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Determination of Cold Damage in Vineyard and Laboratory Conditions in Dormant Buds of Karaerik Grape Cultivar

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ABSTRACT: This study was conducted to detect cold damage in dormant buds of grapevine under vineyard (by shooting test) and laboratory (by sectioning method) conditions. In the determination of the low temperature damage, it has been investigated whether there is a difference between the method of sectioning in laboratory conditions and the real shooting level in the vineyard conditions. The study was carried out in the vineyard which was established with the Karaerik (*Vitis vinifera* L.*)* grape cultivar in the Üzümlü district of Erzincan in 2012, 2013 and 2014. Samples of one-year-old canes from the vineyard was transported to the laboratory on the same day and sections were taken to determine the damage level. Cold damage was assessed based on 1-4 bud averages. In addition, cold damage was evaluated separately in 1^{st}, 2^{nd}, $3^{rd}$and 4^{th} nodes. The mortality rates of primary and secondary buds for the first 1-4 buds average were determined and the vitality rates of tertiary buds were determined in order to determine the ultimate vitality. At the second stage of study, the mortality rates (%) of primary and secondary buds and the viability rates (%) of tertiary buds were determined by counting in spring the shoots come from the primary, secondary, and tertiary buds of the first 4 buds that were left in pruning in vineyard. Secondary and tertiary buds were also considered alive if the primary buds have sprouted in vineyard. In the study that determined the level of damage of the buds, it was found that the difference between the sectioning method and the shooting test was 7.9% in primary buds, 14.56% in secondary buds, and 0.1% in tertiary buds. The mortality rates of primary buds and the viability rates of tertiary buds were found statistically insignificant differences between the methods, however the mortality rates of the secondary buds were found statistically significant differences between the methods.

Keywords: Cold damage, Dormant bud, Grapevine, Sectioning method

Karaerik Üzüm Çeşidinin Kış Gözlerindeki Soğuk Zararının Bağ ve Laboratuvar Koşullarında Belirlenmesi

ÖZ: Bu çalışmada asma kış gözlerinde meydana gelen düşük sıcaklık zararları, bağ (sürme testi) ve laboratuvar ortamında (kesit alma metodu) belirlenmiştir. Düşük sıcaklık zararının belirlenmesinde, laboratuvar şartlarında kesit alma yöntemi ile arazi koşullarında gerçek sürme arasında farklılık olup olmadığı araştırılmıştır. Çalışma Erzincan'ın Üzümlü ilçesinde Karaerik (*Vitis vinifera* L.*)* üzüm çeşidi ile tesis edilmiş bağda 2012, 2013 ve 2014 yıllarında yürütülmüştür. Bağdan alınan bir yaşlı dallar aynı gün içerisinde laboratuvara getirilmiş ve zarar düzeyinin tespit edilmesi için kesitler alınmıştır. Soğuk zararı hem 1-4 göz ortalamasına göre, hem de birinci, ikinci, üçüncü ve dördüncü boğumlarda ayrı ayrı değerlendirilmiştir. İlk 1-4 göz ortalamasının primer ve sekonder tomurcukları ölüm oranları ile nihai canlılığın belirlenmesi için tersiyer tomurcukların canlılık oranları belirlenmiştir. Çalışmanın ikinci aşamasında, primer ve sekonder tomurcukların ölüm oranları (%) ve tersiyer tomurcukların canlılık oranları (%) bağda budama sonrası bırakılan ilk 4 gözün primer, sekonder ve tersiyer tomurcuklarından çıkan sürgünler ilkbaharda sayılarak belirlenmiştir. Bağda primer tomurcukları süren gözlerin sekonder ve tersiyer tomurcuklarının da canlı olduğu kabul edilmiştir. Tomurcukların zarar düzeyinin belirlendiği çalışmada, kesit alma metodu ile sürme testi arasında primer tomurcuklarda %7.9 sekonder tomurcuklarda %14.56 ve tersiyer tomurcuklarda %0.1 oranında farklılık olduğu tespit edilmiştir. Primer tomurcukların ölüm oranı ve tersiyer tomurcukların canlılık oranları bakımından yöntemler arasında istatistik olarak önemli bir farklılığın olmadığı gözlenirken, sekonder tomurcukların ölüm oranları bakımından yöntemler arasındaki fark istatistik olarak önemli bulunmuştur.

Anahtar kelimeler: Soğuk zararı, Kış gözü, Asma, Kesit alma metodu

INTRODUCTION

Viticulture is cultivated between the 11^{th} and 53^{rd} latitude in the northern hemisphere, and between 20^{th} and 40^{th} latitude in the southern hemisphere on the Earth. The grape, *Vitis vinifera* L., is the best part of economically consequential fruit crops worldwide (Akkurt et al., 2013). Grapes are mainly consumed table, raisin, wine and other (molasses, ice, grape juice, vinegar, bioactive extracts, etc.) (Çelik, 2007; Kunter and Keskin, 2018). Although the vine is the plant of hot-temperate climatic zones, it can be grown in cooler or warmer climates due to its high adaptability. For an ideal grapevine cultivation, the annual average temperature should not fall below 10 ºC, during the development period it should not fall below 18 ºC (Happ, 1999; Küpe, 2012). In addition, it is reported that the coldest month should be above -2 ºC and should not fall below -4 ºC (Çelik et al., 1998). In viticulture, the most important of the temperature values are annual average temperatures and low temperatures (Kara 1990). Grapes, due to their wide spreading area on the earth, are one of the temperate fruit crops most frequently damaged by low temperatures (Fennell, 2004; Mickelbert et al., 2006; Köse and Güleryüz, 2009). Ecological factors (climate, location and orientation, latitude, etc.) have a direct impact on growth and development of grapevine (Kunter et al., 2017). Winter cold in terrestrial climatic conditions is one of the most important climatic factors limiting the viticulture (Cindric and Kovac, 1988; Lynn et al., 2006; Ma et al., 2010). The resistance of grapevines against cold is influenced by the morphological and physiological condition of the plant, environmental conditions and applied cultural processes (Çelik et al., 1998).

Severe winter cold can result in reduced yield and substantial economic losses to grape growers, subsequently impacting fruit whole sellers, distributors, vineries and related industries (Fennell, 2004; Zabadal et al., 2007).

For this reason, the knowledge of the effects of low winter temperatures on grapevines is of great importance for practical viticulture (Keller and Mills, 2007; Köse and Güleryüz, 2011; Küpe and Köse, 2015).

Winter buds on one-year-old cane of vine directly affect the yield of the vineyard (Kısmalı, 1984). There are usually 3 shoot drafts in winter's buds of vine. These shoot drafts are expressed as primary bud, secondary bud and tertiary bud. There are significant differences between the levels of cold resistance and the yield levels of these buds (Wample et al., 2000; Çelik et al., 2008).

In the winter pruning; the time of bud swell, vegetative and generative developments, yields, product qualities and harvest times can be affected by the crop load, which is known as the adjustment of the number of buds left on one-year-old cane on grapevine.

It is possible to get more positive results with some preliminary tests to be done while setting the number of buds to be left on grapevine. The most practical of these tests is to take the sections from the cane taken at the end of the dormant period and to obtain the cross sections in which the damage levels can be determined in advance. For this purpose, determination of the degree of damage by looking at the color change (browning of bud tissues) of living and dead tissues in winter buds is one of the most widely used methods (Odneal, 1984; Rekika et al., 2004; Köse and Güleryüz, 2009). By predetermining the level of damage, it is possible to minimize the indirect losses with appropriate pruning (Küpe and Köse, 2015; Ershadi et al., 2016).

In many studies for determining the damage level by the sectioning method, the accuracy of the sectioning method was accepted as 100%. This study was planned with the aim of determining whether there is any difference in the low temperature losses determined in the vineyard (by shooting test) and laboratory (by sectioning method) conditions. In this context, the damages caused by the low temperatures in dormant periods between 2011-2012, 2012-2013, and 2013-2014 in Üzümlü district of Erzincan which have the biggest share of Karaerik vineyards, are determined the in the vineyard and laboratory conditions. In this study, the mortality rates of primary and secondary buds and the viability rates of tertiary buds were taken into consideration while determining the damage levels.

MATERIAL AND METHOD

This study was carried out in order to determine the extent to which the method of sectioning used in laboratory conditions reflects the real shooting level in vineyard conditions in order to determine the low winter temperature losses in vine. In the study, a 30-year-old vineyard with Karaerik (*V. vinifera L.*) grapes cultivar at an altitude of 1197 m in Üzümlü district was used. The vines were Baran system-trained and cultural practices such as fertilization, irrigation, and pest control were uniform across the vineyards. In determining the level of damage caused by low temperatures in the vineyard during the dormant periods 2011-2012, 2012-2013, 2013-2014, the first 4 buds of the cultivar were taken as an effective basis and the level of damage was determined separately in primary, secondary and tertiary buds.

Just before the buds swelling, samples of an old cuttings were cut from the bottom and placed in polyethylene bags and transported to the laboratory. In order to determine the damage level more clearly in the samples, the samples were kept at room temperature for 24 hours in order to provide enzymatic browning. Then, the buds were opened with a razor blade and the vitality of the primary, secondary and tertiary buds was determined by binocular microscope (Odneal, 1984). For the first 4 buds left by conventional pruning method, the mortality of primary and secondary buds in addition the viability rates of the tertiary buds were determined. The mortality rates of primary and secondary buds and the viability rates of tertiary buds for the final viability were determined for the first 4 nodes left by the traditional pruning method.

The sections were taken from the appropriate depth according to the shape and size of the bud. In the sections taken very deeply (such as to reveal wood texture), even if the tissue is dead, it can be perceived as alive. In the sections taken from the center of the bud, the buds appearing as brown-black because of cold damage were accepted as dead.

The mortality rates of the primary and secondary buds (%) and the viability rates of the tertiary buds (%) were determined by counting the shoots from the primary, secondary and tertiary buds of the first 4 nodes that were left in the pruning in the vineyard conditions at spring. Counts were made in the spring when the shoots were about 10-15 cm in vineyards. The vitality of the buds has been determined according to the position of the shoots. If primary bud were shooting in a node, secondary and tertiary buds were also considered alive. If secondary buds were shooting in a node, tertiary buds were also considered alive. It is known that the cold resistance of secondary and tertiary buds is better than the primary buds and the cold resistance of tertiary buds is better than the secondary buds (Wample et al., 2000; Çelik et al., 2008).

In the sectioning method, 60 samples of cane were taken randomly from the same vineyard for each year. The study was planned as 4 replications and 15 canes were examined for each replicate. The same vineyard is used for shooting test and sectioning method. In the shooting test in vineyard, 4 replications and 15 canes were examined for each replicate.

As a result, whether there is any difference in the low temperature losses determined in the vineyard (by shooting test) and laboratory (by sectioning method) conditions were compared using the T test for proportions. In order to increase the reliability of the study, the data received for both methods were accepted as recurrences in 3 consecutive years and the study was evaluated as 12 repetitions in total.

RESULTS AND DISCUSSION

Air temperatures for the 2011-2012, 2012-2013, 2013-2014 dormant periods during in order to give an idea about the fluctuations of the cold in the year and the temperature changes between the years are given in Figure 1, Figure 2, Figure 3 (Meteorology, 2014). It was obtained from the Erzincan Meteorological Station.

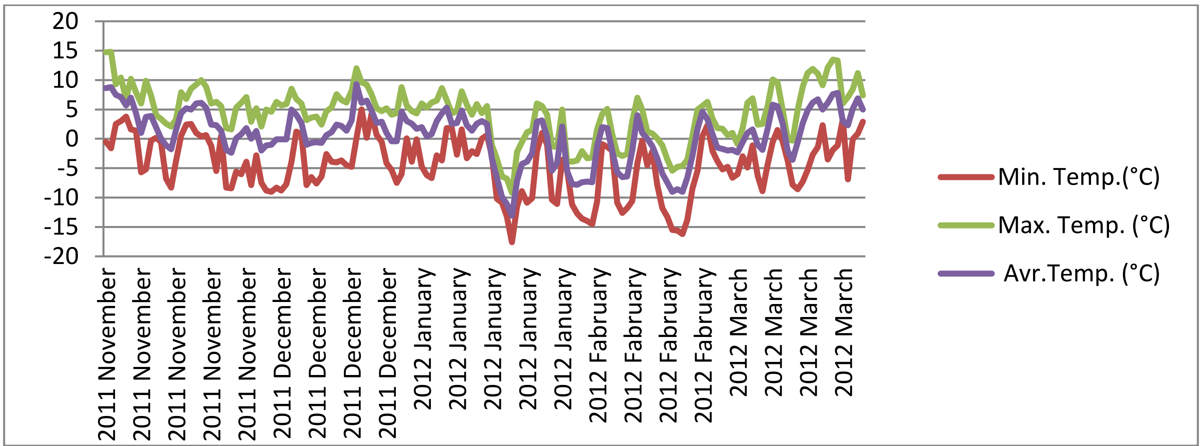

Figure 1. Daily temperature values for November 2011 to March 2012 period (Meteorology, 2014)

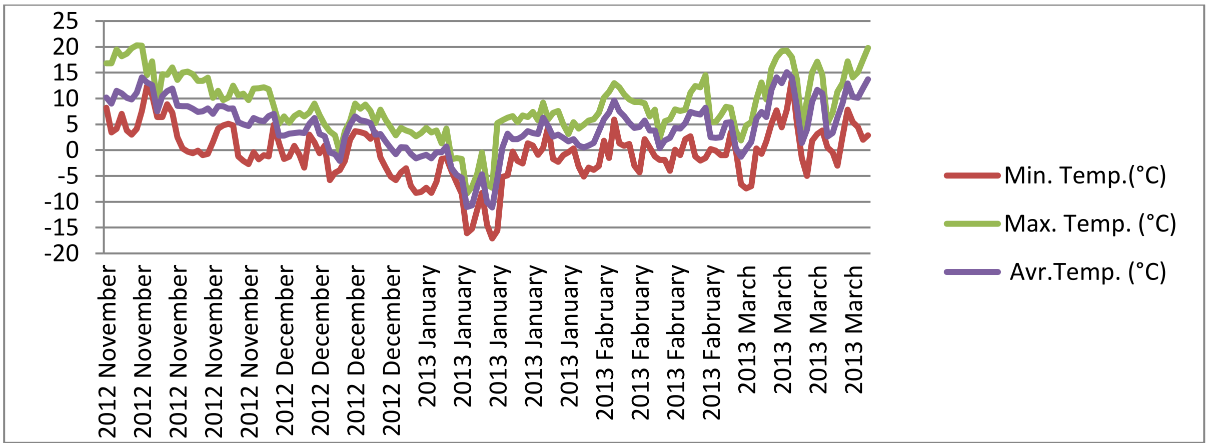

Figure 2. Daily temperature values for November 2012 to March 2013 period (Meteorology, 2014)

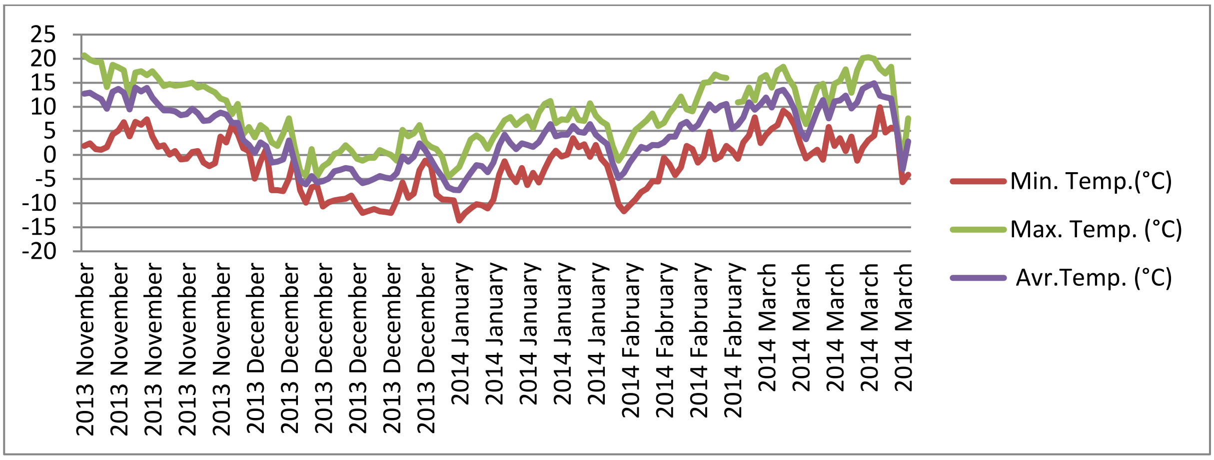

Figure 3. Daily temperature values for November 2013 to March 2014 period (Meteorology, 2014)

Figure 1, 2 and 3 shows that monthly average temperatures are the lowest value for 2012 year -4.6 °C and in February. In 2013, the lowest monthly average temperature value was -2.1 °C in January. In 2014, the lowest monthly average temperature value was 0.3 °C. When the monthly minimum temperature values are examined, it can be mentioned that the lowest values (-13.6 °C/-17.6 °C) are in January and the highest values (-12.2 °C/-14.2 °C) are in August in all three working years (Figure 1, 2 and 3). When the meteorological data of the study years are examined, it can be noted that there are no extreme situations that can affect the results.

Taking the average of years of the study, the mortality ratios of the primary and secondary buds and the viability of the tertiary buds in the dormant period are given in Table 1.

Table 1. Mortality rates (%) of primary and secondary buds and the viability rates (%) of tertiary buds according to shooting test and sectioning methods in Karaerik grape cultivar

	Mortality of primary buds (%)	**Mortality of secondary buds (%)**	**Viability of tertiary buds (%)**
METHOD	**ns**	*****	**ns**
Shooting test in the vineyard	61.95	36.42	64.10
Sectioning method in the laboratory	68.24	49.33	65.66

ns: non-significant, *: p<0,05

The mortality rate of primary buds was found 61.95%, the mortality of secondary buds was 36.42% and the viability rate of tertiary buds was 64.10% when the low temperature loss was evaluated according to the test of shooting in vineyard between 2012, 2013 and 2014 based on 1-4 average. The mortality of primary buds was found 68.24%, the mortality of secondary buds was 49.33% and viability of tertiary buds was 65.66% when the low temperature damage was determined between the same years according to the position of the buds by using the sectioning method from the bottom in laboratory conditions (Table1).

Cold damage rate in the primary, secondary and tertiary buds varied considerably depending on the position on the shoots of the buds. There were no statistically significant differences between the methods in winter buds 3rd and 4th nodes. However, it was found that there were statistically significant differences between the methods in the primary buds of the 1st and 2nd nodes. According to shooting test and sectioning method, the primary buds of 4th nodes on the shoots have been the buds most affected by low winter temperatures during working years. On the other hand, according to shooting test the primary buds of 2nd nodes and according to sectioning method the primary buds of 1st nodes buds were the least damaged buds and they were found more tolerant to low temperatures (Table 2).

Table 2. Mortality rates (%) of primary secondary and tertiary buds of buds according to shooting test and sectioning methods in Karaerik grape cultivar

Position	Methods	Mortality of primary buds (%)	Mortality of secondary buds (%)	Mortality of tertiary buds (%)
1st node		*	**ns**	**ns**
	Shooting test	65.44	42.10	42.10
	Sectioning method	53.40	31.00	25.90
2nd node		**	**ns**	**ns**
	Shooting test	52.30	33.80	32.50
	Sectioningmethod	67.60	46.60	32.70
3rd node		**ns**	**ns**	**ns**
	Shooting test	61.82	34.30	33.60
	Sectioningmethod	73.00	58.50	37.20
4th node		**ns**	**ns**	**ns**
	Shooting test	68.26	35.40	35.40
	Sectioningmethod	79.00	61.20	41.60

ns: non- significant, *:p<0,05, **: p<0,01

Differences in the tolerances of the winter buds to low temperatures according to their positions are confirmed by many researchers (Howell and Shaulis, 1980; Köse and Güleryüz, 2009). The winter buds on the 1st, 2nd and 4th nodes on the shoot of 15 different grape varieties were evaluated for tolerance to low temperatures and 1st winter buds were determined to have the highest tolerance (Çelik et al., 2008).

It is known that the cold damage that occurs in buds differs according to the years due to the influence of genetic factors and cultural practices, severity and duration of the cold. When we found that the mortality rate of primary buds was 68.24% by cross sectioning method according to the average years of our study, Kalkan et al., (2017), in their study in which they determine the damages of the primary buds in Erzincan in the winter season of 2007-2008, were determined as 81.62% approximately, by using sectioning method.

When the data of our study were evaluated, the difference between the sectioning method in laboratory conditions and the shooting test in vineyard was 6.29% in mortality ratio of the primary buds, 12.91% in mortality ratio of the secondary buds and 1.56% in viability ratio of the tertiary buds in the determination of the damage levels of the buds.

In the statistical analysis, it was observed that there was a difference in the determination in vineyard and laboratory conditions for only the mortality rates of the secondary buds. As a matter of fact, it is known that there are differences between the types of buds in the nodes of grapevine in terms of their resistance levels at low temperatures. Howell and Shaulis (1980) in their research for determine the influences of cold on primary and secondary buds of table grapes, they reported that the damage changes according to place and type of bud, in addition to they found some important damage level differences between types of vine. It should not be forgotten that the degree of browning of the sectioned bud will vary according to the cultivar and this may directly affect the results in the sectioning method. Furthermore, when the section is taken, the brown surface may not be 100% dead or it should not be ignored that it can heal this bud afterwards.

When counting according to the shooting test in the vineyard conditions, if the primary bud was shoot, the secondary buds were also recorded 100% live. However, it has been ignored that the secondary buds may be affected by damages, such as bud necrosis. It is important that it alternatively form some fertile shoots in the secondary shoots in cases where the primary buds do not shoot for any reason (Küpe and Köse, 2015). Tertiary buds, which play an important role in determining the ultimate viability, are important for the survival of the grapevine, the protection of the shape of the vine stock, the appropriate pruning of shoots and forming shoots in cases where primary and secondary buds do not shoot.

In areas where terrestrial climate prevails, low-temperature losses, which always pose a risk, cause serious loss of product, even cause the deterioration of the shape of vine stock and necessitate additional workforce and financing. In general, since climatic factors cannot be controlled in vineyard conditions, various measures are taken to try to minimize the impact of adverse climatic conditions on cultivated species. In recent years, the sustainability of economic viticulture has been put at risk by the effects of global climate change in areas where terrestrial climate prevails. As a matter of fact, it is very important for the viticulture to form a possibility of prediction by using the sectioning method, to take cultural and technical measures such as pruning, training system and determination of product load for reducing the losses of winter colds.

When these data are examined, yield estimation can be done earlier by determining the primary bud damage using the sectioning method on cuttings taken before foliation without waiting for the shooting and clustering. In addition, the appropriate pruning scheme for fertilization can be applied as a result of the determination of the level of damage by the sectioning method. The large similarity between the sectioning method and the shooting test in determination of the damage level in the primary and tertiary buds is beneficial not only in the scientific aspect, but also it is beneficial to viticulture farmers to anticipate the loss of yield and quality due to low temperature. Determination of the level of damage by the preliminary sectioning method will give an important idea to make the appropriate pruning in the spring and it will allow the farmer to take necessary measures in this direction.

It is possible to determine the damage levels of primary, secondary and tertiary buds by a simple method such as sectioning of the number of nodes left by traditional pruning in the years when low temperatures have occurred. After the damage level is determined, the number of nodes to be left on grapevine can be adjusted, taking into account the age and developmental status of grapevine. In this way, the vegetative development of the grapevine can be balanced, at the same time prevent loss of yield, and economic losses due to loss of yield can be minimized.

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