# Adjusting the C/N Ratio in Tissue-Cultured Barhee Date Palm Leaves through Irrigation and Fertilization to Overcome Fruit Setting Failures

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## Abstract

Several studies have investigated the impact of high starch reserves, total carbohydrates, and C/N ratio on fruiting and fruit set in perennial fruit crops. This study aims to adjust the C/N ratio to address the fruit set failure of Barhee date palms. During the 2019 and 2020 seasons, Barhee date palms produced through tissue culture were subjected to treatments involving skipped irrigation and nitrogen (N) fertilization, along with a doubling of phosphorus (P) and potassium (K) fertilizers during the flowering and pollination stages. The results demonstrated a significant increase in fruit set percentage and yield when irrigation and N fertilization were skipped, and when P and K fertilization was doubled during these critical periods. Conversely, applying nitrogen fertilization and conducting irrigation during flowering and pollination adversely affected the C/N ratio, fruit set percentage, and yield. In conclusion, skipping irrigation and nitrogen fertilization, combined with doubling P and K fertilization during flowering and pollination, proved to be the most effective treatment for mitigating fruit set failure and enhancing the yield and fruit quality of Barhee date palms produced via tissue culture.

**Keywords:** Fertilization, pollination, skipping irrigation, fruit setting, C/N ratio, Barhee cv., *Phoenix dactylifera* L.

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## Introduction

The date palm (*Phoenix dactylifera* L.) is one of the most important fruit trees in Egypt and Arab countries, significantly contributing to local economies and serving as a vital food source. However, under new valley conditions, Barhee date palms experience failures in fertilization of female inflorescences, leading to poor fruit set and the occurrence of parthenocarpic fruits. Among the major cultivated cultivars, Barhee is highly favored by farmers, yet issues related to inadequate fertilization persist. Numerous studies have explored strategies to overcome this challenge by improving the pollination process. This includes the application of various stimulants such as sugar, boron, zinc, and ascorbic acid in conjunction with pollen grains (Zaen El-Daen *et al*., 2017; Abd-Elhaleem *et al*., 2019; El-Salhy *et al*., 2021), selecting appropriate pollen sources (Al-Hamoudi *et al*., 2006; Al-Muhtaseb and Ghnaim, 2006), delaying the timing of pollination (Al-Obeed and Soliman, 2011), modifying pollination methods (Awad, 2011; Abu-Zahra and Shatnawi, 2019; El-Sharabasy *et al*., 2020), and using bagging materials post-pollination (Farag, 2005).This paper

discusses the phenomenon of poor fruit setting in Barhee date palms through the lens of the carbon-to-nitrogen (C/N) ratio's effect on fruiting and fruit set. Previous research indicates that for flowering to occur, the concentration of total carbohydrates must exceed that of nitrogenous compounds (Chacko and Ananthanarayana, 1982; Iftikhar *et al*., 2017). Therefore, this study aims to adjust the C/N ratio to mitigate failures in fruit setting by optimizing irrigation and fertilizer applications, thereby developing a favorable relationship between the C/N ratio and photosynthesis during the flowering and pollination stages.

## Materials and methods

### Study area and treatments

The experiment was conducted over two successive growing seasons, 2019 and 2020, using 8-year-old Barhee date palms. The selected palms were cultivated under drip irrigation on sandy soil at the El-Ownate Agricultural Research Station in the New Valley Governorate, Egypt. Key physical and chemical properties of the experimental soil and irrigation water are presented in Tables 1 and 2, following the methods outlined by Piper (1950) and Jackson (1973).

**Table (1):** Some physical and chemical characteristics of the experimental soils

| Soil Characteristic | Soil depth (cm) | | |
|---|---|---|---|
| | 0-30 | 30-60 | 60-90 |
| Sand % | 87.87 | 93.12 | 92.93 |
| Silt % | 6.13 | 6.56 | 6.62 |
| Clay % | 6.21 | 2.32 | 2.45 |
| Soil texture | Sand | Sand | Sand |
| CaCO3 % | 4.50 | 5.80 | 4.00 |
| OM% | 0.15 | 0.09 | 0.07 |
| pH (1:1 suspension) | 7.7 | 7.6 | 7.5 |
| EC (1:1 extract) dS $m^{-1}$ | 0.40 | 0.70 | 0.71 |
| $NaHCO_3$ - P (ppm) | 3.77 | 4.14 | 3.57 |
| Available K (ppm) | 123.84 | 113.39 | 102.11 |

**Table (2):** Some characteristics of irrigation water

| Irrigation water characteristics | Values |
|---|---|
| EC $dSm^{-1}$ | 0.48 |
| pH | 6.76 |
| $Ca^{+2}$ meq $l^{-1}$ | 1.09 |
| $Mg^{+2}$ meq $l^{-1}$ | 1.13 |
| Na+1 meq $l^{-1}$ | 1.43 |
| K+1 meq $l^{-1}$ | 1.07 |
| $CO_3^{-2}$ +$HCO_3^{-1}$ meq $l^{-1}$ | 2.30 |
| Cl-1 meq $l^{-1}$ | 1.64 |
| $SO_4^{-2}$ meq $l^{-1}$ | 0.75 |
| SAR | 1.35 |
| Fe (ppm) | 1.29 |
| Mn (ppm) | 0.1 |

**Experimental design**

Thirty 8-year-old Barhee date palms were selected for the study, all planted in a uniform manner with spacing of 6x8 meters and grown under a drip irrigation system. The palms were free of insects, damage, and diseases and they were subjected to consistent management practices, including artificial pollination, pruning, irrigation, and fertilization.

**Pollination**

Hand pollination was performed on all selected palms by inserting 10-20 fresh male strands into the center of one female spathe, using pollen from the same source to avoid the effects of metaxenia. The viability of pollen grains was assessed prior to pollination using acetocarmine staining. A drop of 1.0% acetocarmine was applied, and the pollen grains were examined microscopically; colorless or unstained grains were considered non-viable, following the methods described by Moreria and Gurgel (1941) and Furr and Enriquez (1966).

**Treatments**

The experiment included eight treatment programs summarized as follows:

**A. Irrigation treatments**

- Normal irrigation
- Skipping irrigation during flowering and pollination stages only

**B. Fertilization treatments**

- Control: Recommended doses of N, P, and K (1000 g N + 400 g $P_2O_5$ + 500 g $K_2O$)
- 1/2 N + 1PK during flowering and pollination stages only
- 1/2 N + 2PK during flowering and pollination stages only
- 0 N + 1PK during flowering and pollination stages only
- 0 N + 2PK during flowering and pollination stages only

The recommended doses of ammonium nitrate (33.5% N), phosphoric acid (50% $P_2O_5$), and potassium sulfate (48% $K_2O$) were applied with irrigation water during the growing season in 12 equal doses, except for variations in application timing among treatments.

**Experimental design**

The treatments were arranged in a split-plot design with three replicates. The irrigation regimes were randomly distributed in the main plots, while the fertilization treatments were randomly arranged in subplots.

### Data collection

Leaf nitrogen (N%) and total carbohydrates (%) were estimated at the fruit set stage to calculate the C/N ratio using the method described by Hedge and Hofreiter (1962). Fruit set was calculated at harvest by dividing the number of fruits harvested by the total number of fruits set and multiplying by 100.

### Statistical analysis

All data were statistically analyzed using the analysis of variance (ANOVA) technique as published by Gomez and Gomez (1984), employing the "MstatC 2.1" computer software package. Least Significant Differences (LSD) at a 5% significance level were used to test differences between treatment means.

## Results and discussion

### Nutrient contents of date palm leaflets: Carbohydrate/Nitrogen Ratio (C/N)

The data presented in Table 3 indicate a significant increase in the C/N ratio when irrigation was skipped during the flowering and pollination stages. Specifically, the skipping treatment recorded C/N ratios of 36.74 and 37.38 in 2019 and 2020, respectively. In contrast, normal irrigation resulted in lower C/N ratios of 28.42 and 30.65 for the same years. These findings align with those reported by Tirado-Corbalá *et al*. (2019). All fertilization treatments significantly elevated the C/N ratio compared to the control (Table 3). The highest C/N ratios were observed when nitrogen fertilizer was omitted and phosphorus and potassium levels were doubled during the flowering and pollination stages, yielding values of 37.91 and 38.11. The second highest ratios (36.60 and 37.41) were recorded with the omission of nitrogen while maintaining normal phosphorus and potassium levels during the same stages. The control treatment exhibited the lowest C/N ratios (26.30 and 28.00), consistent with the findings of Mostafa and Abdel-Rahman (2015). The skipping irrigation treatment combined with zero nitrogen and 1PK emerged as the most effective interaction treatment, resulting in C/N ratios of 39.46 and 39.59. Conversely, the lowest C/N ratios were observed in the combination of normal irrigation and fertilization, with values of 21.26 and 22.97 in 2019 and 2020, respectively.

**Table (3):** Effect of irrigation and fertilization on C/N ration and fruit set of Barhee date palm during 2019 and 2020

| Treatments | C/N | | Fruit set (%) | |
|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 |
| **Irrigation effect** | | | | |
| **Normal irrigation** | 28.42 | 30.65 | 21.37 | 24.90 |
| **Skipping irrigation** | 36.74 | 37.38 | 40.29 | 43.91 |
| **F test** | * | * | * | * |
| **Fertilization effect** | | | | |
| **Control** | 26.30 | 28.00 | 17.85 | 20.21 |
| **1/2N +1PK** | 29.04 | 31.55 | 22.30 | 26.36 |

| | | | | | |
|---|---|---|---|---|---|
| **1/2N+2PK** | | 33.03 | 35.01 | 30.07 | 33.93 |
| **0 N+1PK** | | 36.60 | 37.41 | 37.79 | 41.21 |
| **0 N+2PK** | | 37.91 | 38.11 | 46.14 | 50.31 |
| **New LSD 0.05** | | 0.66 | 0.91 | 0.72 | 1.02 |
| **Interaction effect** | | | | | |
| **Normal irrigation** | **Control** | 21.26 | 22.97 | 11.42 | 13.28 |
| | **1/2N +1PK** | 22.84 | 26.12 | 13.14 | 17.00 |
| | **1/2N+2PK** | 27.46 | 30.89 | 18.71 | 23.57 |
| | **0 N+1PK** | 33.75 | 35.22 | 28.44 | 31.42 |
| | **0 N+2PK** | 36.76 | 38.06 | 35.14 | 39.21 |
| **Skipping irrigation** | **Control** | 31.34 | 33.04 | 24.28 | 27.14 |
| | **1/2N +1PK** | 35.24 | 36.97 | 31.45 | 35.71 |
| | **1/2N+2PK** | 38.60 | 39.13 | 41.42 | 44.29 |
| | **0 N+1PK** | 39.46 | 39.59 | 47.14 | 51.00 |
| | **0 N+2PK** | 39.06 | 38.16 | 57.14 | 61.41 |
| **New LSD 0.05** | | 1.62 | 1.83 | 1.95 | 2.21 |

**Fruit set percentage**

The results clearly demonstrate that irrigation treatments significantly influenced the fruit set of Barhee date palms. Skipping irrigation during the flowering and pollination stages resulted in the highest fruit set percentages compared to normal irrigation. These findings are consistent with those reported by Sarker and Rahim (2013). Additionally, the different fertilization treatments had a significant effect on fruit set. The application of zero nitrogen combined with (2PK) yielded the highest fruit set percentages, with values of 46.14% and 50.31% for the years 2019 and 2020, respectively. This was followed by the treatment of zero nitrogen with (1PK), which resulted in fruit set percentages of 37.79% and 41.21%. The treatment of half nitrogen with (1/2N+2PK) ranked third, showing fruit set percentages of 30.07% and 33.93%. These results align with the findings of Khamis *et al*. (2018). Furthermore, the data in Table 3 indicate that all tested fertilization treatments resulted in increased fruit set when the amount of irrigation water was reduced during the flowering and pollination stages. Notably, the highest fruit set values were achieved with the zero nitrogen and 2PK treatment, recording 57.14% and 61.41% in 2019 and 2020, respectively.

## Conclusions

The results of this study indicate that skipping irrigation and nitrogen fertilization during the flowering and pollination periods, combined with an increased application of phosphorus and potassium fertilizers, are the most effective strategies for addressing the issue of fruit setting failure in Barhee date palms. These practices not only enhance the fruit set percentage but also improve overall yield and fruit quality. Implementing these treatment strategies can significantly benefit farmers cultivating Barhee date palms, particularly those propagated through tissue culture, by ensuring better fruit production and quality under challenging environmental conditions.

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# ضبط نسبة الكربون إلى النيتروجين في أوراق نخيل البلح البرحي المزروعة بالأنسجة من خلال الري والتسميد للتغلب على فشل عقد الثمار

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## الملخص العربي

تم إجراء العديد من الدراسات بالتحقيق في تأثير احتياطي النشا العالي، وإجمالي الكربوهيدرات، ونسبة الكربون إلى النيتروجين على الإثمار والنسبة المئوية لعقد الثمار لمحاصيل الفاكهة المعمرة. تهدف هذه الدراسة إلى ضبط نسبة الكربون إلى النيتروجين لمعالجة فشل إثمار نخيل بارحي. خلال موسمي ٢٠١٩ و٢٠٢٠، تم تطبيق معاملات على نخيل البارحي المزروع من خلال الأنسجة، تتضمن تخطي الري وتسميد النيتروجين (N)، بالإضافة إلى مضاعفة الأسمدة الفوسفورية (P) والبوتاسية (K) خلال مراحل الإزهار والتلقيح. أظهرت النتائج زيادة ملحوظة في نسبة عقد الثمار والإنتاج عند تخطي الري وتسميد النيتروجين، وعند مضاعفة تسميد الفوسفور والبوتاسيوم خلال هذه الفترات الحرجة. بالمقابل، أدت المعاملة بسماد النيتروجين وإجراء الري خلال الإزهار والتلقيح إلى تأثير سلبي على نسبة الكربون إلى النيتروجين، ونسبة عقد الثمار، والإنتاج. في الختام، أثبتت النتائج أن تخطي الري وتسميد النيتروجين، جنبًا إلى جنب مع مضاعفة تسميد الفوسفور والبوتاسيوم خلال الإزهار والتلقيح، كانت أكثر المعاملات فعالية في تخفيف فشل عقد الثمار وتعزيز الإنتاج وجودة الثمار لنخيل البارحي المنتج نسيجيًا.

**الكلمات الدالة:** التسميد، التلقيح، الري، عقد الثمار، نسبة الكربون إلى النيتروجين، نخيل البلح صنف البرحي