

Effective Ways to Improve Agro-Ecological Conditions of Vine – Kakheti Region

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Abstract: The aim of our research was to improve the agro-ecological conditions of viticulture in Kakheti region in the way of changing the physical properties of soil. As it is well known, the climatic conditions and soil peculiarities determine the quality of the produced grapes and wine. Academician F. Davitaia mentioned that the species of vine and the place of their growth are reflected in the wine as in the mirror [4]. Research is based on the method of Italian Professor M. Frigon – “The impact of black soil on the vine”. The Chernozems regulate vegetative and reproductive processes of the plant, support growing of roots. By this activity vegetation period is changing, air temperature is increasing and roots are growing intensively. The experiment was held in one vineyard plot of Telavi municipality. 20 cm thick alluvial material of the Duruji River was added to the soil. The dark cleavingstone has enriched the soil and improved its airing. There were many gray pebbles and small stones in waste material, which supported increase of growing degree days by 300-400°C in vegetation period. As a result, the grape harvest has increased and tasting properties of grape has improved. The experiment showed that river material improves agro-ecological conditions of the vine, increases its productivity and improves wine quality.

Keywords: Georgia, Kakheti Region, Alluvial Material, Agro-Climatic Condition, Growing Degree Days

1. Introduction

Climate is a complicated complex of meteorological factors from which thermal conditions and atmospheric precipitation can be distinguished as they determine type and quality of wine. We carried out certain works in this direction in the Shida Kakheti region (Figure 1). The main goal of our research was to study the influence of soil conditions according to the Fregoni method [5]. We examined Napareuli and Kindzmarauli viticulture micro zones, where the soils are nourished with Duruji River alluvial material. To improve agro-ecological conditions of vine in Shida Kakheti we recommend to use Duruji River's alluvial material for

enrichment of soil.

2. Methods and Materials

The object of our study is the plain areas and foothills of Shida Kakheti located at 300-600 m above sea level. These territories are characterized by favorable agro-ecological conditions for production of a high quality wine grape. Here are unique micro zones of Kindzmarauli and Napareuli, where the excellent wine material is produced, the best one in Georgia and well known in the world. We think that the unique agro-ecological conditions of this place are created by the decomposed material carried down by the

Duruji River. Micro-zones of Kindzmarauli and Napareuli vineyards are created on the debris cones of Duruji River. The soil of this area is naturally covered by the alluvial material of the river.

Our goal is to widen this area by means of bringing artificially the alluvial material of Duruji River into the plain and foothills of Shida Kakheti [1].

The climate in Shida Kakheti significantly differs from the climate of other places located in the same altitude of the eastern Georgia. Here the climate is moderately humid subtropical and is characterized with hot summer and moderately cold winter. The climate and soil are favorable for the development of agriculture; viticulture of this place is characterized with wines famous in the world.

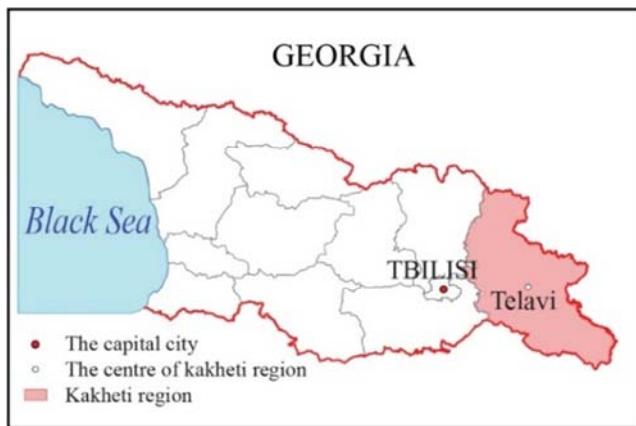


Figure 1. Schematic map of Georgia.

Sunshine duration exceeds 2300 hours per year. The total solar radiation on the left bank of Alazani River is less and makes up 110-120 kkal/cm², but on the right bank - 120-139 kkal/cm². It is caused by the increased cloudiness on the left side. The radiation balance on the right side is more than 51 kkal/cm² [6].

The average annual air temperature in Shida Kakheti is high and varies in the range of 11-13°C; the coldest month is January; the temperature is 0°C-1°C. The warmest months are July and August; both months are equally hot and the average air temperature is 23,6°C. The average daily amplitude of air temperature is over 9.5°C in summer and autumn; the average annual amplitude is about 23°C. The average absolute maximum of air temperature is 35°C, absolute maximum is 38°C; the average absolute minimum is -11°C, while absolute minimum is -23°C.

Average daily air temperature reaches base temperature 10°C in 5-th April and the commencement of autumn is marked on November 4th. Therefore, the vegetation period lasts for 212 days. In the mentioned period growing degree days exceeds 4000°C on average. Autumn is a warm period, which is very important for rising of sugar content in grapes.

The sum of annual atmospheric precipitation is 1070 mm. The minimum amount of precipitation is 40 mm in winter (January), maximum 181 mm (May), in the cold

period the amount of precipitation is 265 mm, in the warm period 805 mm. The number of precipitation days is 132 days per year.

The average annual relative humidity is 72%; in the driest month (August) it makes up 64%; in the same month from 13 o'clock the low relative humidity is 48%.

The winds mainly blow along the gorge in the region. Prevailing winds are of north and northeast direction in the cold period of the year, while south and south-west direction in summer. From the south (Azerbaijan) summer winds are bringing the additional warmth, enhancing the temperature conditions in the region. The average annual wind velocity is not high and makes 1.2 m per sec.

The number of hail days in Shida Kakheti is 2.1. Hail days are most frequent in May (0.9 days); in other month of vegetation period this number varies between of 0.1-0.3 days [6]. We recommend to use hail protection netting for hail protection.

3. Result and Discussions

The variety of the Georgian wine is mainly caused by the specific physical-geographical conditions of the country.

Vine belongs to the small group of agro-cultural crops, and wine produced from it is sensitive to the changes of environmental conditions. Species of the vine and the place of its growth are reflected in the wine as in the mirror. The wine Saperavi produced in Kakheti is quite different from the wine produced from the same species of grapes in the Crimea.

Shida Kakheti is located between the Caucasus, Gombori range and Iori plateau; such gentle and soft climate is not observed anywhere in eastern Georgia. This natural condition is the basis for a prosperous economy of Kakheti. Wine produced in this area is famous in the world for its wine bouquet [3].

Besides the climatic conditions the quality of the produced wine depends on the soil. The soil does not only supply vine with the necessary nutrients, but at the same time it has a great influence on the aromatic and taste properties of the wine produced from the grapes grown there. Soils (alluvial noncalcareous soil, calcareous clay soil, brown forest soil and brown forest acid soil, meadow grey cinnamonic soil) in Shida Kakheti are favorable for growing of unique species of grapes. Particularly high quality aromatized table wines are produced from grapes grown on the south foothills of the Greater Caucasus and especially on the detrital cones of the river.

Duruji River basin is developed on the south slope of the Greater Caucasus range within the Kakheti region. Duruji River is represented by the 2 river arms in the headstream – the Shavi Duruji River and the Tetri Duruji River. Their outlets are in the alpine zone. The Shavi Duruji River has bigger exposures than the Tetri Duruji River. The height of its exposed banks is in the range of 500 m -1000 m, the width is over 4 km. The banks are formed by clay slates of the Lower Jurassic period and are intensively weathered. On the exposures of the Shavi Duruji River, especially on Shavi

Klde, there are developed long and wide hollows, in which the exposed solid materials are continually moving down. A large amount of the weathered loose material is also accumulated in the Tetri Duruji River bed (Figures 2, 3, 4, 5).



Figure 2. Source of the Duruji River – Shavi Klde.

The micro zones of Kindzmarauli and Naphareuli vineyards include detrital cones of the Duruji River. The detrital material is creating the unique conditions for producing wines of high quality.



Figure 3. The Shavi Duruji River.



Figure 4. Alluvial material of the Duruji River.



Figure 5. Alluvial material of the Duruji River.

The detrital cone of the Duruji River, covered with blackish slates (area of $10 \times 6.5 \text{ km}^2$) is considerably heated by the solar radiation during a day. The same can be said about the gorges of the Chelti and Bursa Rivers. For this reason, in this micro zone the soil temperature and air temperature are by $2-3^\circ\text{C}$ higher than the temperature of the adjacent places. On the other side of Alazani River there are Napareuli, Kindzmarauli and Kvareli micro zones famous for their high quality wines.

Viticulture micro zone of the wine Napareuli is located between the left bank of Alazani River and the southern slope of the Great Caucasus range of Kakheti part within the altitude of 350-500m. Here the growing degree days ($\sum t > 10^\circ\text{C}$) on average is in the range of 3980-3780 $^\circ\text{C}$. In the micro zone on the altitude 300 m growing degree days on average is 4250 $^\circ\text{C}$. The naturally semi-sweet wine is getting from Saperavi material in 70% of the years, i.e. 7 times per 10 years; at the 400 m height micro zone – the naturally semi-sweet wine material can be got in 25% of years, i.e. once per 4 years; at the height of 500m the naturally semi-sweet wine material, which is produced in case of accumulation of the heat more than 4000 $^\circ\text{C}$, can only be got in 10% of the years, i.e. once per 10 years.

Along the left bank (on the other side) of the Alazani River, the alluvial soils are created in the elevated areas. There are forest brown and chestnut soils. In the micro zone the average monthly air temperature is 12.4°C , the hottest months' (July, August) monthly air temperature is over 23°C , the sum of annual precipitation is 845mm, in the vegetation period it is 630mm.

To get the wine material of Napareuli brand, the vintage of Saperavi grapes is gathered, when its sugar content is over 19%. It was created in 1890 and was awarded gold (7), silver (4) and many bronze medals [1].

The micro zone of the wine Kindzmarauli is located in the Duruji River gorge, the left tributary of Alazani River, in the flattened area, sloped by $3-5^\circ\text{C}$ to the south of the Greater Caucasus range of Kakheti. The detrital cone brought down by the Duruji River (area is $10 \times 6.5 \text{ km}^2$) is covered with blackish slates.

It is heated by the solar energy during a day. In this micro zone the soil temperature and air temperature are by 2-3°C more than the temperature of the adjacent places. The growing degree days accumulated in the micro zone of Kindzmarauli reaches 4150°C on average. In this case, the total amount of heat is in the range of 3850°C (95%) – 4400°C (10% of the years). In the micro zone, the base sugar content is over 22%, it often exceeds 26-27% and the acidity is 5-7 g/dm³.

The natural peculiarities of Kindzmarauli micro zone, its climate and soil are preconditions for production of the famous brand of Kindzmarauli. Apart from Duruji River gorge, the similar wine brands can be produced in the specific zones of Chelti and Bursa River gorges. Kindzmarauli brand was planted in 1942. The wine was awarded by 5 gold medals, 7 silver medals and many bronze medals.

We assure that the high quality of wines produced from micro zone of Kindzmarauli and Napareuli are mostly due to the influence of the decomposed material of the Duruji River covering the soil of the above mentioned territory. In order to prove this idea, we carried out a certain experiment.

We were interested in micro zones of Napareuli and Kindzmarauli and in 2010 we brought the detrital decomposed material of Duruji River into one vineyard (50 m²) of Telavi. The result was successful: the soil temperature increased by 3-4°C. The blackish slates enriched the soil, improved its aeration and had a positive effect on taste properties of grapes. We assume that the same thing can be done for the large area. We offer to spread drift material into the vineyards. It will raise the average daily air temperatures sum by 300-400°C, the average soil temperature – almost by 3-4°C; it will improve the soil aeration and have positive effect on taste properties of grapes and the quality of wines.

According to our research carried out in 2014, there is a high correlative relationship between the wine quality and the temperatures sum over 10°C [2].

The decomposed material brought by us into the vineyard of Telavi, was heated 4-5°C more especially at noon. In the morning before sunrise its temperature was equal to the soil temperature of the adjacent plot of land. In the trial plot the surface (at the height of 2m) air temperature in the windless weather was more than the air temperature of the adjacent plot of land by 2-3°C on average, which is responsible for the increase of the sum of the heat by 200-300 in the vegetation period, which, as it is seen from Table 1, will improve the wine quality.

Table 1. A 12 – Point system of defining the wine quality by temperatures sum over 10 in the period of vegetation.

Quality in points	Temperature range °C	Quality by 4 grades
1	<3280	
2	3280-3440	Bad
3	3445-3560	
4	3565-3645	
5	3650-3700	Average
6	3705-3740	
7	3745-3770	
8	3775-3805	Good
9	3810-3840	
10	3845-3900	
11	3905-3980	Very good
12	>3980	

We believe that the next approach to improve the agro-ecological conditions for vine in Shida Kakheti shall be battling the hail. Hail is one of the most hazardous natural disasters; it mechanically damages the plant and represents a big problem for the population of our country [2, 7].

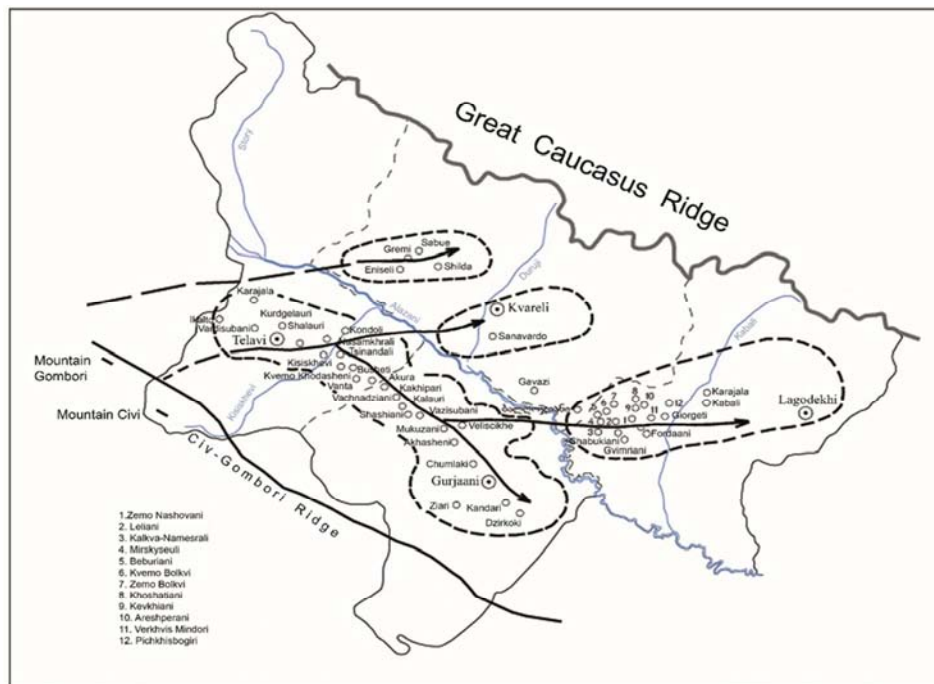


Figure 6. The main directions (→) of hail in Kakheti on the 19th of July, 2012 and the scope of the hailed areas (hatched).

Gombori ridge is a hail source area, which is very hazardous to Kakheti vine. The highest peak of the ridge is Mt. Tsivi (1990m). North-west peaks of the ridge are: Gombori, Satibe and others (1500-1850m). From Manavi Mountain the crest of the ridge is starting lowering to southeast; in the vicinity of Cheremi village its height is within the range of 1200-1300m [3].

Hail in the territory of Georgia is caused by frontal, as well as by local processes. Hail caused by the frontal processes mostly covers larger territories. According to individual observations, hailstones sometimes reach the size of a hen's egg; in some cases, the hail covers the soil like snow with the thickness of several centimeters. Hail processes are mostly observed in mountainous places. A considerable part in these processes are played by orography, vegetation, orientation of mountain ridges to the privileged directions of air flows [4].

In Kakheti agricultural plants, including vineyards, almost every year are being hailed. Vakhushti Bagrationi pays attention to hail in Kartli and does not say anything about Kakheti [10]. It is presumable that during the period of Vakhushti, the big part of Alazani valley was covered with forest, which weakened of air masses vertically ascending flow and accordingly, occurrence of hail. At present with the considerable devastation of forests the probability of hail is increased [11, 2].

In Kakheti, the hail creating processes are not frontal; transformation of water vapor existing in cumulonimbus clouds (Cb) into a liquid or ice crystals is done by dust or other impurities involved in them (condensation nuclei); upon the further vertical movement of air masses (about 1.5-3.0 km), when their temperature is below 0°C. In Kakheti the hail creating sources are peaks of the Gombori ridge (Tsivi, Gombori, Satibe), where the annual number of haily days is up to 4 on average.

Here we want to draw attention especially to the most painful 2012, when vineyards were hailed three times and 11000 ha were damaged. We are discussing the case of July 19 (see Figure 4), when the hail covered a big part of Inner Kakheti and damaged vineyards in the municipalities of Telavi, Gurjaani, Kvareli and Lagodekhi).

On the 20th of August of the same year, the hail was repeated; vineyards were seriously damaged in the village of Kakabeti of Sagaredjo municipality, in the villages Chumlaki and Akhasheni of Gurjaani municipality, in Chkaani and Zenobiani of Kvareli municipality.

On the 23rd of September of the same year, the vineyards in the villages of Kvareli municipality were caught in the hail: Eniseli, Gremi and Sabue. The hail was accompanied by storm. 50-60% of vineyards, which were ready for vintage, were damaged.

In the 60s of the last century, rocket equipments were used in Kakheti for protection of agricultural plants from hail. Upon the influence of the rocket on the clouds the substances crystallizing by lead compounds are very harmful ecologically from the point of view of pollution of the environment and producing pure products. By this reason this

method was banned.

Since the 70s of the last century it has been started to cover vine yards permanently with nets in order to protect them from hail.

Tens of hectares of vineyards were covered with nets in Kakheti. Study of the influence of covering upon the growth and development of vine was started. The agro-ecological department of Georgian Scientific-Research Institute of Gardening, Vinery and Winery was actively involved in the above mentioned activity. Researches were conducted in the village of Manavi of Sagarejo municipality simultaneously on two variants: covered with the net (24X40m²) and controlling (uncovered) variants (Figure 5).

There was revealed the following: radiation intensity of the crown of the vine under covering is decreased by 12%, the direct solar radiation is decreased by 9%, and accordingly the scattered radiation is increasing by 5%. The wind velocity under the net is decreased by 44%; the maximal temperature of the soil surface is less by 2-3°C, minimal temperature is more by 0.5-1.5°C. Such change of the soil surface temperature causes the decrease of its amplitude by 3-4°C. The temperature of the plant it under the covering is higher by 0.5-1.0°C, which can be explained by reduction of aeration.

In the period of technical ripeness, the results for the sweetness of 130-130 kg grapes "Kakhuri Mtsvane" on the test variants were the following: on the controlling variant the sugar content was 18.39%, under the net – 17%, the total acidity on the controlling variant 7.82 g/dm³, under the net – 8.03 g/dm³. The wine material taken from the vintage under the net got a low grade at the degustation.

In order to avoid the quality decrease of grape we think that covering of vine yards with a net must be carried out only in hail hazardous situations. For this reason, a specialized mechanized rule of covering with nets must be applied, for which it is advisable to use capron nets because of their lightness and mobility. As for metal nets, they change agro-ecological conditions of plants, so we think that their usage is not advisable.

According to the results of the analogous research conducted in the village of Vazisubani of Gurjaani municipality researchers conclude that a better temperature regime of the air and the soil is developed under the Capron net, the wind velocity is decreasing and the intensity of evaporation of the moisture from the soil is significantly decreased. The direct solar radiation is decreased by 10%, the scattered radiation is increased by 15-20%. In the end there are creating better microclimatic conditions in the vineyards which favor the better development of the plant. So it is reasonable to introduce this measure (usage of a capron net) widely in practice. So it is reasonable to take steps for implementation of using capron nets in production according to the specialized mechanized rule.

In order to avoid analogous natural disasters in the future, it is necessary to finance agriculture properly to

equip viticulture with special mechanized nets. Continuous covering of vine yards in the vegetation period is not profitable from the agro-ecological point of view. The covering of vineyards is advisable to be carried out by Capron nets only in hail hazardous situations observing a mechanized rule.

4. Conclusions

For improving wine quality and taste properties, we recommend to bring into the vineyard alluvial materials clayfish of the Duruji River.

During the vegetation period the permanent covering of the vineyard with capron nets is not profitable. The covering of vineyards is advisable to be carried out by capron nets only in hail hazardous situations observing a mechanized rule.

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