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THE EFFECT OF COVERS ON THE VINEYARD SUBSOIL TEMPERATURE

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Abstract

Cropping covers are used in an attempt to promote the growth of cultivated plants, and to raise ground temperature. Their usage has achieved a raise of several degrees in soil surface temperature, compared with bare ground. This is especially important to grape vine cultivation in cooler climates. The study set out to find out how much black plastic ethylene foil, transparent greenhouse plastic and south facing wall of a building raise subsoil temperature. The measurements were made using waterproof temperature loggers set in the ground at 40 cm depth in Tuusula community, in the Helsinki region (60°24’N; 25°01’E).

This area is located at the northern rim of the European hemiboreal vegetation zone. The temperature loggers recorded the soil temperature eight times a day, throughout the year. The measurements showed that these covers did not raise the vineyard subsoil temperature significantly in comparison with grass cover or bare ground, but subsoil temperatures made at the building wall were significantly lower ($P<0.05$) than all the others. Based on the results, the covers used did not have a significant effect on soil temperature when applied to vines planted in 40 cm depth which is used in the North, nor did growing by the wall bring the advantage commonly believed in.

Key words: Nordic viticulture, cropping covers, subsoil temperature, greenhouse effect.

INTRODUCTION

In the Baltic Sea environment, from 55°N to 60°N latitude, cultivation of grapevine is limited by the relatively short growing period of 180 to 200 days (Rötzer and Chmielewski, 2001). The harmful effects it causes to the vine are attempted to be mitigated at the start of the growth season by black plastic polyethylene foils and frost gauzes spread over the earth surface, by growing vines in unheated greenhouses, by using grass and straw covers, by taking advantage of outer walls of buildings, and by utilizing cover structures and tunnel growing (Sölva, 1970). Black plastic polyethylene foils have proved to be an efficient growth promoter, especially in cultivation of young vines. The raise the topsoil temperature by 3ºC to 4ºC, retain moisture, and promote the growth of roots and sprouts (Bauer, 2002; Ibanez et al., 2011).

Inside unheated greenhouses covered with greenhouse plastic foil, the topsoil remains snow free throughout the winter. There the bare topsoil absorbs the sun’s radiation energy more efficiently than open ground which in the north can still be covered by a layer of radiation reflecting snow even in the beginning of April. The greatest reason for the earlier warming up of the unheated greenhouses during spring is the same as for nature’s greenhouse effect, in other words the transparent greenhouse plastic let’s through short wave solar radiation, but not as much long wave infra-red or heat radiation, so the temperature inside the greenhouse raises (Schroeder, 2000). Due to this, in unheated greenhouses the growth of vines starts 2 to 3 weeks earlier in spring than on open ground. The downside is that during summer their internal temperature may raise up to 55ºC which is dangerously high for grapevine; but this may be from time to time used to terminate pest causing vegetable diseases (McGullock, 1978).

During spring, the warming of topsoil in greenhouses and on open ground has been improved by watering the soil with warm water, so that the soil will warm up earlier, and the start of growth becomes quicker and more efficient. In vineyards of the Southern Finland, the warm cooling water of nuclear power stations has been utilized for this purpose. By channelling it to the soil of the vineyard nearby the power station it has been possible to achieve an increase of 1ºC to 2ºC in both the soil temperature and growth location air temperature, and the earlier start of the growth period by 2 to 3 weeks (Karvonen, 2002). In cool climate the use of building walls and protective structures has been considered a factor in improving vine growth, because these protect against cold winds, and because the snow layer accumulated in them prevents the soil from freezing. During winter, a 60 cm to 70 cm thick layer of snow is a good protection for vines, since underneath it the temperature is – 0.5ºC to –1.5ºC, even when it's –25ºC outside (Karvo-nen, 2013). The importance of growth tunnels for vine growing is comparable with unheated greenhouses, but their use in Southern Finland has been marginal.

There are several studies about the effects of coverings on the soil and topsoil temperature, but their effects on subsoil temperature has received less attention. The purpose of this study is to find out the effects of coverings on vineyard subsoil temperature in the Baltic Sea environment at the commonly used 40 cm vine planting depth, and whether there is significant difference between the various coverings. In addition, the object was to discover, if the conditions of building wall frontages significantly raise the subsoil temperature in comparison with coverings at 40 cm depth.

MATERIALS AND METHODS

The measurements were made in Tuusula, in the Helsinki region (60°24'N; 25°01'E), circa 20km away from the sea coast, at a vineyard located at level open ground, and at the southern wall of a house located in the immediate vicinity. This area is located at the northern rim of the European hemiboreal vegetation zone. In 2014 the mean annual air temperature was 7.2°C, the annual precipitation was 652 mm, and there was permanent snow cover of 2 cm to 33 cm in February only. The wines were planted in the depth of 40 cm with row spacing of 150-200 cm and plant to plant spacing of 200 cm on sandy clay soil with high organic matter content of 6-8% and pH ranging from 5.8 to 6.2. The soil at the building wall was sandy soil with less organic matter.

The metering areas of 25 m^2 located on open ground were: soil covered with black plastic polyethy-lene foil, soil covered with transparent colourless greenhouse plastic foil, the bare and grass covered soil of the vineyard, and the bare soil at the building's southern wall. The subsoil temperatures of the measurement areas were measured at the depth of 40 cm round the year (1 January 2014 to 31 December 2014), every third hours, by using water resistant temperature loggers (Thermo Button 21G, Proges-Plus, France) which registered and stored the temperatures. At this depth, a total of 2920 temperature registrations were completed in each measurement area during one year.

The temperature registrations of the measurement areas were analyzed and compared with subsoil temperatures from uncovered soil and from the building wall front at 40 cm depth, using identical loggers, and with each other. A statistical treatment was completed with a Student t-test: $t = \frac{\bar{X}-\bar{Y}}{V^{1/2}}$. As part of the t-test, $\bar{X}$ was the mean value of the variables, and $\bar{Y}$ was the mean value of the other variables, and V an estimate of the variance of random error. P<0.05 was used to estimate statistical significance.

RESULTS AND DISCUSSION

In vineyards plastic foils and cold greenhouses have be used to prevent damage by birds, pests, hail, storm, and too high or low temperatures, to remove weeds, and to increase harvest quality and quantity. The use of plastic foils has been increased and become more versatile since the 1960 s (Branas, 1969; Rader, et al., 2013). In northern vine growing, they are mainly used to increase topsoil temperature, to extend growth season, and to protect the vines from stress and root and sprout freezing cause by the cold. In pest control, they have no relevance, as the common fungus and pest diseases prevalent in the Central European vineyards are rare in the north for the time being.

In earlier studies, a black 0.07 mm thick black plastic foil has been found an effective growth enhancer of 1 to 2 year old vines. It retains the soil moisture and raises soil surface temperature (Sölva, 1970; Bauer, 2002). In this study, the effect of black plastic polyethylene foil on subsoil temperature at 40 cm depth of planting was followed throughout one year. At this depth, the variations of soil temperature were significantly smaller than the temperature variations in air and grass covered topsoil, and the soil temperature there rose to its maximum with a delay of almost two months in comparison to air and topsoil temperature (Fig. 1).

The results showed that a 40 cm thick layer of soil makes a good insulation against cold and heat, since only the black plastic polyethylene foil caused on uncovered soil only a minor annual temperature raise of 0.4ºC which, however, is statistically significant (P<0.05). On the other hand, black plastic polyethylene foil had no significant effect on grass covered subsoil temperature. Similarly, there were no significant differences between the temperatures of soil covered by black plastic polyethylene foil and greenhouse plastic foil (Tabl. 1 and 2) and (Fig. 2). Long-term temperature averages between soil layers are generally quite small, only 0.20 to 0.25°C/10 cm (Karvonen, J. Own observation, 2015). The smaller effect of coverings on grass covered subsoil temperatures may be due to the grass growth dividing equally soil temperature in all seasons. In winter this is also affected by the snow bound in the grass growth.

Glossy surfaced greenhouse plastic foil does not absorb solar radiation energy the same way as black plastic polyethylene foil, as it reflects part of it back due its glossy surface (Geiger et al., 2003). Its warming effect is shown only as material in greenhouse walls. Greenhouse plastic foil allows in the early spring short-wave solar radiation energy to pass through, and prevents the exit of long-wavelength ultraviolet radiation and convection, so that the temperature of a greenhouse will rise, and the growth season can be extended by 10 to 40 days (Novello and de Palma, 2008). Penetration of radiation can be improved, and a significant effect on the concentration of anthocyanins and other phenol compounds can be made by using different colour greenhouse plastic foils on the greenhouse walls and ceiling (Todic et al., 2008).

The different effect of coverings and soil surfaces on soil temperature is caused by their different albedos (Ångström, 1926).The albedo of bright and transparent plastic is strong, so when spread over soil, it does not raise the soil temperature. Likewise, the physical qualities of the soil have an effect on the albedo. The albedo of humus rich organic soil is during summer days 8% to 12%, the albedo of grass covered soil is 10% to 15%, and of light-coloured mineral soils 15% to 20%. According to Geiger et al. (1961), the black surface of soil (cf. black plastic foil), on a midsummer sunny

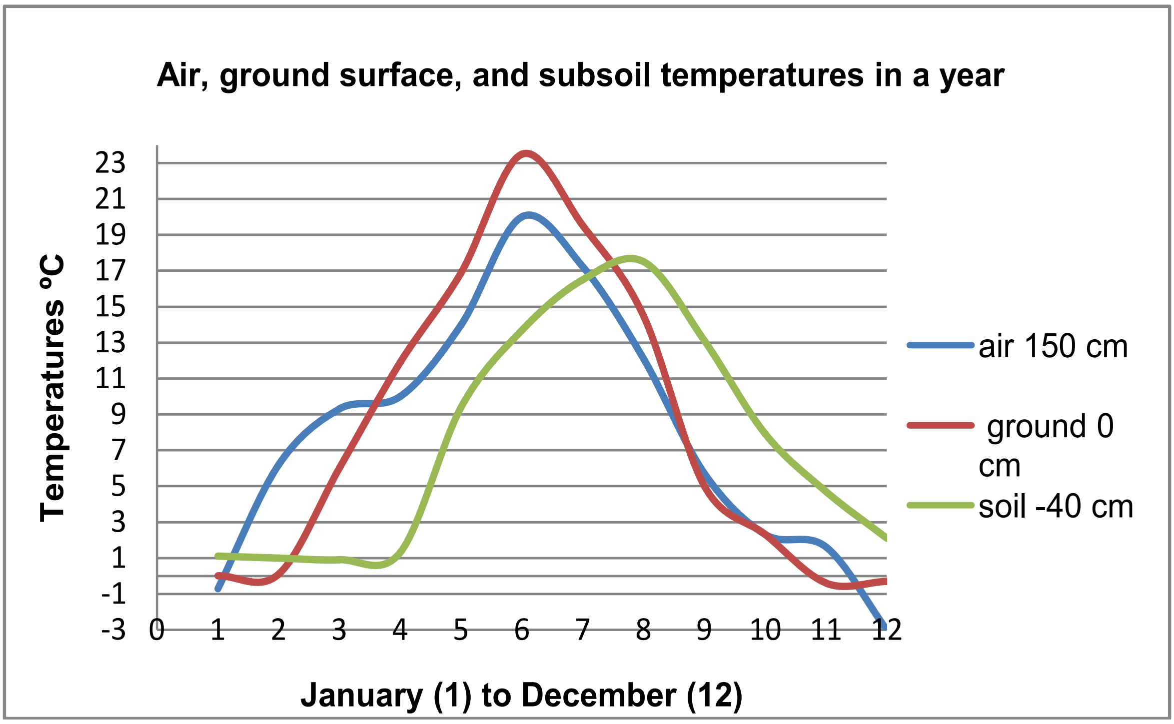

Fig. 1. Changes in air, grass covered ground, and soil temperatures in a year

Table 1. Subsoil temperatures measured throughout the year, at a depth of 40 cm in a vineyard under black plastic foil, plus under transparent greenhouse plastic foil, alongside the wall of a building, and grass-covered and bare vineyard grounds

	Black plastic foil	Greenhouse plastic foil	Building wall	Vineyard ground	
				grass cover	bare ground
Temperatures	ºC	ºC	ºC	°C	°C
Mean	7.52	7.34	6.23	7.43	7.14
SD	6.11	5.99	5.35	6.17	5.68

day, raise the soil temperature at 1cm depth by 6%, and light surface of soil (cf. greenhouse plastic foil) lowers it by 8%, in other words, the coverings may be used both to raise and lower soil temperature.

The southern wall of a building is usually considered as warmer location than its surroundings. This is affected not only by the direction of the wall (Jackson, 2008), but also the soil surrounding the building, which is often sand or gravel due to construction engineering reason. In a sandy topsoil the albedo is stronger and the sun's radiation energy is absorbed less to the subsoil. This may explain why the subsoil temperature at the foot of a building wall was, with the exception of winter and early spring months, lower than in grass covered and bare subsoil (Tabl. 2; Fig. 2). The cooling effect of the foot of a building wall may be similar to the cellar. Despite this, the air temperature by the wall may be higher than elsewhere around the building, this may in turn be affected by the wall surface colour in the same way as the colour of greenhouse plastic foil and the lessened effect of wind.

Table 2. The statistical significance between mean annual temperatures measured under covers, on open vineyard ground, and alongside the wall of a building at a depth of 40 cm

Cover and building wall	Vineyard ground	n	t	P	Significance
Black plastic foil	Bare ground	2920	2.4627	<0.05	s
Greenhouse plastic foil	Bare ground	2920	1.3089	>0.05	ns
Building wall	Bare ground	2920	6.3063	<0.05	s
Black plastic foil	Grass cover	2920	0.5604	> 0.05	ns
Greenhouse plastic foil	Grass cover	2920	0.5660	> 0.05	ns
Building wall	Grass cover	2920	7.9418	< 0.05	s

n = sample size, s = statistical significant; ns = no statistical significant

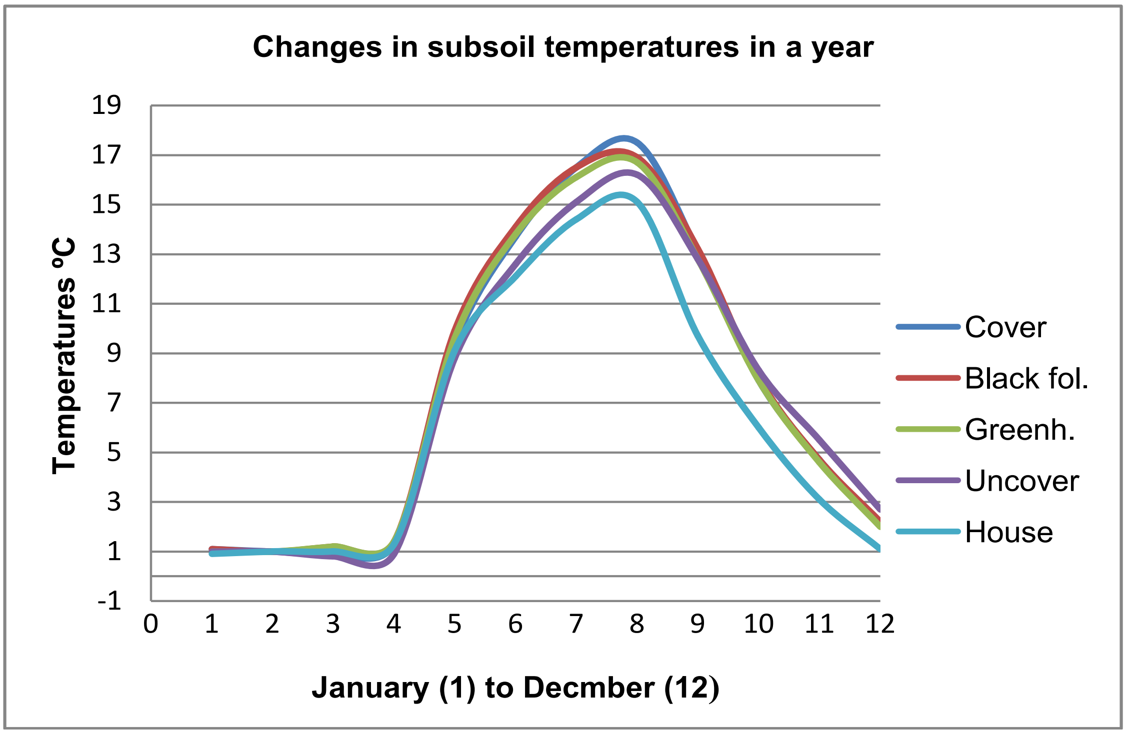

Fig. 2. *Vineyard subsoil temperatures at a depth of 40 cm under grass cover (shown here as 'cover'), black plastic foil ('Black fol.'), greenhouse plastic foil ('Greenh.'), bare ground ('uncover'), and alongside the wall of a building('House')*

CONCLUSIONS

Coverings, greenhouses and various protective structures may be used to raise or lower the vineyard surface and topsoil temperature according to the requirements of the growth season. This study compared the effect of black plastic polyethylene foil, greenhouse plastic foil, grass covered and bare ground on the vineyard subsoil temperature as the annual mean temperature values. Only black plastic polyethylene foil significantly raised the soil temperature at the depth of 40 cm ($P<0.05$). Contrary what is commonly believed, the annual mean temperature of building wall soil was significantly ($P<0.05$) lower than the annual mean soil temperatures of foil covered, grass covered and bare ground.

REFERENCES

Bauer, K., 2002. In: Bauer, K.: Weinbau. Österreichischer Agrarverlag, 7., aktualisierte Auflage, 116.

Branas, J., 1969. Concerning the use of plastics. Procres Agricole et Viticole 86: 63–73.

Geiger, R., R. Aron, P. Todhunter, 2003. The Climate Near the Ground. Rowman and Littlefield Publishers, Lanham, MD, USA, 6th edition, 16, 143–213.

Ibanez, S., J. Perez, F. Peregrina, E. Garcia-Escudero, 2011. Utilication de Cubiertas Vegetales en Vinedos de la D.O.Ca. Rioja (Espana). Bulletin de l´OIV 84: 247–256.

Jackson, R.S., 2008. Site Selection and Climate, In: Wine Science. Academic Press, London, UK, 3th edition, 239–269.

Karvonen, J., 2002. Outdoor viticulture in Finland. Thesis, Häme Polytechnic, Mustiala, Finland, 39–48.

Karvonen, J., 2013. Effect of snow layer on ground surface temperature in cool wine-growing regions. EJPAU 16.

McGullagh, J., 1978. The Solar Greenhouse Book. Emmaus, PA, Rodale Press, 1th edition, 240, 256.

Novello, V., L. de Palma, 2008. Groving grapes under cover. Acta Horticulturae 785, 353–362. DOI: 10.17660/Acta Hortic. 2008. 785. 44.

Rader, J., D. Handeen, S. Virajita (editors), 2013. Cold Climate Greenhouse Resource. In: A guidebook for designing and building a cold-climate greenhouse, University of Minnesota, 24.

Rötzer, T., F. M. Chmielewski, 2001. Phenological maps of Europe. Climate Research 18, 249–255.

Schroeder, D.V., 2000. An Introduction to Thermal Physics. Addison-Wesley, San Francisco, California, 305–307.

Sölva, J., 1970. Abdecken mit Plastikfolien im Winbau. Obstbau und Weinbau (2) 7: 37.

Todic, S., Beslic, Z., Vajuc, A., Tesic, T., 2008. The effect of reflective plastic foils on berry quality of Cabernet Souvignon. Bulletin de ÍÓIV 81: 165–170.

Ångström, A., 1926. The albedo of various surfaces on the ground. Monthly Weather Review 54 (11): 453.