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The effects of rootstocks on growth and development of sour cherry (*Prunus cerasus* L. cv. "Kütahya") in the growing conditions of Bursa

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Abstract: Turkey is one of the most important sour cherry (*Prunus cerasus* L.) producers in the world, mostly producing the cultivar "Kütahya." To date, no previous study published on the effects of clonal roodstocks on the growth and development, yield, and fruit quality of "Kütahya" sour cherry. Therefore, this study was carried out from 2015 to 2019 to determine the influences of SL-64, Piku 3, Maxma 14, CAB 6P and PHL-C rootstocks on vigor, yield, and fruit quality of "Kütahya" sour cherry cultivar in Bursa, Marmara Region, Turkey. The effects of rootstocks on blooming period, ripening time, trunk diameter, trunk cross-sectional area, pruning waste, fruit weight and volume, fruit stalk length, soluble solids content, titratable acidity, pH, and ripening index were evaluated. No sour cherry trees on CAB 6P and PHL-C rootstocks died throughout the study period whereas trees on SL-64 rootstock showed high mortality (87%) in the first year of the study. In general, CAB 6P rootstock promoted the highest vigor and annual and cumulative yield. Yield efficiency was the highest for PHL-C but it was not significantly different from that for CAB 6P. CAB 6P rootstock induced the highest fruit weight and volume whereas Maxma 14 rootstock induced the lowest. Moreover, CAB 6P tended to induce higher fruit stalk length whereas Piku 3 induced the lowest. The soluble solids content was the highest in fruit from trees grafted on Maxma 14 but without significant differences with those in fruit from trees grafted on other rootstocks. In general, CAB 6P and PHL-C rootstocks tended to induce higher titratable acidity. In light of the findings of this study, it is concluded that CAB 6P was the best-adapted rootstock and it is recommended for establishing orchards of "Kütahya" sour cherry in the Marmara region.

Key words: Tree mortality, tree vigour, phenology, fruit quality

1. Introduction

Sour cherry (*Prunus cerasus* L.), a member of the *Rosaceae* family, is one of the most extensively consumed fruits, both in fresh and processed forms. Most of the sour cherry fruit produced is frozen or used in making jam, juice, marmalade, puree, concentrate, and confectionery products such as chocolates and candies (Bonerz et al., 2007; Kirakosyan et al., 2009; Ademović et al., 2017). Sour cherry originates from the territory extending between the Caspian Sea and the North Anatolian Mountains (Özbek, 1978; Demirsoy and Demirsoy, 2003; Demir et al., 2011; Demirsoy et al., 2017). It is particularly valued in countries such as Russia, Turkey, Ukraine, Serbia, and Poland, where it is produced in large quantities[1]. In 2021, Turkey produced 183,757 t of sour cherry[2]. Although sour cherry cultivation has spread to all regions in Turkey, commercial cultivation is done in limited areas with suitable climate conditions (Önal, 2002). Among the sour cherry cultivars produced in Turkey, "Kütahya," a cultivar of Anatolian origin, is the most popular. Its trees grow vigorously, fruits are very big, round, heart-shaped and stalks are long. The choice of cultivars has a big impact on the development and productivity of sour cherry trees. However, the production characteristics of sour cherry cultivars can be improved by using an appropriate rootstock, which can modify the growth and yields of trees to varying degrees (Ugolik and Hołubowicz, 1990; Kopytowski and Markuszewski, 2010).

In Turkey, seedlings of the mahaleb (*Prunus mahaleb*), wild cherry (*Prunus avium*), sour cherry (*Prunus cerasus*) and some clonal rootstocks are used in cherry production. In general, seedling rootstocks have a goodcompatibility with many cherry cultivars and are better adapted to

[1] Food and Agriculture Organization of the United Nations (2020). FAOSTAT [online]. Website http://www.fao.org/faostat/en/ [accessed 29.05.2022].

[2] Turkish Statistical Institute (2021). Crop Production Statistics [online]. Website https://biruni.tuik.gov.tr/medas/?kn=92&locale=en [accessed 29.05.2022].

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different soil types (Lang, 2000). However, these rootstocks have tended to promote tree height and take a long time to start bearing fruit. To deal with these problems, clonal rootstocks with different growth performances that can adapt to different ecological conditions are used (Rakonjac et al., 2016).

Most previous studies have demonstrated that cherry rootstock influences tree vigor, yield, and some fruit characteristic such as fruit size, soluble solids content (SSC), titratable acidity (TA), skin color, polyphenols, accumulation of sugars, anthocyanins, and vitamins. In addition, the rootstocks influence water use efficiency and time to flowering and harvesting (Lang et al., 1997; Webster, 2004; Spinardi et al, 2005; Whiting et al., 2005; Zarrouk et al., 2005; Gonçalves et al., 2006; Tareen and Tareen, 2006; Hajagos et al., 2012).

An important factor for successful sour cherry production is the appropriate choice of rootstock (Rakonjac et. al 2016). Because some rootstocks can increase tolerance to drought, humid soils, and salinity. Also, resistance to diseases, soil exhaustion, and nematodes depend on the vigor of rootstocks (Kiprijanovski et al. 2018).

Sour cherry rootstock studies have been carried out with different cultivars in other countries such as Poland, Serbia, Hungary, and USA. In these countries, rootstocks such as mahaleb seedling, Mazzard seedling, Colt, Maxma 14, SL-64, Gisela 5, and Gisela 6 were tested (Anderson et al., 1996; Hrotkó et al., 2005; Wociór, 2008; Daverynejad et al., 2009; Kopytowski and Markuszewski, 2010; Rakonjac et al., 2016; Milošević et al., 2020). However, there is still limited research on the appropriate rootstocks for the sour cherry to use in different ecosystems (Wociór, 2008). Also, the behavior of the rootstocks differs with soil and ecological conditions (Sarısu et al., 2016). Therefore, this study was carried out to analyze the influence of CAB 6P, Maxma 14, Piku 3, PHL-C, and SL-64 clonal rootstocks on vegetative growth, yield and fruit quality of the "Kütahya" sour cherry cultivar in the ecological conditions of Bursa, Turkey.

2. Materials and methods

2.1. Materials

The study was carried out between 2015–2019 in Bursa Uludağ University Faculty of Agriculture in Bursa (40°13'50.58" N; 28°51'34.51" E) located in the southern Marmara Region of Turkey. The altitude of the trial area above sea level was 111 m and the region had a mild climate. The trial was carried out on clay soil texture, pH value of 7.54, organic matter content 1.74% and lime content 1.22%. 'Kütahya' sour cherry cultivar grafted on CAB 6P, Maxma 14, PHL-C, Piku 3, and SL-64 rootstocks was used as a material. "Kütahya" sour cherry cultivar has a long period to start fruiting and it is considered to be less productive than the 'Montmorency' sour cherry[3].

2.2. Methods

The trees were planted at 4 × 5 m distance and trained as a central leader training system in 2012. The study plot was irrigated by flood irrigation method between 2012–2015. In the following years, irrigation was not carried out. Bordeaux mixture consisting of a combination of copper sulfate and lime was applied to the plants during the dormant period. In trees, phenological development stages such as bud burst, first bloom, full bloom, and end of bloom were recorded starting along with the growth-development season in the trial including data between 2015–2019 (Ballard et al., 1982). Tree mortality rates were monitored annually. In order to determine the vegetative growth of the trees, every year during the dormant period, trunk diameter was measured at 10 cm above the graft union and trunk cross-sectional area (TCSA) estimated by the formula TCSA = πr^2. Also in terms of vegetative growth pruning waste was determined. At harvest season, yield per tree was determined from the harvest data. Yield efficiency was determined by the division of cumulative yield per tree by the value of trunk cross- sectional area (TCSA). Fruit characteristics were studied with 20 fruit samples for each replication. Fruit characteristics such as fruit weight (g), fruit size (mm), and fruit volume (cm^3) (calculated by using ($V = 4 \times \pi \times r^3/3$, $r = (L + W + T)/6$ formula) (Pérez-Sánchez et al., 2010; Shahbazi and Rahmati, 2013; López-Ortega et al., 2016), fruit stalk length (mm) were measured according to standard morphometric methods. In addition, fruit chemical traits such as the soluble solid content (SSC) by hand refractometer, total acidity (TA) by titration with 0,1 N NaOH and pH value were determined in each replication. Also ripening index (RI) was estimated by the ratio of SSC and TA values (López-Ortega et al., 2016).

2.3. Statistical analysis

The trial was established in randomized blocks with three replications and three trees per replication. Statistical analysis of data was evaluated using the JMP 7.0 statistical software tool. Mean separation was performed using LSD's multiple range test at $p < 0.05$ level.

3. Results and discussion

3.1. Tree mortality

Tree mortality rates were recorded during the trials and tree losses were calculated. The highest tree mortality rate (87%) was recorded in trees grafted on SL 64 in the first year of the trial. Due to this high mortality rate, trials of trees on SL 64 were discontinued after the first year. Also, noticeable tree losses occurred on Piku 3, and Maxma 14 rootstocks with 27% and 7% of deaths, respectively (Figure 1).

[3] Personal communication with Dr. Mehmet Emin AKÇAY on 15 December 2021.

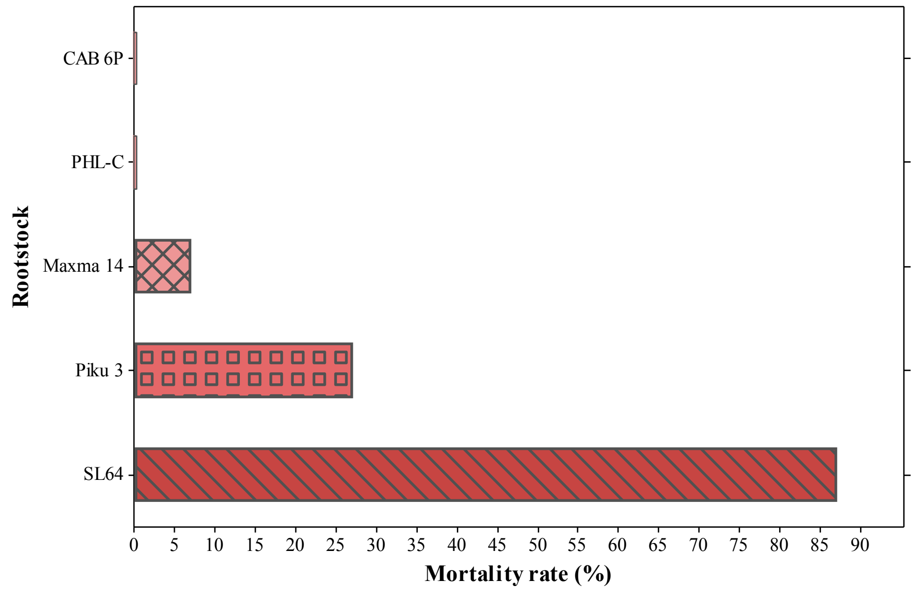

Figure 1. The mortality rate of sour cherry 'Kütahya' trees grafted on rootstocks CAB 6P, PHL-C, Maxma 14, Piku 3, and SL 64 during the study period (2015–2019).

In this study, it was observed that tree losses were influenced by rootstocks and soil conditions. The high mortality showed by trees on SL 64 rootstocks has already been reported for some cherry cultivars elsewhere (Moreno et al., 1996; Jiménez et al., 2007; Cantín et al., 2010; Long and Kaiser, 2010; López-Ortega et al., 2016). These tree losses could be explained by root asphyxia, commonly observed in heavy soils or where waterlogging and drainage problems occur. In contrast, no trees on *Prunus cerasus* selection (CAB 6P) and *P. cerasus* hybrid (PHL-C) rootstocks died. The observation of no mortality on CAB 6P rootstocks agrees with tree mortality values reported by Moreno et al. (2001) for the "Sunburst" sweet cherry cultivar grafted on different rootstocks. However, Godini et al. (2008) reported losses of trees on CAB 6P beginning in the first year after planting in some sweet cherry cultivars under nonirrigated conditions in South Italy. In addition, no mortality recorded in this study for trees on PHL-C rootstock contradicts the results of Bassi et al. (2016) who reported the highest mortality rate of sweet cherry trees grafted on PHL-C rootstock compared to other rootstocks. These differences in results suggest that tree mortality depends on soil and climatic conditions under which the rootstocks the using of cherry species.

3.2. Phenological observations

During the trials, phenological observations were recorded and average values for the years 2015–2019 are shown in Figure 2. In general, blooming periods of trees grafted on different rootstocks were observed between the first week and the third week of April. Trees on the Piku 3 rootstock started to bud burst and bloom 1 to 2 days earlier than on other rootstocks. In contrast, the blooming process of trees grafted on Maxma 14 rootstock began 2–3 days later than that of trees grafted on other rootstocks. The timing of the blooming process was similar for trees on CAB 6P and PHL-C rootstocks.

Choice of rootstock can influence the time of flowering in the spring as has been previously reported (Webster, 1995; Drkenda et al., 2012). In addition, rootstocks influence spring frost sensitivity by accelerating or delaying flowering time (Webster, 1995). Therefore, it can be predicted that trees grafted on Maxma 14 rootstock will be less affected by frost damage in the following years under these conditions. The average fruit ripening dates of trees grafted on different rootstocks are shown in Figure 3. These results indicate that trees on different rootstocks started ripening in the second week of June until the beginning of July. In general, trees on Piku 3 were the first to reach harvest maturity whereas trees on Maxma 14 were the last to reach harvest maturity. The trees on CAB 6P and PHL-C reached harvesting maturity at almost the same time.

3.3. Tree growth characteristics

Tree growth characteristics such as trunk diameter and trunk cross-sectional area (TCSA) were significantly affected by rootstocks (Figure 4). The highest values were recorded on CAB 6P rootstock. Moreno et al. (2001) pointed out that *P. cerasus* selections seemed to be the best-adapted rootstocks for sweet cherry cultivars in heavy soils under flood irrigation. As expected, our results indicate CAB 6P rootstock was better adapted to heavy soil conditions under which the trial was carried out. Also,

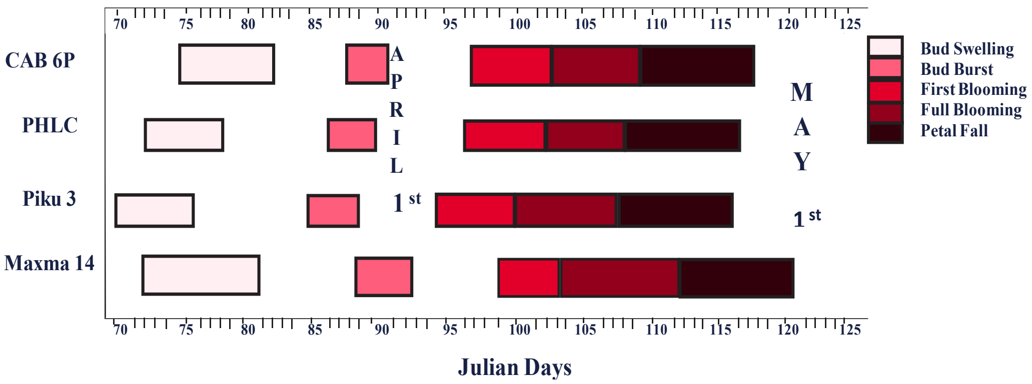

Figure 2. Blooming period of sour cherry 'Kütahya' in average four years (2015–2019) grafted on rootstocks CAB 6P, PHL-C, Piku 3, and Maxma 14.

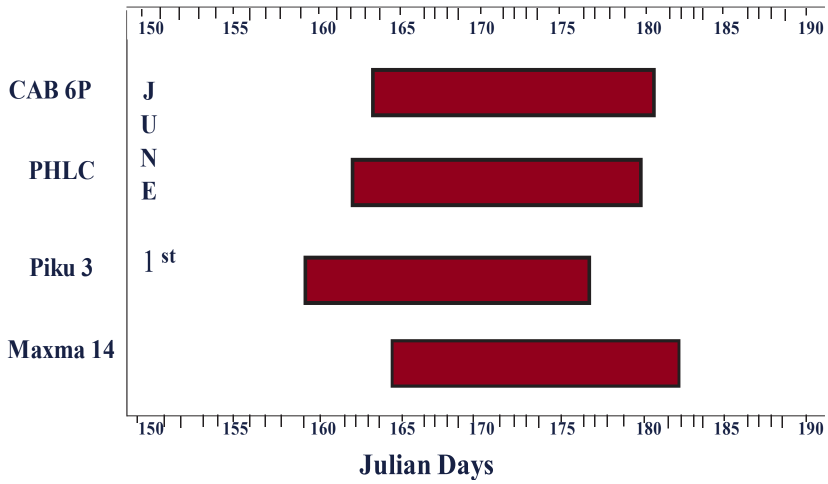

Figure 3. Rootstock effect on ripening date of sour cherry 'Kütahya' in average four years (2015–2019).

Cantín et al. (2010) reported that trees of "Van" and "Stark Hardy Giant" sweet cherry cultivars grafted on Maxma 14 showed a higher TCSA value than those on CAB 6P although they found no significant differences between these rootstocks.

For pruning waste, significant differences were observed among rootstocks (Figure 4). The highest weight of pruning waste was recorded for trees on CAB 6P followed by those on PHL-C and was lowest on Piku 3 rootstock. These results indicate that *P. cerasus* origin rootstocks, which are better adapted to heavy soil conditions, resulted in higher growth rates of the scion, probably inducing more pruning waste. Vigorous rootstocks have strong root systems and are more tolerant of drought and poor soils, but the trees are greater, and agricultural practical analyses such as mechanical harvest are made more complicated (Kiprijanovski et al., 2018).

3.4. Yield, cumulative yield, and yield efficiency

In this study, the cumulative yield was significantly higher for trees on CAB 6P rootstock than that of trees on other rootstocks. However, no significant difference was observed for yield per tree between trees on CAB 6P and PHL-C in 2017. The lowest yield values were recorded during the 4 years of study on Maxma 14 (Table 1). The high yields recorded for CAB 6P in this study support the findings of Serradilla et al. (2008) who recorded the highest yield for trees on CAB 11 E and CAB 6P in some sweet cherry cultivars. Also, some previous studies reported CAB 6P promoting greater yields than the other rootstocks for sweet cherries (Moreno et al., 2001; Jiménez et al., 2004). In contrast, Battistini and Battistini (2005) reported that "Lapins" sweet cherry on Maxma 14 had higher cumulative yields than CAB 6P in the dry conditions region of Italy. In addition, Font i Forcada et al. (2017)

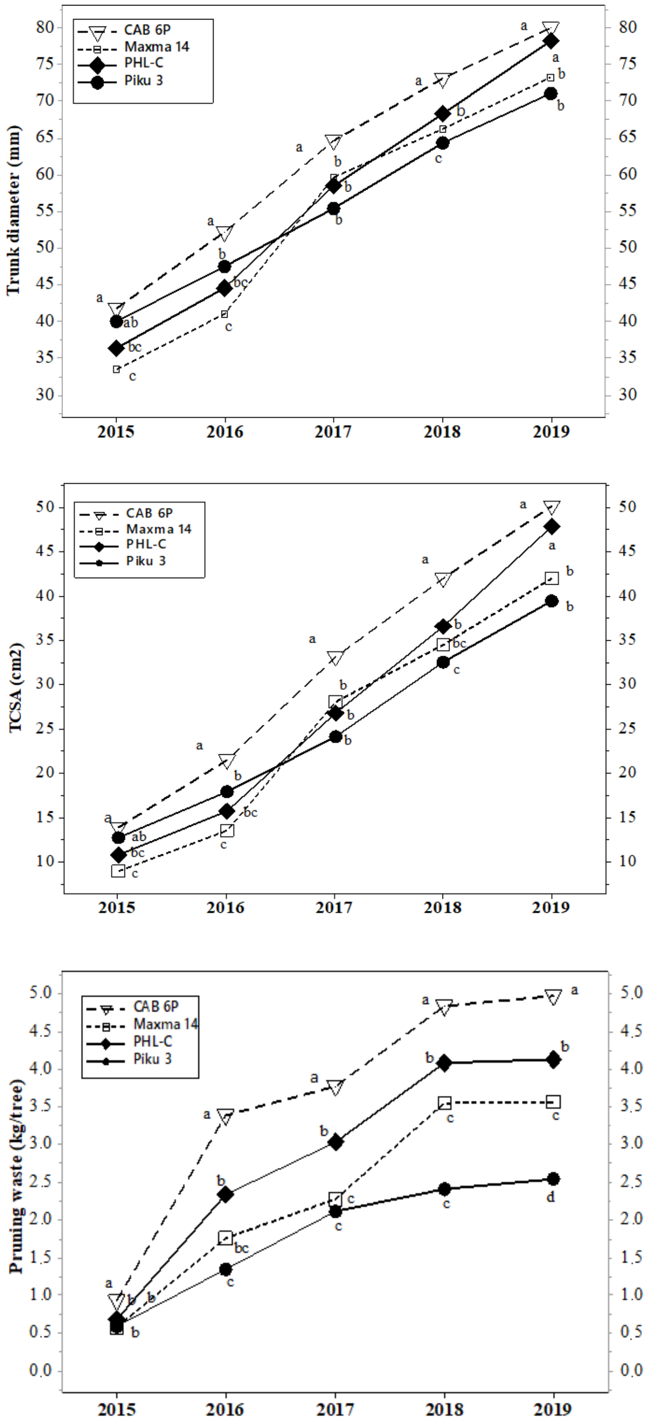

Figure 4. Rootstock effect on the trunk diameter, TCSA, and pruning waste of sour cherry 'Kütahya' during the study period (2015–2019).

reported that cumulative yield for "Stark Hardy Giant" sweet cherry did not significantly differ between CAB 6P and Maxma 14 rootstocks. These findings demonstrate that ecological conditions and cultivars interact in influencing the rootstock effect on cherry tree yields.

Yield efficiency is defined as cumulative yield per TCSA. In this study, yield efficiency was highest on PHL-C, although no significant difference was found with CAB 6P rootstock (Table 1). Also CAB 6P and Piku 3 rootstocks showed statistically similar results whereas Maxma 14 showed the lowest value. These results are similar to those of some previous studies reporting greater yield efficiency for CAB 6P than Maxma 14 (Cantín et al., 2010; Jiménez et al., 2004, 2007). According to Jiménez et al. (2007), Maxma 14 and *P. mahaleb* selections induced the lowest yield efficiency for some sweet cherry cultivars, possibly due to the imbalanced nutrition when grafted on these rootstocks. Contrary to the present results, Bassi et al. (2016) reported that "Kordia" and "Regina" sweet cherries on PHL-C had the lowest yield efficiency values among different rootstocks in the Alphe Adria Region.

3.5. Fruit weight, fruit volume, and fruit stalk lenght

Fruit weight showed significant differences among the rootstocks. The four-year average fruit weight values ranged from 5.0 to 6.1 g (Table 2). CAB 6P promoted the highest fruit weight whereas Maxma 14 induced the lowest fruit weight. These findings are compatible with those of some previous studies that found the lowest fruit weight on Maxma 14 (Simon et al., 2004; Grzyb et al., 2005; López-Ortega et al., 2016; Milošević et al., 2020). In addition, Jiménez et al. (2004) reported that *Prunus cerasus* based rootstocks such as CAB 6P showed high fruit weight values whereas Maxma 14 rootstock showed low values for "Sunburst" sweet cherry in their trial. However, some previous studies also reported that both CAB 6P and Maxma 14 showed high values for fruit size (Moreno et al., 2001; Cantín et al., 2010; Font i Forcada et al., 2017).

For fruit weight, CAB 6P had the highest value followed by PHL-C and Piku 3 rootstocks, respectively. Bassi et al. (2016) obtained similar results in two sweet cherry cultivars with high fruit weight for PHL-C. In addition, Hajagos et al. (2012) reported that PHL-C gave the best fruit weight results for the "Kordia" sweet cherry. López-Ortega et al. (2016) also obtained similar results reporting that Piku 3 induced the highest fruit weight in "Newstar" sweet cherry. In contrast, Grzyb et al. (1998) reported the

Table 1. Yield, cumulative yield, and yield efficieny values of sour cherry 'Kütahya' on rootstocks CAB 6P, PHL-C, Piku 3, and Maxma 14 in 2016–2019.

	Yield (kg tree^{-1})				Cumulative yield (kg tree^{-1})	Yield efficiency (kg cm^{-2})
Rootstocks	**2016**	**2017**	**2018**	**2019**		
CAB 6P	0.20 a	3.4 a	3.7 a	5.1 a	12.4 a	0.29 ab
PHL-C	0.17 b	3.3 a	3.4 b	4.8 b	11.7 b	0.31 a
Piku 3	0.15 b	2.2 b	2.7 c	4.0 c	9.1 c	0.27 b
Maxma 14	0.07 c	1.9 b	2.4 d	3.1 d	7.5 d	0.21 c

Means followed by the same letter in the same column are not significantly different at p ≤ 0.05 by LSD's multiple range test.

Table 2. Rootstock effect on fruit weight, fruit volume and fruit stalk lenght of sour cherry 'Kütahya' in 2016–2019.

Character	Rootstocks	2016	2017	2018	2019	Average
Fruit weight (g)	CAB 6P	5.0 a	6.8 a	6.4 a	6.1 a	6.1 a
	PHL-C	4.5 ab	5.9 b	5.9 b	5.7 b	5.5 b
	Piku 3	4.3 b	5.8 b	5.6 c	5.6 b	5.3 c
	Maxma 14	3.6 c	5.6 c	5.5 c	5.3 c	5.0 d
Fruit volume (cm^3)	CAB 6P	3.5 a	4.4 a	4.5 a	3.6 a	4.0 a
	PHL-C	3.2 b	4.2 a	4.1 b	3.5 ab	3.7 b
	Piku 3	2.9 c	4.1 a	3.9 b	3.5 ab	3.6 c
	Maxma 14	2.6 d	3.7 b	3.8 b	3.4 b	3.4 d
Fruit stalk lenght (mm)	CAB 6P	62.4 a	67.3 a	60.3 a	60.2 a	62.5 a
	PHL-C	61.6 ab	62.6 b	58.5 b	58.1 a	60.2 b
	Piku 3	53.2 c	56.4 c	52.5 d	50.7 c	53.2 d
	Maxma 14	59.7 b	62.5 b	53.9 c	54.3 b	57.6 c

Means followed by the same letter in the same column are not significantly different at p ≤ 0.05 by LSD's multiple range test.

lowest fruit weight in five different sweet cherry cultivars for PHL-C. These results suggest that the scion-rootstock relationship is very important in influencing some fruit properties such as fruit weight and size (Cantín et al., 2010).

Fruit volumes, which depend on fruit width, length, and thickness are given in Table 2. Average fruit volume values for four years ranged from 3.4 to 4.0 cm^3. Fruit volume differed significantly among rootstocks with fruits on CAB 6P showing the highest fruit volume and those on Maxma 14 showing the lowest. López-Ortega et al. (2016) obtained similar results with Maxma 14 giving the lowest fruit volume in "Newstar" sweet cherry.

In this study, rootstocks had a significant effect on fruit stalk length. The highest values were observed on CAB 6P (65.5 mm) followed by PHL-C (60.2 mm) and Piku 3 (53.2 mm) showed the lowest value (Table 2). Longer fruit stalk length is preferable to shorter ones because it makes picking easier and has a lower probability of decaying (Stojanovic et al., 2012). Thus, the fruit of trees grafted on CAB 6P are more favorable because of their durability and long shelf-life, especially for export.

3.6. SSC, pH, titratable acidity, and ripening index

Fruit characteristic values for pH, SSC, TA, and ripening index (RI) are given in Table 3. Except in 2016, rootstocks had no significant effect on pH throughout the study. These results conform to those of previous studies reporting that pH was not affected by rootstocks (Jiménez et al., 2004; Cantín et al., 2010; López-Ortega et al., 2016).

The effect of rootstocks on fruit SSC was significant for two out of the four years of the trial. Maxma 14 showed the highest value whereas CAB 6P showed the lowest (Table 3). Previous studies give conflicting results on the effect of rootstocks on fruit SSC. Cantín et al. (2010) report no effect but Jiménez et al. (2004) reported a significant effect. Present results are in agreement with those of Jiménez et al. (2004) who reported that "Sunburst" sweet cherry showed the highest SSC values on Maxma 14. López-Ortega et al. (2016) opined that rootstocks with the lowest yields induced higher fruit SSC mostly due to a more balanced leaf area-to-fruit leaf ratio. In agreement with López-Ortega et al. (2016) present results indicate that Maxma 14, which induced the lowest yields, gave the highest fruit SSC values. However, Cantín et al. (2010) reported a positive correlation between fruit size and fruit SSC, suggesting that rootstock-scion combinations with greater fruit sizes could induce higher fruit SSC values. Hajagos et al. (2012) concluded that the rootstock-scion combination was a more significant factor than scion or rootstock alone in determining fruit quality characteristics of cherry.

Table 3. Rootstock effect on fruit chemical characteristics values including SSC, pH, titratable acidity, and ripening index of sour cherry 'Kütahya' in 2016–2019.

Character	Rootstocks	2016	2017	2018	2019
SSC (%)	CAB 6P	13.6	15.7 b	16.1	16.1 b
	PHL-C	14.3	15.9 ab	16.3	16.7 ab
	Piku 3	14.4	16.4 ab	16.7	16.5 ab
	Maxma14	14.5	16.5 a	16.7	16.9 a
Titratable acidity (TA) (g/100 mL)	CAB 6P	0.47 a	0.65 a	0.67 a	0.67 a
	PHL-C	0.42 b	0.63 a	0.67 a	0.66 ab
	Piku 3	0.34 c	0.59 b	0.62 b	0.64 ab
	Maxma 14	0.42 b	0,58 b	0.64 b	0.62 b
pH	CAB 6P	3.13 b	3,09	3,15	3,15
	PHL-C	3.18 a	3,10	3,15	3,15
	Piku 3	3.20 a	3,11	3,16	3,16
	Maxma 14	3.19 a	3,11	3,16	3,16
Ripening index (IR)	CAB 6P	28,9 c	24,1 b	23,7 b	23,8 c
	PHL-C	34,1 b	25,0 b	24,3 b	25,2 b
	Piku 3	42,5 a	27,6 a	26,8 a	25,6 b
	Maxma 14	34,5 b	28,1 a	26,1 a	26,8 a

Means followed by the same letter in the same column are not significantly different at $p \leq 0.05$ by LSD's multiple range test.

In the study, both CAB 6P and PHL-C rootstocks induced higher titratable acidity (TA) values than those of the other two rootstocks. These findings are in agreement with those previous studies in which *P. cerasus* based rootstocks such as CAB 6P promoted higher TA values in some sweet cheery cultivars (Moreno et al., 2001; Cantín et al., 2010). TA affects consumer perception as it is related to fruit taste and quality and greatly depends on the cultivar (Serradilla et al., 2017). In addition, rootstock also plays a significant role in determining the acidity of sour cherry fruits (Kopytowski and Markuszevski, 2010; Bijelić et al., 2014). However, some previous studies reported that TA levels of fruits obtained from "Oblačinska" sour cherry grown on their own roots and those grafted on Mahaleb were similar, suggesting that the genotype had a stronger effect than the rootstock (Milutinovic et al., 2008; Kiprijanovski et al., 2018).

RI depends on the ratio of SSC and TA values. In this study, rootstocks had a significant effect on RI, with Maxma 14 and Piku 3 rootstocks showing higher values. In contrast, CAB 6P showed lower RI values due to higher TA values (Table 3).

4. Conclusion

In conclusion, the results of our study showed that, in growing conditions with heavy and clay soil, trees grafted on Maxma 14 rootstock induce lower vigor, yield, and fruit weight. In contrast, better agricultural productivity was found for trees grafted on CAB 6P rootstock, which showed higher vigor, yield, and fruit weight. Therefore, CAB 6P appears to be the best-adapted rootstock for "Kütahya" sour cherry under the conditions used in this study. Moreover, it is not recommended the use of SL 64 rootstock under clay soil conditions due to the high mortality rate recorded for trees grafted on it.

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