Acta Geographica Croatica	Volumen 35 (2000.)	67 - 96	Zagreb, 2001.

UDK 911.2:663.2](497.4)

PHYSICAL GEOGRAPHIC CONDITIONS FOR VINE GROWTH IN THE KARST REGION, SLOVENIA

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Abstract:

The paper presents the results of research that focused on dependence of vine growth to physical geographical conditions in the research area of Karst region - geologic, geomorphologic, climatic and soil conditions. Among the conditions the biggest impacts are climatic and soil conditions. We have found that in the case of the research area the geologic conditions are as important as climatic and soil conditions. Vine growth is best in the middle part of the research area, between the villages of Tomaj, Dutovlje in Križ and also in the area of Avber and Komen where specific geological formations cause the better soil quality.

Key words:

Slovenia, Karst, vine, limestone, Chromic Cambisol

FIZIČKO-GEOGRAFSKI UVJETI ZA RAST VINOVE LOZE NA PODRUČJU KRASA, SLOVENIJA

Izvadak:

U radu su predstavljeni rezultati istraživanja utjecaja fizičko-geografskih čimbenika (geološka građa, reljef, klima i pedologija) na rast vinove loze. Uz klimu i tlo, kao najvažnije čimbenike za rast vinove loze, istraživanjima je ustanovljeno da na području Krasa jednako značenje ima i geološka podloga. Vinova loza najbolje uspijeva na središnjem dijelu proučavanoga područja, i to između Tomaja, Dutovlja i Križa te u okolici Avbera i Komna, gdje su specifične geološke osobine pogodovale i nastanku kvalitetnijih tala.

Ključne riječi:

Slovenija, Kras, vinova loza, vapnenac, kromični kambisol

Introduction

The purpose of the research was definition of dependence of vine growth to physical geographic conditions in the Karst area. On the west the research area is limited by the state border between Slovenia and Italy, on the north and northeast with Vipavska valley, on the east by Trstelj hills and on southeast and south by land register units that still have vineyards. The total research area is 30.700 ha large.

Fig. 1, 2: The research area
Sl. 1, 2: Istraživano područje

The geologic and geomorphologic part we mostly studied by the available literature and we have checked the facts on various field studies. The climatic conditions we studied by the available data and we have calculated different indicators, important for vine growth. The field studies included mostly soil examinations and gathering samples of soil that were afterwards analyzed in the laboratory. The GIS program Idrisi we used for cartography and morfometric analysis.

1. Geological conditions

The research area entirely belongs to Trst - Komen anticlinorium that is cut by many faults. One of the biggest leads on the dry valley of Notranjska river, past Divača and toward Opatje selo, where it goes on to the Italian territory. The fault has the dinaric direction and it has cut the top of the Trst - Komen anticlinorium between Kreplje and Brestovica. There we can find the zone of crumbled limestone and dolomite. Because of the faults there are different layers of layered Upper Senonian limestone with quartz among the layers of rudistid Senonian limestone (Buser, 1973).

The oldest strata of the research area are of the Lower Cretaceous period and are positioned between Opatje selo, Veliki dol, Brestovica and Sežana. They are developed as dark-gray bituminous dolomite and limestone. North from Vrhovlje is also a large complex of dolomite breccia with limestone particles. Dolomite is usually massive, only near the contact to limestone it becomes layered. Limestone is dark-gray, dense with shell like breakage and layered (BUSER, 1972; 1973).

Turonian strata are exposed between Kazlje, Kopriva, Komen and Opatje selo and between Vrhovlje and Sežana. Among the strata the dark-gray to light-gray rudistid limestone is developed, together with layers of layered micritic limestone without rudistid remnants. In the area of Komen the dark-gray to black bituminous limestone of Komen is developed. The limestone contains lenses and knobs of quartz and in some parts also thin layers of rudistid limestone. As a result of layered limestone weathering, is a large amount of red soil, which contains lots of quartz. The soil unables the corrosion and in this areas the karst phenomena is much more rare than in the areas of pure limestone without quartz (BUSER, 1972; 1973).

Senonian strata are developed between Štorje, Tomaj and Dutovlje. They are present in the form of rudistid granular limestone that is usually layered. The lower part of the strata presents the white granular limestone that consists of rudistid remnants and points of sea urchins (type of marble from Nabrežine). Above them is positioned the thinly layered, partly bituminous limestone with lenses and knobs of quartz. The limestone resembles the Komen limestone. The Upper

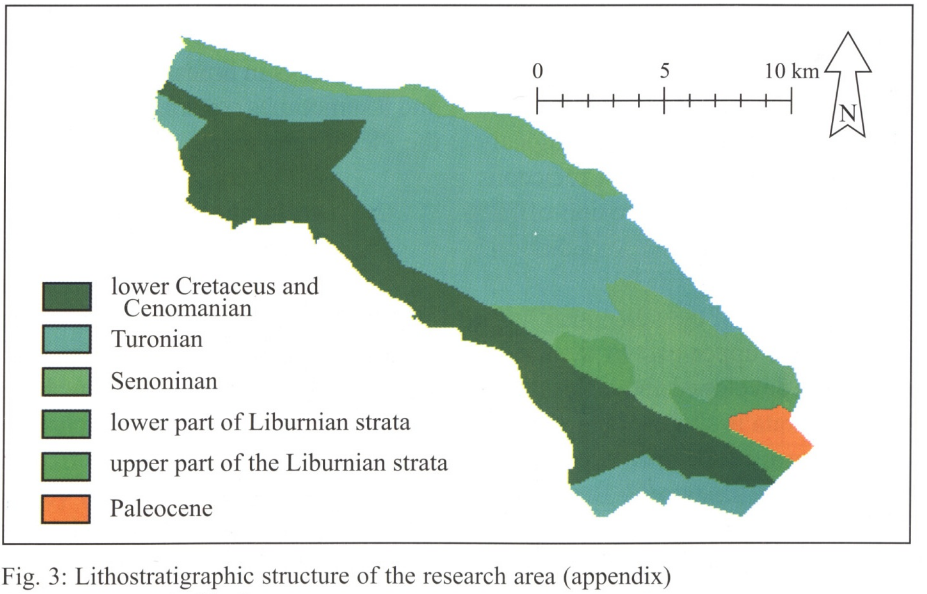

Fig. 3: Lithostratigraphic structure of the research area (appendix)
Sl. 3: Litostratigrafska karta

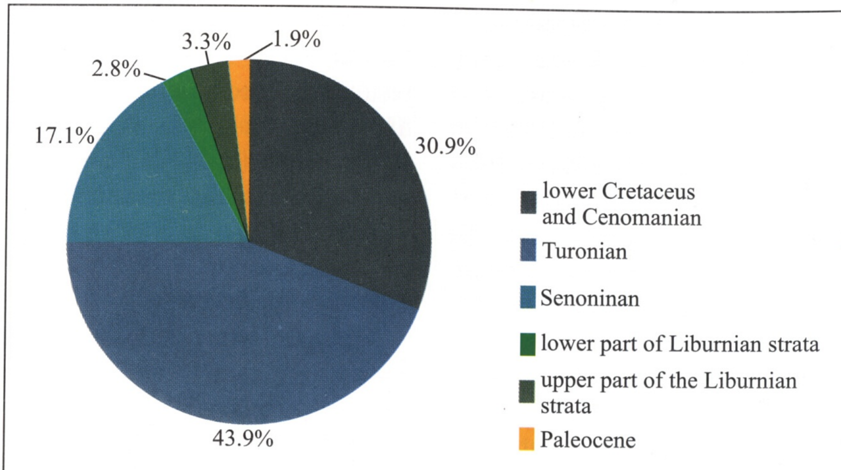

Fig. 4: Percentage of litho-stratigraphic units
Sl. 4: Udio pojedinih litostratigrafskih članova
Source: Mrak, I. (1997).

Senonian strata are developed in the northern part of the research area and also south from Dutovlje and Tomaj. The Upper Senonian strata are called also as Lower Liburnian strata and they lay transgressivly on the Senonian and also Turonian strata. The lower part of the Liburnian strata is developed as dark-gray micritic layered limestone, which is lithologicaly different from the rest of the Cretaceous rudistid limestone. The corrosion of this limestone is minor and the vegetation is intense (Buser, 1972; 1973).

The lower part of the Paleocene strata or the so-called upper part of the Liburninan strata is developed above the Lower Liburninan strata in shape of narrow stripes. The strata are developed as dark-gray micritic Kozina limestone. Because of the high content of clay the limestone is less corroded than the Cretaceous strata (Buser, 1972).

Among the Quaternary sediments the research area is known by large areas covered in terra rossa. Terra rossa prevails around Komen, Kobjeglava, Pliskovica, Brje, Tomaj and Dutovlje. Around Vrhovlje and Krajna vas the terra rossa fills the cracks in limestone and dolomite and it sometimes contains bone breccia of the Pleistocene animals (Buser, 1972).

2. Geomorphologic conditions

A main characteristic of the Karst landscape is lowering from southeast towards northwest. Minimal altitude in the area is 37 m, maximum 643 m with an average of 340 m. The major part of the research area has an altitude from 250 to 299 m and 300 to 349 m.

The major part (41.4%) of the researched area belongs to the surface inclination unit 3° - 6°, 28.3% of the area

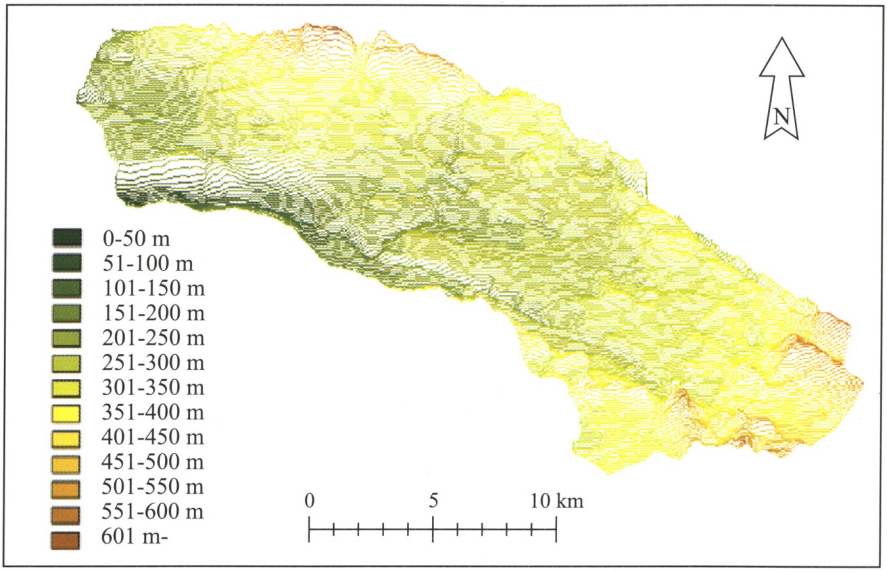

Fig. 5: Digital elevation model with altitude units

Sl. 5: Digitalni model reljefa s visinskim razredima

belongs to the unit 0° - 2°, 19.4% to the unit 7° - 12°, and all the rest units are barely participated.

The main part of the research area has the southern exposition (31%), following by western (28%) and northern (26%) and eastern (15%).

In the southwestern part of the research area the main geomorphologic form is Brestoviški dol, a dry valley that is according to Radinja the continuation of the active valley of river Raša (RADINJA, 1972). The dry valley goes from the village Dane, north from Sežana to lake Doberdob. Brestoviški dol is lowering towards north-west, which indicates that it was made by a surface river in the past. The altitude of

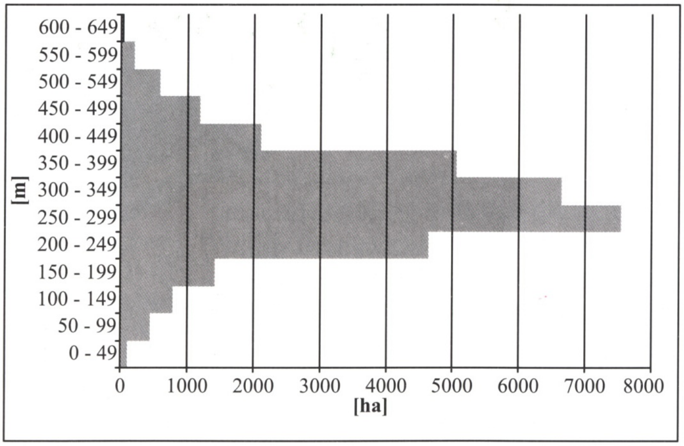

Fig. 6: 50-meter altitude units in hectares

Sl. 6: Površinski udjeli prema 50 –metarskim visinskim razredima

Source: Mrak, I. (1997).

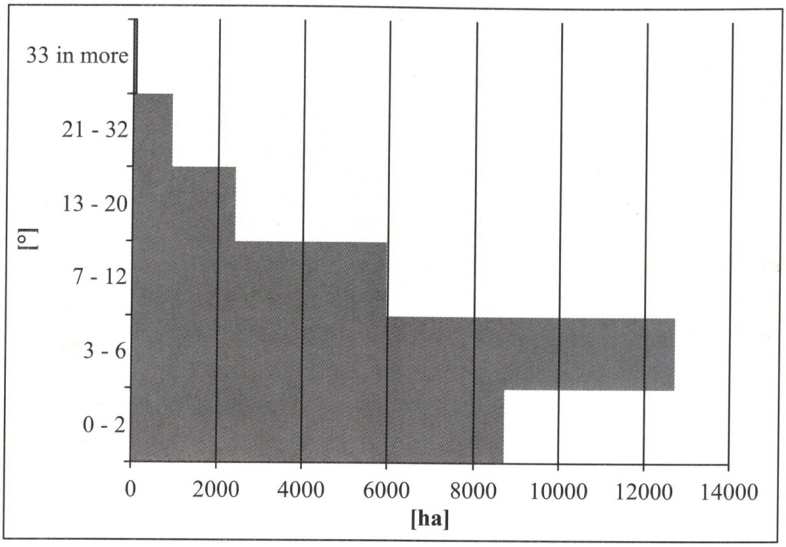

Fig. 7: Areas according to surface inclination units
Sl.7: Površinski udjeli prema kategorijama nagiba

Source: Mrak, I. (1997).

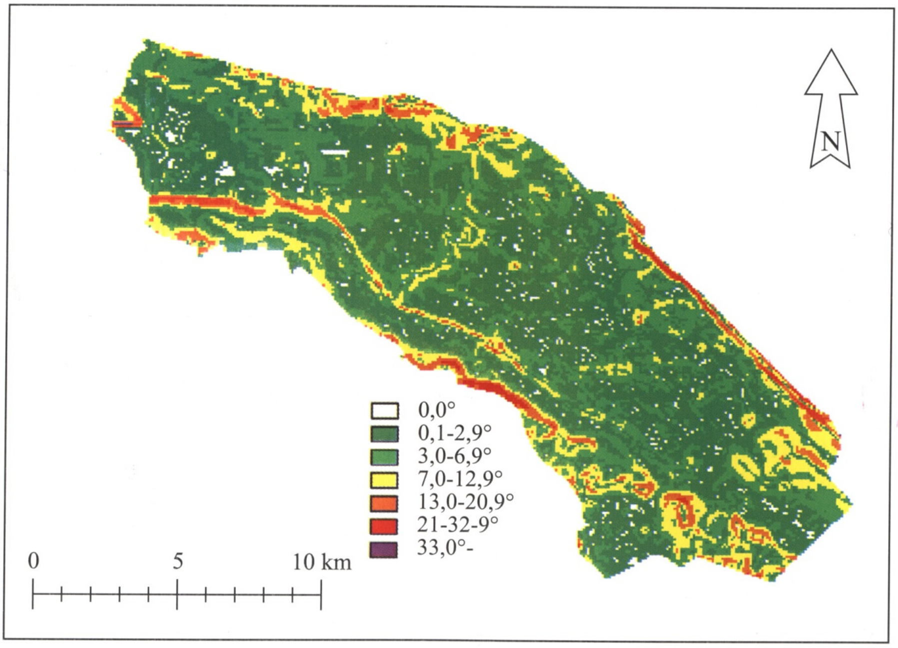

Fig. 8: Surface inclination. (appendix)
Sl. 8: Karta nagiba

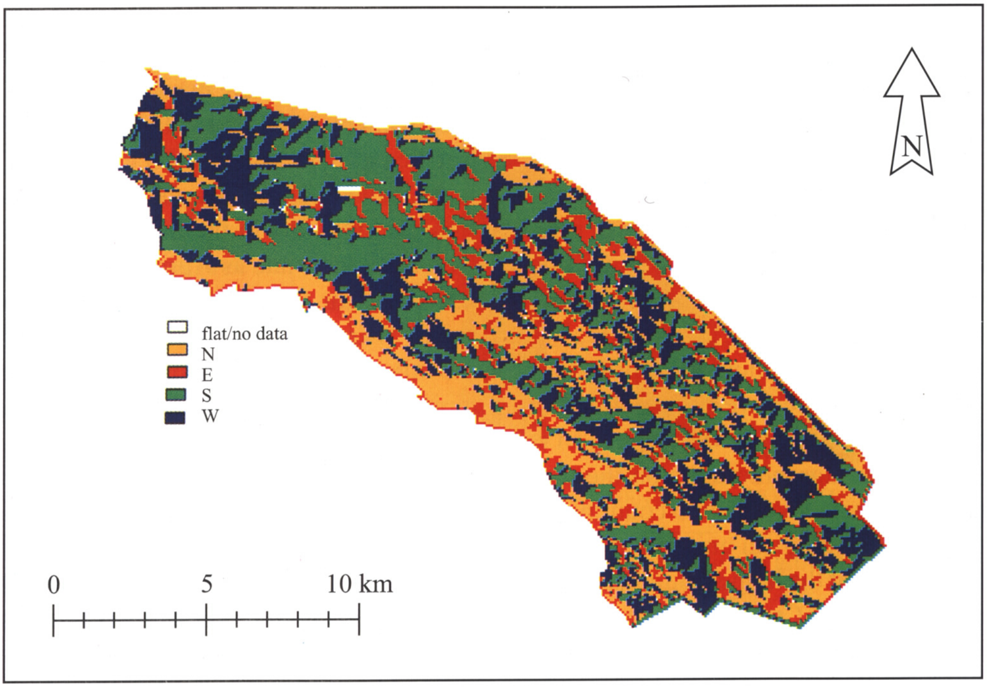

Fig. 9: Exposition. (appendix)
Sl. 9: Karta ekspozicija

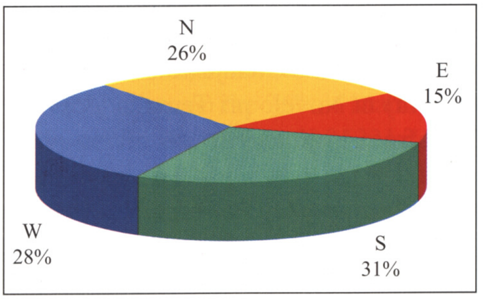

Fig. 10: The research area according to exposition
Sl. 10: Udio pojedinih ekspozicija u istraživanom području
Source: DMR, (1999)

the dry valley is 31 - 81m and in most parts the past river (Notranjska Reka) inclination is maintained. The main cause for the largest dry valley of the research area is the tectonics of the area - the dry valley is actually a narrow sincline between the two parallel anticlines. Brestoviški dol is shallow and covered with dolines till the village of Krajna vas. From the village it continues as the real dry valley, and it also becomes deeper (Gams et al., 1971).The western and southwest part of the research area is limited by hills that divide the dry valley Brestoviški dol from the dry valley Nabrežinski dol on the Italian side. Karst is divided from the Vipavska valley on the north by the hill chain Trsteljsko hribovje or Black Hills. Both above mentioned hill chains have the so-called dinaric direction and are parallel among each other. The same direction has also the dry valley Brestoviški dol.

Today corrosion and humans are the strongest surface changers. The corrosion result is the numerous dolines. In the research area the dolines are not present only on dolomite. On different kinds of limestone they emerge depending on chemical and physical properties of rocks. In the study of land register unit Krajna vas (GAMS et al., 1971) the highest number (80) of dolines per 100 hectares was defined on gray Cenomanian limestone.

In our research we have defined the number of dolines per 100 hectares on varies lithostratigraphic units on the topographical maps. We chose 5 counting areas on each geological unit and in average found out that the highest number of dolines is on Lower Cretaceous and Cenomanian limestone - 48/100 hectares, on Turonian limestone 30/100 hectares and on Senonian limestone 24/100 hectares. On younger limestone dolines are few or are not present at all.

3. Climatic conditions

Climatic conditions are mostly the result of geographical position and relief characteristics of the researched area. In our case the area is slightly higher than the neighboring areas. Its edges are hilly and this is the main cause for the climatic isolation and specific climatic conditions of the area. Position relatively near to the sea has positive influence to the climate and the mild sea influences are coming to the interior part of the area mostly by Brestoviški dol dry valley.

Partial isolation is the main reason that Karst climate also has some continental characteristics that are mostly featured in cold winters caused by cold air from the northeast. The consequence is strong wind, called burja. This wind can sometimes bring snow in the area as soon as October and as late as April. Position relativen / near to the sea is featured with mild, warm southwest wind, called mornik and sufficient amount of precipitation. Their disposition is quite equal through the year, which is a typical continental feature. Mediterranean climatic characteristics are shown in highest precipitation rates in October and December. As continental characteristics we need to mention also high precipitation values in May and June and very dry months January and February and also August, which is good for vine growth. The plant in the ripening phenophase needs less rain.

The research area is covered by three weather stations Godnje (295 m), Komen (289 m) in Novelo pri Temnici (350 m). Data from 1960 - 1990 was reviewed.

Temperature characteristics

The highest average annual temperature is at the Novelo pri Temnici station (11.7°C), and the lowest is at the Godnje station (10.6°C).

Average temperatures in the growing season are approximately one degree Celsius higher than the average annual tempe-ratures. Average annual minimal air temperature is the lowest at Godnje 5.8°C, in Komen 7.7°C and in Novelo pri

Temnici 8.4°C. Average annual maximum air temperature is the lowest in Novelo pri Temnici 15.5°C, in Godnje 16.1°C and in Komen 16.4°C.

Satisfactory average monthly air temperatures are in August and September when the grapes are ripening and therefor need high temperatures.

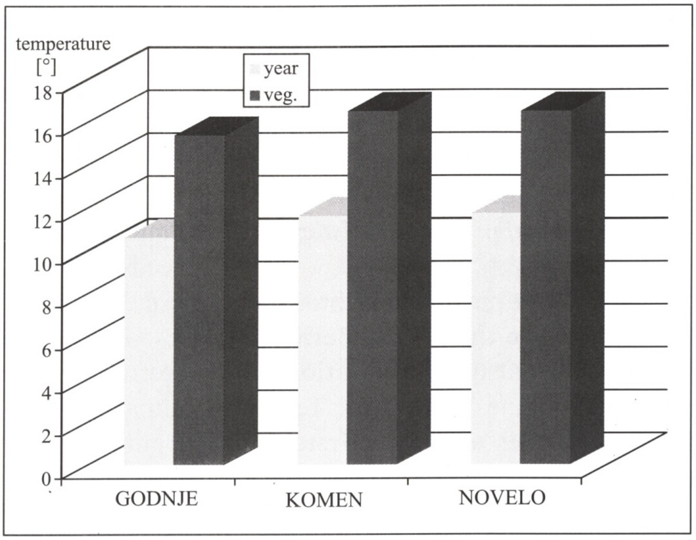

Fig. 11: Mean annual air temperature and mean growing season temperatures (veg.) in the period 1961 - 1990 (in °C)

Sl. 11: Prosječne godišnje temperature zraka i prosječne temperature zraka u vegetacijskom periodu u razdoblju 1961. - 1990. (u °C)

Source: Klimatografija Slovenije 1961 - 1990, Temperatura zraka, (1995)

With the sap emission date and resting-time date we have calculated the vine growing season, which in Godnje starts on the 1st of April and ends on the 7th of November (221 days). In Komen it starts on the 25th of March and it ends on the 1st of November (222 days) and in Novelo it starts on the 25th of March and it ends on the 31st of October (221 days). The Godnje station is six days late in spring but the growing season is longer then in fall. The Godnje station is late also in the case of other dates. The relief features could explain this fact since the station is positioned in the area of large dolines.

An important vine-growing indicator is also the sum of active temperatures. According to Žiberna the optimal sum in eastern Slovenia is 2200 to 2800°C and more, depending on the sorts of vines (Žiberna, 1992). The calculated sums in

Table 1: Vine phenophases

Tab. 1: Fenofaze vinove loze

Weather station	Date of 8°C sap emission	Date of 10°C budding	Date of 15°C flourishing	Date of 12°C end of ripening	Date of 10°C resting-time
GODNJE	1st of April	16th of April	22nd of May	20th of September	7th of November
KOMEN	25th of March	10th of April	14th of May	30th of September	1st of November
NOVELO PRI TEMNICI	25th of March	10th of April	15th of May	29th of September	31st of October

Source: Mrak, I. (1997).

the researched area were higher - Godnje 3342°C, Komen 3579°C and Novelo pri Temnici 3585° C, which indicates that the area from this point of view is highly appropriate, even for late sorts of vine.

Precipitation characteristics

The area gets precipitation throughout the year. In the thirty-year period the highest amount of precipitation was measured on the Novelo pri Temnici station, that lies under the Trstelj hill chain. The hills reach up to 640 m, so the elevation is around 300 m, high enough to present an orographic barrier for wet air masses from the sea. They stop here and cause higher moistness of that part of the Karst area. The driest month is February while November gets the highest amount of precipitation. Winter and spring are the driest periods of the year and fall is the wettest.

The precipitation distribution is not optimal for vine growth because the plant needs the highest amounts of precipitation in the beginning of the growing season and less in the ripening stage. The growing season on all the three stations gets approximately 60% of annual precipitation. Optimal annual precipitation amount for vine growing is 600 - 800 mm, because vine prefers drier to wetter climate (Žiberna, 1992). The research area gets higher than optimal precipitation amount just in the growing season.

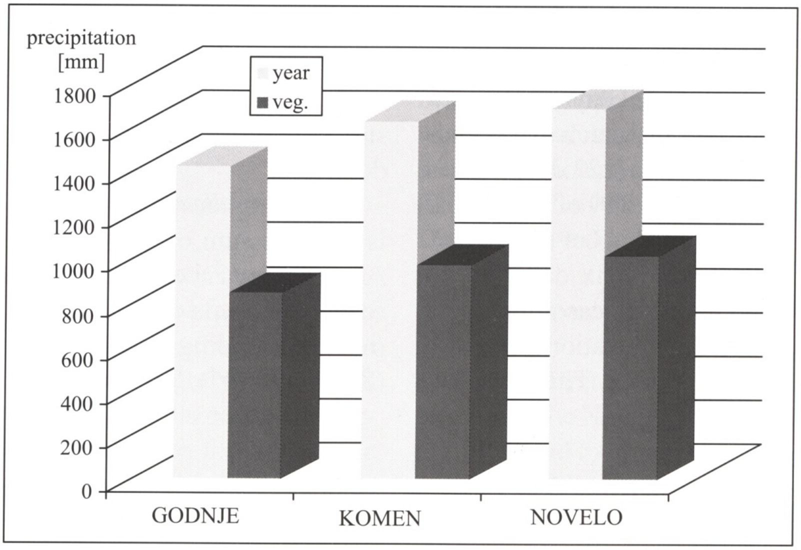

Fig. 12: Average annual precipitation and average growing season precipitation (veg.) in the period 1961 - 1990 (in mm)

Sl. 12: Prosječna godišnja količina padalina i prosječna količina padalina u vegetacijskom periodu u razdoblju 1961. - 1990. (u mm)

Source: Klimatografija Slovenije 1961 – 1990, Padavine, (1995)

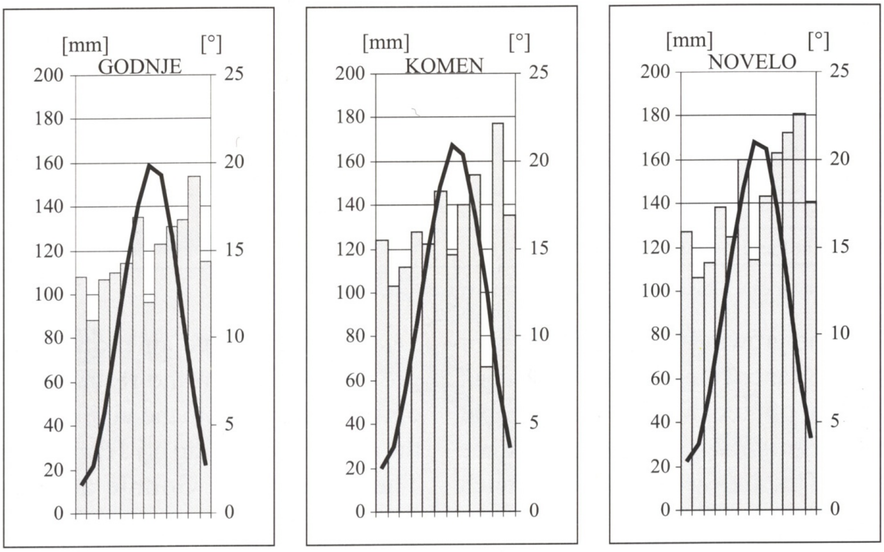

Fig. 13: Climatic diagrams for weather stations of the research area (1961 - 1990)
Sl. 13: Klimatski dijagrami meteoroloških postaja u razdoblju 1961. - 1990.
Source: Klimatografija Slovenije 1961 – 1990, Padavine, (1995)

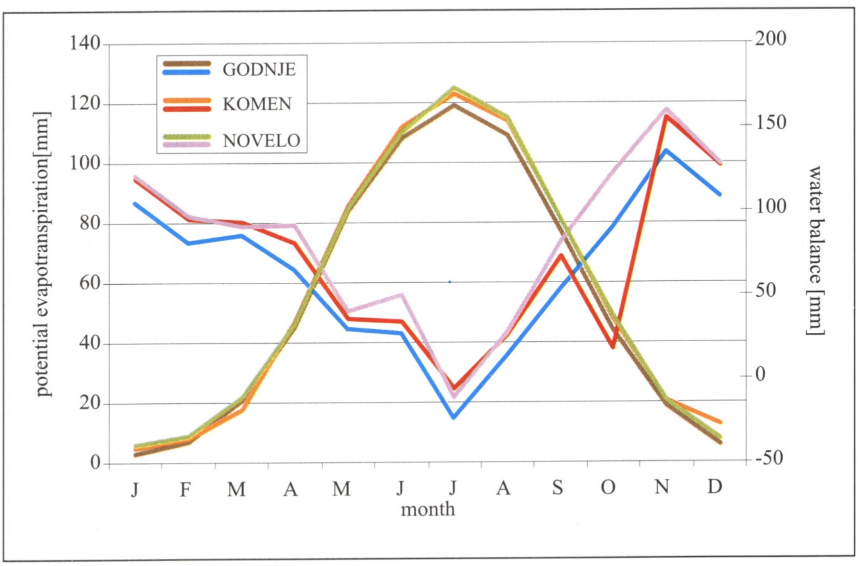

Fig. 14: Potential evapotranspiration (according to Thorntwaite) and water balance (in mm)
Sl. 14: Potencijalna evapotranspiracija (po Thorntwaitu) i vodna bilanca (u mm)
PE - potential evapotranspiration (complete line)
WB - water balance (dashed line)
Source: Mrak, I.(1997).

Table 2: Relative air moisture in the growing season (in %)
Tab. 2: Relativna vlažnost zraka u vegetacijskom periodu (u %)

	GODNJE	KOMEN	NOVELO
7 a.m.	79.6	80.7	71.5
2 p.m.	58.9	62.2	59.3
9 p.m.	85.2	81.4	72.4
average in the growing season	74.6	74.7	67.7

Source: Klimatografija Slovenije 1961 – 1990, Relativna zračna vlaga, (1995)

For vine growing water balance is of great importance (the difference between the amount of precipitation and potential evapotranspiration). The water balance indicates if the area gets enough, too much or not enough water. On the three stations the potential evapotranspiration percentage in growing season presents around 90% of annual evaporated water. The highest moisture rate is at the Novelo pri Temnici station that also gets the highest amount of the precipitation. This station also gets highest moisture surplus in the grape-ripening period - from August to October, which is not good from the vine growth point of view. The best conditions for vine growth according to potential evapotranspiration and water balance are in the area of the Godnje sta-tion. All the three stations have negative water balance in July when there is less precipitation and the evaporation is the highest.

Among the vine growth conditions the relative air moisture is also of great importance. Optimal amounts in the growing season are 60 to 70%. At the relative air moisture 60 to 40 % the photosynthesis reduces and at the relative air moisture under 20 % the photosynthesis can completely stop (Žiberna, 1992).

Average relative air moisture in the growing season in the research area is optimal according to the vine demands in the area of the Novelo pri Temnici station. The areas of the Godnje and Komen stations have approximately a 4% of surplus from the optimal values. The rate of 80% is not being exceeded - this is the rate when different diseases can damage the vine. During the day the highest relative air moisture is obtained at 9 p.m. and the lowest at 2 p.m. The relative air moisture never gets too low and is all the time optimal for vine growth.

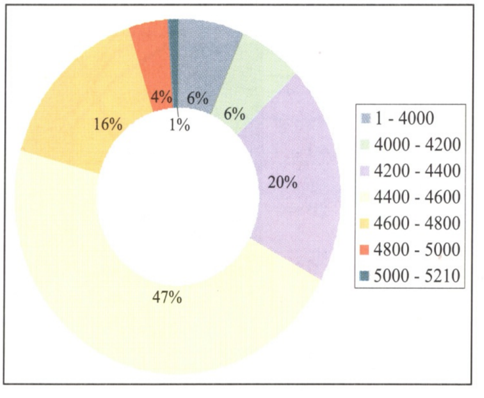

Fig. 15: Average annual solar energy (in MJ/m^2)
Sl. 15: Prosječna godišnja količina sunčevog zračenja (u MJ/m^2)
Source: Gabrovec, M.(1997)

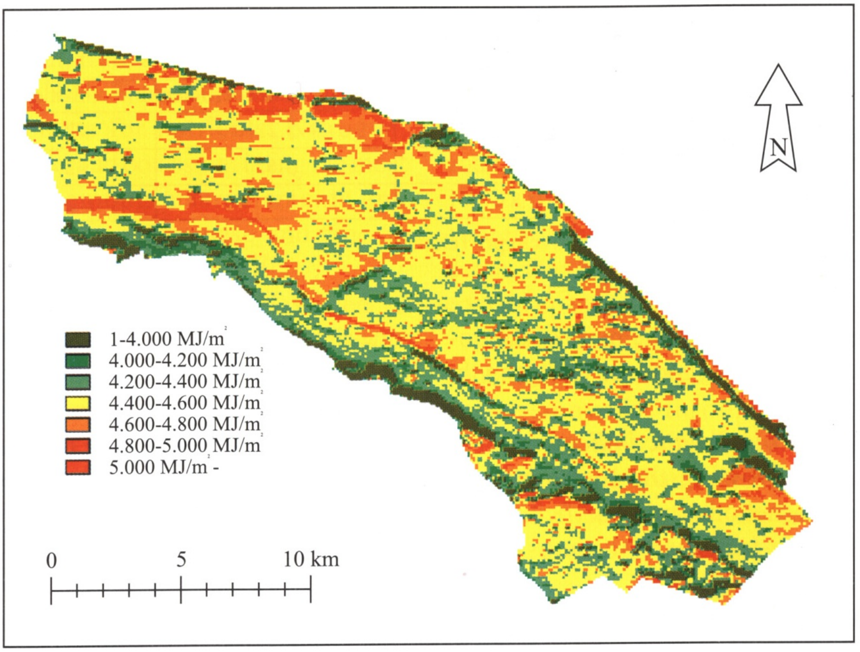

Fig. 16: Average annual solar energy (in MJ/m^2)
Sl. 16: Karta prosječnog godišnjeg sunčevog zračenja (u MJ/m^2)

Insolation

The length of the insolation is one of the important indicators for vine growth since the plant needs lots of warmth especially in the ripening phenophase. The insolation data is available only for the Novelo pri Temnici station and the annual value is 2154.2 hours (1558.7 hours in the growing season).

For the Godnje and Komen stations only data for cloudy days is available. From July to October the number of cloudy days is few which is also good for vine growth. The data of insolation length and number of cloudy days cannot give the real amount of solar energy that a certain area receives in reality. A very important factor is relief, which can highly influence on values of received solar energy. Different exposition and surface inclination change the angle between sun-rays and surface and with this also the amo-unt of solar energy is changing. Especially higher relief is causing a barrier to sunrays. The surface in shadow receives only the diffuse insolation (Gabrovec, 1997).

We were using the solar energy map (Fig. 16) that shows the annual solar energy measured in MJ/m^2 according to relief features of each hectare cell.

The values of the received solar energy show the area has a submediterranean climate. According to exposition the southeast, southwest and southern slopes

Table 3: Bioclimatic indicators
Tab. 3: Bioklimatski pokazatelji

station	hydrothermic coefficient	heliothermic coefficient	bio climatic index
GODNJE	2.5	5.2	2.8
KOMEN	2.7	5.6	2.4
NOVELO PRI TEMNICI	2.8	5.6	2.5

* insolation data is for the station Novelo pri Temnici
Source: Mrak, I.(1997)

and lowlands receive the most of the solar energy, which is good for vine growth.

Some bioclimatic indicators

In vine growing the hydrothermic coefficient, heliothermic coefficient and bio climatic index are the most used (Žiberna, 1992).

The hydrothermic coefficient shows the relation between the precipitation amount in the growth season (combined by 10) and the sum of active temperatures in the growth season. Optimal values are from 1.0 to 2.0. Lower values are better.

The heliothermic coefficient is a product of the active temperatures sum in the growth season and the length of insolation also in the growth season, divided by 1.000.000. Optimal values of heliothermic coefficient are from 2.6 to 4.5. Higher values are better.

The bioclimatic index is the most complex of the three and it compares the insolation, precipitation and temperature characteristics and the growth season length. For vine growth better are higher values of bioclimatic index (Žiberna, 1992).

The hydrothermic coefficient shows the research area is not highly suitable for vine growth since the values are higher than optimal. The heliothermic coefficient values are above the optimal and the bioclimatic index values are not optimal. The reason for the results can also be that the three indicators do not consider local climatic conditions.

4. Pedological conditions

Not many types of soil can be found in the research area. Mainly are of two types: rendzinas and cambisols. A special type of cambisol can be found here and that is chromic cambisol (FAO, 1998). In literature it can be found under different names: terra rossa, jerovica, jerina.

Vine growing is affected by physical and chemical soil properties. Among physical properties sand/clay ratio is one of the most important. It was established that sandy and clay loams are the most appropriate. Little less appropriate is sandy soil, because of its low water retention capacity and consequently vines are often affected by drought. In sandy soil there is also noticeable leaching of organic matter and fine mineral particles. Even less suitable is clayey soil for its heavy texture (high draught values, possible compaction, and water content is often too high).

Vine growth requires pH values around neutral, from slightly acid to slightly alkalic (pH 5 - 7) and soil has to meet its requirements for nutrients. Nitrogen, phosphorus, and potassium being the most important among macroelements and boron, copper, manganese and zinc as microelements (Žiberna, 1992).

Soils in Karst area are classified as chromic cambisol. Chromic cambisol is a relict remnant from former, much warmer climatic conditions. One of the most typical properties is the depth of solum, which can change considerably within very short distances. In general chromic cambisol is shallow to medium-deep soil. Maximum depths of soil can be found in pockets (cracks in limestone), on the bottom of dolines or on colluvial deposits. A - B_{rz} - C or R is a typical sequence of horizons for chromic cambisol, while colour is one of the most distinct visual and morphological properties. It varies through the profile in shades of red to reddish brown (hues of 5 or 7.5 YR) (Sušin, 1964).

According to parent material, two types of chromic cambisol can be distinguished:

- reddish brown soil (ilovka) on limestone from Lower Cretaceous period,
- skeletal reddish brown soil (kremenica) on lime slate from Upper Cretaceous period that contains quartz (Gams et al. 1971).

Kremenica contains quartz skeletal parts as opposed to ilovka which does not. Skeletal parts in kremenica come from limestone weathering and quartz which is insensitive to chemical weathering and therefore enters the soil profile in the form of skeletal and sand fractions. Ilovka differs from kremenica in morphological and chemical (acidity) properties. (Sušin, 1968). Ilovka is marked by high clay content which increases greatly with depth. On the other hand, kremenica can contain up to 80% of quartz skeletal parts.

Chromic cambisol in general does not contain free primary carbonates as they are removed through chemical weathering. Soil reaction is neutral or slightly acidic from surface to parent material. When nutrients are leached, pH values drop significantly (acidic to strongly acidic). Ilovka reaches pH values down to 5.2 - 4.1, while acidity in kremenica can be even stronger (4.2 - 3.7).

Organic content in both varieties of chromic cambisol is low. Because of higher clay content, ilovka has also higher cation exchange capacity and consequently higher base saturation (calcium, magnesium, potasium, sodium) (Sušin, 1968).

According to their properties, the pedologists have characterised ilovka as mildly leached (degraded) chromic cambisol and kremenica as strongly leached (degraded) chromic cambisol, but formation of both being influenced by former climatic conditions (Sušin, 1968). Mechanical weathering of kremenica is a fairly quick process which bonds the skeletal parts and makes tillage much easier than in ilovka.

Chromic cambisol can be classified as cambisols, where diagnostic horizon is cambic (B), which lies below A and above

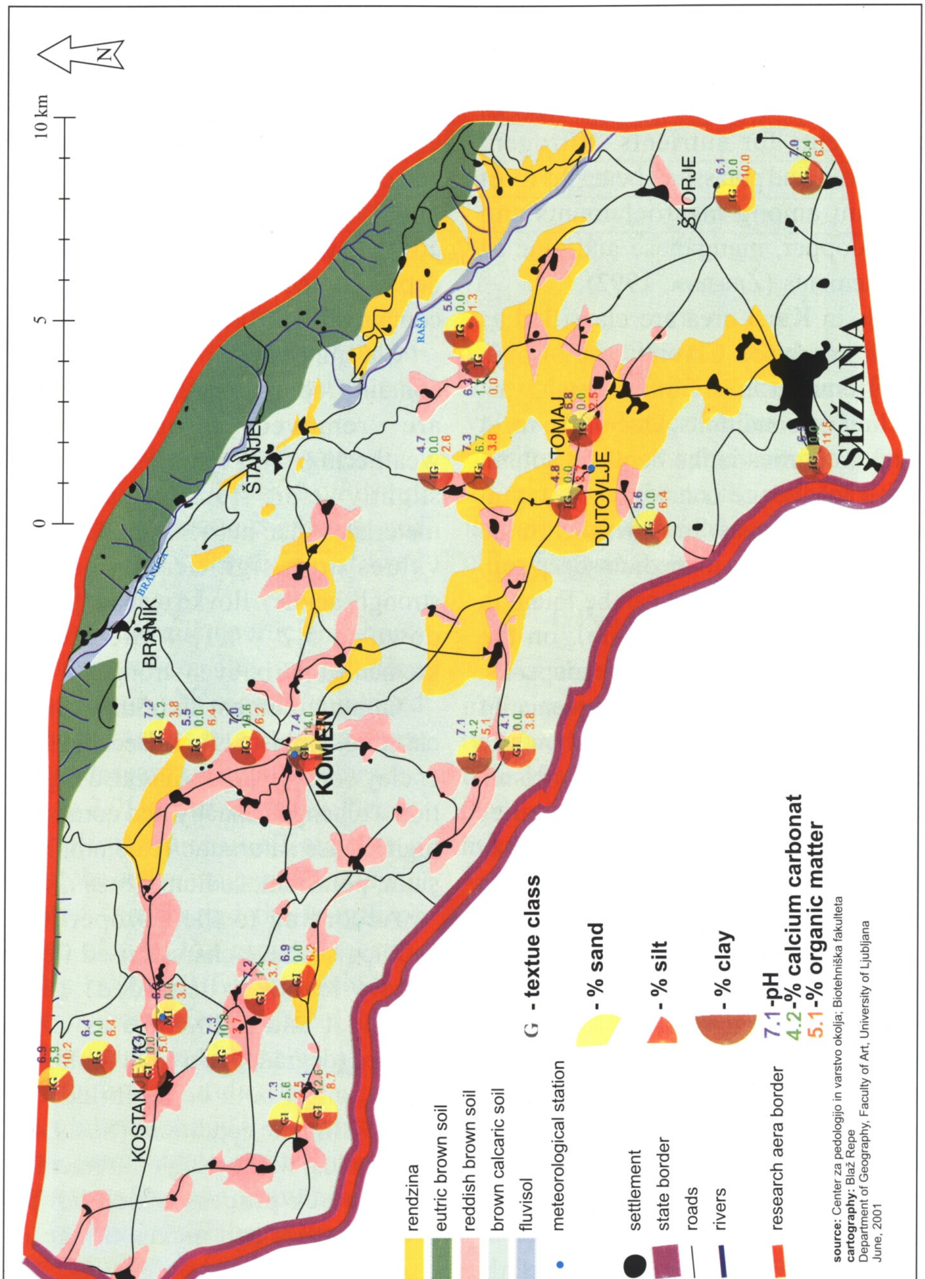

Fig 17: Soil properties in the resarch area

Sl. 17: Pedološke značajke tala na istraživanom području parent limestone. Ferric oxides dye cambic horizon in shades of brown, but also yelowish or reddish colours can be found (Lovrenčak, 1994).

Soil properties in the research area
(Fig./Sl. 17*)*

In the research area 27 soil profiles have been examined. Soil samples have been gathered according to lithological units in order to find differences in soil properties related to parent material. To recognise human impacted soil properties, samples in vineyards have also been examined.

Colour was determined in-situ, using standard colour charts (Oyama et al., 1976). Other properties (pH values, carbonates and organic matter content and texture) were recognised using laboratory analysis. Samples of parent material have also been taken and placed in hydrochloric acid (HCl). The insoluble residue has been weighted to determine the purity of limestone.

Table 4: The colour determined on fresh samples in-situ are as follows
Tab. 4: Boja svježih uzoraka tala

colour	visual description	number of samples
7.5 YR 3/4	dark brown	2
7.5 YR 4/4	dark brown	1
7.5 YR 4/6	brown	1
7.5 YR 5/6	light brown	1
5 YR 3/3	dark reddish brown	6
5 YR 3/4	dark reddish brown	7
5 YR 4/4	reddish brown	1
5 YR 3/6	dark reddish brown	5
5 YR 4/6	reddish brown	3
5 YR 4/8	reddish brown	3

Source: Mrak, I.(1997)

Table 5: Texture class of analysed samples.
Tab. 5: Tekstura analiziranih uzoraka

texture class	number of samples
loamy clay	18
clay loam	8
silt loam	2
silty loamy clay	1
clay	1

Source: Mrak, I.(1997).

Apart from soil depth, thickness of horizons and their colour, type of vegetation have also been observed.

Soil in the research area is rather shallow, as depths range from 12 to 30 cm, with exceptions being in the bottom of dolines, where soil thickens.

Soil colour
(Fig./Sl. 18, 19)

The table shows the obvious prevalence of dark reddish brown colour, which differs only according to chroma. Soil on older parent material (Lower Cretaceous period - Cenomanian and Turonian) is of higher value, more dark to dark brown, (7.5 YR). Soil with reddish values (5 YR) differs in hue and particularly in chroma and is found on younger parent material (the darkest soil, with chroma 3 covers Liburnian and Paleozoic rock formation).

Soil colour values in vineyards are the same as in "natural" soil (over the same

Fig 18: Soil profile in doline
Sl. 18: Pedološki profil u ponikvi

Fig 19: Vineyard soil
Sl. 19: Vinogradarsko tlo

parent material) and differs only in hue and chroma.

Results of laboratory analysis

Particle size analysis was conducted by pipet sedimentation method with prior sodium pyrophosphat dispersion and wet sieving. The results were interpreted with texture diagram and the following texture classes were recognised:

Texture has a significant influence on air-water regime of the soil and its physical and chemical properties. All together this has great influence on root growth, as well as on air, water and nutrient supply. Texture plays an important role in soil fertility (Lovrenčak, 1994).

There is a domination of loamy clay and clay loam texture classes in the research area which both have good properties for commercial plant growth and can be both considered as quite fertile (Lovrenčak, 1994).

In some vineyards, particularly where parent material is dolomite, soil has a higher clay content than natural ones of the same parent material. A sample was taken on the meadow and in the vineyard near Vojščica, both soil samples lying over dark grey dolomite. A meadow sample could be recognised as loamy clay while clay loam was determined in the vineyard.

Soil reaction shows whether soil has acid, neutral or alkalic properties. It depends on the H_3O^+/OH^- ratio or in

Table 6: Particle size distribution of the samples
Tab. 6: Granulometrija uzoraka prema veličini čestica

particles (%)	loamy clay	clay loam	silt loam	Silty loamy clay	clay
coarse sand	7.8	10.5	12.7	3.5	4.3
fine sand	28.2	31.8	23.9	18.4	29.7
silt	28.2	28.9	53.8	60.5	15.0
clay	35.8	28.8	9.7	17.6	51.0

Source: Mrak, I.(1997)

general on the concentration of H^+ ions in the soil solution. It is expressed as a pH value with 7 being neutral (LOVRENČAK, 1994). Lower values represent acidic reaction, higher alcalic.

Reaction of the samples was determined by an electric pH-meter, where samples were previously soaked in KCl overnight.

The results show prevalence of slightly acidic soil, followed by slightly alkalic and strongly acidic soil. Slightly alkalic soil can be found on dolomite and quartz containing limestone. All other samples showed some acidic reaction despite carbonate parent material which in general contributes to higher pH values. All primary carbonates are removed from the soil matrix through chemical weathering. Vineyard soil has a reaction around neutral and is obviously impacted by man since noticeable differences were found while comparing to natural soil. Samples were taken near Škrbina (meadow and vineyard, on the same parent material).

Table 7: Number of samples according to pH values

Tab. 7: Broj uzoraka tala prema pH vrijednosti

pH	classes	number of samples
10.0 - 9.1	strongly alkalic	/
9.0 - 8.1	alkalic	/
8.0 - 7.1	slightly alkalic	9
7.0	neutral	/
6.9 - 6.0	slightly acidic	12
5.9 - 5.0	acidic	3
4.9 - 4.0	strongly acidic	6
Pod 3.9	extremely acidic	/

Source: Mrak, I.(1997)

The natural sample was acidic (pH=5.53) but the vineyard sample was slightly alkalic (pH=7.23).

Calcium carbonate content of sampled soil was determined by hydrochloric acid (HCl). The method is based upon the following reaction:

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

where we measure the volume of CO_2, using a Scheibler calcimeter.

18 samples showed no reaction, which meant no calcium carbonate content. Highest carbonate content (19.55%) was found over quartz containing limestone (Komen strata). Soil that overlays dolomite also contains some free carbonates.

Soil organic matter is formed by amorphous particles in size of 0.002 mm. The quantity depends on the annual amount of organic litter and its properties, pedogenetic processes (humification and mineralization), climate (temperatures, rainfall), soil air-water regime and human activities (LOVRENČAK, 1994).

The Kotzman method, with potassium permanganat VI was used to determine soil organic content. The highest contents were found on Turonian limestone near Sežana (11.49%), while the lowest were found near Avber (1.28%) on Senonian limestone. Soil in vineyards had considerably lower amounts of organic matter than their natural companions. Maximum percentage was 5.1% on lower Cretaceous and Cenomanian dark grey dolomite, while 0% was found again near Avber on Senonian limestone.

Table 8: An overview of soil properties in the research area

Tab. 8: Pregled svojstava tala istraživanog područja

profile no.	location	horizon	thickness [cm]	CS	FS	S	C	texture	pH	% $CaCO_3$	% organic matter	vegetation	parent materia	colour
XXV	Sežana	A	0 - 12	2.7	25.2	34	31	IG	6.5	0	11.49	shrub	K^2_2	5 YR 3/3
XXIV	Avber	A	0 - ?	1	34.8	25	39	IG	6.3	1.68	0	vineyard	K^2_3	5 YR 3/4
XXIII	Avber	A	0 - 25	2.8	33.1	22	42	IG	5.6	0	1.28	forest	K^2_3	5 YR 3/4
XXII	Kopriva	A	0 - ?	13	36.4	24	27	IG	7.3	6.7	3.83	vineyard	K^2_2	5 YR 4/6
XXI	Kopriva	A	0 - 20	5.3	28.4	23	44	IG	4.7	0	2.55	forest edge	K^2_2	5 YR 4/6
XX	Kreplje	A	0 - 45 ?	2.4	31	29	38	IG	5.6	0	6.38	forest edge	$K_{1,2}$	5 YR 4/8
XIX	Veliki dol	A	0 - 20	7.1	40.9	38	14	GI	4.1	0	3.83	forest	$K_{1,2}$	5 YR 4/8
XVIII	Veliki dol	A	0 - ?	4.3	29.7	15	51	G	7.1	4.19	5.1	vineyard	$K_{1,2}$	5 YR 3/6
XVII	Škrbina	A	0 - 30	11	23.1	24	43	IG	5.5	0	6.38	meadow	K^2_2	5 YR 3/4
XVI	Škrbina	A	0 - ?	24	19.6	21	35	IG	7.2	4.19	3.83	vineyard	K^2_2	5 YR 4/4
XV	Ovinek	A	0 - 12	6.1	25.2	25	44	IG	7	8.38	6.38	forest	K^2_3	5 YR 3/6
XIV	F. Hrib - Trstelj	A	0 - 50	2.9	34.3	36	27	IG	6.4	0	6.38	doline (meadow)	$K_?$,Pc	5 YR 3/3
XIII	Nad Renčami	A	0 - 12	11	24.3	30	34	IG	6.9	5.86	10.21	forest bor	Pc, E	5 YR 3/3
XII	Dutovlje	A	0 - 21	1.5	36.2	32	30	IG	4.8	0	3.74	meadow	K^2_3	5 YR 3/6
XI	Tomaj	A	0 - ?	10	26.9	27	36	IG	6.8	0	2.49	vineyard	K^2_3	5 YR 3/6
X	Štorje	A	0 - 23	10	22.6	33	34	IG	6.1	0	9.97	forest edge	$K_?$,Pc	5 YR 3/6
IX	Sveto	A	0 - 13	9.1	21.4	34	36	IG	7	19.55	6.23	meadow	K^2_2	5 YR 3/6
VIII	Komen	A	0 - ?	23	27.5	27	23	GI	7.4	13.96	4.99	vineyard	K^2_2	7.5 YR 3/4
VII	Vale	A	0 - 13	3.8	32.6	39	28	GI	6.9	0	6.23	meadow	$K_{1,2}$	5 YR 3/4
VI	Brestovica	A	0 - 24	18	30.5	28	24	GI	7.1	12.57	8.73	meadow	$K_{1,2}$	7.5 YR 3/4
V	Brestovica	A	0 - ?	7.3	47.4	25	21	GI	7.3	5.58	2.49	vineyard	$K_{1,2}$	7.5 YR 4/4
IV	Vojščica	A	0 - ?	5.3	32.7	34	28	GI	7.2	1.4	3.74	vineyard	$K_{1,2}$	5 YR 3/4
III	Vojščica	A	0 - ?	16	29.7	21	34	IG	7.4	9.77	3.74	meadow	$K_{1,2}$	5 yr 3/4
	Kostanjevica	(B)	0 - 30	9.8	22.7	42	26	GI	6.2	0	1.25	vineyard	K^2_2	5 YR 4/8
I^I	Kostanjevica	A	0 - 20	10	24	43	23	GI	6.3	0	3.74	vineyard	K^2_2	5 YR 4/6
	Novelo	C	0 - 25	3.5	18.4	61	18	MGI	4.1	0	0	forest	K^2_2	7.5 YR 5/6
	Novelo	(B)	0 - 13	10	23.7	55	11	MI	4.2	0	2.49	forest	K^2_2	7.5 YR 4/6
I	Novelo	A	0 - 8	15	24	52	8.2	MI	4.4	0	4.99	forest	K^2_2	7.5 YR 3/4

Source: Mrak, I.(1997)

Parent material is the foundation from which, in pedogenetic process, soil is formed. The mineralogical and chemical properties of parent material play a significant role in soil, morphological, physical, mineralogical and chemical properties, texture and air-water regime being among them. Chemical compounds that dominate in parent material will also dominate in soil and therefor determine the quantity and type of nutrients in soil.

On parent material that contains more than 60% of calcium carbonate, rendzinas, brown soil (cambisols) or chromic cambisol are developed.

Parent material also greatly influences soil texture. Clay loam texture is very common for soil on limestone. (LOVRENČAK, 1994).

While digging a profile pit parent material was reached in twenty cases. Samples of parent material were taken to the laboratory and poured in hydrochloric acid (HCl). After a while only insoluble residue remained which was weighted and percentage of calcium carbonates (purity) in parent material was calculated:

For each type of parent material two samples were taken on different locations. Low percentages were found on Komen strata, which contain quartz. Highest percentages were found in Cenomany and Lower Liburnian limestone which turned out to be the purest.

5. Vegetation in the research area

Vegetation in Karst area is continental. Due to high annual rainfall deciduous trees covered the entire plateau in the past. (MELIK, 1960).

Natural forest association that can be found in Karst is a pubescent oak *(Quercus pubescens)* and hop hornbeam *(Ostrya carpinifolia)* forest and its degraded shrubby form of hornbeam *(Ostrya carpinifolia)* and autumn moor grass *(Sesleria autumnalis)*. Where forest was removed one can find meadow-pasture association of dwarf sedge *(Carex humilis)* and centaurea *(Centaurea rupestris)*.

Very specific is the Mediterranean sessile oak *(Quercus petraea)* and sweet chestnut *(Castanea satva)* forest, which

Table 9: Percentage of calcium carbonate in parent material
Tab. 9: Udio kalcijevog karbonata u matičnoj podlozi

type of rock	% $CaCO_3$
Lower Cretaceous and Cenomanian limestone	85.3
Lower Cretaceous and Cenomanian dark grey dolomite	43.3
Stratified Turonian limestone	54.8
Turonian limestone and slate containing quartz	37.7
Senonian limestone	68.8
Lower Liburnian strata - dark grey, dense limestone	82.6
Mid Liburnian strata - dark grey, dense limestone	70.1
Paleocen limestone	79.3

Source: Mrak, I.(1997)

in present form was heavily influenced by man (Gams et al., 1971). Most of the sweet chestnut areas were transformed into vineyards. Areas of hop hornbeam cover upright brome *(Bromus erectus)* and golden-saxifrage *(Chrysopgon gryllus)* association and the most termophyl varieties of hop hornbeam. More than 1 m tall king ranch bluestern *(Dichantium ischaemum)* gives the association a very distinct appearance and forms thick sod (Sušin, 1964).

Most common tree species in Karst area are: pubescent oak, hop hornbeam, flowering ash/manna ash *(Fraxinus ornus),* but also turkey oak *(Quercus cerris)*, sessile oak, hornbeam *(Carpinus betulus)*, oriental hornbeam *(Carpinus orientalis)*, common maple/field maple *(Acer campestre)*, montpelier maple *(Acer monspessulanum)* and beech *(Fagus sylvatica)* can be found. Among bushes smoke tree *(Cotinus coggygria)*, cornelian cherry *(Cornus mas)*, dogtree *(Cornus sanguinea)*, dog rose *(Rosa canina)*, glastonbury thorn *(Crataegus monogyna)*, hazel *(Corylus avellana)* and common juniper *(Juniperus communis)* are the most common. Autumn moor grass, burning bush *(Dictamnus albus)*, peony *(Paeonia lactiflora)* etc. are the most common among herbs.

Field observation has been made and very few barren land was noticed. A general impression one can get is that Karst is very "green". Most of the area is covered with monocultural black pine *(Pinus nigra)* forest which is endangered by pine beauty moth (*Panolis flammea*) and forest-fires. Where soil depth is inadequate karst pastures can be found, but smoke tree and common juniper are heavily overgrowing them.

In Karst area percentage of forests is constantly increasing. Before inhabitation by humans pubescent oak and hop hornbeam forests dominated the entire area, but most of it has been cleaned (slash and burn cultivation, pasturing, wood) before the Roman period. Most of the forest area was transformed into pastures and later, due to overgrazing, in barren stony land. By the end of the 19th century removing of forest was so intensive that all the landscape looked like stone desert with a few green oasis. According to sources, Karst area resembled todays appearance of Dalmatia. Water conditions have changed; barren land stimulated stronger winds and consequently wind erosion. Much of the desertification was caused by overpopulation.

In the middle of the 19th century first projects were made in order to re-forest the Karst area. Many species were introduced, but black pine turned out to be the best. Local residents were used in reforestation. Costs were extremely high, 7.000 - 8.000 DEM/hectare (Udovič, 1993). Most of the areas were re-forested by the First World War, but it continued after the Second World War. The results were evident - 41% of the area was forested in 1980, comparing to 14% in 1875 (Prelc, 1993). The research area also shows increase of forested area, but less as in other parts of Karst (27% in 1999).

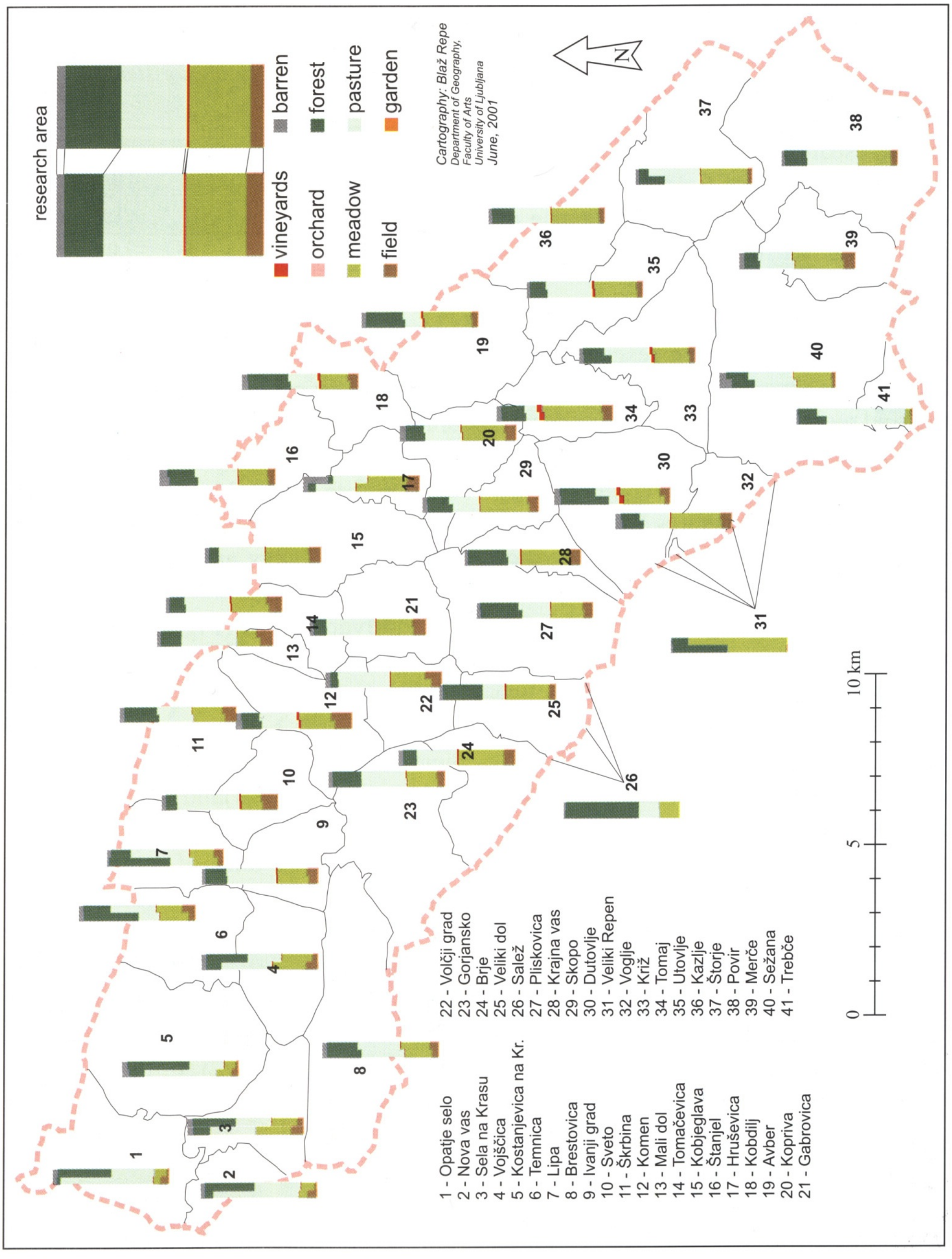

Fig 20: Changes in land use 1961 - 1999

Sl. 20.: Promjene u načinu korištenja zemljišta 1961. - 1999.

6. Land use in the research area

From the 1961 and 1999 land register units data, has been used to study land use in the research area. The period studied shows a decrease of fields and pastures, increase of forest, a slight decrease of vineyards while the percentage of meadows remained the same.

In 1961 the vineyards covered 3174 hectares or 1.4% of the research area. Most of the vineyards could be found in the land register units of Dutovlje, Tomaj, Križ, Avber, Komen, Kobdilj and Utovlje. In 1999 the vineyard coverage slightly decreased to 3059 hectares or 1.0% of the research area. Among previously mentioned land register units, Sežana has joined the ones with the highest percentage of vineyards.

Field and pasture percentage decline can be attributed to general decrease in the number of people employed in agricultural sector. In general, Karst vineyards are very small which allows the owners to retain their regular jobs and cultivate in their spare time. Pasture areas decrease due to natural reforestation. Some forest areas already gained economic value and are being properly used.

Table 10: Changes in land use 1961-1999 (Fig. 20)
Tab. 10: Promjene u načinu korištenja zemljišta 1961. - 1999. (sl. 20)

type of land use	1961/99
fields	-1.6%
meadows	+1.0%
pastures	-7.0%
forest	+8.0%

Source: Mrak, I.(1997)

The situation is reversed and is quite the opposite as it was a century ago. Here we should look for reasons for decline in numbers of farmers, animals and therefore less pasture areas.

Vineyard areas (Fig. 23) were classified according to their size in land register units. Largest part of land register units fall into 0.3-0.5 hectares and 0.5-1.0 hectares class. More than 2.0 hectares can only be found in the land register units of Dutovlje, Križ in Tomaj.

Land register units of Avber, Komen and Utovlje show the second highest values. Between the years 1961 and 1999

Fig. 21: Refošk grapevine in Karst area
Sl. 21: Vinova loza refošk na području Krasa

Fig. 22: Vineyard renewal
Sl. 22: Obnovljeni vinograd

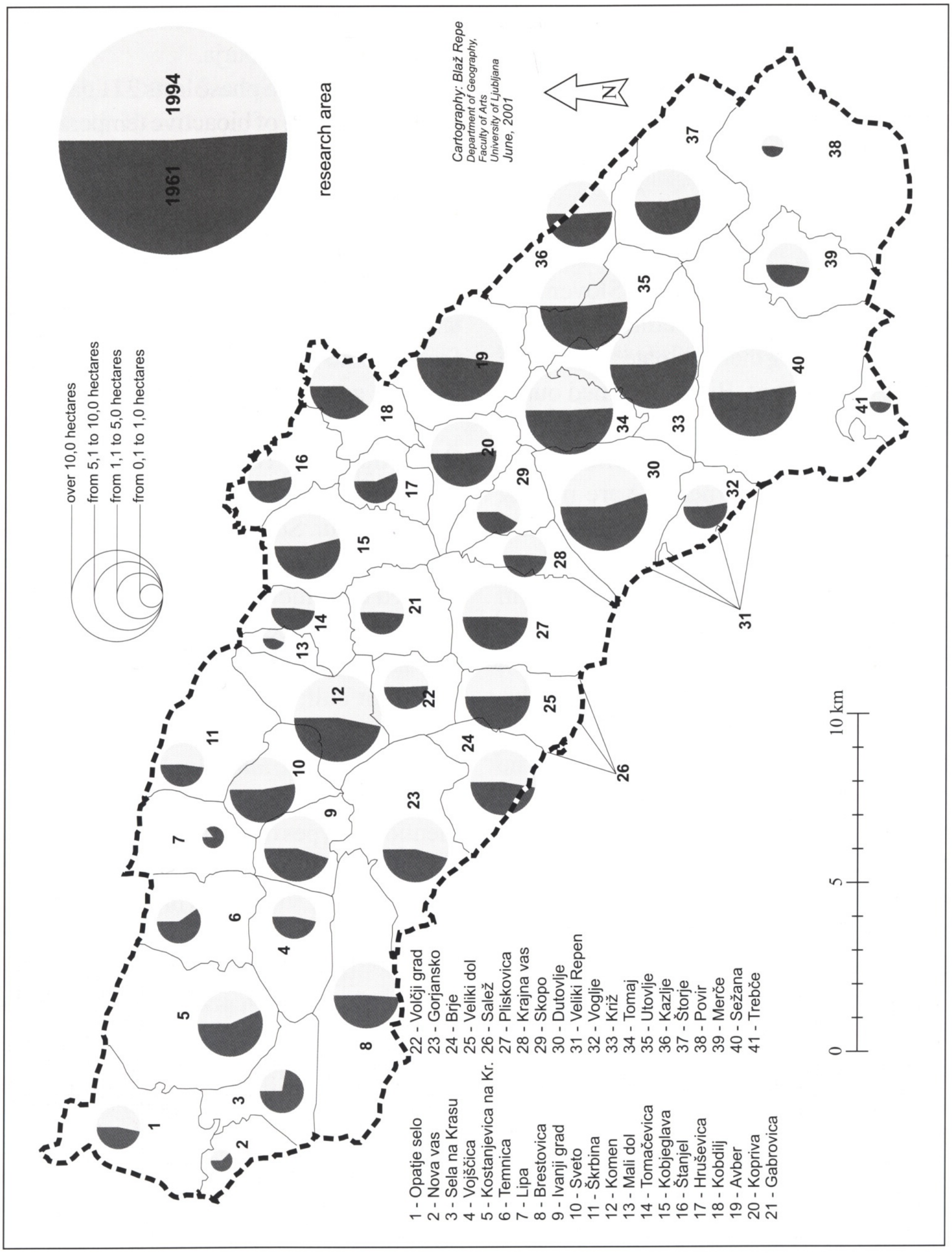

Fig. 23: Changes in vineyard areas 1961-1999

Sl. 23.: Promjene površina pod vinogradima u razdoblju 1961. - 1999.

the percentage of vineyards increased in land register units of Sežana, Kobdilj, Kopriva and Kostanjevica na Krasu and decreased in Komen, Tomačevica, Hruševica and Sela na Krasu.

7. Conclusions

Karst area in the Western Slovenia is having specific natural conditions for vine growing. Among them climate and soil are far most important. But as it turned out in the research area, there are also geological conditions that play a very significant role. Different types of limestone are mainly from Cretaceous period. The best conditions for vine growing is on the limestones of Tomaj and Komen that contain a lot of quartz, which does not corrode and therefore remains in the soil.

The limestone bedrock heavily influenced the genesis of numerous dolines that characterize the low karst plateau. The dolines tend to accumulate cold air, which holds back the growth of vine. Insolation analysis shows the domination of the southern and southeastern expositions. In that way vineyards get the majority of the annual solar energy.

Climatic analysis of meteorological stations of Novelo pri Temnici, Komen and Godnje data shows the submediterranean climate type with some continental features.

Summer temperatures are quite high (mean July temperature is 21°C) as an opposite to cold winters (mean January temperature is 2.5°C) often accompanied by strong winds - burja.

The vegetation phase lasts 221 days per year and the sum of bioactive temperatures is over 3300°C which is sufficient also for late sorts of vines.

The precipitation are evenly distributed over the year with February being the driest month. Most of the area precipitation falls in autumn. Some bioclimatic features show the area to be appropriate for vine growing.

Regarding the bedrock in the area of Karst there are two basic types of soil (chromic cambisol) with typical red to red-brown colour. Soil is mildly leached chromic cambisol - "ilovka" and heavily leached chromic cambisol - "kremenica". "Kremenica" decomposes much quicker and is therefore easier and more appropriate for cultivation.

Particle size analysis of the soils showed loam-clay and clay-loam texture classes to be most frequent. Both afore mentioned types of soil contain high shares of fine fractions what is again very beneficial for vine growing. Reaction of soil in Karst area is also favourable - mildly alkaline to mildly acid.

The most inappropriate bedrock and on it developed soil for vine growing are the dark grey turonian limestones.

Most of the vineyards in the research area are found around the settlements Dutovlje, Križ and Tomaj. And according to experts also the best qualitiy of wine is obtained.

LITERATURE AND SOURCES:

Azarov, E. (1994): Črni bor na Krasu, Kras, 4, Sežana, 18-21.

Buser, S. (1972): Geologija Slovenskega primorja, Vodnik za ekskurzije: Matični Kras, Matarsko podolje, Notranjski kras, Jamarska zveza Slovenije, Postojna, 87pp.

Buser, S. (1973): Tolmač geološke karte list Gorica L 33 - 78, Zvezni geološki zavod, Beograd.

Center za pedologijo in varstvo okolja, (1997): Pedološka karta, Biotehniška fakulteta, Ljubljana.

Cerkvenik, D. (1994): Kraški teran, Kras, 5, Sežana, 36-37.

Cerkvenik, D. (1994): Kraški vinorodni okoliš, Kras, 3, Sežana, 48-49.

Cucchi, F., Forti, F., Ulcigrai, F. (1994): Zniževanje kraškega površja zaradi korozije, Acta carsologica XXIII, Ljubljana, 55-61.

Čehovin, S.(1986): Kraško gozdnogospodarsko območje, Zavod za pogozdovanje in melioracijo Krasa, Sežana, 36pp.

Digitalni model reliefa R Slovenije 100x100, (1999), Geodetska Uprava R Slovenije, Ljubljana.

FAO (1998): World Reference Base for Soil Classification, FAO, ISRC & ISSS, 78, 91.

Gabrovec, M.(1996): Sončno obsevanje v reliefno razgibani Sloveniji, Acta geographica XXXVI, SAZU, Ljubljana, 47-69.

Gams, I., Lovrenčak, F., Ingolič, B.(1971): Krajna vas. Študija o prirodnih pogojih in agrarnem izkoriščanju Krasa, Geografski zbornik XII, Ljubljana, 221-261.

Gams, I. (1993): Geografske značilnosti Slovenije, Mladinska knjiga, Ljubljana, 118pp.

Gams, I. (1986): Osnove pokrajinske ekologije, Filozofska fakulteta, Ljubljana, 175pp.

Ilešič, S. (1979): Pogledi na geografijo, Partizanska knjiga, Ljubljana, 612pp.

Jakša, J. (1995): Gozd pokriva že polovico Krasa, Kras, 4, Sežana, 19-21.

Jurkovšek, B., Toman, M., Ogorelec, B., Šribar, L., Drobne, K., Poljak, M., Šribar, L. (1996): Formacijska geološka karta južnega dela Tržaško - komenske planote, Kredne in paleogenske karbonatne kamnine, 1: 50 000, Inštitut za geologijo, geotehniko in geofiziko, Ljubljana, 143pp.

Klimatografija Slovenije (1995): Temperatura zraka 1961 - 1990, MOP, HMZ Slovenije, Ljubljana, 42,53,82.

Klimatografija Slovenije (1995): Padavine 1961 - 1990, MOP, HMZ Slovenije, Ljubljana, 57, 106, 184.

Klimatografija Slovenije (1995): Sončno obsevanje 1961 - 1990, MOP, HMZ Slovenije, Ljubljana, 73, 185, 241, 295.

Klimatografija Slovenije (1995): Relativna zračna vlaga 1961 - 1990, MOP, HMZ Slovenije, Ljubljana, 53, 102, 183.

Lovrenčak, F. (1994): Pedogeografija, Filozofska fakulteta, Ljubljana, 187pp.

Melik, A. (1960): Slovensko primorje, Slovenska Matica, Ljubljana, 546pp.

Mrak, I.(1997): Razprostranjenost vinske trte na Krasu, diplomska naloga, FF, Oddelek za geografijo, Ljubljana, 126pp.

Natek, K. (1982): Metoda izdelave in uporabnost splošne geomorfološke karte, magistrska naloga, FF, Oddelek za geografijo Ljubljana.

Ogrin, D. (1995): Naravnogeografske značilnosti Slovenske Istre, pomembne za vinogradništvo, Dežela Refoška.Vinogradništvo in vinarstvo slovenske Istre, Knjižnica Annales 10, Zgodovinsko društvo za južno Primorsko, Koper, 7-29.

Osnovna geološka karta SFRJ (1968): List Gorica, 1: 100 000, Geološki zavod Ljubljana.

Oyama, M. (1967): Standard soil colour charts, Ministry of Agriculture and Forestry, Tokio, 64pp.

Raba tal v katastrskih občinah na proučevanem območju (1961,1999), Geodetska Uprava, Občina Sežana, Sežana.

Zavod za statistiko SFRJ, (1961): Popis prebivalstva SR Slovenije, Prebivalstvo in stanovanja.

Zavod za statistiko R Slovenije, (1991): Popis prebivalstva R Slovenije, Prebivalstvo in stanovanja.

Prelc, F. (1993): Varstvo gozdov na kraškem gozdnogospodarskem območju, Gozdarski vestnik, Vol.51, No.1, Ljubljana.

Radinja, D. (1972): Matični Kras, pokrajinska in morfogenetska oznaka, Vodnik za ekskurzije: Matični Kras, Matarsko podolje, Notranjski kras, Jamarska zveza Slovenije, Postojna, 87pp.

Sušin, J. (1964): Doprinos k poznavanju terre rosse v Slovenskem primorju, doktorska disertacija, Biotehniška fakulteta, Oddelek za agronomijo, Ljubljana, 106pp.

Šušteršič, F.(1994): Klasične vrtače klasičnega krasa, Acta carsologica XXIII, Ljubljana, 123-152.

Thornthwaite, C.W. (1948): An approach toward a rational classification of Climate, Geographical Review Vol. 38, New York, 55-94.

Vodopivec, M. (1992): Vpliv obremenitve trte sorte refošk na kakovost vina kraški teran, magistrsko delo, Biotehniška fakulteta, Oddelek za živilsko tehnologijo, Ljubljana, 154pp.

Udovič, M. (1993): Poskus ovrednotenja stroškov ogozditve krasa na Kranjskem v obdobju 1886-1911, Gozdarski vestnik 51,1,18-26.

Žiberna, I.(1992): Vpliv klime na rabo tal v severovzhodni Sloveniji s posebnim ozirom na vinsko trto na izbranih primerih, magistrsko delo, FF, Oddelek za geografijo, Ljubljana.

SAŽETAK
FIZIČKO-GEOGRAFSKI UVJETI ZA RAST VINOVE LOZE NA PODRUČJU KRASA, SLOVENIJA

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U ovom radu osnovni je cilj bio utvrditi uspijevanje rasta vinove loze s obzirom na geološke, geomorfološke, klimatske i pedološke osobine.

Za rast vinove loze najveće značenje imaju klimatske i pedološke osobine, no istraživanjima na području dijela regije Kras (Slovenija) utvrđeno je da potpuno jednaku važnost imaju i geološke osobine.

Upravo geološki sastav, pogoduje rastu pojedinih sorti vinove loze. Tako na području Koparskog primorja na flišnoj podlozi uspijeva sorta refošk (koja daje i istoimeno vino), dok na području Krasa, na vapnenačkoj podlozi, također uspijeva ova vinska sorta, a od njega se proizvodi vino kraški teran. Među raznim vrstama vapnenaca, koji su pretežito kredne starosti, vinska loza uspijeva najbolje na komenskim i tomajskim vapnencima. Ovi vapnenci sadrže fragmente rožnjaka (u obliku gomolja i tankih pločica) koji zbog svoje otpornosti na trošenje zaostaju u nastalom tlu.

Karbonatna podloga pogodovala je oblikovanju brojnih ponikava, koje prekidaju inače prilično uravnjenu površinu. Reljefnih ograničenja za uzgoj vinove loze je malo, a odnose se prvenstveno na duboke ponikve. Naime, ograničavajući faktor za rast vinove loze predstavlja hladni zrak koji se zadržava u njima. Analizom osunčanosti utvrđeno je da prevladavaju jugoistočne, južne i jugozapadne ekspozicije, koje tijekom godine primaju najveću količinu sunčeve energije potrebne za rast vinove loze.

Klimatski podaci za meteorološke postaje Novelo pri Temnici, Komen i Godnje ukazuju da proučavani dio Krasa ima submediteransku klimu s nekim obilježjima kontinentalne. Značajne su prilično visoke ljetne temperature zraka (srednja mjesečna temperatura zraka u srpnju je 21 ^{0}C) i hladne zime (srednja mjesečna temperatura zraka u siječnju je 2,5 ^{0}C) često praćene burom. Vegetacijski period na području Krasa traje 221 dan, što pogoduje rastu kasnih sorti vinove loze. To potvrđuje i suma aktivnih temperatura, koja iznosi preko 3300 ^{0}C.

Padaline su ravnomjerno raspoređene tijekom godine. U veljači je minimum, dok svoj maksimum dostižu tijekom jesenskih mjeseci. To nepovoljno utječe na rast vinove loze, s obzirom da ona upravo tijekom jeseni, u doba dozrijevanja zahtijeva puno topline. Također i neki bioklimatski pokazatelji upućuju da je ovo područje veoma pogodno za uzgoj vinove loze.

Obzirom na matičnu podlogu, na području Krasa prevladava kromični kambisol od karakteristično crvene do crvenosmeđe boje. Ovo tlo, s obzirom na razlike u boji poznato je pod lokalnim nazivima jerina i jerovica. Na vapnencima s većim udjelom $CaCO_3$ nastao je srednje isprani kromični kambisol ili ilovača, dok je na komenskom i tomajskem vapnencu nastao jako ispran kromični kambisol ili kremenasto tlo. Za kremenasto tlo, značajno je da se brže mehanički raspada, što olakšava njegovo obrađivanje. Analizom mehaničkih svojstava

tala utvrđeno je da su prema veličini čestica najrasprostranjenije ilovaste gline i glinovite ilovače, što pogoduje vinovoj lozi. Također, uzgoju vinove loze pogoduje i pH reakcija tala, koja je slabo kisela do slabo alkalna.

Površine pod vinogradima, u razdoblju od 1961. do 1999. godine nisu bitno promijenjene. Najviše površina pod vinogradima je u katastarskim općinama Dutovlje, Križ i Tomaj, gdje je prema enolozima i najbolje vino. Najvećim dijelom vinogradi se dobro održavaju i obnavljaju.

Najmanje površine pod vinogradima su na sjeverozapadnom dijelu istraživanog područja, gdje je za vinovu lozu manje pogodna geološka podloga (turonski tamnosivi gusti uslojeni vapnenci) kao i klimatska obilježja (veća količina padalina).

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