
SŠ BRAĆA RADIĆ - GIMNAZIJA
GLOBE ŠKOLA

**Osjetljivost masline** (*Olea europea* L.) **na niske temperature**

**Olive sensitivity** (*Olea europea* L.) **to low temperatures**

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## Summary

This project was intended to investigate whether low temperatures at the end of February 2018, after excessive warm weather, caused damage to the olive trees, favored disease development and reduced yield. Is there a correlation between the time of implementation of agrotechnical measures with the degree of damage caused by low temperatures?

The GLOBE atmosphere protocol and the BBCH scale for determination of olive phenophase were used. Field monitoring of olive cultivars in the Kastela area was carried out in April, May and October 2018 when the total yield per cultivars was estimated.The results have shown that olive cultivars originating from the southern and warmer regions such as Italy (Pendolino, Leccino) and Southern Dalmatia (Lastovka), which were in the phenophase of leaf development or appearance of inflorescences as well as olives on which was previously performed pruning and fertilization, are more sensitive to low temperatures.Oscillation of temperatures in a short period of time (-2.4 ˚C to -6.8 ˚C from February 25 to March 1, 2018) caused partial or total decay of flower buds, freezing and cracking of barkon branches, leaf drop, increase ininfection by olive bacterial canker and smaller yield (only 33.13% of standard yields).It is desirable to select locations where there is less chance of such oscillations in temperatures, resistant cultivars like Middle Dalmatian, and avoiding agrotechnical measures until the danger of low temperatures passes.

## Introduction

Olive is an inseparable part of the coastal landscape, united with the life of the local people; it is unique and irreplaceable. Olive growing is not just an industry, it is a cultural phenomenon, a symbol of peace, wisdom and a cure. Olive culture in our region is one of the indispensable ones in our coastal area and olive as a culture deserves all the attention.

Olive (Olea europaeaL.) is an evergreen plant that grows in a temperate zone and is grown as a stalk or shrub. The root is branched and found at a depth of 15-80 cm, depending on the soil characteristics. The trunk is crooked, lumpy, and is located between the stump and the crown of the canopy. The leaves are oblong-elliptical in shape opposite to each other and have the role of assimilation, dissimilation and transpiration. The leaves remain on the olive for 2-3 years. The flowers are bisexual, white, united in erect inflorescences. The olive produces fertile flowers and "morphologically-sterile" flowers, so varieties for optimal fertilization require the presence of pollinators. The fruit is an egg-shaped bone berry, 1-3 cm long, 1-5 cm thick, at the beginning of the green color, and when it ripens, it is reddish to black (Elezović, 1997).

The first olive varieties were isolated from wild olive populations, most likely because of their own productivity, fruit size and adaptability to different environmental conditions (Barranco, 2008; Besnard et al., 2013). The varieties differ in biological, morphological and agronomic characteristics such as canopy shape, color and size of leaves, fruit and stone, flowering

age, number of flowers in the cluster, intensity of fertilization, maturation, quantity and quality of oil, resistance to cold, drought, pests, etc. It is thought that there are more than 2000 varieties in the world today (Lavee, 1994), 1 200 of which are still cultivated (Bartolini et al., 2005). In Croatia, 46 varieties are known, most of which are locally significant (Strikić et al., 2010). The most significant variety in Croatia is the form Oblica, grown from Konavle to Istria. In addition to Oblica, among the autochthonous varieties in the area of Kastela there are Lastovka, Levantinka and Drobnica that are grown the most. There are also Leccino and Pendolino, which were imported from Italy. It is worth mentioning the old olive tree from Kastel Stafilic as a kind of symbol of the City and a natural monument. Although it cannot be defined as a variety, it is well known that it was created by spontaneous hybridization and as such it is unique in the world. The age of the tree is estimated at 1500 years.

Today, olives are grown on six continents, between 30º and 45º north and south latitude. On this belt, the climate is typical Mediterranean and is characterized by hot and dry summers (Civantos, 2008), mild and rainy winters, and short transitional seasons, autumn and spring. The most influential climatic factors are temperature and precipitation, winds, relative humidity and insolation. The average annual temperature for growing olives ranges from 15-20˚ C, while the absolute maximum temperature can reach up to 40˚C, without adverse effects on the olive if the tree is supplied with water (Perica, 2006). A temperature lower than 7˚C can cause serious damage if the cooling lasts longer than ten days. The olive begins to vegetate at temperatures above 5 ° C. Bud differentiation begins in early February at about 7 ° C. In order for the olive tree to have sufficient flower buds, it requires sufficient optimal nutrients and soil moisture during this period. Buds emerge at 10 ° C and this period lasts about 60 days when flowering occurs. Flowering takes place at a temperature of 15-20 ° C and lasts only a few days. Fertilization and development of fruits last from 1 June to 15 October, and the ripening of fruits begins in October.

**Research questions and hypothesis**

In early 2018, we witnessed above-average warm weather during January and early February and low temperatures in late February and early March.

Is the cold end of February 2018 that hit Dalmatia causing significant damage to olive trees? Did below-zero temperatures at the threshold of spring adversely affect the yield? Will the damage affect the development of the disease on the olive tree?

The fact that we had temperatures below zero by the end of the calendar winter does not mean that there will certainly be olive damage. However, if the olive has started vegetation, damage can occur at relatively lower temperatures, with the assumption that not all varieties will suffer equally. Due to the resulting damage, olive trees will be more susceptible to various diseases and lower yields can be expected.

**Research methods**

The GLOBE Atmospheric Protocol was used. The air temperature from January 1 to April 30 2018 and rainfall for the period from January 1 to February 28 were taken from the school metering station to determine the onset of olive vegetation depending on the temperature and the period of extra-average temperatures in the study area.

Field observation of the most common olive varieties in the plantation of the Institute for Adriatic Crops and Karst Reclamation in the Kastela area was conducted during April, May and October 2018.

Olive phenophase was determined according to the BBCH scale, which is the official scale of the European Plant Protection Organization (EPPO), to describe the growth stages of cultivated and weed plant species (SanzCortes et al., 2002).

In early April, low temperatures were recorded with the help of experts from the Institute. Damage was assessed by wax, branches (one-year, two-year and basic) and trunk. Through field visits to the plantations, the intensity of damage, expressed as a percentage, was recorded for each tree: 0% (no damage); 50% (half of the leaves on the tree are damaged, discoloration); 100% (all one-year branches are visibly damaged, cracks in all branches), etc.

During May and October, the intensity of infection with plant diseases, primarily bacterial olive cancer (Pseudomonas syringae pv. Savastanoi), expressed as a percentage of the observed outbreaks of disease on the damaged branches, was recorded. At the end of October 2018, the total yield by variety was estimated in collaboration with the Institute staff. The yield was selected, weighed and compared with data from previous years and expressed as a percentage of standard (normal) yields for each variety.

Other olive groves were visited in the field and many olive growers were interviewed.

For the graphical representation of basic descriptive statistics of numerical temperature data a box diagram (Box and whisker plot method) was used to indicate the degree of dispersion and asymmetry of quantitative data and to show deviating values.

**View and analyze data**

In the light of climate change and the frequent weather extremes, nature has given us unexpected values of daily temperatures in the winter months.

During January, the maximum air temperature (Tmax) was 17.4˚C, while the minimum temperature (Tmin) was 1.0 ˚C. Of the total temperature measurements in January, 75% of daily temperature values were 5 to 17.4˚C, and only 25% of 1 to 5 ˚C (Figure 1). It should be noted that the median daily temperature was 12 ˚C, while the average monthly temperature (Tsred M) was 9.7 ˚C.

In February, Tmax 16.2 ˚C and Tmin -6.8 ˚C were recorded (Figure 1). A total of 75% of the measured daily temperatures ranged from 4.0 ˚C to 16.2 ˚C. The rest of the 25% included temperatures in the range of minimum -6.8 ˚C to 4.0 ZC. Unlike the month of January, the median daily temperatures in February were equal to Tsred M of 7.3 ˚C.

In March, Tmax was 18 ˚C and Tmin -3.4 ˚C. Tsred M was 10.4 ˚C while the median was 11.5 ˚C (Figure 1). Of the total temperature measurements in March, 75% of daily temperature values were from 6.8 ˚C to 18˚C, and only 25% from -3.4 ˚C to 6.8 ˚C.

During April, an increase in daily temperatures was seen, with Tmax at 28.9 ˚C and Tmin 3.6 ˚C. Tsred M was 16.6 ˚C. Compared to the previous three months, the median was higher; it was 15.8 ˚C (Figure 1). Of the total temperature measurements in April, 75% of daily temperature values were from 11.8 ˚C to 28.9˚C, and only 25% from 3.6 ˚C to 11.8 ˚C.

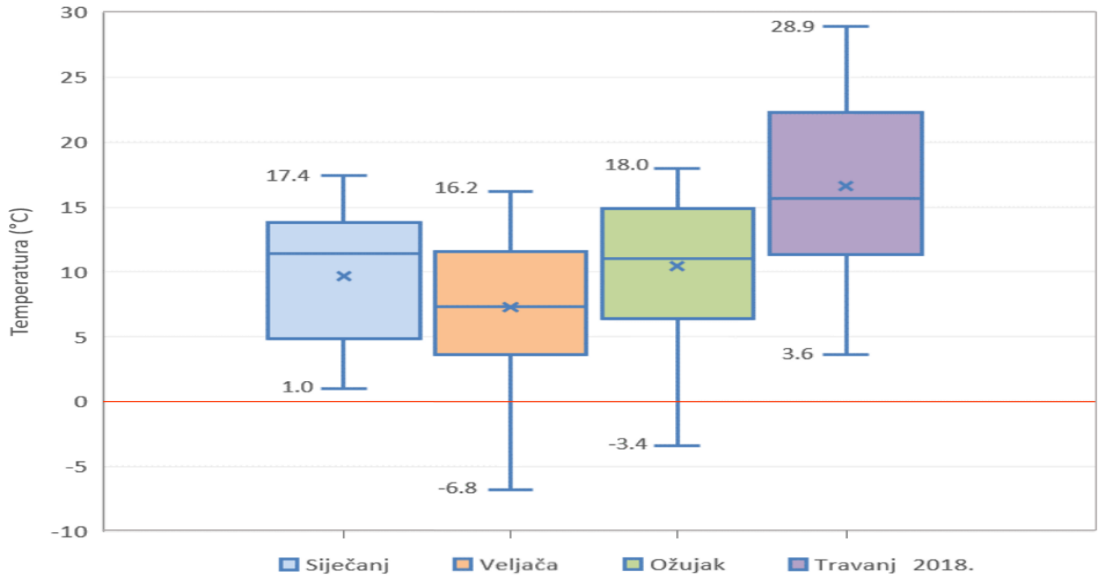


Figure 1. Box and whisker plot indicating the degree of dispersion and asymmetry of temperature values (Tmax, Tmin, Tsred M (in the figure "x"), median (in the horizontal line within the square) for the months of January, February, March and April 2018.

Above-average warm weather during January and much of February 2018 (Figures 1 and 2) with precipitation in January totaling to 29mm and February 38mm (Fig. 3) stimulated olive vegetation as early as January.

The end of February and the beginning of March are marked by cold and low temperatures (-2.4˚C to -6.8˚C) for 5 cold days from 25.2. to 1.3. (Figure 2). During this period, there was a dramatic decrease in temperature, Tmax from 15.2 ° C to 1 ° C, and Tmin from 8.6 ° C to -6.8 ° C.

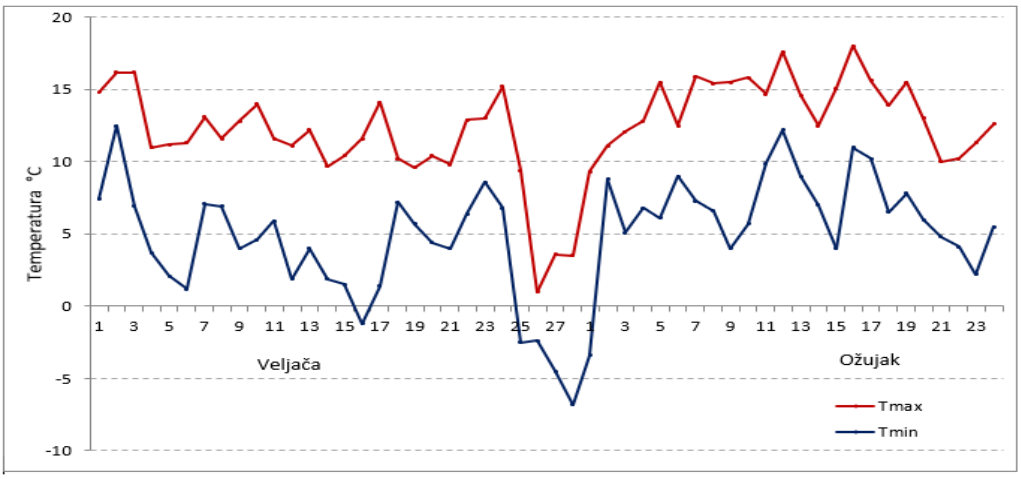


Figure 2. Maximum and minimum daily temperatures during February and March 2018.

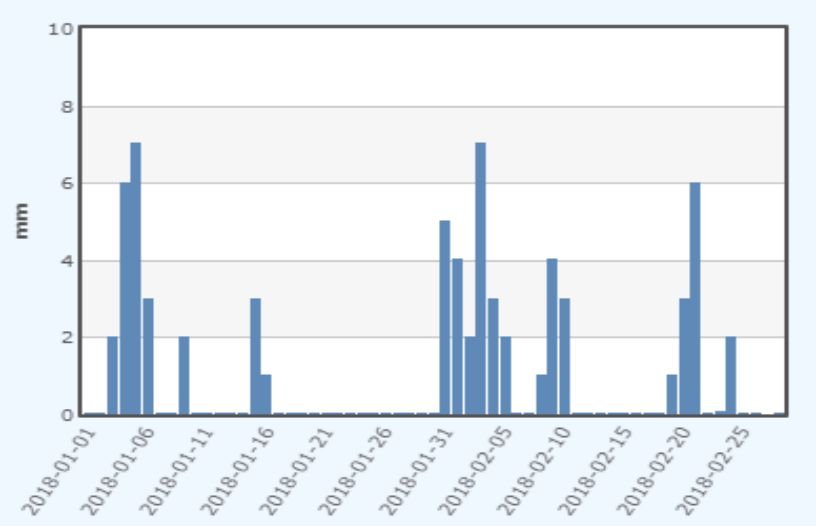


Figure 3. Rainfall in January and February 2018

Carrying assimilates to the tissues of the phloem, the plant juices traveled from the leaves and shoots to the roots. Floem is found in the bark of the tree and low temperatures have caused the juice to frost. The ice was spreading, causing the bundles to break and the crust to burst.

In the collecting plantation of the Institute for Adriatic Cultures at the Kaštel Stari site, differences in damage were observed depending on the variety (Table 1).

Table 1. Reported degree of damage (%), phenophase of olive development before February 24, 2018, presence of olive diseases and yield expressed as a percentage of the standard, for the seven most significant varieties grown in the area of the City of Kastela and Old Kastela olive.

| **Sorta** | **Origin of species** | **Oštećenje (%)** | | | | | **Prosjek oštećenja (%)** | **Fenofaza (BBCH skala)** | **Prisutnost bolesti (%)**** | **Prinosi (% standard)** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Lista** | **Jednogodišnjih grana** | **Dvogodišnjih grana** | **Osnovnih grana** | **Debla** | | | | |
| Drobnica | Middle Dalmatia | 5.00 | 10.00 | 10.00 | 0.0 | 0.0 | 8.33 | 15.00 | 8.33 | 61.25 |
| Dužica | Srednja Dalmacija | 0.00 | 1.67 | 0.00 | 0.0 | 0.0 | 0.56 | 0.03 | 0.56 | 78.75 |
| Lastovka | Južna Dalmacija | 20.00 | 30.00 | 10.00 | 0.0 | 0.0 | 20.00 | 15.00 | 20.00 | 35.00 |
| Leccino | Italija | 23.75 | 45.63 | 10.63 | 0.0 | 0.0 | 26.67 | 15.00 | 26.67 | 26.09 |
| Levantinka | Srednja Dalmacija | 5.00 | 10.00 | 15.00 | 0.0 | 0.0 | 10.00 | 15.00 | 10.00 | 57.50 |
| Oblica | Srednja Dalmacija | 10.00 | 10.00 | 0.00 | 0.0 | 0.0 | 6.67 | 12.00 | 6.67 | 65.00 |
| Pendolino | Italija | 33.44 | 51.25 | 27.81 | 15.0 | 0.0 | 37.50 | 35.06 | 37.50 | 22.34 |
| SKM* | Srednja Dalmacija | 15.00 | 30.00 | 10.00 | 0.0 | 0.0 | 18.33 | 15.00 | 18.33 | 38.75 |
| **Ukupni prosjek** | | **14.02** | **23.57** | **10.43** | **1.88** | **0.00** | **27.45** | **15.26** | **16.01** | **33.13** |

*SKM- Stara kaštelanska maslina; **Prisutnost bolesti masline na oštećenim granama

Variety Origin of variety Damage (%) Average damage (%) Phenophase (BBCH scale) Presence of disease (%) ** Yields (% standard) * SKM- Old Castelian olive; ** Presence of olive disease on damaged branches

Low temperatures caused different intensity of defoliation (leaf fall), cracking and bark

separation of one-year, two-year and basic branches depending on the variety. No damage to trunks was observed on the cultivars studied. The most sensitive varieties to low temperatures are the Italian varieties Pendolino and Leccino with average damages of 37.5% and 26.67% respectively. Of the autochthonous varieties, the most sensitive are Lastovka (20% damage) and Old Kastela olive (18.33%). The onset of the vegetation phase is evident from the BBCH scale values. The onset of vegetation (juice movement, budding) is the first phenophase. If conditions are favorable for growth and development, phenophases continue on top of each other. It follows that the trees on which Phenophase 35.06 (bloom development) was recorded entered vegetation earlier, while those on Phenophase 0.03 were only in the vegetation movement phase.

Varieties that had previously entered the vegetation phase that were in the phenophase of leaf development or the appearance of inflorescences (Pendolino) were more affected than those that were in the dormant phase or at the beginning of vegetation movement (Rainbow and Shrub). Disease incidence and disease intensity were higher for varieties that had greater damage (Pendolino). It should be pointed out that the disease is bacterial olive cancer present on damaged trees and that it cannot be treated, but it can only be prevented. The aforementioned disease does not significantly affect yields, but in years where mechanical damage such as hail, freezing, etc. can occur yields can be affected. The total yield in 2018 was only 33.13% of standard yields. As expected, the Pendolino variety had the lowest yields (only 22.34% of the standard) and the largest Dužica variety (78.75%).

**Discussion and conclusions**

Due to the above-average warm weather in early 2018, some olive varieties entered the vegetation phase in January, significantly earlier than usual. Some of them were also in the flowering phase, which is certainly inappropriate for the end of February. In January and February, the work was normally done in March. The cuts stimulate metabolism and growth, thus making the tissue susceptible to damage from low temperatures. Visiting numerous olive groves and talking to olive growers, it has been observed that the damage caused by low temperatures is greater on olives that have previously been pruned and fertilized than on those listed agrotechnical operations were not carried out.

It is important to emphasize that in short periods of time the olive tolerates a cold of -8° C and freezing occurs at -12° C. The olive can withstand low temperatures during the deep winter hibernation (December and January). Older trees of the cultivar forms in standstill can withstand temperatures of -15 ° C. Young olives freeze as early as -12 ° C. and with wet weather and longer cooling, they can partially freeze at -3 ° C (Gucci and Cantini, 2008). Flower buds are the most sensitive organs in fruit trees, and if frosts and low temperatures occur during bloom buds and flowering, partial or complete decay of the flower buds and its organs results in a lower yield.

Low temperatures in the last decade of February have left many olive trees in the form of freezing and cracking of bark on branches of different ages. This, unfortunately, resulted in a lack of fertility and an increase in infection with bacterial olive cancer.

The observed differences in the degree of damage to the cultivars examined suggest that the susceptibility of the olive to low temperatures is highly genetically conditioned. Specifically, varieties originating in southern and warmer areas such as Italy and southern Dalmatia have proven to be significantly more sensitive to low temperatures (Pendolino, Leccino and

Lastovka). On the other hand, there is a marked increase in the intensity of infection with bacterial cancer of the olive tree with a degree of damage.

From all of the above, we can conclude that the influence of temperature fluctuations in a very short period of time has had a negative impact on the continuity of olive growing and development, the damage and health of the trees and the yield. If we add to this the findings from olive growers, it is of utmost importance to select suitable locations where such fluctuations in temperatures are less likely to occur, to grow more resistant varieties such as the Central Dalmatian ones, and to avoid agrotechnical measures (pruning and fertilization) until the danger of low temperatures has passed.

**References**


Barranco D. (2008). Variedades y Patrones. U: El cultivo del olivo (D Barranco, R Fernández-Escobar, L Rallo, eds), Mundi-Prensa y Junta de Andalucía. Madrid. 37-62

Bartolini G., Prevost G., Messeri C., Carignani C. (2005). Olive germplasm: cultivars and world-wide collections. Rome: Seed and Plant Genetic Resources Service, FAO. Raspoloživo: http://apps3.fao.org/wiews/olive/oliv.jsp. Pristupljeno dana 11.01.2019.god.

Besnard G., Khadari B., Navascués M., Fernández-Mazuecos M., El Bakkali A., Arrigo N., Baali-Cherif D., Brunini-Bronzini de Caraffa V., Santoni S., Vargas P., Savolainen V. (2013). The complex history of the olive tree: from Late Quaternary diversification of Mediterranean lineages to primary domestication in the northern Levant. Proc R Soc B: Biol Sci 280(1756):20122833 doi: 10.1098/rspb.2012.2833.

Civantos L. 2008. La olivicultura en el mundo y en España. U: El cultivo del olivo (D. Barranco, R. Fernández-Escobar, L. Rallo, eds), Mundi-Prensa y Junta de Andalucía, Madrid, 18-35

Elezović,D.1997.Maslina,Zadružni savez Dalmacije „Zadrugar“, Split

Gucci, R.,Cantini, C. 2008.Uzgoj maslina, Naklada Uliks, Rijeka

Lavee S. (1994). ¿Por qué la necesidad de nuevas variedades de olivos? Fruticultura. 62: 29-37

Perica, M. Glasnik zaštite bilja 6/2006, Hrvatski zavod za poljoprivrednu savjetodavnu službu, Split,

Sanz-Cortés, F., Martínez-Calvo, J., Badenes, M.L., Bleiholder, H., Hack, H., Llácer, G., Meier, U. (2002) Phenological growth stages of olive trees (Olea europaea). Ann. appl. Biol. 140: 151-157

Strikić F., Klepo T., Rošin J., Radunić M. (2010). Udomaćene sorte masline u Republici Hrvatskoj. Institut za jadranske kulture i melioraciju krša Split.

**Badge description**

Due to our contribution to the 2019 research project „Investigating difference in the increase of mussel population (*Mytilus galloprovincialis* Lamarck, 1819) between two different localities in the Kaštela Bay “ we were awarded with “ I am a dana scientist ” badge. We had a successful cooperation with Institute of Oceanography and Fisheries in Split. We used their data to answer the main research questions from our report.

As our 2019 project „Investigating difference in the increase of mussel population (*Mytilus galloprovincialis* Lamarck, 1819) between two different localities in the Kaštela Bay “was supported by data that our school members provided on their own. We acquired “ badge I make an impact“ badge. As part of the project, we gave lectures at a teacher-parent meeting and informed students and parents about what the project was about.