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# THE RESPONSE DIFFERENT APPLE TRANSPLANTS (*MALUS DOMESTICA* BORKH.) CULTIVARS TO AUTUMN BUDDING DATES AND BALANCED FERTILIZERS IN REGARD OF BUD TAKING AND GROWTH CHARACTERISTICS

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## ABSTRACT

**This experiment was conducted during 2021-2022 in the Duhok University nursery, Iraqi Kurdistan region, to study the effects of three different Apple cultivars (Super red, Scarlet and Royal caka), three different budding dates (28$^{th}$ August,18$^{th}$ September and 8$^{th}$ October of 2021) and three levels of balanced fertilizer N20%, P20% and K20 %; (0 g, 2g and 4g. l$^{-1}$) on the budding successful percentage and some vegetative growth characteristics of apple transplants. The results indicated that the Royal caka cultivar had significant effect on the budding success percentage, transplant(scion) height, transplant (scion) diameter, lateral branches number, leaves number and single leaf area. On the other hand, the date (8$^{th}$ Oct.) give the highest significant effect on budding success, transplant(scion) height, leaves number, and single leaf area. However, the 3$^{rd}$ fertilization concentration (4 g. l$^{-1}$) had a significant effect on the budding success percentage, transplant (scion) height and transplant (scion) diameter, lateral branches number, leaves number and single leaf area. The triple interaction among (Royal caka cultivar + 3$^{rd}$ budding date (8$^{th}$ Oct.) + 3$^{rd}$ fertilization concentration (4 g. l$^{-1}$) significantly affected on budding successful percentage and most vegetative growth characteristics.**

***KEYWORDS:*** Apple, cultivars, budding, dates, balance fertilizer

## INTRODUCTION

Apple trees (*Malus domestica* Borkh.) are one of the most widely planted fruit trees worldwide **(Shafi *et al.*, 2019)**. This popular fruit tree has thousands of different cultivars. Apple belongs to the genus *Malus*, Family Rosaceae, the great family of the roses, which includes not only apples but also several other fruits such as peaches, pears and plums. Apple is one of the oldest fruit in the world and is native to Southwestern Asia and European countries. It grows wild in most temperate regions of the world, as well as in the colder higher hills of sub-tropical areas **(Westwood, 1978)**.

The global apple production is 86,442,716 tons, with an upward trend over the last few decades. China is the world's greatest producer, accounting for over 40,501,041 tons of world production. With 11,833,470 tons, the European Union is the second largest producer, followed by United States 4,650,684 tons, Turkey 4,300,486 tons, and India 2,734,000 tons **(FAOSTAT, 2020)**.

Cultivars affect the budding process can be measured through genetic map and characteristics which describes hormones content and compatibility of both rootstocks and scions. This is why, genetic traits of cultivars can have affected by environmental conditions and climatic changes which effect budding success and vegetative growth habit of opening buds. All these mentioned factors could effect on callus formation, cells elongation and differentiation during growing of budded scions **(Hartmann *et al.*, 2014)**.

The date of budding has an impact on the budding's success, because budding at the suitable time helps in the establishment of a good union area, which has an impact on the tree's vegetative growth, root growth, and production efficiency **(Janick, 1986)**. T-budding on seedling rootstocks is used to propagate the

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fruit cultivars in the fall, spring, and summer **(Hartmann *et al.*, 2014; Polito *et al.*, 1996)**. Late summer and early autumn is the most important time for budding in the propagation of fruit tree nursery stocks.

Fertilization is one of the most important nursery practices for producing high seedlings quality. As well Fertilization is a method of feeding fruit trees in order to promote their growth, production, and quality of fruit. Many elements, however, play a role in the process, from nutrient uptake to allocation and utilisation by leaves and fruits **(Mészáros *et al.*, 2019)**.

In study to estimate the influence of various levels of nitrogen fertilization on vegetative growth and leaf nutrient status of two peach seedling rootstocks, the application of 200 kg sulphate ammonium $ha^{-1}$ for Yazdi and Missouri rootstocks with Dixiered as peach scion cultivar demonstrated the highest shoot length, leaf surface, and shoot diameter in the second trial year **(Mirabdulbaghi and Pishbeen, 2012)**.

The aims of this experiment is to study the response of cultivars to find the best cultivar in giving the best results of budding, the effect of budding dates and the best vegetative growth of it, to increase the budding success percentage in apple transplants cultivars, and to study the effect of fertilizer balanced on the growth of apple cultivars, produce seedlings with good characteristics by choosing good cultivars, and to test the best date for budding.

## MATERIALS AND METHODS

This study is conduct during the growing season of 2021-2022 in the Duhok University nursery, Iraqi Kurdistan region, the nursery is situating at latitude of: 36◦ 51' 12"N and longitude 42◦ 55' 15"E and at an altitude of 491 m above the sea level, in order to study the effects of three different Apple cultivars (Super red, Scarlet and Royal caka), three different budding dates (28$^{th}$ August,18$^{th}$ September and 8$^{th}$ October of 2021) and three levels of (Solucat fertilizer) balanced fertilizer that contains N.20%, P20% and K20 %; (0 $g.l^{-1}$, $2g.l^{-1}$ and $4g.l^{-1}$) this fertilizer give to the plant at twice time in the first season (30$^{th}$ august, 30$^{th}$ September), and twice time in the second season (1$^{st}$ March,1$^{st}$ April), and their interactions on the budding successful percentage and some vegetative growth characteristics of apple transplants. The following parameters were recorded: Budding success percentage (%), transplant(scion) height(cm), transplant (scion) diameter (mm), Number of lateral branches, Number of leaves/transplant (scion), Single leaf area (cm²). So, the number of total treatment plants will be (3x3x3x3x10) =810 seedling plants using factorial (split split plot design)**(Al-Rawi and Khalafalla, 2000)**. by using (SAS) program to analyze the data. and the means comparison was done by Duncan's Multiple Ranges Test under 5% which was claimed by**(SAS, 2002)** .

## RESULTS

**A. Budding success percentage (%):**

From Figure (1), it's clearly found that Royal caka cultivar scored the highest significant budding success percentage value which gained (92.28 %), compared to Super red and Scarlet cultivars which scored the lowest value reached at (86.41%) and (88.4%).

According to budding dates, both dates (18$^{th}$ Sep.) and (8$^{th}$ Oct.) recorded the highest significant budding success percentage, which was (93.19 %) and (95.35%)as compared with the date (28$^{th}$ Aug.) which had the lowest percentage of budding success obtained (78.56 %).

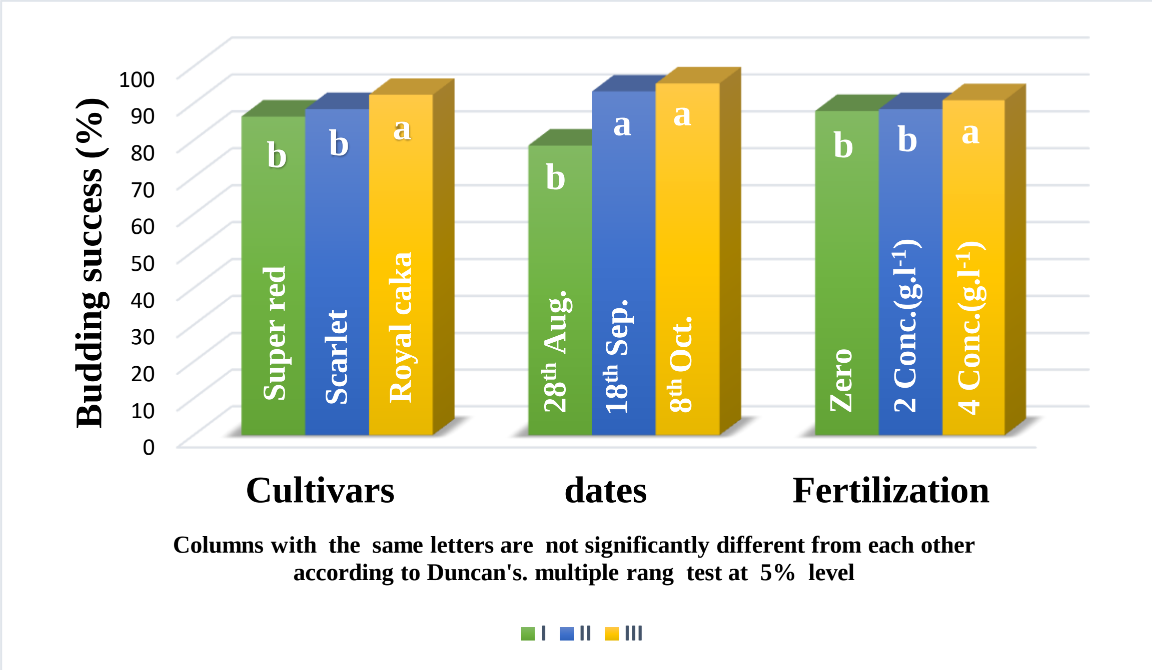


**Fig.(1) :** Response different Apple transplants (Malus domestica Borkh.) cultivars to autumn budding dates and balanced fertilizers on budding success percentage (%).

From the same Figure, the balanced fertilizers concentrations also influenced on the budding success percentage which the 3rd concentration (4 $g.l^{-1}$) treatment gained the highest significant budding successful percentage value (90.81 %) compared with the other treatments.

Table (1) shows the interaction between cultivars and budding dates, the highest budding successful percentage result was at the interaction of Royal caka cultivar and the 3rd budding date (8th Oct.) which recorded (98.41 %), while the lowest value (73.1 %) obtained at the interaction between Super red cultivar and the 1st budding date (28th Aug.).

**Table (1):** Response different Apple transplants (*Malus domestica* Borkh.) cultivars to autumn budding dates and balanced fertilizers on budding success percentage (%).

| Cultivars | Dates | Fertilization Conc.($g.l^{-1}$) | | | Cultivars * Dates | Cultivars effect |
|---|---|---|---|---|---|---|
| | | zero | 2 | 4 | | |
| Super red | 28th Aug. | 69.70 f | 77.38 c-f | 72.22 ef | 73.10 c | 86.41 b |
| | 18th Sep. | 95.00 ab | 93.33 ab | 88.89 a-d | 92.41 ab | |
| | 8th Oct. | 95.24 ab | 90.90 ab | 95.00 ab | 93.71 a | |
| Scarlet | 28th Aug. | 72.08 ef | 76.19 c-f | 83.33 b-e | 77.20 c | 88.40 b |
| | 18th Sep. | 95.24 ab | 97.06 ab | 90.00 a-c | 94.10 a | |
| | 8th Oct. | 97.22 ab | 91.67 ab | 92.86 ab | 93.91 a | |
| Royal caka | 28th Aug. | 83.77 b-e | 77.38 d-f | 95.00 ab | 85.38 b | **92.28 a** |
| | 18th Sep. | 87.50 a-d | 91.67 ab | 100.00 a | 93.06 a | |
| | 8th Oct. | 95.24 ab | 100.00 a | 100.00 a | 98.41 a | |
| Cultivars * Fertilization | Super red | 86.65 b | 87.21 b | 85.37 b | **Dates effect** | |
| | Scarlet | 88.18 b | 88.30 b | 88.73 b | | |
| | Royal caka | 88.83 b | 89.68 b | 98.33 a | | |

| | | | | | |
|---|---|---|---|---|---|
| Dates * Fertilization | $28^{th}$ Aug. | 75.18 c | 76.98 bc | 83.52 b | 78.56 b |
| | $18^{th}$ Sep. | 92.58 a | 94.02 a | 92.96 a | 93.19 a |
| | $8^{th}$ Oct. | 95.90 a | 94.19 a | 95.95 a | **95.35 a** |
| **Fertilization effect** | | 87.89 b | 88.40 b | **90.81 a** | |

Means with the same litters for each factors and interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test.

In the same Table at the interaction between cultivars and fertilization treatments, the highest budding successful percentage was gained at (Royal caka cultivar + $3^{rd}$ Fertilization concentration (4 $g.l^{-1}$)) which recorded (98.33 %)as compared with the other values.

Where, the interaction between budding dates and fertilization treatments the combination of the $3^{rd}$ budding date ($8^{th}$ Oct.) with $3^{rd}$ Fertilization concentration (4 $g.l^{-1}$) treatment gained the highest significant budding successful percentage value (95.95 %), while the lowest budding successful percentage (75.18 %) was obtained at the interaction between $1^{st}$ budding date ($28^{th}$ Aug.) with $1^{st}$ Fertilization concentration ($g.l^{-1}$).

In triple interaction among cultivars, budding dates and Fertilization, concentration the highest value was three combinations which gained the same significant value (100 %), these combinations were ((Royal caka cultivar+$3^{rd}$ date ($8^{th}$ Oct.) + $2^{nd}$ Fertilization concentration (2 $g.l^{-1}$), ((Royal caka cultivar+ $2^{nd}$ date ($18^{th}$ Sep.) + $3^{rd}$ Fertilization concentration (4 $g.l^{-1}$)) and ((Royal caka cultivar+$3^{rd}$ date ($8^{th}$ Oct.) +$3^{rd}$ Fertilization concentration (4 $g.l^{-1}$)).

However, the lowest budding successful percentage value was recorded at the interaction among ((Super red cultivar plus $1^{st}$ date ($28^{th}$ Aug.) plus $1^{st}$ Fertilization concentration (control treatment)) which scored (69.7 %).

**B. The transplant(scion) height(cm):**

In Figure (2), the results clearly show that Royal caka cultivar obtained gave the highest value of transplants (scion) height (100.92 cm) as compared to Super red cultivar which obtained (95.74 cm) and Scarlet cultivar which scored the lowest value (89.26 cm).

Budding dates as well influenced clearly the transplants (scion) height since $3^{rd}$ budding date ($8^{th}$ Oct.) scored the highest significant height value (98.92 cm) compared with the other two treatments.

In the same Figure, the Fertilization concentration treatments also influenced on the transplant(scion) height which the $3^{rd}$ concentration (4 $g.l^{-1}$) treatment gained the highest value of transplant (scion) height (97.31 cm) compared with $1^{st}$ and $2^{nd}$ treatments that obtained (93.17cm) and (95.44cm).

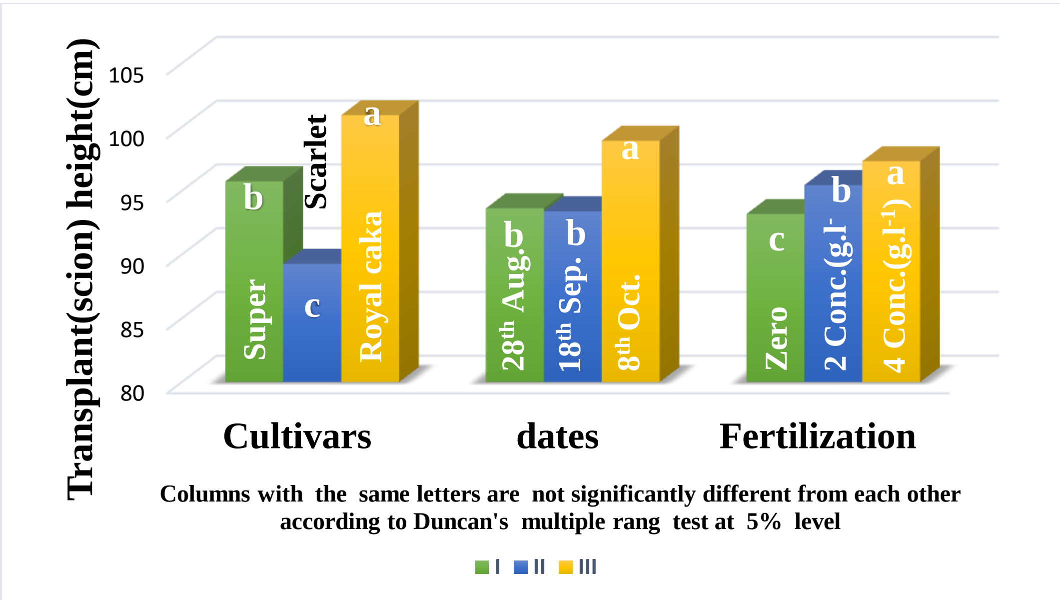


**Fig. (2):** Response different Apple transplants (*Malus domestica* Borkh.) cultivars to autumn budding dates and balanced fertilizers on transplant(scion) height(cm).

In Table (2), the interaction between the Royal caka cultivar and the 3rd budding dates (8th Oct.) treatment influenced significantly the height transplants (scion) which scored (110.97 cm), while the lowest value was (86.93 cm) which scored by the interaction between the Scarlet cultivar and 2nd budding date (18th Sep.).

Interaction results of fertilization and cultivars in same table show that transplants (scion) height was affected by the combination between Royal caka cultivar and 3rd Fertilization concentration (4 g.l$^{-1}$), which scored the highest significant value reached up to (106.39 cm), while the lowest value was the interaction between Scarlet cultivar and 1st Fertilization concentration (control treatment), that recorded (82.94 cm).

also shows in the Table (2), that the interaction between budding dates and fertilization treatments gave the highest value of transplants (scion) height at combination of the 3rd budding dates (8th Oct.) and 3rd Fertilization concentration (4 g.l$^{-1}$) treatments scored (104.97 cm), and the lowest value was the combination between 1st budding dates (28th Aug.) and 1st Fertilization concentration (control), which obtained (91.53 cm).

**Table (2):** Response different Apple transplants (*Malus domestica* Borkh.) cultivars to autumn budding dates and balanced fertilizers on transplant(scion) height(cm).

| Cultivars | Dates | Fertilization Conc.(g.l$^{-1}$) zero | 2 | 4 | Cultivars * Dates | Cultivars effect |
|---|---|---|---|---|---|---|
| Super red | 28th Aug. | 98.25 d-f | 92.63 f-j | 90.96 g-j | 93.94 bc | 95.74 b |
| | 18th Sep. | 105.73 bc | 95.00 e-i | 90.54 g-j | 97.09 b | |
| | 8th Oct. | 102.33 cd | 96.13 d-h | 90.07 h-j | 96.18 b | |
| Scarlet | 28th Aug. | 88.83 ij | 90.67 g-j | 94.19 e-i | 91.23 cd | 89.26 c |
| | 18th Sep. | 79.50 k | 87.37 j | 93.92 e-j | 86.93 e | |
| | 8th Oct. | 80.50 k | 91.38 g-j | 97.00 d-g | 89.63 de | |
| Royal caka | 28th Aug. | 87.50 j | 99.79 c-e | 99.72 c-e | 95.67 b | **100.92 a** |
| | 18th Sep. | 100.46 c-e | 96.33 d-h | 91.60 g-j | 96.13 b | |
| | 8th Oct. | 95.44 e-h | 109.63 b | 127.83 a | 110.97 a | |
| Cultivars * Fertilization | Super red | 102.11 b | 94.58 c | 90.52 d | **Dates effect** | |
| | Scarlet | 82.94 e | 89.80 d | 95.04 c | | |
| | Royal caka | 94.47 c | 101.92 b | 106.39 a | | |
| Dates * Fertilization | 28th Aug. | 91.53 d | 94.36 cd | 94.96 cd | 93.62 b | |
| | 18th Sep. | 95.23 c | 92.90 cd | 92.02 cd | 93.38 b | |
| | 8th Oct. | 92.76 cd | 99.04 b | 104.97 a | **98.92 a** | |
| **Fertilization effect** | | 93.17 c | 95.44 b | **97.31 a** | | |

Means with the same litters for each factors and interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test.

In respect of the interactions effect of the three studied factors, the interactions among cultivars, budding dates and fertilization concentrations, showed the interaction among Royal caka cultivar + 3rd budding date (8th Oct.) + 3rd fertilization concentration (4 g.l$^{-1}$) obtained 127.83 cm, which was the highest significant transplants (scion) height and the lowest transplants (scion) height value was 79.5 cm that gained from combination of Scarlet cultivar, 2nd budding date (18th Sep.) and 1st fertilization concentration (control treatment).

**C. The transplant (scion) diameter (mm):**

The Figure (3) shows that transplants diameters were affected by cultivars, Royal caka cultivar scored the highest significant value (9.5 mm) as compared to the other two cultivars Super red and Scarlet which recorded (8.93mm) and (8.39 mm) respectively.

Below in the same Figure the results of transplants' diameters were not affected by variation of budding dates. The three budding dates (28th Aug.), (18th Sep.) and (8th Oct.) gave 9.04, 8.88 and 8.9 mm respectively.

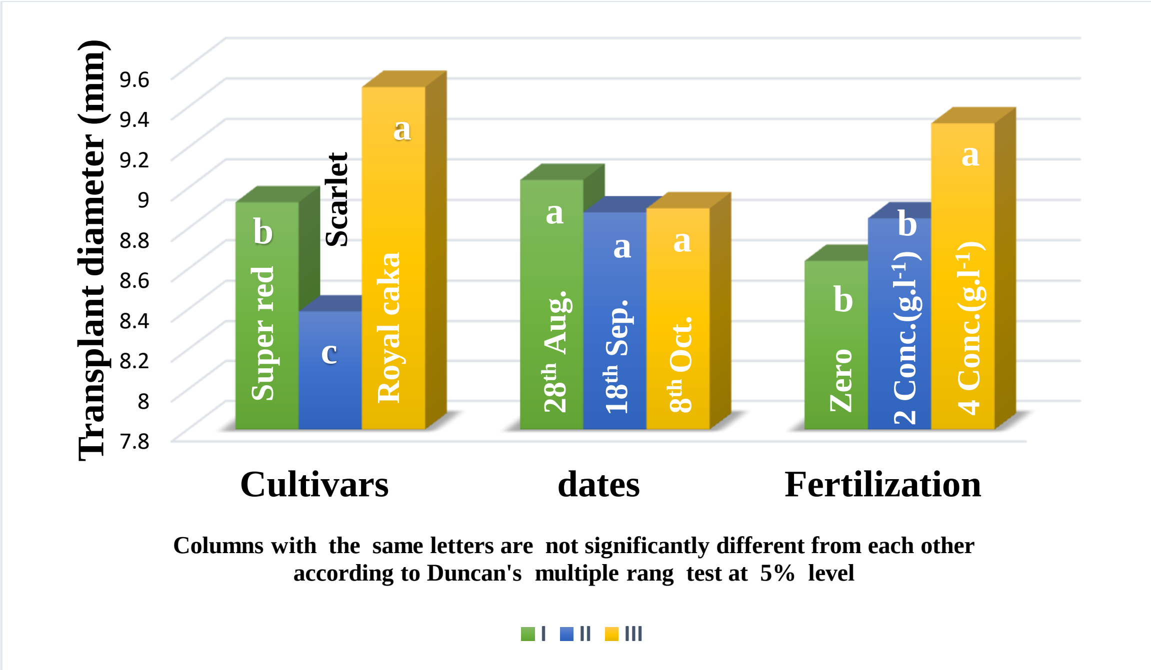


**Fig. (3):** Response different Apple transplants (*Malus domestica* Borkh.) cultivars to autumn budding dates and balanced fertilizers on transplant (scion) diameter (mm).

From the same Figure, the transplants(scion)diameters were affected by variation of fertilization concentrations, which the 3rd concentration (4 g.l$^{-1}$) treatment gained the highest significant transplants(scion)diameter (9.32 mm) compared with control and (2 g.l$^{-1}$) concentrations that gained (8.64mm) and (8.85mm) respectively.

Table (3) clearly reveals the interaction effect between Royal caka cultivar and both budding dates (28th Aug. and 18th Sep.) gave the highest transplants diameter value (9.57 mm), as compared to the lowest value (7.99 mm), scored at the interaction between Scarlet cultivar and 2nd budding dates (18th Sep.).

Table (3) manifests the interaction of both the Royal caka cultivar and 3rd fertilization concentration, which gave the highest transplants (scion) diameter value (10.29 mm), and did differ significantly with all other interactions values.

**Table (3):** Response different Apple transplants (*Malus domestica* Borkh.) cultivars to autumn budding dates and balanced fertilizers on transplant (scion) diameter (mm).

| Cultivars | Dates | Fertilization Conc.(g.l$^{-1}$) | | | Cultivars * Dates | Cultivars effect |
|---|---|---|---|---|---|---|
| | | Zero | 2 | 4 | | |
| Super red | 28th Aug. | 8.92 c-e | 9.82 a-c | 8.41 c-g | 9.05 ab | 8.93 b |
| | 18th Sep. | 9.35 b-d | 8.49 c-g | 9.38 a-e | 9.07 ab | |
| | 8th Oct. | 9.23 b-e | 8.26 d-g | 8.51 c-g | 8.67 a-c | |
| Scarlet | 28th Aug. | 8.48 c-g | 8.26 d-g | 8.80 c-g | 8.51 bc | 8.39 c |
| | 18th Sep. | 7.32 fg | 7.10 g | 9.54 a-e | 7.99 c | |
| | 8th Oct. | 8.31 d-g | 9.32 b-e | 8.40 c-g | 8.67 a-c | |
| Royal caka | 28th Aug. | 9.45 a-e | 9.61a-e | 9.65 a-d | 9.57 a | **9.50 a** |
| | 18th Sep. | 8.63 c-f | 9.67a-d | 10.42 ab | 9.57 a | |
| | 8th Oct. | 8.11 e-g | 9.16 b-e | 10.81 a | 9.36 ab | |
| Cultivars * Fertilization | Super red | 9.17 b | 8.85 bc | 8.77 b-d | **Dates effect** | |
| | Scarlet | 8.03 d | 8.23 cd | 8.91 bc | | |
| | Royal caka | 8.73 b-d | 9.48 b | 10.29 a | | |


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|---|---|---|---|---|---|
| Dates * Fertilization | 28th Aug. | 8.95 b | 9.23 ab | 8.95 b | 9.04 a |
| | 18th Sep. | 8.43 b | 8.42 b | 9.78 a | 8.88 a |
| | 8th Oct. | 8.55 b | 8.91 b | 9.24 ab | 8.90 a |
| **Fertilization effect** | | 8.64 b | 8.85 b | **9.32 a** | |

Means with the same litters for each factors and interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test.

Besides, in the interaction between budding dates and fertilization, the highest transplant (scion) diameter value recorded from interaction of the 2nd budding date (18th Sep.) and 3rd fertilization concentration (4 g.l$^{-1}$) which gained (9.78 mm), while the lowest value was at the interaction between 2nd date (18th Sep.) and 2nd fertilization concentration (2 g.l$^{-1}$) which recorded (8.42 mm).

At the triple interaction, the highest results of transplants (scion) diameter scored by interaction among Royal caka cultivar + 3rd budding date (8th Oct.) + 3rd fertilization concentration (4 g.l$^{-1}$) obtained (10.81 mm), while the lowest transplants (scion) diameter value was (7.1 mm) at the interaction among Scarlet cultivar, 2nd budding date (18th Sep.) and 2nd fertilization concentration (2 g.l$^{-1}$).

**D. Number of lateral branches:**

The obtained results of Figure (4) indicated that the Royal caka cultivar scored the highest significant value of the lateral branches number per transplant (3.82 branches. transplant$^{-1}$), which was more than the other two cultivars; while the lowest value was at the Scarlet cultivar that gained (2.49 branches. transplant$^{-1}$).

Additionally, the data in Figure (4) exposed that the budding dates did not show any significant effect on the number of lateral branches per transplants.

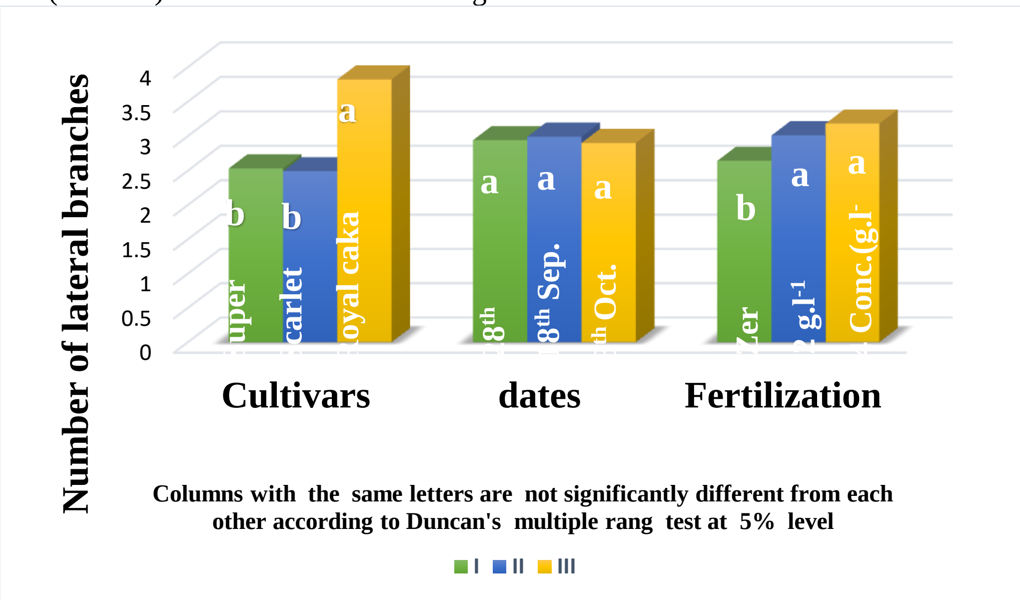


**Fig. (4):** Response different Apple transplants (*Malus domestica* Borkh.) cultivars to autumn budding dates and balanced fertilizers on Number of lateral branches.

In the same Figure, the 2nd and 3rd fertilization concentrations scored significantly higher values of lateral branches (3.01 and 3.18 branches. transplant$^{-1}$) compared to the 1st fertilization concentration(control) recorded (2.64 branches. transplant$^{-1}$).

The data in Table (4) indicated that the interaction between cultivars and budding dates affected significantly on the number of lateral branches, the highest result was at the interaction between Royal caka cultivar and three budding dates (28th Aug.,18th Sep., and 8thOct.) that recorded (3.64, 3.95 and 3.87 branches. transplant$^{-1}$) respectively compared with other treatment, whereas the lowest number of branches reach (2.22 branches. transplant$^{-1}$) at the interaction between Super red cultivar and 3rd budding date (8th Oct.).

The data pertaining in the same Table, showed the highest result of the number of lateral branches gained at the interaction between Royal caka cultivar and 3rd fertilization concentration (4 g.l$^{-1}$), which was (3.94 branches trnasplant$^{-1}$). while the lowest number of branches was (1.83 branches. transplant$^{-1}$) at the interaction between Scarlet cultivar and 1$^{st}$ fertilization concentration (control treatment).

**Table (4):** Response different Apple transplants (*Malus domestica* Borkh.) cultivars to autumn budding dates and balanced fertilizers on Number of lateral branches.

| **Cultivars** | **Dates** | **Fertilization Conc.(g.l$^{-1}$)** | | | **Cultivars * Dates** | **Cultivars effect** |
|---|---|---|---|---|---|---|
| | | zero | 2 | 4 | | |
| Super red | 28$^{th}$ Aug. | 2.26 f-h | 3.50 b-d | 2.78 d-g | 2.85 b | 2.53 b |
| | 18$^{th}$ Sep. | 2.44 f-h | 2.40 f-h | 2.72 e-h | 2.52 b-d | |
| | 8$^{th}$ Oct. | 2.50 f-h | 2.00 hi | 2.17 gh | 2.22 d | |
| Scarlet | 28$^{th}$ Aug. | 2.15 gh | 2.22 gh | 2.67 f-h | 2.35 dc | 2.49 b |
| | 18$^{th}$ Sep. | 2.00 hi | 2.00 hi | 3.50 b-d | 2.50 b-d | |
| | 8$^{th}$ Oct. | 1.33 i | 3.50 b-d | 3.00 c-f | 2.61 bc | |
| Royal caka | 28$^{th}$ Aug. | 3.42 b-e | 3.67bc | 3.83 ab | 3.64 a | **3.82 a** |
| | 18$^{th}$ Sep. | 4.17 ab | 4.17 ab | 3.50 b-d | 3.95 a | |
| | 8$^{th}$ Oct. | 3.44 b-e | 3.66 bc | 4.50 a | 3.87 a | |
| Cultivars * Fertilization | Super red | 2.40 c | 2.63 bc | 2.55 bc | **Dates effect** | |
| | Scarlet | 1.83 d | 2.57 bc | 3.06 b | | |
| | Royal caka | 3.68 a | 3.83 a | 3.94 a | | |
| Dates * Fertilization | 28th Aug. | 2.61 bc | 3.13 a | 3.09 a | 2.94 a | |
| | 18th Sep. | 2.87 ab | 2.86 ab | 3.24 a | 2.99 a | |
| | 8thOct. | 2.42 c | 3.05 a | 3.22 a | 2.90 a | |
| **Fertilization effect** | | 2.64 b | 3.01 a | **3.18 a** | | |

Means with the same litters for each factors and interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test.

The third dual interaction between budding dates and fertilization concentration showed that the best significant interaction was at 2$^{nd}$ budding dates (18$^{th}$ Sep.) + 3$^{rd}$ fertilizers concentration (4 g.l$^{-1}$) which gave (3.24 branches. transplant$^{-1}$) in comparison with the least value (2.42 branches. transplant$^{-1}$) at 3$^{rd}$ budding dates (8$^{th}$ Oct.) + 1$^{st}$ fertilizers concentration (control tretment).

The triple interaction among cultivars, budding dates and fertilization factors indicated that the Royal caka cultivar + 3$^{rd}$ budding date (8$^{th}$ Oct.), + 3$^{rd}$ fertilizers concentration (4 g.l$^{-1}$) gave the highest value of branches number reach 4.5 branches per plant in compared with other triple interaction treatment, while the lowest value 1.33 branches per plant recorded at the interaction among Scarlet cultivar + 3$^{rd}$ budding date (8$^{th}$ Oct.) + 1$^{st}$ fertilizers concentration (control treatment).

**E. Number of leaves/transplant (scion):**

Figure (5) shows that the leaf number average of Royal caka cultivar was (166.38 leaves. transplant$^{-1}$), and it was significantly higher than the Scarlet cultivar which recorded (147.09 leaves. transplant$^{-1}$). In addition, the Super red cultivar was significantly lowest than the Scarlet cultivar in leaves number which recorded the lowest value (130.69 leaves. transplant$^{-1}$).

The obtained results of Figure (5) revealed that 3$^{rd}$ budding date (8$^{th}$ Oct.) resulted in a significant increase in the leaves number. transplant$^{-1}$, that recorded (156.19 leaves. transplant$^{-1}$), as compared with 1$^{st}$ budding date (28$^{th}$ Aug.) and 2$^{nd}$ budding date (18$^{th}$ Sep.), which recorded (143.24 and 144.74 leaves. transplant$^{-1}$).

Regarding the effect of fertilization concentration on the number of leaves per transplant, the 3$^{rd}$ fertilization concentration (4 g. l$^{-1}$) was significantly the highest value (156.6 leaves. transplants$^{-1}$) compared with other treatments, while the 1$^{st}$ fertilization concentration(control) gave the lowest value (135.34 leaves. transplants$^{-1}$).

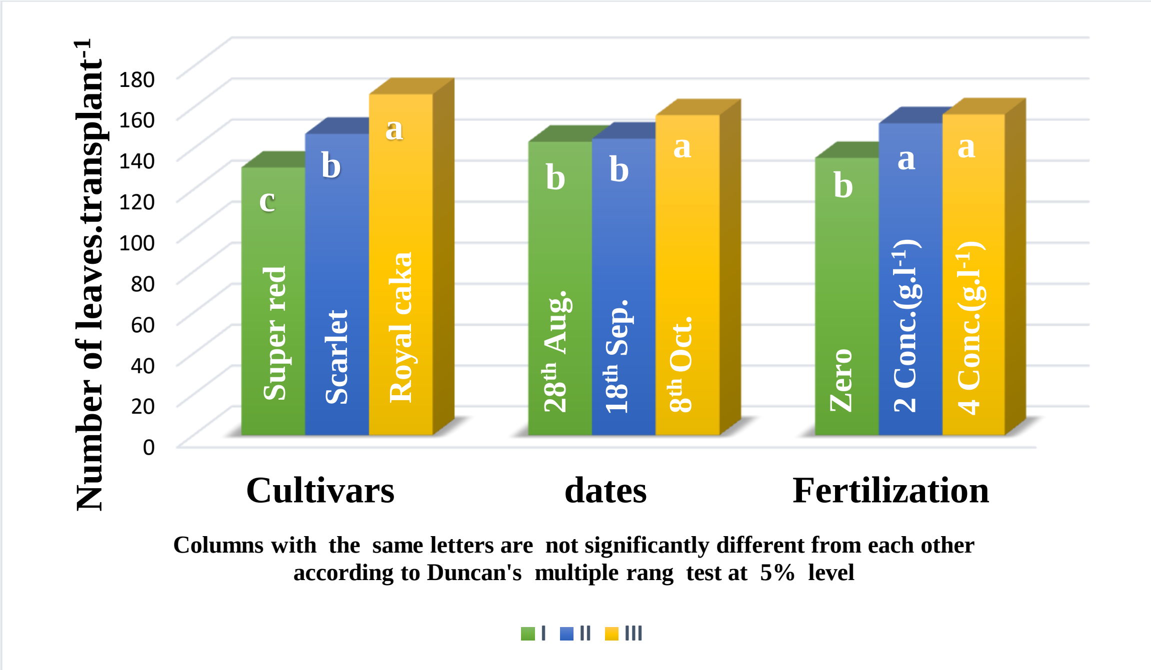


**Fig. (5):** Response different Apple transplants (*Malus domestica* Borkh.) cultivars to autumn budding dates and balanced fertilizers on number of leaves.transplant$^{-1}$.

Table (5) displays that the interaction of Royal caka cultivar and the 2$^{nd}$ budding date (18$^{th}$ Sep.) gained the highest value of leaves number per transplant which was recorded (174.64 leaves. transplant$^{-1}$), while the lowest value was at the interaction of the Scarlet cultivar with the 2$^{nd}$ budding date (18$^{th}$ Sep.) (123.97 leaves. transplant$^{-1}$).

In addition to that the second dual interaction between cultivars and fertilization concentration indicated that significant effect, the (198.89 leaves. transplant$^{-1}$) is the highest value of leaves number per transplant obtained from the interaction of Royal caka cultivar and 2$^{nd}$ fertilization concentration (2 g.l$^{-1}$) as compared with other treatment. However, the lowest value (119.22 leaves. transplant$^{-1}$) which obtained from the interaction of Super red cultivar and 2$^{nd}$ fertilization concentration (2 g.l$^{-1}$).

**Table (5):** Response different Apple transplants (*Malus domestica* Borkh.) cultivars to autumn budding dates and balanced fertilizers on number of leaves.transplant$^{-1}$.

| **Cultivars** | **Dates** | **Fertilization Conc.(g.l$^{-1}$)** | | | **Cultivars * Dates** | **Cultivars effect** |
|---|---|---|---|---|---|---|
| | | zero | 2 | 4 | | |
| Super red | 28$^{th}$ Aug. | 100.75 m | 145.42 f-h | 127.89 h-k | 124.69 d | 130.69 c |
| | 18$^{th}$ Sep. | 144.56 f-h | 105.58 lm | 156.67 ef | 135.60 cd | |
| | 8$^{th}$ Oct. | 139.83 f-i | 106.67 lm | 148.83 f-h | 131.78 d | |
| Scarlet | 28$^{th}$ Aug. | 185.56 cd | 135.50 g-k | 114.83 k-m | 145.30 c | 147.09 b |
| | 18$^{th}$ Sep. | 117.83 j-m | 130.75 g-k | 123.33 i-l | 123.97 d | |
| | 8$^{th}$ Oct. | 121.17 i-m | 149.50 fg | 245.38 a | 172.01 a | |
| Royal caka | 28$^{th}$ Aug. | 104.00 lm | 192.25 c | 182.94 cd | 159.73 b | **166.38 a** |
| | 18$^{th}$ Sep. | 170.42 de | 214.67 b | 138.83 f-j | 174.64 a | |
| | 8$^{th}$ Oct. | 133.92 g-k | 189.75 cd | 170.67 de | 164.78 ab | |
| Cultivars * Fertilization | Super red | 128.38 de | 119.22 e | 144.46 c | **Dates effect** | |
| | Scarlet | 141.52 c | 138.58 cd | 161.18 b | | |
| | Royal caka | 136.11 cd | 198.89 a | 164.15 b | | |

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| | | | | | |
|---|---|---|---|---|---|
| Dates * Fertilization | 28th Aug. | 130.10 e | 157.72 b | 141.89 cd | 143.24 b |
| | 18th Sep. | 144.27 c | 150.33 bc | 139.61 c-e | 144.74 b |
| | 8th Oct. | 131.64 de | 148.64 bc | 188.29 a | **156.19 a** |
| **Fertilization effect** | | 135.34 b | 152.23 a | **156.60 a** | |

Means with the same litters for each factors and interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test.

Whereas, the interaction of both budding dates and fertilization concentration recorded the highest number of leaves per transplant in combination of the 3rd budding date (8th Oct.) and 3rd fertilization concentration (4 g. $l^{-1}$) which gave (188.29 leaves. $transplant^{-1}$) and the lowest value was obtained from the interaction of the 1st budding date (28th Aug.) and 1st fertilization concentration (control) which gained (130.1 leaves. $transplant^{-1}$).

In the triple interaction, the highest value of leaves number per transplant was obtained from the combination of scarlet cultivar + 3rd budding date (8th Oct.) + 3rd fertilization concentration (4 g. $l^{-1}$) that recorded (245.38 leaves. $transplant^{-1}$). On the other hand, the lowest value was (100.75 leaves. transplant [1]) which was obtained from the combination of Super red cultivar, 1st budding date (28th Aug.) and 1st fertilization concentration (control).

**F. Single leaf area (cm²):**

In the Figure (6), the results clearly show that the single leaf area of both Super red and Royal caka cultivars was 29.68 $cm^2$and 28.83 $cm^2$ and they were effect significantly higher than Scarlet cultivar (27.08 $cm^2$).

Also, it shows that the single leaf area in the 3rd budding date (8th Oct.) is 30.59 $cm^2$. which were significantly higher than both 1st budding date (28th Aug.) and 2nd budding date (18th Sep.) gained (27.46 and 27.54 $cm^2$) respectively.

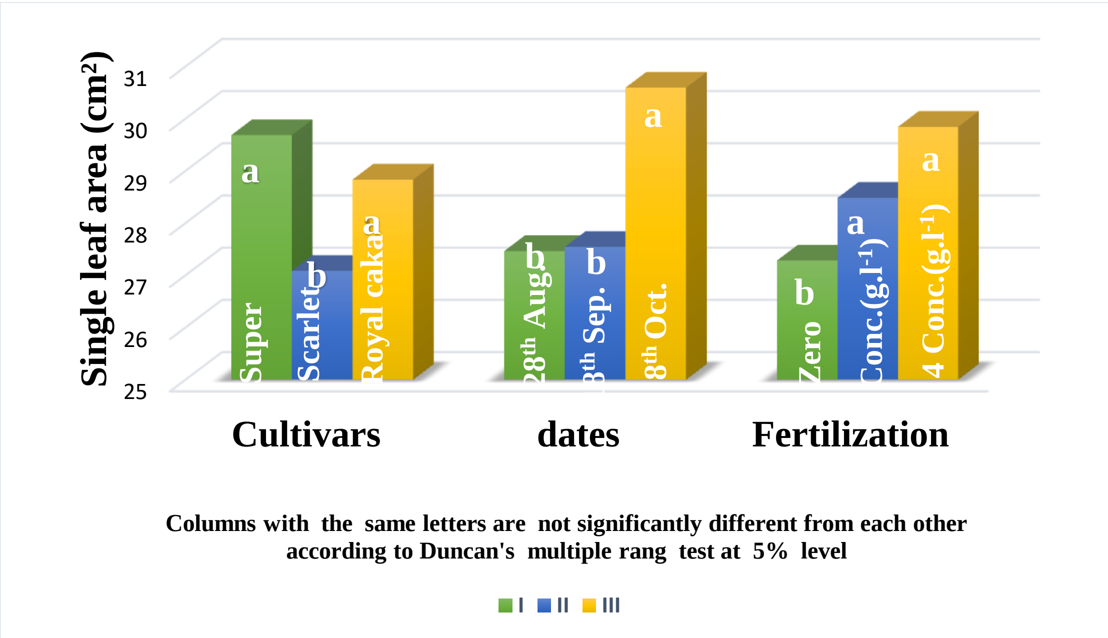


**Fig. (6):** Response different Apple transplants (*Malus domestica* Borkh.) cultivars to autumn budding dates and balanced fertilizers on Single leaf area (cm²).

Whereas, the 3rd fertilization concentration (4 g. $l^{-1}$) scored the highest significant value of single leaf area (29.84 $cm^2$), while the lowest value was at the 1st fertilization concentration (zero g.$l^{-1}$) that was recorded (27.28 $cm^2$).

The data in Table (6) showed the interaction between cultivar and budding dates affected significantly on leaf area, the interaction of Royal caka Cultivar plus 3rd budding date (8th Oct.) gained the highest value of single leaf area (32.54 $cm^2$) which was significantly higher than other values; while the lowest value recorded (26.29 $cm^2$) at the interaction between Royal caka Cultivar and 2nd budding date (18th Sep.).

In the same Table the interaction between Royal caka Cultivar plus 3rd fertilization concentration (4 g. $l^{-1}$), was gained the highest significant single leaf area value (31.45 $cm^2$) as compared with the lowest interaction value between Royal caka Cultivar and 1st fertilization concentration (zero) which gained 25.82 $cm^2$.

**Table (6):** Response different Apple transplants (*Malus domestica* Borkh.) cultivars to autumn budding dates and balanced fertilizers on Single leaf area (cm²).

| Cultivars | Dates | Fertilization Conc.(g.$l^{-1}$) | | | Cultivars * Dates | Cultivars effect |
|---|---|---|---|---|---|---|
| | | zero | 2 | 4 | | |
| Super red | 28th Aug. | 29.19 b-f | 27.43 b-f | 27.52 b-f | 28.05 bc | **29.68 a** |
| | 18th Sep. | 31.03 b-d | 28.49 b-f | 29.36 b-f | 29.62 a-c | |
| | 8th Oct. | 29.82 b-f | 31.41 bc | 32.89 b | 31.37 ab | |
| Scarlet | 28th Aug. | 25.84 c-f | 24.14 ef | 29.97 b-f | 26.65 c | 27.08 b |
| | 18th Sep. | 23.78 f | 26.48 b-f | 29.89 b-f | 26.72 c | |
| | 8th Oct. | 28.38 b-f | 30.65 b-e | 24.59 d-f | 27.87 bc | |
| Royal caka | 28th Aug. | 25.78 c-f | 31.23 b-d | 25.99 c-f | 27.67 bc | **28.83 a** |
| | 18th Sep. | 23.65 f | 27.56 b-f | 27.67 b-f | 26.29 c | |
| | 8th Oct. | 28.03 b-f | 28.91 b-f | 40.69 a | 32.54 a | |
| Cultivars * Fertilization | Super red | 30.01 ab | 29.11 a-c | 29.92 ab | **Dates effect** | |
| | Scarlet | 26.00 d | 27.09 cd | 28.15 b-d | | |
| | Royal caka | 25.82 d | 29.23 a-c | 31.45 a | | |
| Dates * Fertilization | 28th Aug. | 26.94 bc | 27.60 bc | 27.83 bc | 27.46 b | |
| | 18th Sep. | 26.15 c | 27.51 bc | 28.97 bc | 27.54 b | |
| | 8th Oct. | 28.74 bc | 30.32 ab | 32.72 a | **30.59 a** | |
| **Fertilization effect** | | 27.28 b | 28.48 ab | **29.84 a** | | |

Means with the same litters for each factors and interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test.

Also, the interaction between the 3rd budding date (8th Oct.) and 3rd fertilization concentration (4 g. $l^{-1}$) recorded the highest single leaf area 32.72 $cm^2$ as compared with the lowest value interaction between the 2nd budding date (18th Sep.) plus 1st fertilization concentration (zero) which obtained lowest value interaction (26.15$cm^2$).

The highest value of single leaf area obtained from the interaction among (Royal caka cultivar plus 3rd budding date (8th Oct.) plus 3rd fertilization concentration (4 g. $l^{-1}$)) which recorded (40.69 $cm^2$) which significantly differs from other triple interactions, especially from the interaction of (Royal caka cultivar plus 2nd budding date (18th Sep.) plus 1st fertilization concentration (zero)), which recorded the lowest value 23.65 $cm^2$.

## DISCUSSION

It is clear from the Figure (1) and Table (1) that the Royal caka cultivar had a significant effect compared with Super red and Scarlet cultivars on the budding success percentage. This results agreement with **(Al-Aokam *et al.*, 2017)** on Apricot, **(Jody *et al.*, 2012)** on Japanese plum, **(Kalil *et al.*, 2010)** on Apricot seeding and **(Kako *et al.*, 2012)** on peach. These results may return to the differences between cultivars in their budding response. In addition, also might be to the genetic trait difference among cultivars and their responses to the environmental conditions**(Westwood, 1978; Hartmann *et al.*, 2014)**. Also, the reasons behind the budding success percentage may be attributed to the different genetic makeup associated with their different susceptibility to tissue formation. The callus is necessary for the fusion process between the budding and the original in terms of speed and quantity**(Williamson *et al*., 1992)**, and the differentiation of the vascular system across the callus bridges**(Hartmann *et al*., 2014)**, These results agree with**(Al-Safi and Al-Djaili, 2000)** on Apple.

Figure (1) and Table (1) showed that significant effect of the budding dates on budding success percentage, both dates (18th Sep.) and (8th Oct.) recorded the highest significant budding success percentage compared with the date (28th Aug.) which had the lowest percentage of budding success obtained (78.56 %). This is in agreement with**(Akhtar *et al*., 2018)** on peach, **(Kako *et al*., 2015)** on peach ( Dixired cultivar ), **(Aziz *et al.*, 2018)** on black mulberry,**(Mohammed, 2022)** on *Pistacia vera* L. and **(Mir *et al.*, 2016)** on almond. The difference in budding success percentage according to budding dates might be due to favorable climatic conditions having optimum levels of temperature and relative humidity which helps to form a good adhesion area and multiply the callus tissue and formation of tissue and thus transfer water and nutrients to the bud **(Hartmann *et al.*, 2014)**. also, union formation following budding is favored by temperatures around (21°C) when callus formation is rapid. Temperatures above (32°C) slow or stop callus formation**(Kumar, 2011)**. as well the average temperature for August was (33.9°C), with a relative humidity of (26%), for September (28.05°C) a temperature and (33%) humidity, and for October (22.1°C) with a relative humidity of (40%). Also, it may be the result of physiological differences in rootstock and scions, such as differences in their content of growth promoters and inhibitors **(Jody *et al*., 2012)**.

The results in Figure (1) and Table (1) reveals that the 3rd fertilization concentration (4 $g.l^{-1}$) had a significant effect compared with 1st (zero $g.l^{-1}$) and 2nd (2 $g.l^{-1}$) fertilization concentrations on the budding success percentage. This results agreement with **(Al-Allaf and Hadeed, 2020)** when them worked on local oranges, showed that the different rates of NPK fertilizer had a significant effect on the highest percentage of successful grafts. However, this result disagrees with **(Esekhade *et al*., 2013)** when he worked on Hevea plant (*Hevea brasiliensis* Muell) and indicated the fertilizer rate had no significant effect on the budding successes of seedlings. This result may be due to fertilizers increase the efficiency of photosynthesis and make nutrients needed to open and grow buds and increase of their products used in the growth of budded seedlings such as carbohydrates and proteins and thus increase the percentage of successful budding, in addition to its ability to produce a number of growth regulators such as auxins, cytokines, and gibberellins, which would increase plant growth due to its important role in cell division, differentiation and elongation as well as early in the budding open and then get budded seedlings in a short time **(Bhat *et al.*, 2019)**. The fertilizer treatments improved callus quality at the grafting point **(Shafiei *et al*., 2020)**. The formation of callus tissue with active growth is crucial for the success of the budding **(Hartmann *et al*., 2014)**. The results emphasize the importance of proper nutrition to prepare rootstocks for budding and increase the production efficiency **(Mng'omba *et al.*, 2010)**. According to this finding, plants treated with fertilizer had a greater rate of budding success than untreated plants. Rootstock vigour, which affects the ability of cells at the budding point, is strongly correlated with callus quality, which affects cell proliferation and division **(Hartmann *et al*., 2014)**.

As shown in Figure (2, 3, 4 and 5) and Tables (2, 3, 4 and 5) indicated that the Royal caka cultivar had a significant effect over the other cultivars on the transplant(scion) height, transplant (scion) diameter, lateral branches number, leaves number. furthermore, the Table (6) scored that the Royal caka cultivar had a significant effect on the single leaf area compared with the Scarlet cultivar. This results agreement with **(Al-Aokam *et al*., 2017)** on Apricot,**(Jawad and Al-Wahab, 2014)** on Apple seedling, **(Jody *et al*., 2012)** on Japanese plum, **(Kalil *et al*., 2010)** on Apricot plant and **(Kako *et al*., 2012)** on peach. The reason might be due to the genetic variations among Apple cultivars. Also, the reason for this difference may be due to genetic factors specific to the variables related to the strength of the vegetative growth of the variety and its effect on increasing the surface area of the leaf, which contributed to the feeding of the stem, food storage and the diameter growth of the stem of the budded seedlings**(Kalil *et al*., 2010)**. and the difference in the number of branches between the cultivars may be due to the different genetic structure of the cultivars**(Westwood, 1978)**.

Figure (2, 5, and 6) and Tables (2, 5, and 6) are significantly affected by the 3rd budding date

($8^{th}$ Oct.) which compared with the $1^{st}$ and $2^{nd}$ budding dates, they were (transplant(scion) height, leaves number, and single leaf area). These results confirmed the results which drawn by **(Hadi *et al*., 2013)** on Apricot, **(Ali *et al.*, 2012)** on loquat, **(Ahmad *et al*., 2012)** on peach and **(Ahmad *et al*., 2015)** on Guava. There are many reasons behind the obtained results, while the transplant(scion) height might be due to the minimum number and height of branches recorded on plants budded on the $8^{th}$ Oct. which resulted in a significant effect in transplant(scion) height**(Ahmad *et al*., 2015)**. The reason for the increase in the number of leaves may be attributed to the increase in the transplant(scion) height and the increase in the growth of the lateral buds and leaf area, which leads to an increase in the efficiency of the photosynthesis process and an increase in its outputs used in the growth of transplants**(Al-Kayssi, 2019)**. and the reason for leaf area is due to the vigorous growth of plant as it is capable of absorbing more nutrients and prepare more Photosynthetic resulted in maximum leaf area. Similarly, It is due to stronger bud union and development of normal vascular tissues at the bud union which regulates the transport of water and nutrients and thereby increases the leaf area**(Ahmad *et al*., 2015)**.

The results which appeared clearly in Figure (2 and 3) and Tables (2 and 3) show that the $3^{rd}$ fertilization concentration (4 $g.l^{-1}$) significantly affect the other concentrations on some vegetative growth characteristics such as (transplant(scion) height and transplant (scion) diameter). Also, fertilization effects show that Figure (4, 5, and 6) and Tables (4, 5, and 6) explained that $3^{rd}$ fertilization concentration (4 $g.l^{-1}$) influenced significantly compared with $1^{st}$ fertilization concentration (zero $g.l^{-1}$)on the (lateral branches number, leaves number, and single leaf area), these results agreed with**(Saeed and Hamad, 2021)** on peach, ***(El-Sayed et al.*, 2017)** on *Hibiscus rosa*-sinensis, **(Al-Imam and Al-Brifkany, 2010)** on Apple. The reason for the increase in the length of the branches may be due to the role of fertilization in filling the plant's need for the essential nutrients necessary for photosynthesis and various metabolic processes for the solution of the major elements NPK**(Awad and Atawia, 1995)**. As well, potassium aids in the promotion of histopathological tissue, the division of living cells, activation of photosynthesis, the transfer of materials represented by leaves, and movement in the transition from old leaves to the young leaves**(Poni *et al.*, 2003)**. The reason for the increase in leaf number and leaf area may be due to the positive effect of the fertilization nutrient, which contains the major elements of the NPK as a ready-made form, which have a role in the formation of amino acids, nuclei and important enzymes in vegetative growth and the emergence of chlorophyll are the basis for photosynthesis, which increases the proportion of processed materials and increases vegetative growth rates**(Pilbeam and Barker, 2007)**. Nitrogen plays a critical role in the growth and development of plants. This element exists in proteins, metabolites, and compounds that are used in the biosynthesis of materials, energy transferring, and structure of the genetic material**(Marschner, 1995; Power and Prasad, 1997)**. Although nitrogen supply for trees in nursery can increase the quality and value of seedlings and production efficiency, and also improves the rooting potential in rootstocks**(Izadi *et al*., 2016)**. As for improving the characteristics of vegetative growth, this may be due to the combined and interactive effect of the mineral components of this fertilizer. Each component has one or more functions that it is played in plant life, so, providing balanced nutrients to the plant is the basis for improving vegetative growth and tree production **(Nafees *et al*., 2007)**.

## CONCLUSIONS

The cultivar, budding dates, and fertilization level significantly affected on budding successful percentage and some vegetative growth characteristics, the results showed that the Royal caka cultivar gave the best result in budding successful percentage and vegetative growth characteristics. Furthermore, the $3^{rd}$ budding date ($8^{th}$ Oct.) was significant effect on budding success percentage, transplant(scion) height, leaves number and single leaf area. Also, $3^{rd}$ fertilization concentration (4 $g.\ l^{-1}$) gave the best result in budding success percentage, transplant(scion) height, transplant (scion) diameter, lateral branches number, leaves number and single leaf area. While the triple interaction among (Royal caka cultivar + $3^{rd}$ budding date (8th Oct.) + $3^{rd}$ fertilization concentration (4 $g.\ l^{-1}$) significantly affected most characteristics and gave the best results.

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