Environment friendly nutrition supplying and soil cultivation methods applicable in the upper zone of hillside vineyards

Méthodes écologiques de fumure et d'entretien du sol dans la zone supérieure des vignobles en coteaux

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Summary

Somló is Hungary's smallest wine district, however one of the best producing white wines. The majority of vineyard areas are located on the slopes of Somló-hill, situated at the point where the Kisalföld meets Bakonyalja. The upper zone of hillside vineyards was traditionally cultivated by manpower, demanding serious efforts. Nonetheless invested efforts were rewarded by the highest quality, e.g. premium wines. Nowadays machine cultivation also gained ground in these areas. Cultivation by machine had unfavourable effects on the soil in more than one way. Besides ongoing research work focusing on maintaining favourable soil structure extreme weather conditions, dry summers in recent years brought about the necessity to find soil cultivation solutions and technologies able to preserve moisture in soil. In our experiments we have been observing the effects of soil coverage by organic plant debris, turfing and machine cultivation ont the soil and on vines for two vegetation periods. Furthermore we examined the possibilities of N supply in soils with shallow root zone and of unsatisfactory water management in the same area. On the whole for grape growing on such mixed soils of basaltic rubble with shallow root zone, unsatisfactory water management and low mould content it is of primary importance to preserve and maintain adequate moisture and to ensure nitrogen supply among other important nutrients which are provided by the weathering of basalt.

Key words: soil coverage by organic plant debris, mechanic cultivation, turfing, moisture in soil, supply of nutrients

Introduction

Somló is Hungary's smallest wine district, however one of the best producing white wines. The majority of vineyard areas are located on the slopes of Somló-hill, situated at the point where the Kisalföld (plains) meets Bakonyalja (the foot slopes of the Bakony hills). Similarly to other wine districts of the Pannon area the beginnings of viticulture date back to about 2000 years int the Somló district. Apart from Szent-György hill Somló is the only elevation in Hungary where vineyard cultivation is also possible on the northern slopes.

The upper zone of hillside vineyards was traditionally cultivated by manpower, without the aid of machines, demanding serious efforts. Nonetheless invested efforts were rewarded by the highest quality, e.g. premium wines. Nowadays machine cultivation also gained ground in these areas, however the changing market situation, environment protection, the image forming quality of vineyard areas as well as the importance of wine culture in tourism all require researching integrated grape production and oenological technologies in the upper zones of hillside vineyard areas.

The so called terroir has a high impact on grape and wine quality. The use of the term 'terroir' is extremely divers. In viticulture terroir is mainly defined as geographic area, which should be developed better. A terroir concept associated with a study of zones should be adaptable to divers strategies of geographical management. It is vital to specify the characteristics of the spatial resolution, the analytical level and the temporally validity (VAUDOUR, 2001.). From these the influence of soil and climatic components on the overmaturation of Chenin (*Vitis vinifera*) berries was investigated.

The study on the role of site characteristics and the microclimate of the cluster zone was carried out at 5 plots in 1996 and 1997. The variables of the site (soil depth, level of the primary rocks, exposition, altitude, etc.) seem to highly influence the development of ripeness and over-ripeness and explain the marked differences in the composition of the grape berries (BARBEAU et al., 2001.).
Terroir effect on vine vigour, must composition and wine quality was investigated for Cabernet sauvignon during a rainy vintage in a top estate of the Medoc area (Bordeaux, France). Soil was the only variable in this survey. Mild water deficits were observed only on a gravelly soil with a shallow root zone. Nitrogen status varied from deficient to unlimited. Nitrogen deficiency reduced vine vigour to a greater extent than did mild water deficits. The smallest berries, as well as the highest phenolic content for both must and wine, were observed under nitrogen deficiency. Both early mild water deficits and a nitrogen deficiency throughout the growth period were demonstrated to have beneficial effects on the phenolic content of berries and on wine quality. Two combinations of vine water status and vine nitrogen status led to the most highly appreciated wines: a low nitrogen status without water deficits and a medium nitrogen status accompanied by mild water deficits (CHONE et al., 2001.).
In the cultivation systems of environment-oriented grape growing, the protection of the soil and living water including protection against erosion is a major task. But besides the protection against erosion, at habitats that are ecologically dry, like the highlands of Lake Balaton, water saving is also an essential aspect when choosing a definite technology. It has become necessary to develop alternative cultivation and mulching technologies that fulfil the requirements of integrated growing. This could be mulching with organic plant residue, soil covering by sods, and with some restrictions, mechanical cultivation.
Most of the authors recommend the usage of agricultural and communal residue for mulching in grape growing areas where the annual precipitation does not reach the level of 700-800 mm. These materials improve the organic matter content of soils, decrease the danger of erosion and keep the moisture in the soil for the cultivated plant (BASLER, 1992). Similar to this in areas where the annual precipitation does not reach the level of 250 mm or the tilth depth is low, other possibilities must be found to keep the moisture in the soil at the conditions of conventional mechanical cultivation. This can be, for example, covering the soil with straw, bark, foil or with different agricultural organic plant wastage (ZANATHY, 1998; SZABÓ et al. 2001). According to these for example the experiments in South-Australia showed 34% increase in the soil moisture content and 46% increase in the amount of grape production by total covering of the soil (BUCKERFIELD, WEBSTER, 1996). The time for the most efficient spreading of the straw is autumn, while the importance of the method is mainly to keep the winter moisture in the soil. It can be dangerous, because, like the dry grass it is also highly flammable and the power machines can slip on the dry straw layer (NAGY, 1986). If, out of the many positive impacts of covering the soil with organic plant refuse, its effects on structure and moisture was highlighted (VARGA, MÁJER 2004., NÉMETHY et al., 2006.), measuring the soil penetration resistance and moisture with sensing head, found the method of covering the soil (with organic plant refuse) clearly more favourable than the method of sods and mechanical cultivation.
Several authors studied particularly the erosion decreasing effect of mulching by sods in sloping areas (CSIZMAZIANÉ, 1984, ÓVÁRI, 1998. NAGY, 1986), they write about covering the soil of the grape plantations in hilly and mountain areas by mulch. The most important advantage of this method is that it increases the aeration degree and decreases the damage caused by the erosion. But it also has a disadvantage, namely the water demand of the area increases. A specially important task is to decrease or cease the mechanical cultivation in highland plantations next to living waters, such as the grape plantations of the highlands of lake Balaton in Hungary where a significant part is situated in a national park. At the same time, mulching between the rows can cause moisture withdrawal symptoms. Because of the above mentioned reasons, the covering of these areas with environment friendly organic materials which retain the moisture in the soil is a primary task.

Material and method

We started our experiments in Spring 2006 in the upper region of Somló hill in the vineyards of Kreinbacher Birtok Kft. co-operating as partners in a tender (OMFB-00004/2006) with Pannonia Georgikon Faculty of Agriculture, Department of Horticulture and a.m. Kreinbacher Birtok Kft. Vineyard basis of the research work was provided by experiments established in the plots of the

Kreinbacher Estate. One of our experiments focusing on soil cultivation took place in a plot of medium slant of 5 to 8%, where we compared different cultivation methods, whereas the other in a plot of moderate slant of 1 to 2%, where we experimented with nutrition supply. In the course of our experiments we appllied the following treatments:

Soil cultivation experiment: a_1: natural green coverage (haying); a_2: mechanic soil cultivation; a_3: soil coverage by organic plant debris.
All of the three types of treatment were apllied to 5 in-row spaces each, along the whole length of the row, which is equal to an area of 970 sqm per treatment. The experimental plot contained Furmint variety with 1,4x0,8 m distance between rows and vines respectively. It was planted in 2003 with medium high cordon trellising. Green coverage was developed by leaving *spontaneous weed flora tolerating haying*. As to *machine cultivation* of the spaces between rows cultivator and disk were used. Mulching by *organic plant debris* was extended to the entire surface (including rows).

Nutrition supply experiment: b_1: without fertilizer; b_2: applying nitrogenous fertilizer in the concentration of 50 kgs/ha ammonium nitrate agent; b_3: 34 tons/ha organic manure int he first year of the experiment.
Each of the treatments were applied in 3 in-row spaces along the whole length of the row, which is equal to an area of 270 sqm per treatment. The experimental plot contained Olasz rizling (Riesling Italico) variety with 1,5x0,8 m distance between rows and vines respectively. It was planted in 1990 with medium high cordon trellising. For *machine cultivation* of the spaces between rows cultivator and disk were used.

We repeated treatments 4 times in each plot which made statistical analysis possible. In Spring each year we adjusted vine load to 7 buds/sqm. Each year we carried out soil and leaf analysis at blossoming in both experiments in order to characterize eventual changes in plants during vegetation period due to treatments. In Autumn we established the most important vintage parameters (amount of bunch yield, must degree and titratable acidity).

Results and Discussion

Comparing soil cultivation methods

Results of soil analysis

Carrying out chemical analyses of soil samples we obtained differences of assessable measure only in the case of mineral nitrogen content, therefore these are the only data presented when discussing analytical results at blossoming. The same tendency could be observed also at harvest results, however due to limited space we present only results obtained at blossoming.

Treatment	Mineral nitrogen content (mg/kg) 2006			Mineral nitrogen content (mg/kg) 2007		
	0-30 cm	31-60 cm	Average of 0-60 cm	0-30 cm	31-60 cm	Average of 0-60 cm
Mulched	10,57	7,38	8,98	3,25	6,27	4,76
Mechanic	12,57	7,75	10,16	7,84	4,46	6,15
Turfed	9,02	10,53	9,78	7,58	3,27	5,43
$SD_{5\%}$	0,48	1,70	1,09	0,03	0,02	0,02

Table 1 N content of soil during blossoming (Badacsony, 2006-2007.)

We obtained the best results regarding changes in *mineral nitrogen content* by *machine cultivation*. Nitrogen supply level is lower in the case of turfed plots and even lower on plots mulched by organic plant debris. We observed significant differences between *mulched* and *machine cultivated* plots in the average of 0 to 60 cm in 2006, and both *soil covering methods* showed proven difference from *machine cultivation* in 2007 (3rd Table). Nitrogen fertilizer strewed in Spring on the surface of soil

mulched by organic plant debris fairly well compensated pentosan effect, whereas low nitrogen level measured in *turfed* plots was the result of intensive vegetative development (plus additional demand) caused by springtime rains.

Harvest results

2006 yield was heavily determined by the amount and distribution of precipitation as well as extreme rains and cool weather in August. Assessing vintage results (16.10.2006) it can be ascertained that the highest yield was obtained from plots *mulched by organic plant debris*, the lowest from *machine cultivated* plots (2nd Table). Regarding quality of yield all three treatment show significant differences. Highest values of both *titratable acidity content and must degree* were obtainbed from plots *cultivated by machines*. Differences in acidity levels among treatments cannot be proven statistically. Decrease in must degree in the case of plots *mulched by organic plant debris* can be explained by cooler, more humid microclimate.

The amount and distribution of rainfall, frequent occurrence of dry days of extreme heat as well as the excessive rainfall at the end of August together with cooler September weather significantly determined the quantity of the crop in 2007. Assessing vintage results (3.10.2007) it can be ascertained that the highest yield was obtained from plots *mulched by organic plant debris*, the lowest from plots with *natural green coverage* (4th Table). All three treatments show significant differences with respect to qualitative parameters. Regarding *levels of acidity and must degree* we obtained the highest results on *covered plots*. Differences in acidity levels among treatments can statistically be proven. Increase in must degree on the one hand and decrease in levels of acidity are due to extremely hot and dry weather compared to 2006.

Treatment	**Must degree Kl°**		**Titratable acidity of must g/l**		**Bunch-yield kg/m²**	
	2006	**2007**	**2006**	**2007**	**2006**	**2007**
Covered	16,7	18,3	9,17	7,52	0,18	0,44
Machine cultivated	17,3	18,1	9,38	7,26	0,15	0,42
Turfed	17,2	17,8	9,16	6,85	0,16	0,41
$SD_{5\%}$	0,69	0,22	0,85	0,13	0,06	0,03

Table 2Table Results of experiments on soil cultivation methods Somló, 2006-2007

Results of nutrition supply experiment

Results of soil analysis

Carrying out chemical analyses of soil samples we obtained differences of assessable measure only in the case of mineral nitrogen content, therefore these are the only data presented when discussing analytical results at blossoming. The same tendency could be observed also at vintage-time results, however due to limited space we present only results obtained at blossoming.
Regarding changes in *mineral nitrogen content* we obtained the best supply levels related to treatments with fertilizers. We observed lower mineral nitrogen levels on plots treated with manure and even lower on *control* plots. Significant differences were observed among types of treatment in both years; influence of both the application of chemical fertilizers and manure could be proven compared to *control* plots (3rd Table). Low mineral nitrogen level on plots treated with manure in the second year indicates the nitrogen need induced by the decomposition of organic material.

Treatments	Mineral nitrogen content (mg/kg) 2006			Mineral nitrogen content (mg/kg) 2007		
	0-30 cm	31-60 cm	Average of 0-60 cm	0-30 cm	31-60 cm	Average of 0-60 cm
Control	8,28	4,88	6,58	3,84	2,79	3,32
Manure	15,01	7,56	11,29	4,51	3,29	3,9
Fertilizer	17,06	6,31	11,69	7,36	7,45	7,41
$SD_{5\%}$	0,62	0,49	0,56	0,04	0,02	0,03

Table 3Table Mineral nitrogen content of the soil at blossoming (Badacsony, 2006-2007.)

Harvest results

Both the amount and distribution of rainfall as well as excessive rains and cool weather in August heavily influenced the amount of yield in 2006. Assessing harvest (16.10.2006) results it can be ascertained that the highest yields could be obtained from plots treated with *nitrogen fertilizer* (4th Table), the lowest yield from *untreated control* plots. No significant differences could be experienced among treatments. Best results were obtained in the case of acidity levels from plots treated with *manure*, in the case of must degree from *control plots untreated*. Both manure and chemical fertilizer had a retarding effect on ripening. Both *manure and chemical fertilizers* caused an increase in acidity levels. Differences among treatments cannot be proven statistically.

The amount and distribution of rainfall, frequent occurrence of dry days of extreme heat as well as the excessive rainfall at the end of August together with cooler September weather significantly determined the quantity of crop in 2007. Assessing harvest (2007. 10.03.) results we can ascertain that highest yields were obtained from plots *treated with manure* (4th Table), lowest results are provided by *control plots untreated*. No significant differences could be experienced among treatments. Highest values were obtained from plots treated with manure regarding acidity and from plots treated with nitrogen fertilizer regarding must degree. As to *titratable acidity level* both manure and chemical fertilizer had an increasing effect. Differences in levels of acidity among treatments can be positively proven statistically in favour of treatment with manure.

Treatment	Must degree Kl°		Titratable acidity level of must g/l		Bunch-yield kg/m²	
	2006	2007	2006	2007	2006	2007
Control	18,5	17,9	7,08	4,75	0,81	0,95
N fertilizer	17,1	18,3	7,53	4,76	0,97	1,10
Manure	16,7	18,1	7,74	5,75	0,93	1,14
$SD_{5\%}$	1,81	0,5	1,1	0,55	0,21	0,35

Table 4Table:Harvest results of nutrition supply experiment (Somló, 2006-2007.)

Conclusion

On the basis of the results of soil cultivation experiments it can be assessed that mulching the soil with organic plant debris resulted in increased yield in both years, which can be explained by better water management of the soil. Chemical analyses brought to light significant differences in the nitrogen content of the soil. Additional need for nitrogen could be measurably experienced in the case of soils mulched or covered by natural greens.

The most important result of the experiment on nutrition supply is that both manure and ammonium nitrate fertilizer provided for increased yield in both years compared to control plots and this is also statistically proven.

Titrable acidity levels of must increased in both years as an effect of treatments with both manure and chemical fertilizer. In a dry vintage (2007) soil covering resulted in the increase of titratable acidity as compared to machine cultivated plots.
On the whole for grape growing on mixed soils of basaltic rubble with shallow root zone, unsatisfactory water management and low mould content from the point of efficient grape growing it is of primary importance to preserve and maintain adequate moisture and to ensure nitrogen supply among other important nutrients which are provided by the weathering of basalt.

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