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# Performance of grafting loquats combined onto loquat and quince rootstocks on different dates

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## Abstract

This study was carried out during February 20 to July 1, 2023, at the lath house in the College of Agricultural Engineering Sciences, University of Sulaimani, Kurdistan Region, Iraq, and aimed to investigate the impact of rootstock type and grafting time on grafting success of loquat on two rootstocks, loquat and quince, which were used for grafting the local selection cultivar of loquat at three different times (February 20, March 10, and March 30) during the dormant season. The experiment was laid down in a factorial Randomized Complete Block Design (RCBD), involving 6 treatments, each with 5 grafts and 3 replications, resulting in 90 grafts. Data analysis was performed using analysis of variance (ANOVA), and means were separated using Duncan's multiple range tests ($P \leq 0.05$). The loquat and quince rootstocks were grown through seed sowing and cuttings, respectively. Cleft grafting was employed as the grafting method, ensuring the cambium layers of the scion and stock in contact. Grafting success percentage, shoot length, shoot diameter, number of leaves per budling, leaf area, and chlorophyll content were evaluated. Results showed that loquat rootstock exhibited a significantly higher grafting success percentage (97.78%) compared to quince rootstock (84.44%). Regarding vegetative traits, loquat rootstock resulted in significantly longer shoots (11.74 cm) compared to quince rootstock (8.08 cm). The same rootstock showed a higher number of leaves per budling (8.47) and chlorophyll content (43.82 SPAD). Also, the highest significant grafting success percentage (100%) was achieved from the combination of loquat rootstock and two grafting times (February 20 and March 30). The combination of rootstock type and grafting time led to varying shoot characteristics.

Keywords: Cleft grafting, grafting time, loquat, quince, rootstock type.

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## Introduction

Loquat (*Eriobotrya japonica* Lindl.) belongs to the subfamily Maloideae within the family Rosaceae family. It is a subtropical evergreen fruit tree that is well-adapted to temperate regions. Loquat fruits are round or oval with orange or yellow skin, juicy flesh, and a thin, tough skin. The loquat is adeptly adapted for growth, cultivation, and widespread commercial distribution, notably thriving in numerous regions, especially within Mediterranean countries [1]. Loquat propagated by grafting and budding techniques, and the most common rootstock is its own (loquat) rootstock. In this case, the produced tree will be very tall, large-crowned and vigorous, hence, the growers may face several difficulties if they manage to use such large trees in establishing their orchards, additionally, they need more time, space and effort. First of all, the limited number of trees which can be planted per unit area, and the difficulty in performing the cultural operation services such as pruning, spraying, and harvesting [2]. Researchers around the world carried out many trials to facilitate these difficulties in loquat production. The most important actions are the applications that reduce the tree's vigor, meaning for example the use of dwarfing rootstocks [3]. It is well known that rootstocks play an important role in tree behavior, survival, productivity, dwarfing and some other extra scion-rootstock relationships [4]. Likewise, seedling rootstocks with desirable criteria such as rapid growth (in height and diameter) can reduce the ‘waiting period’ for grafting time. Furthermore, proper alignment of scion and rootstock cambium tissues could determine graft success [5]. Many trials have been done to use the quince trees for loquat rootstocks to produce dwarf trees, suitable for high-density planting systems. Documents show that when loquats grafted onto quince rootstocks, the resultant grafted trees will be dwarfed, flower and fruit ripen earlier. In some studies, 20-25% dwarfing ratios were obtained in loquat varieties combined onto quince rootstocks compared to loquat seedling itself [3]. Hence, it is established that quince rootstocks are used as a dwarfing rootstocks for loquats [6, 7]. Although it is very limited. the results of many researches have emphasized that quince is an excellent rootstock for loquat to reduce tree height which may decrease the production cost [8]. Furthermore, [9] suggested that for loquat, Anger quince rootstock is a better rootstock than the loquat itself. Also, [10] stated that the rootstocks can be used for different purposes, since rootstocks affect the scion variety in many aspects. Nowadays, the seedling rootstock of loquat (*Eriobotrya japonica* Lindl.) is being used widely in comparison to quince (*Cydonia oblonga* Mill.) and hawthorn (*Crataegus oxyacanthus* L.) worldwide. It has been reported that cleft grafting is easier to use and more successful than other methods of grafting [11]. Also, the grafted plant requires a smaller space than the seedling plant. Seed propagated plants are taller than their grafted counterparts which are generally dwarf and require a smaller planting space, in addition to the benefit from the capability of accommodating a higher number of plants per unit area, and starting to bear fruit in 2-3 years age, whereas the seedling plants may take 7 or more years to start fruit. Success, survival, and growth performances of grafts depend on several factors including variety, method and time of grafting, age of rootstock, scion materials, and environmental conditions. For grafting success, however, the most important factors include the time of taking the scion parts, the technique of grafting, the graftmanship of the graftman, and the botanical relatedness between the scion and stock [12]. After grafting, the parenchymatous callus cells will be formed and the cambium junction between the scion and rootstock will take place within 7–14 days [13]. The percent grafting success 56.67−100.0% in the pear was reported by [14]. Environmental conditions during grafting, especially air temperature in the first 15 days after grafting directly affects the grafting success. The study aims to compare the effectiveness of loquat and quince rootstocks for grafting loquat trees and determine the optimal timing for successful grafting. Additionally, the research investigates the potential of producing dwarfing rootstocks for loquat by using quince as a rootstock.

## Materials and methods

This experiment was carried out during February 20 to July 1, 2023 at the lath-house in the College of Agricultural Engineering Sciences, University of Sulaimani, Kurdistan Region, Iraq. The experiment involved grafting two types of loquat rootstocks, namely loquat (*Eriobotrya japonica* Lindl.) and quince (*Cydonia oblonga* Mill), which were used for grafting the local selection cultivar of loquat (*Eriobotrya japonica*) during the dormant season at three different times (February 20, March 10, and March 30). The experiment consisted of 6 treatments each with 5 grafts and 3 replications, resulting in a total of 90 grafts.

**Rootstock production**

The rootstocks used in the study consisted of loquat and quince cultivars. The loquat rootstocks were produced from seeds, the seeds were sown in polyethylene bags measuring 10×30 cm, filled with a mixture of river sand and peat moss. The loquat rootstocks were allowed to grow for 1.5 years until they reached a height of 25 cm and 10±2 mm size thickness. On the other hand, quince rootstocks were obtained through cuttings from 3-year-old trees and were planted in polyethylene bags measuring 10×30 cm, using the same mixture of river sand and peat moss. The polyethylene bags were placed in a lath-house and arranged in a randomized complete block design (RCBD), with the same regular maintenance as the loquat rootstocks. The average diameter of both loquat and quince rootstocks was 10±2 mm. The weekly averages of temperature and relative humidity were recorded by a data logger (Model: Perfectprime TH0160) in the lath-house during the entire period of the experiment (Figure 1). After 4 months, on July 1, 2021, the experiment was terminated, and the cuttings were checked to measure the effect of the treatments.

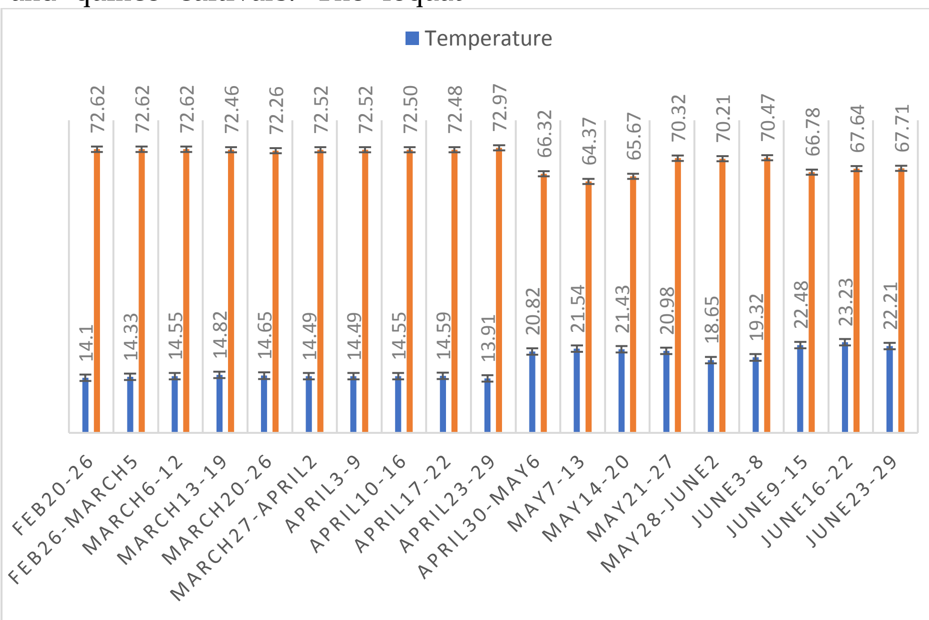


Figure 1. The observed data of mean temperature (°C) and relative humidity (%) in the experiment site during February-July, 2023.

**Selection and preparation of scions**

The scion shoots of loquat (*Eriobotrya japonica* Lindl.) were collected from healthy, matured, and disease-free trees. These source trees were aged 10-12 years and located in Tooy Malik, Sulaymaniyah. The scion shoots were carefully chosen from the terminal shoots of the current season's growths. They were about 7-8 months old at the time of collection. Immediately after separating the bud sticks from the trees, they were wrapped in a moist clean cloth to maintain their freshness and prevent drying and transported to the grafting site. The scion shoots were then divided into several scions, with each scion containing two active buds. This division of scion shoots allowed for multiple grafting attempts and increased the chances of successful grafting. On average, the scions were 6-8 cm long and had a diameter of 8±1 mm.

**Grafting operation:**

Cleft grafting had been used in this work, in which two smooth slanting cuts, about 3–4 cm long, were made at the proximal end of the scion on both sides, opposite to each other, in such a way that the end portion becomes very thin. This was done using a sharp knife. The smooth long sloping wedge cuts at the base of the scion gave the cut an appearance of a sharp chisel. The rootstock was first headed back by making a horizontal cut, and then a vertical split cut or cleft was made by using a thin and sharp-bladed grafting knife at the center of the horizontal cut surface of the stock, having a depth of approximately 3–4 cm. Then, the scion was inserted into the cleft of the rootstock through a slight opening of the splits. As a result, both components were brought into close contact, particularly the cambium layers face to face, and were then tied firmly with a polythene strip. After wrapping the graft union, the scion, along with the union portion, was covered with a polythene cap to protect it from losing moisture through transpiration. In this method, both the stock and scion were of the same thickness to match each other.

**Studied Parameters**

The experiment was terminated on July 1, 2023, by taking the following parameters:

1. Grafting success%
2. Shoot length (cm)
3. Shoot diameter (mm)
4. Number of leaves per budling
5. Leaf area ($cm^2$), measured by using a software program application (Digimizer image analysis) (https://www.digimizer.com/).
6. Total chlorophyll content of leaves (SPAD units), determined using a chlorophyll meter (Model SPAD 502 PLUS).

**Statistical analysis**

The statistical analysis was performed using the analysis of variance (ANOVA), and significant differences were analyzed using Duncan’s multiple range tests ($P \leq 0.05$). The software XLSTAT was used for the data analysis (https://www.xlstat.com).

**Results and discussion**

**Grafting%**

The effect of grafting success percentage on loquat and quince rootstocks showed significant differences between the two types of rootstocks (Figure 2). The highest grafting success percentage (97.78%) was recorded on loquat rootstock, which was significantly higher than quince rootstock which obtained the lowest grafting success percentage (84.44%). This difference may be attributed to genetic compatibility, physiological similarity, and better cambium activity between loquat scions and rootstocks. Other factors, such as environmental adaptation, and rootstock vigor, could also contribute to the difference between rootstocks. The significant difference between the grafting success percentages of the two rootstocks suggests that loquat rootstock is more favorable for grafting success compared to quince rootstock. Our results are in conformity with the results of [15] and [14], who observed that rootstocks and varieties have a very important effect on the graft take ratio in the pear.

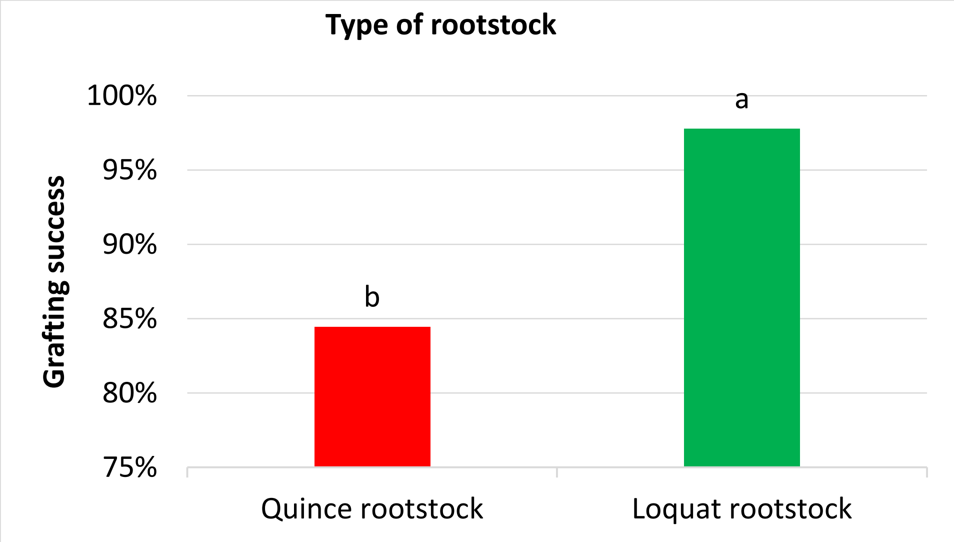


Figure 2. Effect of type of rootstock on grafting success percentage of loquat and quince rootstocks. Values that are not sharing the same superscripts (a, b) differ significantly (P≤0.05).

The data presented in figure (3) demonstrate the effect of grafting time on loquat and quince rootstocks at different periods. However, no significant differences were observed between the grafting times from late February to late March to achieve a successful grafting percentage for the current season on loquat and quince rootstocks. Conversely, the grafting success percentage decreased from February 20 to March 30. Therefore, the highest grafting success rate (96.67%) was recorded on February 20 when grafted on both loquat and quince rootstocks. On the other hand, the lowest grafting success rate (86.67%) was obtained on March 30 when grafted on both loquat and quince rootstocks. This may be due to changing environmental conditions. This result was supported by [16]. Significantly, the highest survival percentage at 120 days after grafting was resulted. Similar results were also mentioned by [17] in mango. Although grafting process can be performed any time during the dormant season. However, in the early spring and during sap flow season, the chances for successful healing of the graft union are better.

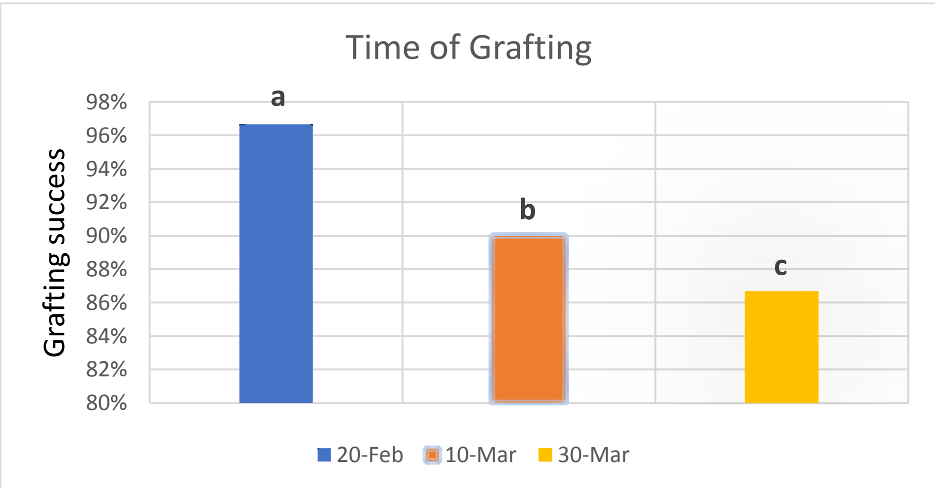


Figure 3. Effect grafting time on grafting success percentage of loquat and quince rootstocks. Values that are not sharing the same superscripts (a, b, c) differ significantly (P≤0.05).

Figure (4) shows that the interaction between rootstock type and grafting time had a significant connection for enhancing the grafting success percentage of loquat grafting. The highest significant grafting success percentage (100%) was achieved from the combination of loquat rootstock and two grafting times (February 20 and March 30). This may be attributed to the genetic compatibility and physiological similarity between loquat scions and loquat rootstocks, resulting in less effective graft unions. This combination likely provided an optimal environment for successful graft union formation and tissue integration. However, the grafting success percentage (93.33%) was recorded from the interaction between quince rootstock on February 20 and loquat rootstock on March 10. Furthermore, the interaction of quince rootstock with March 30 gave rise to the lowest grafting success percentage (73.33%). This might be related to factors such as differences in cambium activity, environmental adaptation, or reduced vigor in the quince rootstock, which hindered the successful integration of the loquat scion.

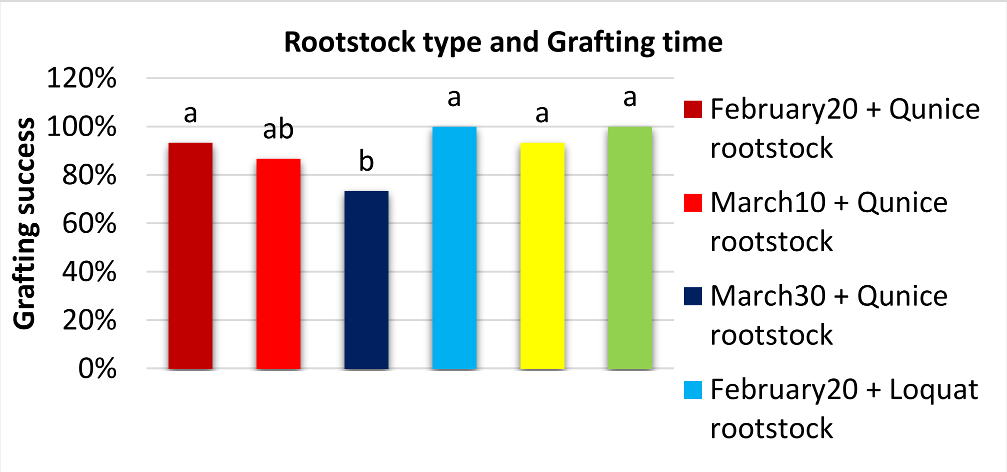


Figure 4. Interaction effect of rootstock type and grafting time on grafting success percentage of loquat and quince rootstocks. Values that are not sharing the same superscripts (a, b) differ significantly (P≤0.05).

The data presented in table (1) compare the impact of loquat grafting on two different rootstock types, namely quince and loquat rootstocks, with a focus on various growth parameters. The results show that loquat rootstock resulted in significantly longer shoots (11.74 cm) compared to quince rootstock (8.08 cm). This may have a more vigorous growth habit or better nutrient uptake, contributing to longer shoots, or might be more adapted to the specific growing conditions or environment of the study. Similarly, a budshoot length of 21.23 cm was reported by [18] in acid lime grafted onto trifoliate orange rootstock at 4 months after grafting. However, there was no significant difference in shoot diameter between loquat (4.06 mm) and quince (4.24 mm) rootstocks. This may be due to similar genetic characteristics that influence shoot diameter. Similarly, [19] observed a non-significant effect of pear rootstocks and cultivars on the graft shoot diameter. Also the values of leaf area for both quince and loquat rootstocks were statistically similar, with values of (69.83 $cm^2$) for quince and (69.98 $cm^2$) for loquat. These results may be due to genetic variations between quince and loquat rootstocks and their specific responses to the growing conditions. Likewise, quince rootstock had a higher significant leaf number (8.47) and chlorophyll content (43.82 SPAD) compared to loquat rootstock (7.67 and 36.82 SPAD), respectively.

Table 1. Effect of rootstock type on grafting success (%) and growth of loquat and quince rootstocks.

| Type of rootstock | Shoot length (cm) | Shoot diameter (mm) | Number of leaves per budling | Leaf area ($cm^2$) | Leaf chlorophyll content (SPAD) |
|---|---|---|---|---|---|
| Quince rootstock | 8.08 b | 4.24 a | 8.47 a | 69.83 a | 43.82 a |
| Loquat rootstock | 11.74 a | 4.06 a | 7.67 b | 69.98 a | 36.82 b |

*The values in each column with the same letter do not differ significantly (P≤0.05), according to Duncan's Multiple Range Test

It can be seen from the data in table (2), regarding the effect of grafting time on vegetative traits of loquat and quince rootstocks that significant effects on grafting at different times on shoot length, leaf number, leaf area, and leaf chlorophyll content were revealed. The loquat grafted on March 30 had a longer shoot length (11.44 cm) compared to those grafted on March 10 (7.52 cm). This suggests that the timing of grafting might influence shoot elongation, but the grafting of loquat for all three times had similar results on shoot diameters, ranging from (4.08 mm) to (4.28 mm). This indicates that the grafting time might not have a significant impact on shoot thickness. These results are contrary to those obtained by [20] working with pistachio. Moreover, the maximum values of leaf number (9.09), and leaf area (81.26 $cm^2$) were recorded from grafting loquat in February 20, but the minimum values were recorded in leaf number and leaf area (7.39 and 63.12 $cm^2$) respectively. Similar results were observed by [21] in custard apples. On the contrary, [22] recorded a significantly higher values of shoot grafts, and the leaf area which were noted when grafting was done on 15th April and 15th March. Higher leaf area is possibly correlated with the higher number of leaves per graft recorded during these months. Correspondingly, the highest values of the number of leaves and leaf area obtained in the graftages conducted on February 20, might be due to the early bud break resulting from early healing and graft union formation due to favorable environmental condition of temperature and relative humidity (Figure 1). The earlier the healing of graft wounds between scion and rootstock, the more the promotion of bud break resulting from the early and easy availability of raw material for photosynthesis which ultimately increased the growth of the whole plant. On the other hand, the lower number of leaves and leaf area in early grafts might be due to low temperature at the time of graft union formation and leaves emergence and development. The present result was inconsistent with [18] in the acid lime sapling. Likewise, the maximum value of chlorophyll (41.42 SPAD) was recorded on March 30, but the minimum value (38.40 SPAD) was observed during grafting on March 10. These may be due to variations in environmental conditions, such as sunlight exposure, temperature, and humidity, which can affect chlorophyll production and accumulation in plants. Other factors, such as differences in nutrient availability, or genetic variations among the loquat plants, could also contribute to the variations in chlorophyll content.

Table 2. Effect grafting time on grafting success (%) and growth of loquat and quince rootstocks.

| Time of grafting | Shoot length(cm) | Shoot diameter (mm) | Number of leaves per budling | Leave area ($cm^2$) | Leaf chlorophyll content (SPAD) |
|---|---|---|---|---|---|
| February-20 | 10.78 a | 4.1 a | 9.09 a | 81.26 a | 41.13 a |
| March-10 | 7.52 b | 4.08 a | 7.72 b | 65.34 b | 38.40 b |
| March-30 | 11.44 a | 4.28 a | 7.39 b | 63.12 b | 41.42 a |

* The values in each column with the same letter do not differ significantly (P≤0.05), according to Duncan's Multiple Range Test.

Data presented in table (3) demonstrate that the combination of the two factors, rootstock type, and grafting time effectively resulted in different shoot characteristics of loquat grafting success. The grafting on loquat rootstock and March 30th had the highest significant shoot length (14.78 cm). Whereas, the combination of quince rootstock and March 10th sharply reduced shoot length (6.59 cm). This may be due to the interaction between the genetic compatibility of the rootstock and scion (loquat), and the environmental conditions during the grafting process. The study found no significant differences between the interaction of rootstock type and grafting time on shoot diameter. However, the highest shoot diameter (4.42 mm) was recorded when grafting on quince rootstock was done on March 30th. On the other hand, the lowest shoot diameter (3.77 mm) was observed when using the combination of loquat rootstock and grafting on March 10th. Conversely, the study found that the highest leaf number (9.11) was observed when using loquat rootstock and grafting on February 20th. The second highest value of leaf number (6.89) was recorded from the grafting on loquat rootstock on March 30th. On the contrary, [23] reported significant relationships between the number of leaves and the timing of grafting, they found that the highest leaf count (22.63) was observed in plants grafted on April 20th, while the lowest count (21.15) occurred for grafting on March 10th. Additionally, there were significant differences in leaf area and leaf chlorophyll content of grafting at different times on loquat and quince rootstocks. The loquat grafted on quince rootstock on February 20th, had the greatest values of leaf area (84.90 cm²), and leaf chlorophyll content (30.31 SPAD), while leaf area was severely diminished to the lowest level (61.29 cm²) in the leaves of the loquat grafted on quince rootstock on March 30th. But the lowest chlorophyll content (34.37 SPAD) was found from grafting the loquat rootstock on March 20th. the observed differences likely arise from environmental conditions, root establishment, nutrient availability, light exposure, genetics, and care practices.

Table 3. Interaction effect of rootstock type and grafting time on grafting success (%) and growth of loquat and quince rootstocks.

| Time of grafting | Shoot length (cm) | Shoot diameter (mm) | Number of leaves per budling | Leaf area (cm²) | Leaf chlorophyll content (SPAD) |
|---|---|---|---|---|---|
| Quince rootstock and February-20 | 9.56 c | 3.93 a | 9.07 a | 84.90 a | 45.51 a |
| Quince rootstock and March-10 | 6.59 d | 4.39 a | 8.44 a | 63.30 c | 42.43 a |
| Quince rootstock and March-30 | 8.11 cd | 4.42 a | 7.89 ab | 61.29 c | 43.51 a |
| Loquat rootstock and February-20 | 12.00 b | 4.27 a | 9.11 a | 77.61 ab | 36.75 bc |
| Loquat rootstock and March-10 | 8.44 c | 3.77 a | 7.00 b | 67.39 bc | 34.37 c |
| Loquat rootstock and March-30 | 14.78 a | 4.13 a | 6.89 b | 64.95 c | 39.33 b |

* The values in each column with the same letter do not differ significantly ($P \leq 0.05$), according to Duncan's Multiple Range Test.

## Conclusion

The study investigated the impact of grafting success percentage, grafting time, rootstock type, and their interactions on loquat grafting. Results indicated that loquat rootstock outperformed quince rootstock in terms of grafting success percentage. Grafting time also influenced the success rates, with February 20

showing the highest success and March 30 giving the lowest. The combination of loquat rootstock with two grafting times achieved the best results. Furthermore, loquat rootstock exhibited better growth parameters, suggesting its suitability for grafting. Overall, genetic compatibility, physiological similarity, and environmental conditions played crucial roles in enhancing grafting success in loquat grafting.

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# اداء تطعيم الينگى دنيا على اصول الينگى دنيا والسفرجل فى مواعيد مختلفة

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- تاريخ استلام البحث 2023/08/08 وتاريخ قبوله 2023/08/31.
- البحث مستل من اطروحة دكتوراه للباحث الاول .

**الملخص**

أجريت هذه الدراسة خلال الفترة من ٢٠ فبراير الى ١ يوليو من عام 2023 داخل الظلة الخشبة التابعة لكلية علوم الهندسة الزراعية، جامعة السليمانية، إقليم كردستان، العراق، بهدف دراسة تأثير نوع الاصل ووقت التطعيم على نجاح تطعيم الينگى دنيا، تم استخدام اصلين؛ الينكى دنيا والسفرجل فى ثلاث أوقات مختلفة (20 فبراير، 10 مارس، و 3 مارس) خلال موسم السكون. تم وضع التجربة العاملية فى تصميم القطاعات العشوائية الكاملة (RCBD)، اشتملت على 6 معاملات، لكل منها 5 مشاهدات و3 مكررات، نتج عنها 90 تطعيمة. تم تحليل البيانات باستخدام تحليل التباين (ANOVA) وقورنت المتوسطات باستعمال اختبارات دنكن المتعددة المدى (P≤0.05). نمت اصول الينگى دنيا والسفرجل من خلال زراعة البذور والعقل، على التوالي. تم استخدام التركيب الشقى كطريقة تطعيم ، مما يضمن تلامس طبقات الكامبيوم مابين الاصل والطعم. تم تقييم نسبة نجاح التطعيم، طول الشمراخ، قطر الشمراخ، عدد الأوراق في الشمراخ ، مساحة الورقة ، ومحتوى الكلوروفيل. أظهرت النتائج أن طعوم الينگى دنيا أظهرت نسبة نجاح تطعيم أعلى بكثير (97.78٪) مقارنة مع اصل السفرجل (84.44٪). فيما يتعلق بالصفات الخضرية، نتجت عن اصل الينگى دنيا براعم أطول بشكل ملحوظ (11.74 سم) مقارنة مع اصل السفرجل (8.08 سم). ايضا، تم تحقيق أعلى نسبة نجاح تطعيم معنوية (100٪) من تداخل اصل الينكى دنيا واوقات التطعيم (20 فبراير و 30 مارس). أدى الجمع بين نوع الاصل ووقت التطعيم إلى اختلاف خصائص الشتلات المطعمة.

الكلمات المفتاحية: التركيب بالشق، وقت التطعيم، الينگى دنيا، السفرجل، نوع الاصل