DOI: 10.29050/harranziraat.910900
Harran Tarım ve Gıda Bilimleri Derg. 2021, 25(3): 279-286

Research Article/Araştırma Makalesi

Investigation of vegetative growth, yield and fruit quality characteristics of 'Hafif Çukurgöbek' loquat cultivar grafted on different quince rootstocks

Farklı ayva anaçları üzerine aşılı 'Hafif Çukurgöbek' yenidünya çeşidinin vejetatif büyüme, verim ve meyve kalite özelliklerinin incelenmesi

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To cite this article:
Akkuş, S. & Polat, A.A. (2021). Investigation of vegetative growth, yield and fruit quality characteristics of 'Hafif Çukurgöbek' loquat cultivar grafted on different quince rootstocks. Harran Tarım ve Gıda Bilimleri Dergisi, 25(3): 279-286.
DOI: 10.29050/harranziraat.910900

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Received Date:
06.04.2021
Accepted Date:
14.07.2021

ABSTRACT

'Hafif Çukurgöbek' loquat budded on three quince rootstock (BA-29, A, and C) were evaluated in 2018 and 2019 in Hatay, Turkey. Fruit ripening was the earliest in BA-29 rootstock in both years. The highest fruit weight was obtained from Quince-C rootstock and followed by BA-29 rootstock, and Quince-A rootstock. Quince-C rootstock yielded significantly higher values in terms of seed number, seed weight, and flesh/seed ratio. BA-29 and Quince-A rootstocks had similar values in terms of total soluble solids, while Quince-C rootstock had the lowest value. Differences between the rootstocks in terms of titratable total acidity and pH were not found to be statistically significant. Quince-C rootstock gave higher values in terms of annual shoot length, scion and rootstock diameter compared to Quince-A and BA-29 rootstocks. The differences between the rootstocks in terms of vegetative parameters were found to be statistically significant at 1% level. Our preliminary data indicate that dwarfing quince rootstocks can be used in intensive plantings of loquat. In this study, BA-29 and Quince C rootstock performed better than Quince-A. Considering yield and fruit quality based on total soluble solid, BA-29 rootstock seems the best choice.

Key Words: Loquat, Quince rootstocks, Fruit quality, Vegetative growth, Yield

ÖZ

Üç ayva anacına (BA-29, A ve C) aşılanmış Hafif Çukurgöbek yenidünya çeşidi, Hatay'da(Türkiye) 2018 ve 2019 yıllarında değerlendirilmiştir. Meyve olgunlaşması, her iki yılda da BA-29 anacında en erken olmuştur. En yüksek meyve ağırlığı Quince-C anacından elde edilmiş ve bunu BA-29 anacı ve Quince-A anaçları takip etmiştir. Tohum sayısı, tohum ağırlığı ve et / tohum oranı bakımından Quince-C anacı önemli ölçüde daha yüksek değerler vermiştir. Suda çözünebilir kuru madde bakımından BA-29 ve Quince-A anaçları benzer değerlere sahipken, Quince-C anacı en düşük değere sahip olmuştur. Titre edilebilir toplam asitlik ve pH açısından anaçlar arasındaki farklılıklar istatistiksel olarak anlamlı bulunmamıştır. Quince-C anacı, Quince-A ve BA-29 anaçlarına göre yıllık sürgün uzunluğu, anaç ve kalem çapı açısından daha yüksek değerler vermiştir. Vegetatif parametreler açısından anaçlar arasındaki farklılıklar, istatistiksel olarak % 1 düzeyinde önemli bulunmuştur. Ön verilerimiz, bodur ayva anaçlarının sık dikim yenidünya yetiştiriciliğinde kullanılabileceğini göstermektedir. Bu çalışmada, BA-29 ve Quince C anaçları, Quince-A'dan daha iyi performans göstermiştir. Toplam çözünür kuru maddeye göre meyve kalitesi ve verim göz önüne alındığında, BA-29 anacı en iyi seçenek gibi görünmektedir.

Anahtar Kelimeler: Yenidünya, Ayva anaçları, Meyve kalitesi, Vejetatif büyüme, Verim

Introduction

World production of loquat (*Eriobotrya japonica* Lindl.) is about 565 thousand t. China is in first place with a production of 453.6 thousand t from 118,270 ha, followed by Spain, 41.4 thousand t from 3,230 ha, while Turkey ranks fourth with of 16 thousand t from 986 ha (Polat, 2018). Since loquat ripens before most fruit species demand and prices are high (Polat and Kaşka, 1991; Özçagıran et al., 2011).

Loquat trees are 5-10 m tall and form a large crown with high cultivation and harvesting costs. The most effective method of controlling plant height is the use of dwarfing rootstocks.

Dwarfed trees reduce costs of pruning, spraying, thinning and harvest and with high populations have high yields with excellent fruit quality (Polat et al., 2003, 2004). Quince, pyracantha and loquat seedling have been used as rootstocks (Ochse et al., 1961; Hızal et al., 1982). Quince rootstocks slow scion growth reducing tree size by 20 to 25% as compared to loquat seedlings, increase earliness, and increase fruit quality and size (Demir, 1987; Polat and Kaşka, 1992a, b; Polat, 1995). Although quince rootstocks have dwarfing effect on loquat, the effects of quince rootstocks on the fruit yield and quality have not been evaluated on Turkish cultivars. The present study evaluated yield and quality of 'Hafif Çukurgöbek' loquat budded on Quince-A, Quince-C and BA 29 rootstocks. Here, the first results were presented.

Material and Methods

Material

This study was carried out in Hatay (36°12'E, 36°52'N, 80 m.a.s.l.), Turkey during 2018 and 2019. The experiment area has a typical Mediterranean climate; the yearly average temperature is 18.3°C, with 1168 mm precipitation which primarily falls during winter and spring. The soil is alkaline (pH:7.76), with very little lime (% 2.4), moderate salt (EC microsiemens: 446) and sandy-loam (%57.37 sand, %25.32 loam and %12 clay).

One-year old 'Hafif Çukurgöbek loquat trees budded on BA-29, Quince-A and Quince-C quince rootstocks were planted (Figure 1) at spacings of 1.0 x 0.5 m (2000 trees/da) in January 2017, drip irrigated, with standard cultural practices. Trees were trained according to open-centre system.

Rootstocks and varieties

The BA-29, Quince-C and Quince-A rootstocks used in the experiment are rootstocks were selected at the East Malling Research station, UK.

'Hafif Çukurgöbek' is an early cultivar with medium-sized, orange-colored fruit, very tasty and sweet was selected in Turkey (Demir, 1987). It is self-fertile and resistant to scab incited by *Spilocaeae eriobotryae.*

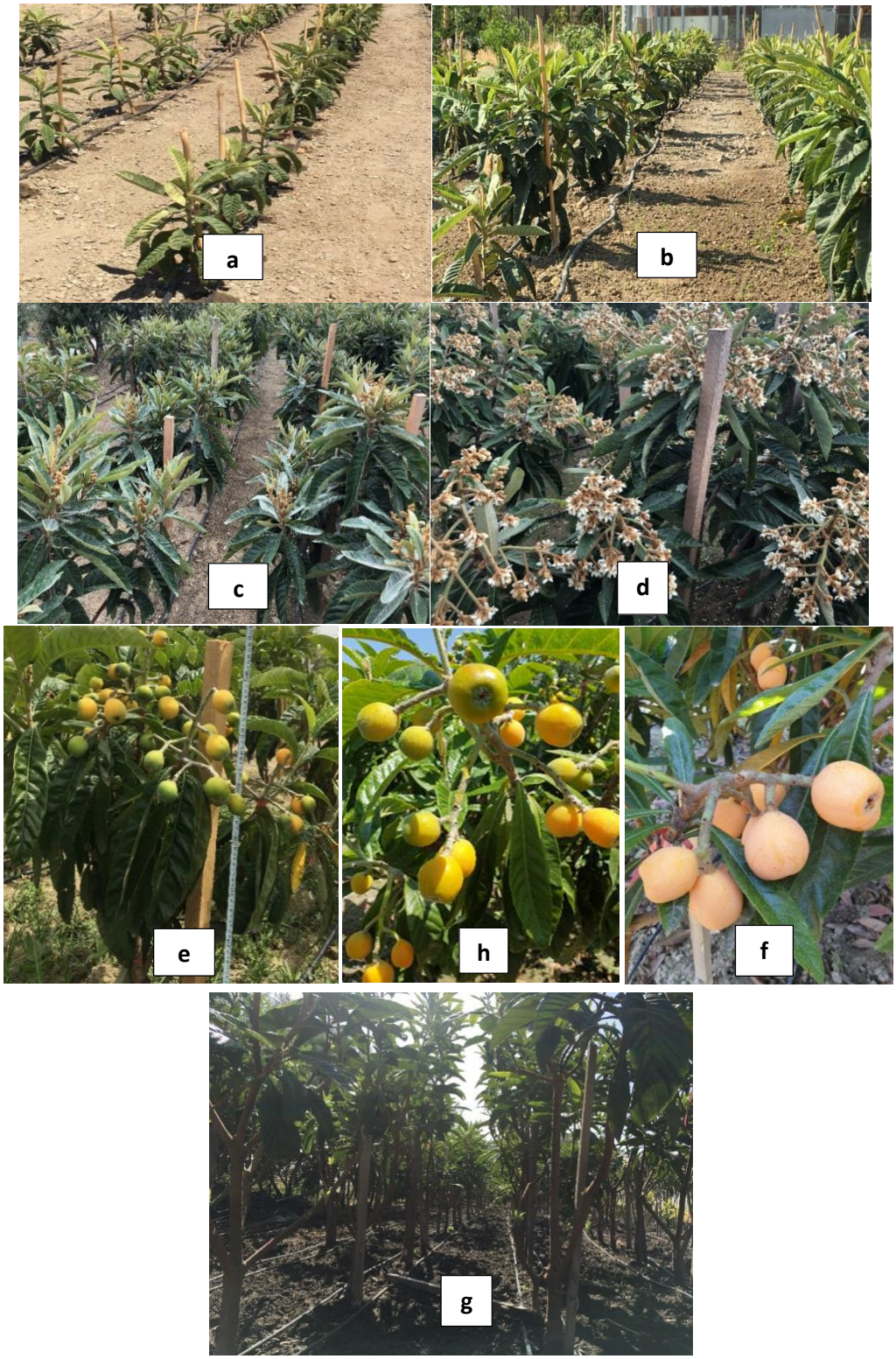

Figure 1. Successive steps of high density orchard of 'Hafif Cukugöbek' loquat. (a) Planting; (b) Irrigation and tillage; (c) Branches of flower cluster begin to elongate; (d) Full bloom; (e,f,g) Fruit maturity stages; (h) Current condition.

Method

The experiment was arranged according to a completely randomized designed with 5 replications and 6 plants were used in each replicate.

Pomological characteristics

To determine fruit quality, 50 fruits (10 fruits from each replicate) were randomly sampled from each cultivar/rootstock combination and physical and chemical measurements and analyzes were carried out including fruit weight (g), fruit dimensions (mm), seed weight (g), number of seeds (pieces), flesh seed^{-1} ratio (%), total soluble solids (TSS) (%), titratable total acidity (TA) (%), pH.

Vegetative growth

Vegetative growth of trial plants was measured

at three month intervals starting from February 2018.

Annual shoot length (cm)

Four shoots from each plant were measured from 4 sides of the plants.

Trunk diameter (mm)

Scion and rootstock trunk diameters (5 cm below and above of bud union) were measured in all plants with a digital caliper sensitive to 0.01 mm.

Bud union-first branching (cm)

The distance between the bud union and the first branching on the scion trunk was measured.

First branching - longest shoot (cm)

The distance between the first branching and the top of the longest shoot on the scion trunk was measured.

Bud union-longest shoot (cm)

The distance between the bud union and the top of the longest shoot on the scion trunk was measured.

Yield

Yield per tree (kg plant^{-1})

Fruit weight of each plant was determined.

Yield per trunk unit cross-sectional area (g mm^{-2})

Stem cross section was measured 5 cm above the budding point in May of each year.

Yield per area (ton/da)

Considering the planting distances in the experiment, the yield for area-basis was calculated by multiplying yield per tree with the number of plants.

Data analysis and statistics

Analysis of variance (Anova) was used based on a completely randomised design, and the means were separated by Tukey's HSD multiple comparison test at 0.01(Steel and Torrie, 1980). The percentage values were transformed to increase normality by the angle transformation before submitting the data to the analysis of variance.

Results and Discussion

Fruit quality

The results of the statistical analysis made according to the two-year averages are given in Table 1.

According to the two-year averages, the highest values in terms of fruit weight and fruit size were obtained from plants with rootstock Quince-C, followed by BA-29. The lowest values were obtained from was Quince-A. This difference between the rootstocks was found to be statistically significant at 5% level (Table 1). Quince-C rootstock also gave higher values in terms of seed number and seed weight ratio than the other two rootstocks. Differences between the rootstocks were be statistically significant. The highest value in terms of flesh seed^{-1} ratio was determined in Quince-A rootstock but the difference between the rootstocks was not significant. In terms of total acidity and pH, close values were obtained from all three rootstocks.

In loquat cultivation, many factors such as cultivar, soil structure, climate conditions and picking time affect the physical and chemical properties of the fruit (Toker et al., 2010). In the previous studies, the fruit weight of 'Hafif Çukurgöbek' on loquat seedling was between 20.45 g and 39.70 g (Paydaş et al., 1992; Polat et al., 2004, 2005 and 2010; Polat and Caliskan, 2011). Durgac et al. (2006) found the fruit weight in 4 loquat cultivars to be between 22.55 g and 25.68 g. Fruit weights determined in our study are lower than the values found in previous studies except for that of Durgac et al. (2006). This difference may have resulted from the fact that the plants in this experiment were younger than the plants in other studies. Fruit size is an important criterion that can vary depending on tree age and fruit set (Durgaç et al., 2006).

In previous studies, researchers measured fruit

width as between 36.79 mm and 40.10 mm; determined the fruit length as between 37.3 mm and 42.40 mm (Polat et al., 2005 and 2010; Polat and Caliskan, 2011). Durgac et al (2006) determined the fruit width to be between 32.83 mm and 36.51 mm, and the fruit length to be between 33.84 and 44.35 mm. The fruit widths determined in our study, while being similar to that of Durgac et al (2006), are different from the findings of other studies. In terms of fruit length, it was partially similar. Our seed weight values are between 4.50-5.71 g. In the previous studies, seed weight was found to be between 4.0 and 7.73 g (Polat et al., 2004, 2005; Durgac et al., 2006; Polat et al., 2010; Polat and Caliskan, 2011). Our seed weight values were found to be lower than those of researchers except for Durgac et al (2006) and Polat and Çalışkan (2011). The number of seeds was determined to be between 3.34-3.82. In previous studies, the number of seeds was between 2.4 and 4.16 (Polat et al., 2004, 2005 and 2010; Durgac et al., 2006; Polat and Çalışkan, 2011). The data of the combinations examined show similarities with the data determined in other studies. The amount of flesh of the fruit is considered as one of the important criteria in fruit quality, and in determining this, the flesh/seed ratio is accepted as a criterion. While this rate was determined to be between 3.21-2.89 in the study, this value was measured as between 3.43 and 5.42 in previous studies (Paydaş et al., 1992; Polat et al., 2004, 2005 and 2010; Durgac et al., 2006). The values obtained in our study are partially similar to those in previous studies. In our study, BA-29 rootstock gave higher values in terms of total soluble solids than the other two rootstocks. In previous studies, researchers measured TTS as between 8.05-12.80%. The values determined in our study are generally similar to those of previous studies. In this study, titratable acid was determined to be between 0.75-0.81 and pH as 3.42-3.79, while in previous studies, acidity was 0.63-9.92 and pH was measured to be between 3.29 and 4.5 (Polat et al., 2004, 2005; Durgac et al., 2006; Polat et al., 2010; Polat and Caliskan, 2011). Our findings are lower than the values of Polat et al (2010) and higher than the values of Polat et al (2005). TTS, acidity and pH are affected by such factors as time of picking, climatic conditions, cultivars, etc.

Table 1. The effects of quince rootstocks on fruit quality parameters of the Hafif Çukurgöbek loquat cultivar (2018-2019 average)

Rootstock	Fruit weight (g)	Fruit width (mm)	Fruit length (mm)	Seed weight (g)	Seed number per fruit	Flesh/seed ratio	Soluble solids (%)	Acidity (%)	pH
Quince-A	18.80 b[(x)]	24.39 b	27.16 b	4.50 b	3.34 b	3.21	12.04 ab	0.81	3.79
Quince-C	23.33 a	34.21 a	37.23 a	5.71 a	3.82 a	3.09	10.32 b	0.74	3.53
BA-29	20.22 ab	32.71 a	35.96 a	5.27 ab	3.58 ab	2.89	12.36 a	0.75	3.42
HSD	*	*	**	**	**	NS[(y)]	*	NS.	NS.

[(x)]: Mean separation by Tukey's HSD at $p < 0.05$(*) and at $p < 0.01$ (**) level.
[(y)]NS: Not significant

Vegetative growth

In terms of annual shoot length, scion and rootstock trunk diameters, Quince-C rootstock showed stronger growth and gave higher values than Quince-A and BA-29 rootstocks (Figure 2 and 3).

The Quince-A rootstock had lower values than the other two rootstocks except for the distance between the budding point and the first branching of the stem. In terms of the distance between the budding point and the first branching of the trunk, Quince-A gave the highest value, followed by BA-29, and Quince-C gave the lowest value (Figure 4).

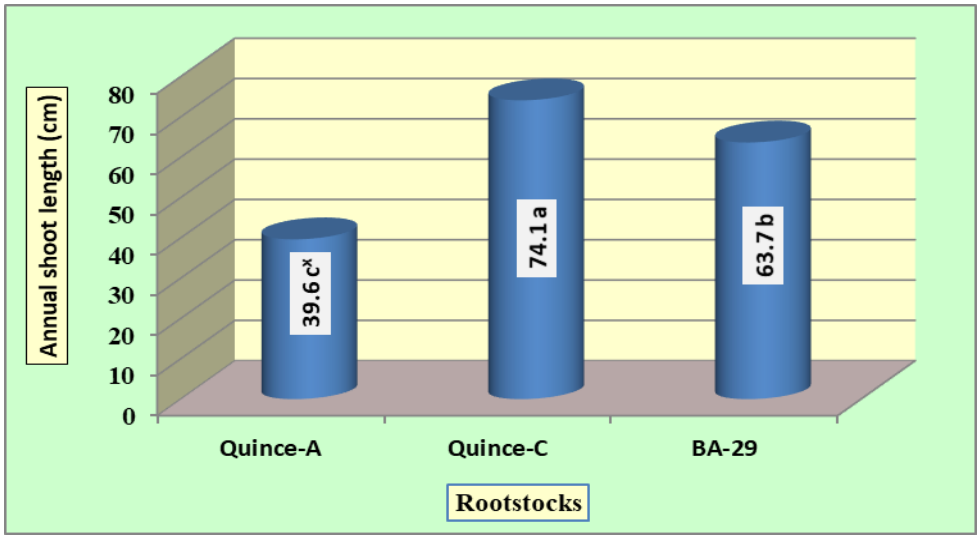

Figure 2. Average annual shoot length of 'Hafif Çukurgöbek' loquat budded on quince rootstocks in 2018-2019.

(x): Means followed by different lowercase letters indicate significant difference by Tukey's test at $p < 0.01$ level.

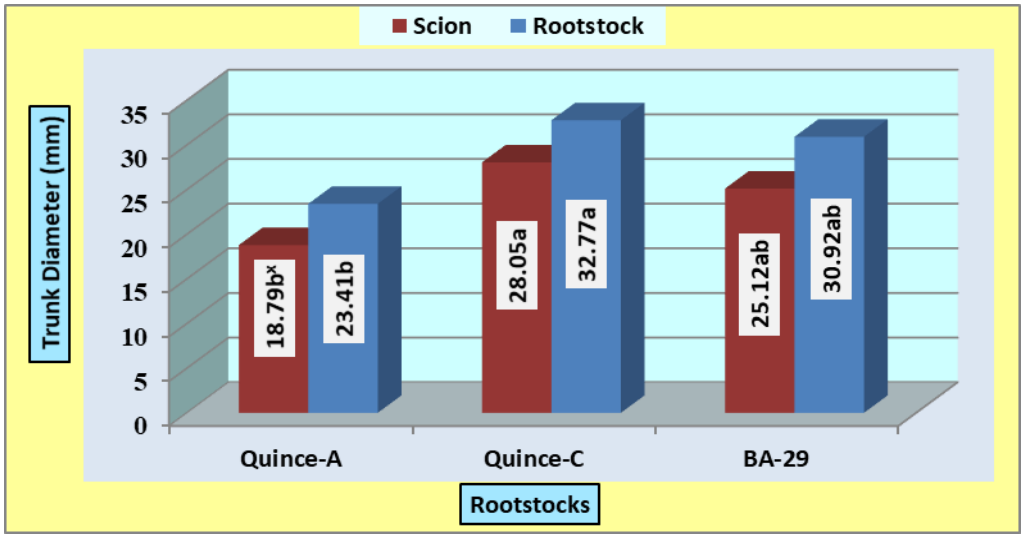

Figure 3. Average scion and rootstock trunk diameter of 'Hafif Çukurgöbek' loquat budded on quince rootstocks in 2018-2019.

(x): Means followed by different lowercase letters within same parameter are indicate significant difference by Tukey's test at $p < 0.01$ level.

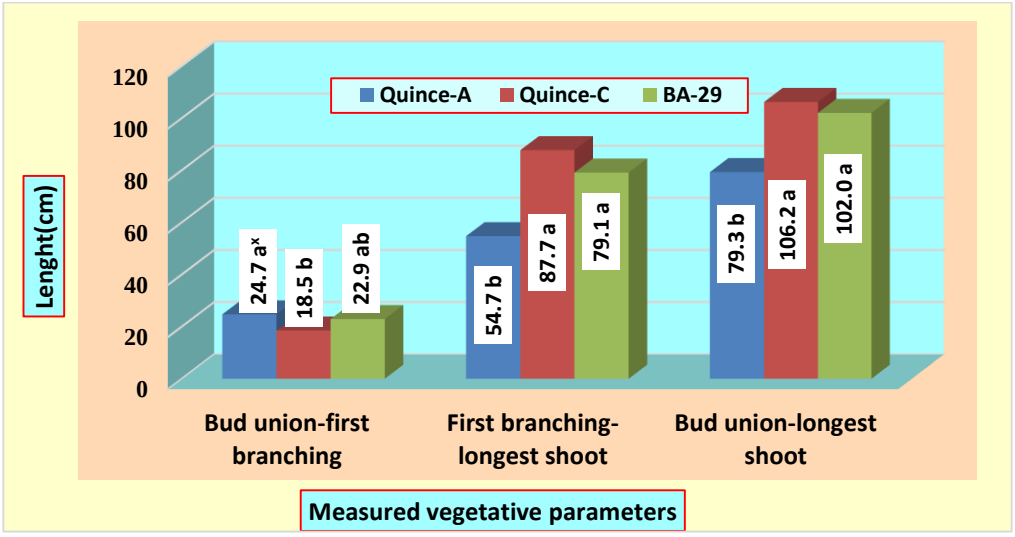

Figure 4. Some vegetative growth parameters of 'Hafif Çukurgöbek' loquat budded on quince rootstocks (2018-2019 average).

(x): Means followed by different lowercase letters within same parameter are indicate significant difference by Tukey's test at $p < 0.01$ level.

The differences of rootstocks in terms of vegetative parameters were found to be statistically significant at 1% level.

In the study, it was determined that the first branching in the plants budded on the Quince-C rootstock was lower than the other rootstocks, while it also formed larger plants compared to the plants budded on other rootstocks. Quince-A rootstock, which has the lowest values, has been found to form smaller plants than other rootstocks.

In previous studies, Polat and Kaşka (1992a) reported the shoot growth as an average of 23.4 cm in buddings on the Quince-A rootstock. Polat (1995), in the measurements made between 1993 and 1995, measured the scion diameter in the loquat (cvs. Akko-XIII and Armut Şekilli) saplings whose rootstocks were Quince – A as 18.24 mm, 30.15 mm and 36.39 mm and the sapling height as 74.3 cm, 120.2 cm and 124.4 cm, respectively. The values obtained from our study were lower than the values measured by Polat and Kaşka (1992a) and Polat (1995). It is thought that this is due to the effect of the difference in the cultivar and rootstocks of the trial material plants as well as the age difference.

Yield

The yields of Hafif Çukurgöbek loquat on different quince rootstocks are given in Table 2.

Table 2. The effects of quince rootstocks on fruit yield of Hafif Çukurgöbek loquat (average of 2018-2019)

Rootstock	Yield (g plant^{-1})	Yield per unit trunk cross-sectional area (g mm^{-2})	Yield (ton da^{-1})
Quince-A	279.35 b$^{(x)}$	0.690 b	0.558 b
Quince-C	632.50 a	0.895 a	1.265 a
BA-29	640.00 a	0.921 a	1.330 a
HSD	**	**	**

(x): Means followed by different lowercase letters within a column are indicate significant difference by Tukey's test at $p < 0.01$(**) level.

According to the two-year averages, the highest yield values (640 g plant^{-1} and 0.921 g mm^{-2}, 1.33 ton da^{-1}, respectively) in terms of all three yield per plant, yield per unit trunk cross-sectional area and yield per decare were obtained from the BA-29 rootstock. This was followed by Quince-C rootstock with values of 632 g plant^{-1}, 0.895 g mm^{-2} and 1.26 ton da^{-1}. Quince-A rootstock gave the lowest values in terms of all three yield elements. This difference between the rootstocks was found to be statistically significant at 1% level (Table 2).

Only four references of high density loquat orchards have been found in the literature. Insero et al. (2004) compared ten cultivars grafted on BA-29 quince and spaced 4 × 2 m. Average cumulative yield from 4th to 8th season was about 45 t/ha. With similar tree density but spacing loquats at 3 × 3 m, Polat et al. (2004) have compared 'HÇG', 'Sayda' and 'Golden Nugget' budded on loquat seedlings. They obtained a mean productivity of 7165 kg/ha during the first three harvests. After two additional seasons, Polat et al. (2005) have published that orchard productivity had raised to 9311 kg/ha/year. In the study by Hueso et al. (2007), to check suitability of loquat to extreme intensification it was designed an orchard of 'Magdal' budded on quince C at a distance of 2.5 × 1.7 m (2353 trees per ha). First yield was reached an average of 2.8 kg/tree on season 2003/2004. Second yield in April 2005 was reached a worthy level of 10.8 kg/tree (25 t/ha). Third yield was limited to 13.0 kg/tree (30 t/ha).

Conclusion

The tall and wide crown structure of loquat suggests that high populations of dwarfed trees achieved with dwarfing rootstocks would increase yields per unit area and facilitate cultural practices including harvest. However, studies of dwarfed loquat produced with quince rootstocks are rare in Turkey. In this study, the effects of three quince rootstocks (Quince A, Quince B, and BA-29) on vegetative growth, fruit yield and quality of 'Hafif Çukurgöbek' loquat spaced 0.5 x 1.0 m and planted in January 2017 were compared in 2018 and 2019.

Yield per plant were highest with Quince-C, followed closely by B-29 but yields with Quince-A rootstock were much lower. However, fruit soluble solid was highest with B-29 closely followed by Quince A and lowest with Quince C. Yield per unit

trunk cross-sectional highest with Quince C and B-29 followed by Quince A. Fruit weight and fruit size were significantly highest with Quince-C rootstock, followed by BA-29 and Quince-A. Shoot length, scion and rootstock diameter were greatest with Quince-C.

Our preliminary data indicate that dwarfing quince rootstocks can be used in intensive plantings of loquat. In this study, BA-29 and Quince C rootstock performed better than Quince-A. Considering yield and fruit quality based on total soluble solid, BA-29 rootstock seems the best choice.

Acknowledgements

We gratefully acknowledge the Research Grant (18-YL-027) of Coordinatorship of Scientific Research Projects, Hatay Mustafa Kemal University. We also thank Professor Jules Janick, Purdue university, USA, for reviewing an earlier version of the manuscript.

Conflict of Interest: Authors have declared no conflict of interest.

Author Contributions: AAP have designed the study and SA have collected the data. SA executed the experiment with the help of by AAP. AAP wrote the article. All authors have read, revised, and approved the manuscript.

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