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Investigations on development of some grapevine cultivars (*V. vinifera* L.) in soilless culture under controlled glasshouse condition

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Abstract — Growing the grapevines in soilless culture began to gather some attention as a rewarding hobby. Although cultivation of grapes in soilless culture needs a lot of care, the vines, if trained properly, can take very little space and provide early harvest when cultivated in glasshouse. The present study was conducted to investigate development of grapevine cultivars Perle de Csaba, Pembe Cekirdeksiz and Italia grown in soilless culture under controlled glasshouse conditions. The soilless culture was performed in 60 L. pots containing equal mixture of peat and perlite. The phenological dates varied among the cultivars as expected due to the alteration in genotype-specific response to a given environment. Although the studied cultivars displayed great variation in berry set (from 25.3% in Italia to 44.4% in Perle de Csaba), satisfying data were obtained in all the genotypes considering the previous literature reports. The average cluster weights were 142.3, 170.5 and 196.0 for Perle de Csaba, Pembe Çekirdeksiz and Italia, respectively. The highest yield was obtained from Italia (1489.6 g vine^{-1}) and was followed by Perle de Csaba (1038.8 g vine^{-1}). However, commercial maturity date of Perle de Csaba was 23 days earlier than that of Italia. Therefore, Perle de Csaba may be considered to cultivate in soilless culture under glasshouse or greenhouse condition, although Italia also may be another option for high yield. The present study is anticipated to be model for indoor cultivation of grapevines with soilless culture.

Keyword — Glasshouse, Grapevine, protected cultivation, soilless culture

1. INTRODUCTION

Turkish Nation have had a unique strong tradition of growing grapes, a fine art that has been passed on from generation to generation. The art of grape growing has gone from just traditional cultivation to a science which had strong impact on international researches. Traditional grapevine cultivation has commonly been characterized with a large vineyard, a spacious garden. Recently, growing the grapevines in pots, called as soilless culture, began to supply grapes throughout the year in certain parts of the world. Further, this method has gathered some attention as a rewarding hobby. However, cultivation of grapes in pots needs a lot of care and the process is time consuming. If the vines are trained properly, they can take very little space and are great for early maturation under glasshouse condition. A flowering and fruiting vine growing in a pot can add interest, color and a bit of sparkle to a glasshouse, patio, balcony, courtyard or porch. One plus of a pot grown vine is the ability to move the plant around to create interest, where you want it. Particular consideration should be focused on the concrete selection of the cultivars [1]. There are hundreds of varieties of grapevines, and they can take a very wide range of climates [2]. İnterestingly, our literature investigations yielded no available experimental data on soilless culture of grapevines.

The Turkish grapevine germplasm is characterized by a high genomic diversity [3], [4] occurring from natural and human selection which established a strict relationship between the cultivar and the environment. The consequence is the presence of a remarkable number of cultivars characterized by a different physiological and morphological characteristic [5]. Such genotypic richness along with the climatic variability in Turkey presents the growers a wide range of purposes in production [6]. For example, Mediterranean Region of the country is characterized with its earliness grape ripening [7]. In this region, early ripening grape cultivars have generally higher income and thus the growers are mainly interested in such cultivars [8], [9]. Previously, many studies have been increasingly conducted on the use of polyethylene cover for early ripening of grapes. The results revealed an earliness period ranging from 14 to 29 days according to the cultivars and environments [7], [10], [11].

This study was conducted to evaluate the feasibility of grape growing in soilless culture under glasshouse condition.

Certain globally known grapevine cultivars were also aimed to compare for their responses to soilless culture (pot conditions).

2. MATERIALS AND METHODS

2.1. Plant materials and growth condition

Investigations were carried out in the research and implementation glasshouse (38°01.814N, 032°30.546E, and 1158 m above sea level) of Selcuk University, Konya, Turkey. Perle de Csaba and Pembe Cekirdeksiz were selected due to their promising early ripening results obtained by a long term doctorate dissertation study [1], while Italia was included due to its worldwide popularity. The three years old vines in equal growth were cultivated in pots (app. 60 L.) containing peat (1.034% N, 0.94% P_2O_5, 0.64% K_2O pH 5.88, Klassman®), perlite (0-3 mm in diameter) and vineyard soil mixture in equal volume under climate controlled glasshouse conditions. The vines (pots) were in a rectangular configuration of 0.5x1.0 m spacing from the vine trunks (2000 vines per 1000 m^2). At the beginning of the experiment, own-rooted vines in their third ages were selected on the basis of homogeneity in growth. Each cultivars consisted of 9 dividing into three replicates [12]. Prior to bud break, the vines were pruned to leave 8 to 12 buds on about 3-4 spurs according to the genotype-specific bud fruitfulness. The shoots were tied with thread to wires 2.5 m above the pots to let plants grow on a perpendicular position to ensure equally benefiting from the sunlight [13]. All the vines received the same annual amount of fertilizer (approx. 20 g N, 12 g P, 20 kg K, and 1.5 g Fe chelate per vine) from April to July. Irrigations were regulated and performed according to soil water matric potential (Ψm) levels using tensiometers (The Irrometer Company, Riverside, CA) [14]. To ensure the uniformity of irrigation, the field capacity of the soil was maintained around 60%. Relatively higher air temperature in the glasshouse was also performed to simulate the typical semi-arid Mediterranean climate. During vegetation periods (15 March - 30 October), daily air temperature and relative humidity, recorded using data logger (Ebro EBI 20 TH1) inside the glasshouse, were 25-38 °C and 33-55%, respectively. During the hot and dry summers (from the beginning of June to September), excessive heat accumulation in glasshouse was avoided by opening the roof and sidewall windows as well as slight whitewash painting (providing approx. 30% light reflection). Under this condition, the instantaneous light intensity inside and outside the glasshouse was 37330 and 53330 lux (Lutron LX-105) at 13:00 p.m.

2.2. Phenology and Growth Investigations

Phenological investigations were carried out with daily controls and averaged according to Jones and Davis [15] and Sabir [1]. The phenological events were considered to occur when, for a given varietal, 50 percent of the plants are exhibiting the physiological response. The total number of the buds left on each vine after pruning was counted. The number of bursting buds was monitored periodically and the bud break percentages were calculated. Bud break was defined as the stage when green tissue was visible beneath the bud scales [16]. Berry set percentage was calculated by counting both flower bud numbers before the beginning of blossom and seeded berries at harvest. Investigations on fresh weight (g plant^{-1}) and dry weight (g plant^{-1}) of pruning residue were performed when the shoots elongation was approaching cessation at the end of the vegetation period [17]. After obtaining the fresh weight, shoot dry weights were determined at 70°C for 72 h to a constant weight. Reproductive developments of grapevines were investigated between the budbreak and harvest. After bud break and subsequent two-month-shoot development, cluster number per vine was recorded [13]. Grapes were harvested when total soluble solids in berry juice reached ca. 16-17°Brix [1] according to the cultivar feature. Grapevine fertility (yield) was predicted by multiplying cluster number with measured final cluster weight.

2.3. Statistical analysis

All data were subjected to the variance analyses using SPSS 13.0 for Windows (SPSS Inc., Chicago, IL, USA) at $P<0.05$ level. The mean values were compared using the least significant difference (LSD) test.

3. RESULTS AND DISCUSSION

As presented in Table 1, bud break dates varied among the cultivars as expected due to the alteration in genotype-specific response to a given environment, as previously indicated by Gok-Tangolar et al. [9]. The earliest bud break occurred in Pembe Cekirdeksiz (25.02.2014), which was followed by Perle de Csaba (26.02.2014) and Italia (03.03.2014). Before bud break, grapevine requires a period of dormancy, which is induced by cold temperatures and a shortening of the photoperiod [2]. If the chilling requirement is not sufficiently fulfilled, budding is erratic, causing heterogeneous phenological development later in the season [18]. The differences in bud-break dates observed in the present investigation proves the findings presented by Nendel [19] as the mean accumulated heat sum for bud break is different for each cultivar. The first full bloom occurred in Perle de Csaba on 03.05.2015 and was followed by Pembe Cekirdeksiz (07.05.2014). The latest full bloom was recorded in Italia (14.05.2014). Similarly, harvest dates of the genotypes also varied from the earliest 17.07.2014 (Perle de Csaba) to the latest 09.08.2014 (Italia) according to the genotype-dependent climatic requirements. Such variant dates is due to the differences in heat summation aptitudes [15], [20] and also Perle de Csaba has been known as one of the earliest cultivars [1]. Furthermore, studying on adaptation of some foreign originated early ripening grape varieties, Ergenoglu [21] has already reported that Perle de Csaba was among the cultivars recommended for early production in greenhouse Mediterranean Region. Nonetheless, it could be underlined that new additional grapevine cultivars recently bred may also give promising results on better yield and quality for early production and thus they could be included in such studies.

Table (1) Phenological stages of the cultivars.

Cultivars	Bud break	Full bloom	Ripening
Perle de Csaba	26.02.	03.05.	17.07.
Pembe Çekirdeksiz	25.02.	07.05.	25.07.
Italia	03.03.	14.05.	09.08.

(day.month.2014).

Although the differences were statistically insignificant,

the bud break percentages among the cultivars varied from the greatest value 85.4% in Italia to the lowest 72.7% in Perle de Csaba (Fig. 1). Bud break percentages of cultivars were similar to that (80.2%) of Mohamed et al. [22] who studied the chilling requirement and bud break characteristics of grapes cultivated in southern Tunisia, an arid mild winter region.

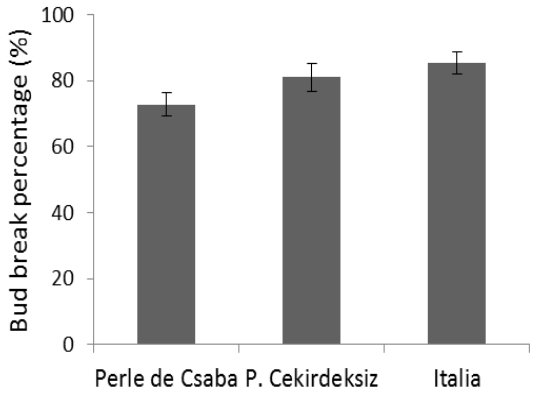

Fig. 1. The bud break percentages of the cultivars. Error bars represent significance of means from each other at $P < 0.05$ using LSD test.

There were significant differences among the cultivars with respect to berry set (Fig. 2). The greatest berry set value was determined in Perle de Csaba (44.4%) and was followed by Pembe Cekirdeksiz (35.0%), while the lowest value was obtained from Italia (25.3%). In this study, satisfying data were obtained in all the cultivars in the case of berry set, considering the berry set ranges reported in various studies by different researchers [23]-[25]. Infact, the berry set stage is essential for grape or wine production since it solely determines the potential grape yield. Not every flower on a cluster is fertilized, with the unfertilized flowers eventually falling from the vine. The percentage of fertilised flowers averages 30–50% but can reach 60% or be much lower [23], although this can vary considerably. Millerandage (heterogenity in berry size on cluster) happens when some fertilized flowers do not form seed.

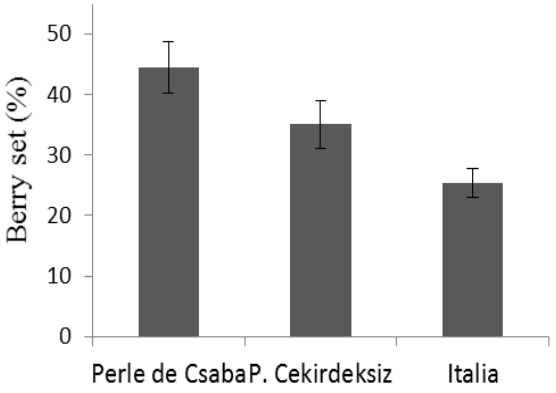

Fig. 2. The berry set percentages of the cultivars. Error bars represent significance of means from each other at $P < 0.05$ using LSD test.

As depicted in Fig 3, pruning residue, proven as a good indicator of the growth measurement [26], [27], has displayed significant differences among the cultivars. The highest pruning residue in fresh and dry weight was obtained from Pembe Çekirdeksiz, indicating more vigorous vegetative development in comparison with other cultivars studied. The present knowledge on vegetative growth of the grapevine cultivars indicates the essence of adjusting the climatic conditions inside the greenhouse in especially early summer period since cultivars differently respond to environmental variables.

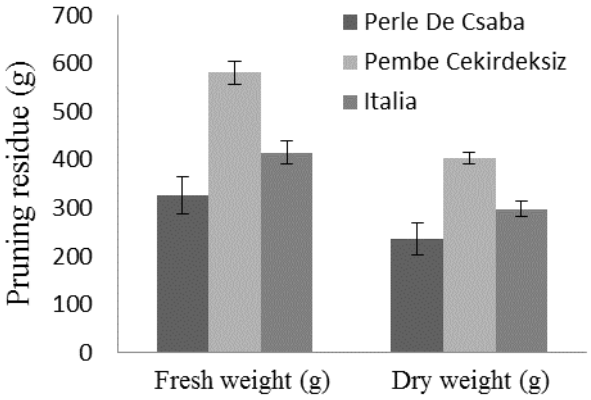

Fig. 3. Pruning residues of the cultivars (in fresh and dry weight). Error bars represent significance of means from each other at $P < 0.05$ using LSD test.

As can be seen in Table 2, bud fruitfullness (fertility), determined as cluster number per vine, greatly varied among the cultivars. The poor fertility determined in Pembe Çekirdeksiz possibly indicate the sensitivity of this genotype to environment. Indeed, yield decrease in potted plants are a common phenomon [28] and accepted in certain levels unless the quality falls below marketable degree [29]. Although the market prices and subsequent income per area is undoubtedly high in greenhouse [30], decrease in grape yield may also occur due to some unfavorable conditions dominated in glasshouse as previously mentioned by Uzun et al. [31]. Comparing the growth performances of various grapevine cultivars, Xia et al. [32] set forth an interpretation and concluded that the poor yield in Pembe Cekirdeksiz was arisen from excessive vegetative development under greenhouse condition. The results of mentioned and the present study imply that the covering material which directly affects the climate in greenhouse, should be carefully chosen to ensure sufficient light penetration to summer buds for both well-balanced vegetative development and healthy bud differentiation. Moreover, growth media such as pots or containers with the soil are also known to have core impacts on growth [33], as the roots release hormonal signals that result in growth regulation [34].

Investigations on cluster number, cluster weight and yield values of the cultivars were presented in Table 2. The average cluster weights were 142.3, 170.5 and 196.0 for Perle de Csaba, Pembe Çekirdeksiz and Italia, respectively. The cluster weight for Perle de Csaba was similar to those of vineyard-grown vines of the same cultivars determined previously by Ergenoglu [21] and Sabir [1]. The three-year-old vines in

soilless culture under glasshouse condition yielded 1489.6 g vine^{-1} grape for Italia, 1038.8 g vine^{-1} for Perle de Csaba and 818 g for Pembe Çekirdeksiz.

Table (2) Cluster number, cluster weight and yield values of the cultivars.

Cultivars	Cluster number	Cluster weight (g)
Perle de Csaba	7.3 a	142.3c
Pembe Çekirdeksiz	4.8 b	170.5b
Italia	7.6 a	196.0a

Means with different letters in a column are significantly different according to Student's t-test ($P \leq 0.05$).

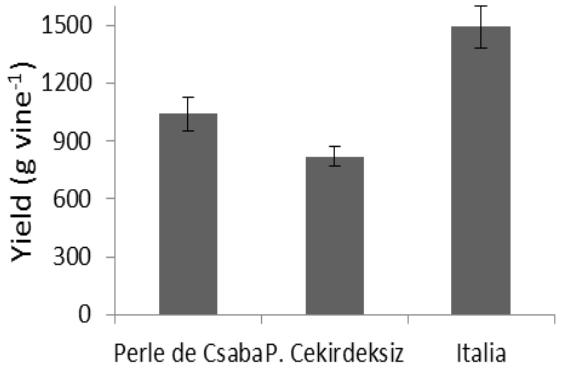

Fig. 4. Vine yields of the cultivars. Error bars represent significance of means from each other at $P < 0.05$ using LSD test.

4. Conclusion

The present study elicited preliminary and precious knowledge on enforceability of soilless culture production of grapevines from both scientific and rewarding hobby perspectives under glasshouse condition, as the literature has a very limited knowledge on experimental information on grapevine soilless culture. Satisfying berry set were obtained from all the genotypes considering the previous literature reports although the studied cultivars displayed great variation. The bud break and the subsequent phenological stages were independently occurred according to the findings on the studied cultivars. It implies that the early bud break under glasshouse condition does not necessarily mean early vegetative or floral growth. Thus, particular attention should be paid when especially allogame cultivars are considered to cultivate.

Among the studied cultivars, Perle de Csaba might be considered as prominent one according to the results when early maturity is a prime consideration. On the other hand, Italia was pioneering with its high yield among the cultivars and thus, this cultivar may also be considered to cultivate in soilless culture under protected cultivation conditions. However, studies with long-term investigations including new-bred cultivars may offer more extensive information on such production method. Finally, the results of this first report, to our best of knowledge, would be a precious reference for the feasibility of soilless culture in grapevines.

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