.0 m), the first mulching material was crushed grain straw (variant A) when consumption of covering material was 1.200 $g \cdot m^{-2}$ and volume weight was 100 $kg \cdot m^{-3}$. The second mulching material was wood chips (variant B) when consumption of cover material was 4.000 $g \cdot m^{-2}$ and volume weight was 400 $kg \cdot m^{-3}$. And the third mulching material was compost made from grape pomace, grass, wood chips and vegetable waste (variant D). The consumption of covering material at this variant was 2.000 $g \cdot m^{-2}$ and volume weight was 560 $kg \cdot m^{-3}$. The fourth control variant (C) consisted of a cultivated interlayer without covering material.

### Measuring of the meteorological data and soil moisture

A weather station installed in the experimental vineyard recorded data on air and soil temperature, rainfall and soil moisture at a depth in between 0.1 and 0.3 m. In all experimental variants, the soil moisture values were measured by "VIRRIB" moisture meters, located at a depth in between 0.1 and

0.3 m. The soil moisture expressed as a percentage by weight was recorded during the vegetation every day at a regular fifteen-minute intervals using the "VIRRIBLOGGER" recording unit.

**Statistical analysis**

A statistical analysis was performed using the software package "Statistics 12.0" (StatSoft Inc., Tulsa, Oklahoma, USA). Analysis of variance was conducted, and the results were compared using Tukey's multiple range assay at a significance level $\alpha = 0.05$.

## RESULTS AND DISCUSSION

The Figure 1 and Figure 2 show all year round values of soil moisture, air temperature and natural rainfall distribution at experimental site. The highest soil moisture was recorded, in both years, in variants that use crushed grain straw as a mulching material covering the soil. In 2017, the average value of soil moisture was 26.95 %, in 2018 the average value of soil moisture was 32.28 %.

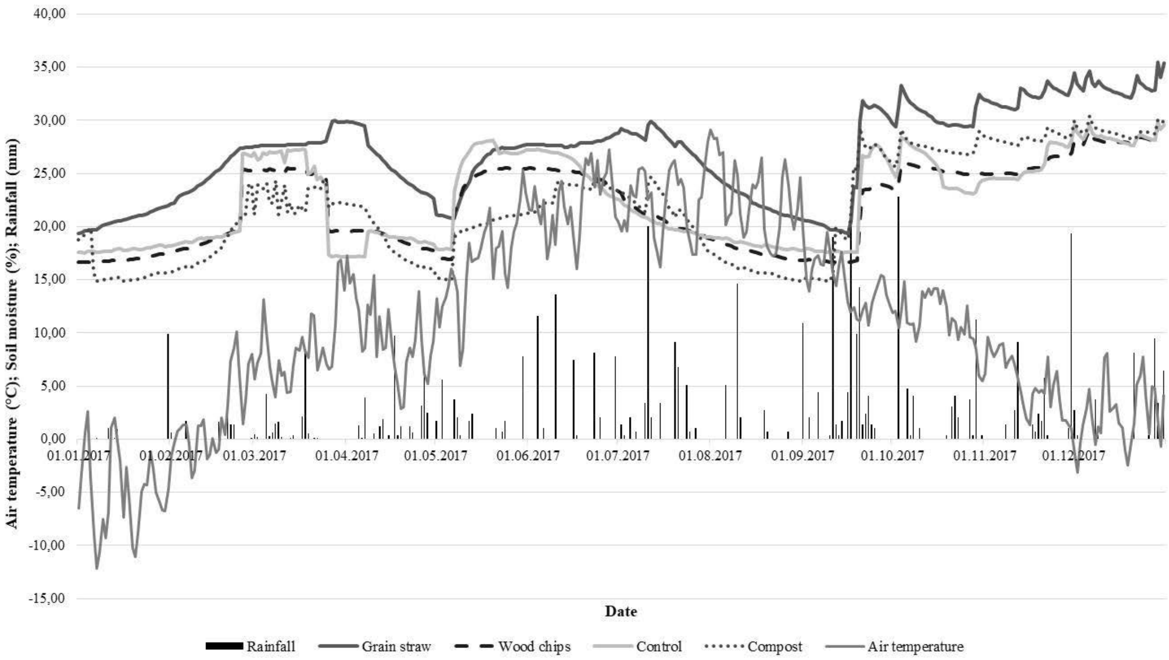


**Fig. 1** The value of air temperature, soil moisture and rainfalls in 2017

The Fig. 1, as well as the Fig. 2 show the uneven distribution of rainfall, especially during vegetation. *Vanek (1996)* reports that in terms of water consumption for wine, the starkest period is from June to August. Fig. 3 shows in detail the monthly rainfall sums for both evaluated years. From the values it is clear that there is a higher amount of precipitation especially at the time of harvest or after harvest, but not during the critical period for grapevine.

According to *Vanek (1996)*, depending on the intensity of foliage, the wine shrub consumes 3-7 litres of water per day, which corresponds to approximately 90-210 litres of water per month. However, the monthly rainfall shows that this amount of water needed for wine shrubs is not fully covered, which results in stress conditions. This trend can be further multiplied by vineyards growing on sloping land. The reason for this is the higher risk of surface runaway of water that is not retained by the soil (*Čížková et al., 2018*).

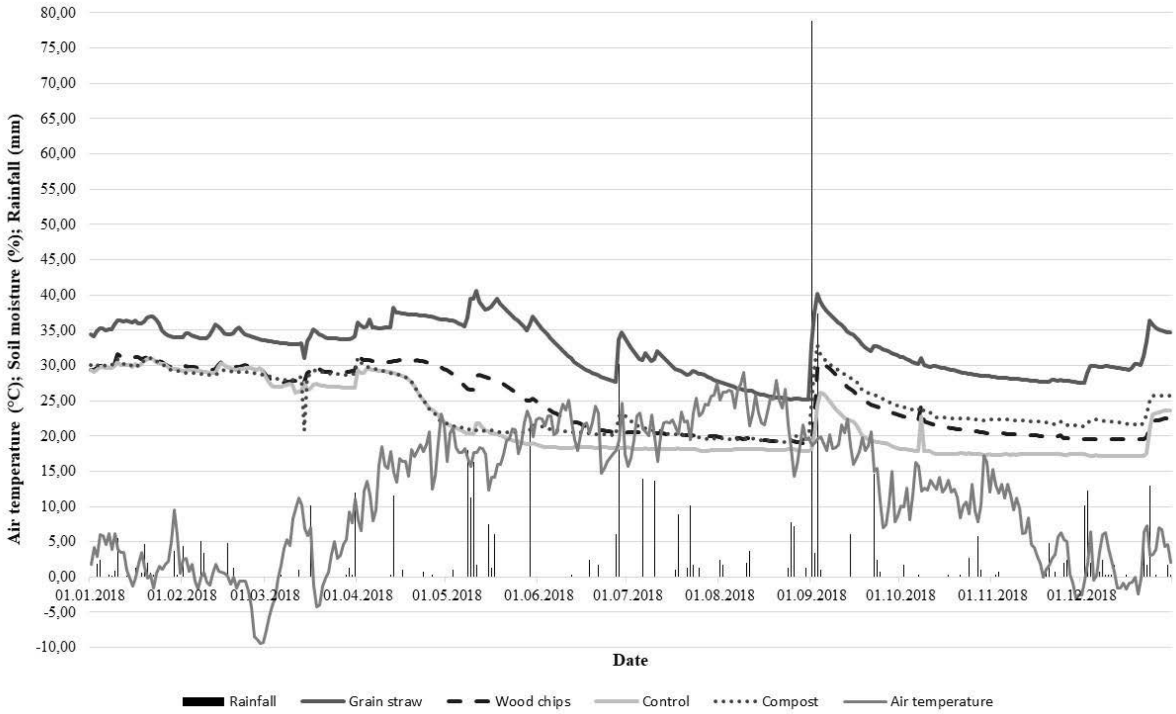


**Fig. 2** The value of air temperature, soil moisture and rainfalls in 2018

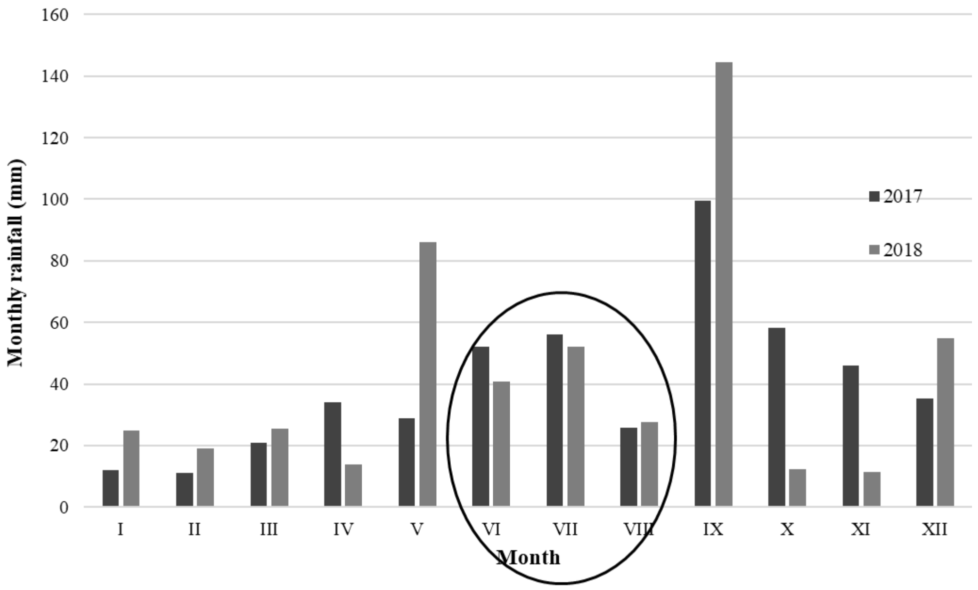


**Fig. 3** Monthly rainfall on the experimental site during the years of 2017 and 2018

The statistical evaluation of the results of soil moisture values, which was carried out by the analysis of variance, show that there is a statistically significant difference between the evaluated variants and the years.

**Tab. 3** The values of soil moisture

| The year of measurement | **Experiment variant** | The soil moisture (percentage of weight) |
|---|---|---|
| 2017 | crushed grain straw (A) | 26.95±0.06[e] |
| 2017 | wood chips (B) | 22.03±0.08[a] |
| 2017 | control (C) | 22.58±0.01[b] |
| 2017 | compost (D) | 21.81±0.06[a] |
| 2018 | crushed grain straw (A) | 32.28±0.09[f] |
| 2018 | wood chips (B) | 24.61±0.08[d] |
| 2018 | control (C) | 21.92±0.10[a] |
| 2018 | compost (D) | 24.29±0.01[c] |

*Legend: Data are expressed as means ± standard deviation, different letters in the same columns represent significant difference ($P < 0.05$).*

Also, in this case, the results confirm the positive effect of straw mulch on soil moisture. In 2017, the soil moisture was higher by 4.37 % in this variant and in 2018 by 10.37 % compared to the control variant. Overall, in 2018, all variations covered by the mulch layer were higher in soil moisture compared to the uncovered control variant. *Li et al. (2018)* states that the use of mulching materials presents an effective way of reducing soil evaporation in semiarid agroecosystems.

Covering the surface with the materials in terms of straw, film or branches can reduce radiation and wind speed at the surface and, hence, reduce evaporation (*Singh et al., 2011*). Also *Mahdavi et al. (2017)* showed that the crushed straw mulching practice significantly reduced total cumulative evaporation up to 40% as compared to the bare soil plot in a field experimental plot. The mulching decreases soil water content loss by evaporation and the variation in the soil temperature by insulating the surface and treatments increased root zone soil water content, which is expected to lead to higher root water uptake (*Jiménez et al., 2017*).

## CONCLUSIONS

This work brings the results of two-year experiment focused on the impact of three kinds of mulch materials - crushed grain straw, wood chips and compost on the dynamics of soil moisture changes. There was also used the control variant which consisted of cultivated interlayer without covering material. The highest values of soil moisture were measured in experimental variants using crushed grain straw. In 2017 the average soil moisture was 26.95 % and in 2018 it was 32.28 %. The results show that wood chips are a suitable alternative for mulching the soil surface. In the broader context, the results obtained suggest that mulching materials and their use in vineyards may have an economic and ecological benefit in semiarid hillslopes. The farmers in the south Moravia region should be encouraged to apply the comprehensive agricultural measures to sustain agroecosystems on sloping field management of vineyards.

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