



Corvinus University of Budapest

**Comparison of several vineyard floor management methods in
Tokaj-Hegyalja**

Thesis of PhD dissertation

Göblyös Judit

2013

PhD School

Name: Doctoral School of Horticultural Sciences

Field: Crop Sciences and Horticulture

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1. INTRODUCTION

In case of vineyards located on **steep slopes**, **erosion** represents a major problem. The climate changes: long drought periods and heavy rainfalls alternate. Because of this hectic, erosion became an important research topic. **Erosion has to be minimized** by the selection of suitable soil cultivation method, e.g. soil covering and cover crops. In Tokaj-Hegyalja due to the special climate *Botrytis cinerea* causes noble rot. Because of the **unusual weather**, the special climate - which causes noble rot - might disappear. Because of this is really important to look for soil **cultivation methods, which improve noble rot**.

2. AIM OF THE STUDY

The aim of our experiment was to investigate the effects the several soil cultivation methods on the soil and on the wine. The vineyard, where the experiment was carried on is organic, so the natural friendly soil cultivation methods are really important for the owners.

3. MATERIALS AND METHODS

During our experiment the following soil cultivation methods were tested: mulching with straw, barley cover crop, mechanical cultivation, pulses cover crop. The pulses cover crop hasn't come up during the experiment, so on this plots wasn't taken any measurements. The experiment was set up in the Tokaj wine region in 2007, the measurements were performed from 2007-2010. The investigated varieties were Furmint and Hárslevelű. Every treatment was located in five rows, in four replications per treatment (4 x 10 Stock). The plantation was located in a steep slope area, where the prevention of erosion is especially important.

During our experiment the following parameters were investigated:

- ✓ soil moisture (in 20 cm, 40 cm and 60 cm depth),
- ✓ nutrient content of the soil and the NO₂+NO₃ content of the soil (in 0-30 cm and 30-60 m depth),
- ✓ soil compaction (in 0-45 cm depth),
- ✓ water potential,
- ✓ yield,
- ✓ vegetative performance, weight of pruned canes,
- ✓ wine quality, ratio of noble rotted berries,

4. RESULTS AND DISCUSSION

Regarding soil moisture and water potential of the wines, we found, that the several soil cultivation methods had an influence on the moisture content of the soil, hereby the water potential of the vines. Straw mulch conserved the moisture content of the soil, while barley cover crop used water, so on this plots the soil water supply was lower. Significant difference wasn't found among the treatments (*Table 1.*)

JACOMETTI et al., 2007 and VARGA, 1994 found, that covering the soil with organic material helps to prevent the moisture content of the soil, through increasing the organic material content and protecting the surface from vaporization.

STEINBERG (1981), MONTEIRO and LOPES (2007), GULICK and his colleagues (1994) and BÖLL (1967) found, that the moisture content of the soil is lower in case of cover crops, because of the water conservation of the cover crop. But in some cases the cover crops increase water infiltration into the soil.

1. Table: Average daily and pre-dawn water potential in case of Furmint and Hárslevelű (Tokaj, 2009)

Soil cultivation method	Furmint average daily water potential (mPa)	Furmint average pre-dawn water potential (mPa)
mechanical soil cultivation	-1,07 a b	-0,56 b b
straw mulch	-0,90 b b	-0,51 b b
barley cover crop	-1,17 b a	-0,64 b
Soil cultivation method	Hárslevelű average daily water potential (mPa)	Hárslevelű average pre-dawn water potential (mPa)
mechanical soil cultivation	-1,17 b b	-0,53 b b
straw mulch	-0,97 b b	-0,43 b b
barley cover crop	-1,33 b b	-0,63 b b

a) difference ($0,01 > p > 0,005$)

b) significant difference ($p < 0,005$)

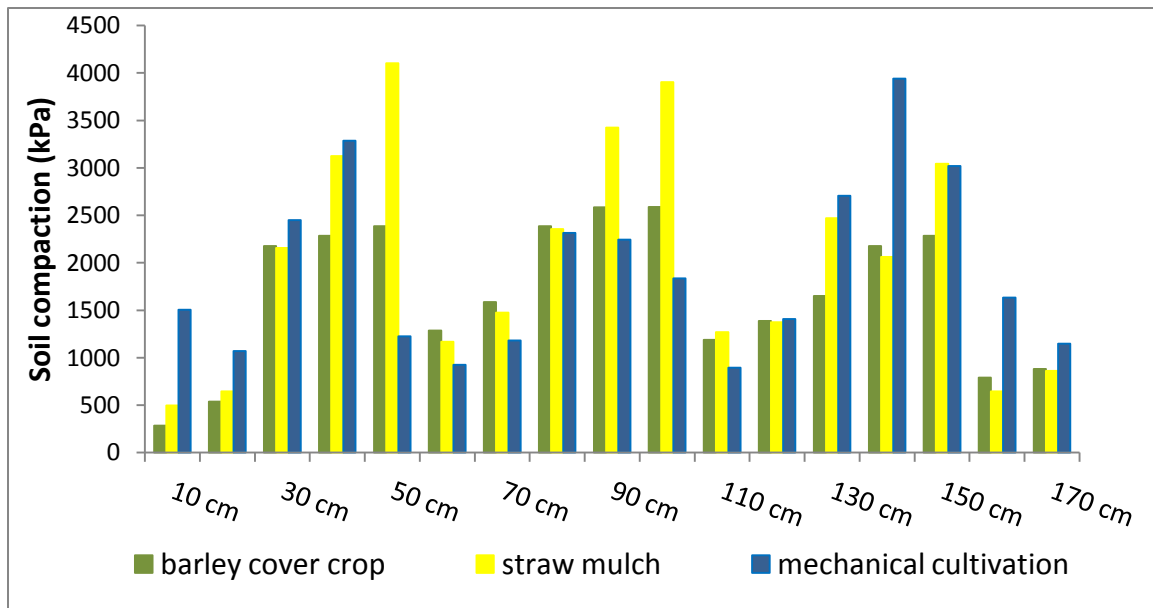
The nutrient content of the soil reduced during the four years of the experiment, but the humus content increased in some cases. The changes of the $\text{NO}_2 + \text{NO}_3$ content of the soil were monitored in every month in 2008 and 2009. It could be observed, that in case of mechanical cultivation the nitrogen content of the soil was higher, but after a heavy rainfall this nitrogen moves easily to the deeper soil layers. In case of the straw much and barley cover crop the soil nitrogen content decreased. While the soil organisms incorporated the

decaying straw into the soil, the nitrogen content reduced. The barley cover crop also used nitrogen from the soil.

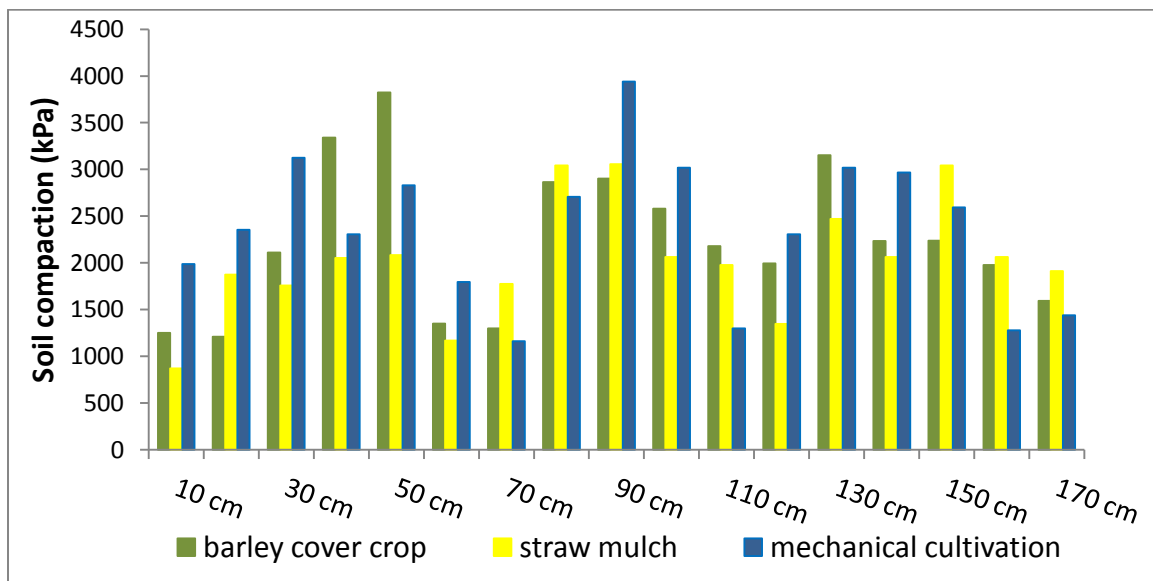
More researchers found, that soil covering has an effect on the nitrogen content of the soil. When the straw decays it adds valuable nutrients to the soil, but because its C:N ratio is wide, additional fertilization with nitrogen (N) is needed. While the soil organisms incorporate the decaying straw into the soil, the nitrogen can be temporarily removed, which has a negative effect on the grapes (FOX, 1981; VARGA et al., 2005).

Cover crops have also negative effects on the vine performance; compete for water and nutrients in the soil with vine (HAYNES, 1980; PRICHARD et al., 1989; DRINKWATER et al., 1998). Cover crops have a positive effect on the nutrient content of the soil, especially when a leguminous plant is used, because of the biological fixation of atmospheric nitrogen. The decaying cover crops increase the nitrogen content of the soil after one month of the incorporation (FINCH et SHARP, 1981; HANGROVE, 1982; INGELS, 1998). VARGA and his colleagues (2005) measured during their experiment in Badacsony, the higher soil nitrogen content in case of mechanical cultivation. In this case there isn't an extra nitrogen demand, caused by the cover crop or the decaying straw. Summarizing my results, I can report about the same experiences.

Regarding soil compaction in the trail of the machines and in the deeper soil layers the soil compaction increased. Significant difference couldn't observe, because on the straw mulched and with barley covered plots the tractor traffic wasn't less frequent as on the mechanical cultivated plots (*Figure 1-2*). Some experts found that the soil compaction was lower in the interrows with straw mulch, than in the interrows with cover crop (WHEATON et al., 2007; NÉMETHY és NÉMETH, 2002). WHEATON and his colleagues measured the soil compaction in case of oat cover crop and straw mulch, at the beginning of the experiment and after 2 years. The soil compaction was higher in case of oat cover crop after two years, while in case of straw mulch reduction could be observed. MORLAT és JACQUET measured the soil compaction in case of interrows with grass and with herbicide treatment (MORLAT és JACQUET, 2003). While in case of grass the average soil compaction was 1600 kPa, in case of the herbicide treatment higher, approximately 2600 kPa values were measured.



1. Figure: Average soil compaction in September in case of Furmint (Tokaj, 2008)



2. Figure: Average soil compaction in September in case of Hárslevelű (Tokaj, 2008)

The soil cultivation methods had an effect on the yield. In the most cases the higher yield was measured in case of the straw mulched plots, but in some years on the mechanical cultivated plots was the yield higher. The fewer yields were measured in every year on the plots with barley cover crop, in case of both varieties (Table 2.). This can be explained with the nutrient and water uptake of the barley. The straw mulch preserved the moisture content of the soil increasing the generative wine performance.

2. Table: Average yield/wine in case of Hárslevelű and Furmint (Tokaj, 2007-2010)

Average yield/wine (kg)	Hárslevelű				Furmint			
	2007	2008	2009	2010	2007	2008	2009	2010
mechanical soil cultivation	0,81 a	1,8	0,98 a	1,070	1,33 a	1,03 b	1,56	1,37 b
straw mulch	0,68 a a	1,6 b	0,84 a b	0,990	1,24 b	0,8 b	1,38 b	1,09 b b
barley cover crop	0,75 a	1,91 b	1,08 b	1,050	1,68 a b	2,07 b b	1,72 b	1,3 b

a) difference ($0,01 > p > 0,005$)

b) significant difference ($p < 0,005$)

Some experts also found, that cover crops have a negative effect on the vegetative and generative performance of the wines (VAN HUYSSTEEN és WEBER, 1980; SOYER et al., 1984; LOMBARD et al., 1988; POOL et al., 1990; SICHER et al., 1995; PINAMONTI et al., 1996; INGELS et al., 2005, VARGA et al. 2005), while in case of soil covering with organic material the yield was higher (POOL et al., 1990; PINAMONTI et al., 1996, JACOMETTI et al. 2007; BUCKERFIELD és WEBSTER, 1990).

The soil cultivation methods didn't influence the sugar and acid content of the most, but had an effect on the noble rotted berries. In case of the Hárslevelű variety the more noble rotted berries were found in case of the barley cover crop (Table 3). Most likely the vine vigor was moderate on this plots, so more sunshine reached the bunches and therefore the circumstances for noble rot were more favorable. In case of the Furmint variety we couldn't observe this trend, because the Furmint plot is more exposed and dry.

3. Table: The percent of noble rotted berries in case of Furmint and Hárslevelű (Tokaj 2007-2010)

Percent of noble rotted berries (%)	Hárslevelű				Furmint			
	2007	2008	2009	2010	2007	2008	2009	2010
mechanical soil cultivation	2 b b	8 b b	3 b	22	6 b	34	8 b b	31 a
straw mulch	3 b b	21 b	16 b b	27	4 b	30	20 b	39
barley cover crop	10 b b	19 b	14 b	25	11 b b	31	20 b	40 a

a) difference ($0,01 > p > 0,005$)

b) significant difference ($p < 0,005$)

Summarizing our results, we can see that the use of pulse cover crops is in the most cases not successful in the dry regions. The nutrient and water uptake of the barely caused lower yield, but in some year increased the ratio of noble rotted wines. Straw mulch preserved soil moisture, therefore increased the vegetative and generative performance of the wines. Straw mulch can be an effective method, when it is laid down in a thick layer and is renewed regularly.

5. NEW SCIENTIFIC RESULTS

- ✓ The use of **legumes** with higher water demand (e.g. crimson clover) as cover crop is **not successful in dry years**, in the plantations in Tokaj, with loes soil.
- ✓ In case of **mechanical cultivation**, due to a big amount of precipitation **the nitrogen content** of the soil can go down to the deeper soil layers. Because of this, the **too often used mechanical cultivation is not advised** during the vegetation period. In the course of the soil cultivation must be considered, that the infiltration of the precipitation and the movement of NO_2+NO_3 content in the soil, is influenced by the location and the slope.
- ✓ The soil cultivation methods have an influence on the noble rot. During our experiment (from 2007 to 2010) in three years was significant difference between the treatments in case of the Furmint and Hárslevelű variety. The increased nitrate content, due to the mechanical cultivation didn't cause more intensive noble rot in the most years.
- ✓ Significant difference was found between the treatments regarding the average daily water potential. The results have shown that the **moisture content of the soil was the higher in case of the straw mulch**.
- ✓ The staw mulch didn't increases the K_2O content of the soil in case of steep slopes, if the straw layer is thin ($0,3 \text{ kg/m}^2$).
- ✓ The **straw mulch increases the generative and vegetative performance** of the vine through preventing the moisture content of the soil. During our experiment the average yield and the pruning weight was higher in case of straw mulched plots, than the mechanical cultivated and with barley covered plots.

6. CONCLUSIONS AND SUGGESTIONS

Summarizing our results we can see, that the use of legumes as cover crop is not successful in dry places. The barley cover crop reduced the vine vigor and the yield, due to the water and nutrient competition, but in some years had a positive effect on the noble rot. Straw mulch increased the vegetative and generative performance of the vines through preserving the soil moisture. But the straw is not effective enough if it is laid down in a thin layer and won't be renewed regularly.

According to my results I make the following suggestions:

- ✓ Straw mulch should be laid down in a thick layer and renewed regularly.
- ✓ Straw mulch and cover crops should be alternate in the interrows in ever one or two years.
- ✓ In case of mechanical cultivation, the soil surface shouldn't be left uncovered for the winter period and cover crops should be turned down in the spring, in order to increase the nitrogen content of the soil.

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