Influence of Rootstocks (Gisela 5, Gisela 6, MaxMa, SL 64) on Performance of '0900 Ziraat' Sweet Cherry

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Abstract: This study was carried out in order to determine the effect of rootstocks (Gisela 5, Gisela 6, MaxMa 14 and SL 64) on performance of sweet cherry cultivar '0 900 Ziraat' during 2010-2013 years. The trail in randomized block design was established as to factorial design. Each graft combination included 20 trees. The trees was trained as Spanish Bush training system. At the end of study, effect of rootstocks on vegetative growth was found significant. It has been determined that the trees grafted on SL 64 and MaxMa 14 rootstocks were more vigorous than the those grafted on Gisela 5 and Gisela 6. The rootstocks formed significant differences at the precocity. While the first blooming on the trees grafted on Gisela 5 and Gisela 6 rootstocks occurred at the second year after planting, the first blooming on the trees on MaxMa 14 and SL 64 rootstocks occurred at fourth year after planting. It has been determined that occur significant differences on yield per tree and yield efficiency among rootstocks. In terms of yield per tree and yield efficiency, While the lowest value was in SL 64 rootstock, the highest value was recorded in Gisela 5, and it has been determined that the differences between three rootstocks (Gisela 5, Gisela 6 and MaxMa 14) were not significant. While fruits weight varied according to the rootstock used in study, the trees grafted on Gisela 5 had the smallest fruit. Accompanied with differences between MaxMa 14 and SL 64 rootstocks were not significant, the biggest fruits were produced on trees grafted on SL 64 rootstock. As a result of the statistical analysis, it has determined that the rootstocks that used in trial did not create significant differences on soluble solids content (SSC) value. One of the most significant diagnosis was 6 % mortality rate that occurred on trees grafted Gisela 5 and Gisela 6 rootstocks.

Keywords: Rootstock, Gisela 5, Gisela 6, MaxMa, SL 64, Prunus avium, 0900 Ziraat.

INTRODUCTION

Anatolia is quite a convenient place to cultivate multitude of existing fruit and vegetable species in the world, considering ıts convenient ecological conditions in terms of growing horticultural plants, its being an intersection point of trade routes and a cradle for many civilizations since ancient times. While the most produced three species of fruits in Turkey are grape (4.296.350 tons), apple (2.680.080 tons) and orange (1.730.150 tons), sweet cherry is the tenth most produced fruit with 435.550 tons [1].

Sweet cherry is quite a popular fruit, because of its beautiful color and unique taste, and its being on the market during spring when the variety of ripe fruits is not that wide. Taxonomy done by botanist Linne's works, focused on plant and particularly flower characteristics, shows that sweet cherry (*Prunus avium. L*) belongs to *Prunus* genus of *Rosaceae* family of *Rosales* order. It is assumed that the origin of sweet cherry is somewhere around South Caucasus, coasts of the Caspian Sea and Northeastern Anatolia. The place where cherry was cultivated for the first time is known to be Anatolia [2]. Production of sweet cherry in Turkey has increased day by day, through there are not any problems in marketing of sweet cherry and it is more profitable, compared to many other fruit species.

Even though Turkey is the number one among sweet cherry producing countries in the world by producing 20% of the total sweet cherry production in the world, it can export only 10% of its cherry production. Moreover, yield per hectare in Turkey is quite below the world average.

While yield and fruit quality in sweet cherry vary dependent on many factors, the rootsocks that are used in orchard have particularly a significant role on vegetative growth, yield and fruit quality. The first blooming on the trees on vigorous rootstocks used in sweet cherry occurs at fourth or fifth year after planting and they produce higher trees that have narrow-angled branches so they are planted at 7 m x 8 m. For these reasons in the countries where vigorous rootstocks are used in sweet cherry is not profitable enough and growers are not satisfied. Therefore, production of sweet cherry in these countries decreases. The rootstocks that are used in sweet cherry directly affects the size and form of tree, fruit size, yield, precocity and fruit quality. Moreover, they affect pruning, training system and labor decisions [3]. Unfortunately, none of rootstocks ensure all the qualifications such as yield

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and fruit colour, firmness, fruit size etc. Choosing the appropriate rootstock does not only dependent on grower's managing skills, but also cultivar, training system and the place of orchard. In many countries, in order to obtain more yield from the unit area, dwarfing or semi-dwarfing rootstocks (Gisela series, Krymsk series, Weiroot series, P-HL series and Tabel Edabriz) are used, and by appropriate training systems are applied to these rootstocks that decrease the vegetative growth of tree, the orchards are estabilished with high-density systems [4]. But, in Turkey, sweet cherry growing is performed by using vigorous rootstocks (Mazzard and Mahlep). Use of dwarfing or semi-dwarfing rootstocks is not wide and there are so few studies on this subject in Turkey. Taking this situation into consideration, in this study, the influence of Gisela-5, Gisela-6, MaxMa 14 and SL 64 rootstocks on the performance of 0900 Ziraat cultivar that has a significant role in sweet cherry growing of Turkey, are aimed to be determined.

MATERIALS AND METHODS

The study was carried out between 2010 and 2013 in Suşehri, a district of Sivas, Turkey. According to climate data, in Suşehri, average temperature over years is 10° C, the hottest month average is 35.9° C, the coldest month average is -16.6° C, annual rainfall is 40 mm; relative humidity rate is 65% and monthly average sunshine duration is 209 hour. Soil analysis before planting showed that orchard soil is clayey-loamy, pH value is 7,9 and lime rate is 3%. Order to establish the trial, the young trees of 0900 Ziraat cultivar grafted on Gisela 5, Gisela 6, MaxMa 14 and SL 64 rootstocks were planted with spaces 3 x 4 m (Gisela 5 and Gisela 6), 3.5 x 4 m (MaxMa 14) and 4 x 4 m (SL 64) on 21 March 2010. The trail in randomized block design was established as to factorial design. Each graft combination included 20 trees. The trees were trained as Spanish Bush training system. In order to determine the vegetative growth of the trees, every year in autumn, on the rootstocks 15 cm below the grafting point and on the cultivar 15 cm above the grafting point, diameter of trunk of each tree was measured by a digital caliper with 0.01 mm sensitivity rate in the north-south and east-west directions. The cross-sectional area (A) of each trunk was calculated by the formula $A = \pi r^2$. Canopy volume (V) was calculated by measuring canopy height and canopy width and using the formula $V = \pi r^2 * h/2$.

Phenological stage of the trees are as follows: start of blossoming was designated as the time when 10% of flowers on the trees blossomed; complete blossoming was designated as the time when 80% of flowers on the trees blossomed; end of blossoming was designated as the time when 80% of petals were lost and fecundation occurred. The dates of each phenological stage were recorded. Harvest time was determined by considering harvest criteria such as fruit color. Yield per tree was determined by measuring the amount of harvested fruit by a weighting scale with 0.1 gram sensitivity rate. Yield efficiency was determined by dividing yield per tree by the value of Trunk Cross-Sectional Area (TCSA). Average fruit weight was determined by dividing yield per tree by the number of fruits a tree produced. Color of the fruit was determined by taking 20 fruit from each tree and measuring the color of each fruit from two distinct points on the fruit with the help of a colorimeter (Minolta Co., model CR-400, Tokyo, Japan). Fruit skin color was determined in three categories, L^*, a^* and b^*. According to prepared scale, a^* defines redness-greenness, b^* defines yellowness-blueness and L^* defines brightness. Chroma value was calculated by the formula $C^* = (a^{*2} + b^{*2})^{1/2}$ and hue angle was calculated by $h^0 = tan^{-1}(b^*/a^*)$.

Fruit firmness was determined in terms of the maximum force (N) that is needed to penetrate the fruit vertically. Measurements were carried out by the universal test device Zwick Z0.5 (Zwick/Roell Z0.5, Germany), a device that can apply force up to 500 N and has a 1,8 mm thick stainless-steel tip, at a speed rate of 0,5 mm/s and maximum 10 mm deep into the fruit. Fruit's flesh/seed ratios were calculated as the average of the ratios obtained by dividing flesh weight without seed by seed weight of each of 20 fruit harvested from each tree. 20 fruit harvested from each tree were divided into 3 groups and juice obtained from these fruit was tested in three different measurement to find the amount of soluble solids content (SSC) by a digital hand-held refractometer [%, (PAL-1, McCormick Fruit Tech. Yakima, Wash.)] and pH value by a pH-meter (Hanna, model HI9321).

For titratable acidity (TA) measurements, 10 mL sample from juice was taken and 10 mL distilled water was added to the samples. The samples were titrated with NaOH up to the value of pH was 8,1. And the value of TA is determined from type of malic acid by taking to note spent amount of NaOH in analysis. Ripening index rate was determined by taking the averages of the values founded by dividing soluble solids content (SSC) values of trees by titratable acidity values. The data taken the trail in randomized block design was established as to factorial design were treated by the ANOVA procedure in the SAS statistical program. The differences between treatments were determined by using Duncan test (p<0,05).

DISCUSSION AND CONCLUSION

Tree Vigor

In the study, when the traits (Tree height, canopy volume, rootstock trunk diameter, cultivar trunk diameter, shoot length, shoot diameter, TCSA rootstocks, TCSA cultivar, pruning waste) that influence the tree vigor are analyzed (Table **1**), it was observed that used rootstocks play a significant role in the vegetative growth of the trees. While generally there is not a significant difference between SL 64 and MaxMa 14 rootstocks, the most vigorous trees were produced by SL 64 rootstocks. While in terms of vegetative growth there is not statistically considerable difference between Gisela 5 and Gisela 6 rootstocks, the smallest values were obtained from these two rootstocks throughout the study. As a matter of fact, many studies [4-11] show that tree vigor changes according to rootstock that used, and vigorous rootstocks produced more vegetative growth compared to dwarfing rootstocks.

Blossoming

The precocity is significant in terms of amortizing expenditures and its contributions to fruit growing. The first fruit set on the trees on the vigorous rootstocks that are traditionality used in sweet cherry growing occur at fourth year or fifth after planting. As to train the young trees, pruning that is applied the young trees delays the first fruit set. So it is significant to use precocity rootstocks that shorten the period of the first fruit set. While the first blooming on the trees on Gisela 5 and Gisela 6 rootstocks occurred at second year after planting, the first blooming on the trees on MaxMa 14 and SL 64 rootstocks occurred at fourth year after planting. Late spring frosts have quite restricting effects on the economic fruit growing in Turkey. Sweet cherry is one of the earliest blossoming fruit species. Phenological stage in sweet cherries (blossoming and harvest time) are quite important in terms of protecting trees, and thus fruits, from severe effects of late spring frosts and prolonging the marketing period of sweet cherries. In the study, it is determined that phenological stage (start of blossoming, full blossoming, end of blossoming and harvest time) change by years. In last year of the study, while there was no significant time difference, Gisela-5 and Gisela-6 rootstocks were observed to blossom and be ready for harvest 1 or 2 days earlier, compared to the others. Studies (Tareen and Tareen 2004) show that blossoming time changes by chilling, rootstocks do not have considerable effect on blossoming and harvest time and there is only 1 day difference between rootstocks.

Fruit Yield and Quality

One of the most significant issues in Turkey's sweet cherry growing is that the yield per tree and yield per hectare are low. In the study, it was observed that rootstock choice has a significant effect on yield per tree. The highest yield per tree was obtained with Gisela 6 rootstock and although it was not a considerable difference, Gisela 5 rootstock's yield per tree was a bit less than Gisela 6 rootstock's. The lowest yield per tree was obtained with SL 64 rootstock (Table **2**). It can be said that the difference between rootstocks' precocity plays an important role in these results. The effect of rootstocks on yield per tree is supported by many studies [4-11].

According to results of the study, yield efficiency changes by rootstocks. While the lowest value was recorded with SL 64 rootstock, the differences among the other three rootstocks (Gisela 5, Gisela 6 and MaxMa 14) were not statistically significant, though the highest value was obtained with Gisela 5 (Table **2**). As a matter of fact [7], determined that rootstock has a significant effect on yield efficiency, and Gisela 5 rootstock has the highest and P-HL-B rootstock has the lowest yield efficiency.

Fruit quality in sweet cherries is significant in terms of marketing of them. Considering the direct relation between fruit quality and sunlight, with appropriate rootstocks, pruning and training systems high quality fruits can be produced. In the study, while fruit size changes by rootstock, the smallest fruit were obtained with the trees on Gisela 5 rootstocks. Studies carried out by [4] show that although there is not too much difference on fruits size between rootstocks, it was recorded that the smallest fruits were on Gisela 5 and the largest fruit were on Weiroot 154 rootstocks. It was observed that rootstock does not have an effect on the fruit color categories h^0 and L^* (h^0: hue angle, L^*: brightness). On the other hand, it has been determined that effect of rootstock is considerably important on the other three categories, namely a^* (redness-greenness), b^* (yellowness-blueness) and C^* (chroma value). While the highest values were obtained with Gisela 5, the lowest values were obtained with SL 64 rootstock

Table 1: Influence of Rootstocks on Vegetative Growth of '' 0900 Ziraat'' Sweet Cherry

Character	Rootsock	2010	2011	2012	2013
Tree Height (cm)	Gisela 5	127.7 b	172.3 a	191.0 c	217.6 b
	Gisela 6	118.4 b	197.8 a	217.1 b	231.2 b
	MaxMa 14	155.7 a	213.5 a	248.7 a	279.8 a
	SL 64	166.2 a	211.2 a	262.1 a	303.8 a
Canopy Volume (m^3)	Gisela 5		0.27 b	1.09 b	1.6 c
	Gisela 6		0.27 b	1.45 b	1.8 c
	MaxMa 14		0.51 a	1.98 ab	2.7 b
	SL 64		0.64 a	2.43 a	3.7 a
Rootstock Trunk Diameter (mm)	Gisela 5		38.5 c	50.1 b	51.6 c
	Gisela 6		39.4 bc	45.3 b	52.8 c
	MaxMa 14		46.5 ab	56.5 ab	77.7 b
	SL 64		51.7 a	68.4 a	97.9 a
Cultivar Trunk Diameter (mm)	Gisela 5	19.5 cb	35.3 b	48.5 b	60.3 b
	Gisela 6	17.3 c	38.8 ab	50.4 b	64.7 b
	MaxMa 14	21.0 b	37.9 ab	50.9 b	65.4 b
	SL 64	26.4 a	41.9 a	61.1 a	78.0 a
Rootstock TCSA (mm^2)	Gisela 5		977.7 b	2014.0 b	2132.8 b
	Gisela 6		1187.3 ab	1601.6 b	2046.4 b
	MaxMa 14		1141.5 ab	2513.7 b	4749.9 ab
	SL 64		1414.3 a	3814.3 a	7624.1 a
Cultivar TCSA (mm^2)	Gisela 5	303.8 cb	953.8 b	1881.0 b	2789.7 b
	Gisela 6	242.9 c	1125.5 ab	2015.4 b	3137.7 b
	MaxMa 14	359.7 b	1221.6 b	2040.1 b	3361.5 b
	SL 64	558.1 a	1455.8 a	3034.3 a	5333.8 a
Shoot Lenght (cm)	Gisela 5	44.2 ab	61.4 a	50.0 a	41.1 b
	Gisela 6	33.6 b	80.3 a	56.9 a	44.8 b
	MaxMa 14	40.7 ab	66.7 a	59.4 a	54.9 ab
	SL 64	49.0 a	68.8 a	56.9 a	64.8 a
Shoot Diameter (mm)	Gisela 5	8.4 a	7.5 b	6.9 a	6.5 c
	Gisela 6	8.2 a	10.4 a	6.9 a	6.8 c
	MaxMa 14	8.8 a	7.3 b	7.5 a	7.7 b
	SL 64	8.7 a	7.8 b	7.1 a	8.5 a
		2011	2012	2013	Total
Pruning Waste (g)	Gisela 5	46.1 b	159.2 a	235.2 b	440.5 b
	Gisela 6	43.8 b	206.0 a	165.0 b	414.8 b
	MaxMa 14	42.6 b	283.7 a	500.3 a	826.6 a
	SL 64	108.4 a	303.6 a	591.6 a	1003.6 a

The difference between mean values shown on the same column with the same letter is not significant according to Duncan's Multiple Range test at P<0.05.

Figure 1: Tree height in 2013, SL 64 (1), MaxMa 14 (2), Gisela 6 (3), Gisela 5 (4).

(Table **2**) [13]. In their studies carried out to determine the effects of rootstock-variety interactions on fruit quality, show that brightness and color of cherry change considerably by rootstock and variety-rootstock combinations. While fruit firmness and flesh/seed ratio change by rootstock, fruits on the trees grafted on SL 64 rootstock were determined to be softer and fruits on the trees grafted on Gisela 5 rootstock were measured to be the firmest ones. flesh/seed ratios of fruits on the trees grafted on MaxMa 14 rootstock were the highest and the lowest ratio values were observed with Gisela 6 and Gisela 5 rootstocks, though the ratio of Gisela 6 was insignificantly higher than the ratio of Gisela 5 (Table **2**). It has been verified that rootstock has effects on the fruit quality by several studies [14, 15]. It has also been determined that acidity and pH value are affected considerably by rootstock. The highest value of acidity was measured on the trees grafted on Gisela 5 rootstocks. The fruit on the trees grafted on SL 64 and MaxMa 14 rootstocks were measured to have the lowest acidity rates, though acidity rate of fruit on the trees grafted on SL 64 rootstock was found to be a bit lower than acidity rate of the ones on the trees grafted on MaxMa 14. In terms of the pH values, while SL 64 rootstock was found to be in the lead, the lowest pH values were obtained from fruits of the trees with Gisela 5 rootstock (Table **2**) [13]. In their studies carried out to determine the effects of rootstock-variety interactions on fruit quality, show that the amount of titratable acid changes significantly by variety, but has almost no effect on pH value. Moreover, it has been shown that the variety of rootstock does not have an important effect on both the amount of titratable acid and pH value.

Table 2: Influence of Rootstocks on Yield and Fruit Quality of '' 0900 Ziraat'' Sweet Cherry

Rootstock	Yield per tree (g)	Yield efficiency g /cm²	Fruit weight (g)	Fruit firmness (N)	Flesh/ seed ratio	Titratable acidity (%)	pH
Gisela 5	2708.0 a	35.6 a	5.8 b	3.297 a	10.6 b	0.77 a	3.80 b
Gisela 6	3013.6 a	36.9 a	6.2 b	3.138 a	12.1 b	0.74 a	3.80 b
MaxMa 14	1714.0 b	25.5 a	7.2 a	2.978 b	16.0 a	0.69 b	3.91 a
SL 64	359.6 c	3.9 b	6.8 a	2.962 b	15.4 a	0.65 b	3.95 a
			Fruit Colour				
	SSC (°Brix)	Ripening index	a*	b*	C*	h°	L*
Gisela 5	14.16 a	18.26 b	38.9 a	25.9 a	46.8 a	33.6 a	41.1 a
Gisela 6	13.73 a	18.56 b	36.6 a	23.2 a	43.3 a	32.1 a	38.9 a
MaxMa 14	14.60 a	21.02 a	32.9 b	20.9 b	39.0 b	32.3 a	38.1 a
SL 64	14.20 a	21.95 a	32.8 b	20.5 b	38.8 b	31.3 a	37.9 a

The difference between mean values shown on the same column with the same letter is not significant according to Duncan's Multiple Range test at P<0.05.

Figure 2: Yield in 2013, SL 64 (1), MaxMa 14 (2), Gisela 6 (3) ve Gisela 5 (4).

As a result of statistical analyses carried out, rootstocks used in the study were determined to have no significant effect on the amount of soluble solids content (SSC) (Table **2**). As a matter of fact, [9], show that although it is very small and inconsistent, rootstock and fruit load have an effect on the amount of (SSC). Ripening index of the fruits on the trees grafted on SL 64 rootstocks was measured to be the highest in the study. On the other hand, it has been concluded that there is not a significant difference between Ripening index of the fruits on the trees grafted on both SL 64 and MaxMa 14. Furthermore, the lowest Ripening index was recorded fruit on the trees grafted on Gisela 5 rootstock. (Tablo:2). It has been determined that the rootstocks used in the study have no significant effect on fruit cracking and moreover, fruit cracking did not occur throughout the study. According to obtained results, it can be claimed that variety and climate play role in fruit cracking. Studies carried out regarding cracking issue support the results as well. Another significant result of the study is that 6% death rate has been detected among the trees grafted on Gisela 5 and Gisela 6 rootstocks [15]. In their study, show that all of the trees on Gisela 4 rootstocks in Croatia and 80% in Slovenia died before the study finished.

CONCLUSION

In sweet cherry growing, using vigorous rootstocks that produce the big tree that grows vertically, has narrow-angled branches and sets fruit at fourth or fifth year after planting causes problems on fruit yield and fruit quality. Using rootstocks that are able to control vegetative growth and precocity might contribute to solve such issues. As a result in this study, it has been determined that rootstocks play a significant role in both vegetative and generative growth of trees.

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