Menoufia J. Plant Prod., Volume 10 Issue 4 (2025): 57 – 63

MENOUFIA JOURNAL OF PLANT PRODUCTION

https://mjppf.journals.ekb.eg/

THE EFFECT OF SOME TREATMENTS ON TOTAL CHLOROPHYLL AND NEW LEAF LENGTH OF DATE PALM VARIETY BARHI DURING THE ACCLIMATIZATION STAGE

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Received: Apr. 5, 2025 Accepted: Apr. 15, 2025

ABSTRACT: This study evaluated the effects of sodium nitrophenolate (SNP) and N-Acetyl-Thiazolidine-4-carboxylic acid (AATC) treatments on leaf morphology and chlorophyll content in date palm (*Phoenix dactylifera* L., Barhi cv.) over an 18-month period. Seven treatments, including varying concentrations of SNP (0.1, 1, and 10 ppm) and AATC (0.1, 1, and 10 ppm), were assessed alongside a control. Results demonstrated significant improvements in leaf length, width, and chlorophyll content, with distinct dose-response relationships. SNP 10 ppm exhibited the highest mean leaf length, representing a 371% increase over control, while SNP 0.1 ppm and AATC 0.1 ppm produced the greatest enhancements in leaf width, respectively and chlorophyll content. AATC treatments showed an inverse dose-response for width and chlorophyll accumulation, indicating potential over-inhibition of ethylene at higher concentrations. Overall, both compounds elicited rapid and sustained morphological improvements, underscoring their value in enhancing vegetative growth and photosynthetic capacity. These findings support the strategic use of SNP and AATC in sustainable date palm cultivation to promote early vigor and long-term productivity.

Keywords: Date palm, Acclimatization, Nutrition, Auxin, Plant growth regulator, Ex vitro.

INTRODUCTION

Barhi is a globally recognized and commercially significant date cultivar (Hajian, 2007). The successful acclimatization of tissue culture-derived plantlets underscores the efficacy and relevance of this propagation technique. Research indicates that transferring rooted shoots to an MS salts solution and elevating light intensity improves photosynthetic activity, facilitating the transition from heterotrophic to autotrophic growth (Khieralla and Bader, 2007). A well-developed root system in date palm plantlets is crucial for their successful adaptation to ex vitro conditions (El-Bahr *et al*., 2004). In micrografted citrus plants, studies have examined the role of growth media and auxin applications in promoting in vitro rooting and enhancing post-transplant survival (Abo-El-Soaud *et al*., 1999). Pre-treatment of plantlets with a concentrated IBA solution (10 g/L) prior to culturing significantly improved lateral root formation in 68% of cases, while 25% exhibited enhanced secondary root development. Optimal results were achieved when plantlets were treated with IBA immediately before transplantation, leading to 100% successful soil establishment and robust secondary root growth (Plastira and Karetsos, 2007). Further studies demonstrated that ex vitro rooting efficiency depends on auxin type and concentration. Dipping the basal ends of in vitro shoots in 1 g/L IBA yielded the highest rooting success, with an average of five roots per shoot in 85% of cases, along with improved survival rates (Gonçalves and Romano, 2007). The present study aims to optimize the production of high-quality date palm (Barhi cv.) plantlets during acclimatization to ensure successful field transplantation.

MATERIALS AND METHODS

1. Experimental procedures

The current investigation was carried out over the years 2023 and 2025 at the Egyptian French

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Company for Plant Tissue Culture S.A.E (EFC Plants), located in Plot 777, Line 5 South, Ahmed Orabi Agricultural Association, El Obour City, Cairo, Egypt. The research examined the influence of various growth regulators on Barhi cultivar date palm plantlets during the acclimatization phase. Plantlets measuring 20–25 cm, prepared for acclimatization, were transplanted into 5 × 18 cm plastic pots filled with a substrate mixture of vermiculite, peat moss, and sand (1:1:1 v/v/v) and maintained for six months. The experiment was conducted in a plastic greenhouse under controlled conditions, including a light intensity of 8000–10,000 lux, high humidity, and a temperature of 30 ± 2°C (El-Sharabasy *et al.,* 2001). The plantlets were irrigated twice weekly with a nutrient solution consisting of 5.0 mg/L complete fertilizer (19:19:19 NPK plus micronutrients) supplemented with varying concentrations of auxins.

2. Experimental treatments

Two types of auxins were studied, i.e. Nitrophenolate (SNP) and N-Acetyl-Thiazolidine-4-carboxylic acid (AATC) with different concentrations. Seven treatments, including varying concentrations of SNP (0.1, 1, and 10 ppm) and AATC (0.1, 1, and 10 ppm), were assessed alongside a control. The treatments were soil applied twice weekly with the previous nutrient solution. The tested treatments were arranged in randomize complete block design (RCBD) with three replicates.

3. Characters studied

Leaf length (cm), leaf width (cm) and chlorophyll content (SPAD value) were recorded after 9, 12 and 18 months from culturing the plantlets in greenhouse.

4. Statistical analysis

Measurements data were statistically analyzed according to the methods described by Gomez and Gomez (1984). The statistical analysis was done using CoStat package program, version 6.45. The differences between the means of different treatments were tested using Duncan's multiple range test (Duncan, 1955) at 5% probability level. The mean values within each column followed by the same letter (s) are not significant at 5% level of probability.

RESULTS AND DISCUSSION

1. Effect of treatments on leaf length for date palm (BARHI cv.)

The results presented in Table (1) demonstrate significant variations in leaf length development of date palm BARHI cv. in response to different growth regulator treatments over an 18-month evaluation period. The data reveals distinct patterns of growth enhancement that warrant detailed analysis within the context of plant growth regulation mechanisms.

Table (1): Effect of treatments on leaf length (cm) for date palm (BARHI cv.).

Treatments	Period			Overall mean
	9 months	12 months	18 months	
Control	3.6 c	3.6 c	4.1 c	3.8
SNP 0.1	8.0 bc	8.5 bc	9b c	8.5
SNP 1	13.7 ab	14.2 ab	14.7 ab	14.2
SNP 10	17.4 a	17.9 a	18.4 a	17.9
AATC 0.1	11.4 a	11.9 ab	12.4 ab	11.9
AATC 1	14.1 ab	14.6 ab	15.1 ab	14.6
AATC 10	15.5 a	16.0 a	16.5 a	16.0

The Sodium nitrophenolate (SNP) treatments demonstrated superior growth enhancement effects, with the 10 ppm concentration achieving the highest mean leaf length of 17.9 cm, representing a remarkable 371% increase over the control. This exceptional performance reflects SNP's function as a nitric oxide donor, which promotes cellular processes involved in cell division and elongation (Zhang *et al.*, 2022 and Corpas and Barroso, 2024). The clear dose-dependent response pattern (0.1 < 1 < 10 ppm) indicates that higher SNP concentrations correlate with greater leaf elongation, consistent with research showing enhanced plant growth parameters under optimal SNP applications (Hameed *et al.*, 2019).

While less effective than SNP, the N-Acetyl-Thiazolidine-4-carboxylic acid (AATC) treatments still produced substantial leaf length increases, with the 10 ppm concentration achieving 16.0 cm mean length (321% increase over control). AATC's effectiveness stems from its role as an ethylene biosynthesis inhibitor, promoting vegetative growth by reducing ethylene-mediated growth inhibition. The similar dose-response relationship observed for AATC suggests consistent growth regulator mechanisms across different treatment types.

The analysis revealed that growth regulatory effects were rapidly established and maintained throughout the 18-month evaluation period, with minimal variation across assessment timepoints. These findings have significant implications for date palm cultivation, as the substantial leaf length increases could enhance photosynthetic capacity and overall plant vigor, potentially improving plantation establishment and long-term productivity in this economically important crop (Chao and Krueger, 2007 and FAO, 2024).

2. Effect of treatments on leaf width for date palm (BARHI cv.)

The results presented in Table (2) demonstrate significant variations in leaf width development of date palm BARHI cv. in response to different growth regulator treatments over an 18-month evaluation period. The data reveals distinct patterns of growth enhancement that warrant detailed analysis within the context of plant growth regulation mechanisms.

Table (2): Effect of treatments on leaf width (cm) for date palm (BARHI cv).

Treatments	Period			Overall mean
	9 months	12 months	18 months	
Control	0.80 a	0.80 b	1.05 b	0.88
SNP 0.1	0.85 a	1.10 ab	1.50 ab	1.15
SNP 1	1.45 a	1.70 a	1.95 a	1.70
SNP 10	1.45 a	1.70 a	1.95 a	1.70
AATC 0.1	1.40 a	1.65 a	1.90 a	1.65
AATC 1	1.25 a	1.49 ab	1.80 ab	1.51
AATC 10	1.10 a	1.35 ab	1.60 ab	1.35

The sodium nitrophenolate (SNP) treatments produced the most substantial leaf width increases, with both 1 ppm and 10 ppm concentrations achieving identical mean widths of 1.70 cm, representing a 93% increase over the control. This significant enhancement demonstrates SNP's effectiveness as a nitric oxide donor in promoting cellular expansion processes that contribute to lateral leaf growth through enhanced cell division and elongation (Hussain *et*

al., 2022). The dose-response relationship exhibited a threshold pattern where moderate to high concentrations (1-10 ppm) produced optimal results, while the lowest concentration (0.1 ppm) showed reduced effectiveness, suggesting that sufficient SNP levels are required to trigger the necessary cellular mechanisms for lateral expansion.

The N-Acetyl-Thiazolidine-4-carboxylic acid (AATC) treatments demonstrated a contrasting inverse dose-response relationship, with the lowest concentration (0.1 ppm) achieving the highest mean leaf width of 1.65 cm (87% increase over control), while higher concentrations showed progressively reduced efficacy. This pattern reflects AATC's mechanism as an ethylene biosynthesis inhibitor, where optimal leaf width enhancement occurs at lower concentrations that effectively reduce ethylene-mediated growth constraints without disrupting normal developmental processes (Yang and Hoffman, 1984). The inverse relationship suggests that excessive ethylene inhibition at higher AATC concentrations may interfere with the delicate balance required for optimal leaf morphogenesis (Kende, 1993).

The analysis revealed that growth regulatory effects on leaf width were rapidly established and maintained throughout the 18-month evaluation period, with most treatments showing consistent performance across assessment timepoints. While the control treatment exhibited minimal natural variation (0.8-1.05 cm), the treated plants maintained stable enhanced leaf width measurements, indicating that the treatments successfully modified fundamental developmental processes (OSU Extension Service, 2024). This temporal stability demonstrates that morphological enhancement effects are both quickly established and persistent, providing important practical implications for date palm cultivation where sustained vegetative improvements are crucial for long-term productivity and successful plant establishment (Chao and Krueger, 2007).

3. Effect of treatments on chlorophyll content for date palm (BARHI cv.)

The results presented in Table (3) evaluated the temporal effects of various fertilizer treatments on chlorophyll content in date palm Barhi cv. over an 18-month period. The results demonstrate significant variations in chlorophyll accumulation patterns among different treatment regimes, with notable implications for date palm cultivation and physiological performance. Chlorophyll content serves as a critical indicator of photosynthetic capacity and overall plant health in date palms, as emphasized by recent studies on rapid chlorophyll assessment methods in this species (Al-Tamimi *et al.,* 2021). The temporal analysis revealed distinct treatment responses across the experimental period, suggesting differential mechanisms of nutrient uptake and chlorophyll biosynthesis enhancement.

Table (3): Effect of treatments on chlorophyll content (SPAD value) for date palm BARHI cv.

Treatments	Period			Overall mean
	9 months	12 months	18 months	
Control	18.40 d	19.20 c	19.80 d	19.1
SNP 0.1 ppm	23.84 a	24.20 a	25.00 a	24.3
SNP 1 ppm	21.04 bc	21.60 b	22.60 bc	21.7
SNP 10 ppm	19.88 cd	20.40 bc	21.20 cd	20.5
AATC 0.1 ppm	23.44 ab	24.00 a	25.00 a	24.1
AATC 1 ppm	21.80 abc	22.60 ab	23.80 ab	22.7
AATC 10 ppm	21.08 bc	22.60 ab	23.60 ab	22.4

SNP treatments (0.1, 1, and 10) showed varying effectiveness, with SNP 0.1 demonstrating the highest mean chlorophyll content (24.3), followed by SNP 10 (20.5) and SNP 1 (21.7). This concentration-dependent response aligns with previous research demonstrating that specific nutrient formulations can significantly enhance chlorophyll synthesis in date palms under various stress conditions. The superior performance of the lower SNP concentration suggests an optimal threshold beyond which additional nutrients may not provide proportional benefits, consistent with established principles of plant nutrition. AATC treatments exhibited similar patterns, with AATC 0.1 achieving the highest chlorophyll content (24.1), while AATC 1 (22.7) and AATC 10 (22.4) showed comparable but lower values. These findings corroborate research by Yaish *et al.* (2017) on date palm physiological responses, indicating that N-Acetyl-Thiazolidine-4-carboxylic acid (AATC) treatments can enhance photosynthetic pigment accumulation through improved chlorophyll biosynthesis pathways.

The analysis revealed increasing chlorophyll content from 9 to 18 months across most treatments, with the control group showing moderate increases from 18.4 to 19.8. This pattern suggests natural maturation effects combined with treatment-specific enhancement mechanisms. Notably, the 5-aminolevulinic acid-based fertilizers have been previously demonstrated to promote chlorophyll synthesis in date palm seedlings under stress conditions, supporting photosynthetic gas exchange and overall plant performance (Al-Whaibi, 2008). The consistent superiority of lower concentration treatments (SNP 0.1 and AATC 0.1) throughout the experimental period indicates sustainable enhancement effects without nutrient toxicity, which is crucial for long-term date palm cultivation strategies. These results provide valuable insights for optimizing fertilization protocols in date palm production systems, particularly given the increasing importance of sustainable cultivation practices in arid regions where date palms serve as essential crops for food security and economic stability.

Conclusion

The findings support the strategic use of SNP and AATC in sustainable date palm cultivation to promote early vigor and long-term productivity.

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تاثير بعض المعاملات علي الكلورفيل وطول الورقة الجديدة علي نخيل البلح صنف البرحي بمرحلة الاقلمة

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الملخص العربي

هدفت هذه الدراسة إلى تقييم تأثير كل من نيتروفينولات الصوديوم (SNP) وحمض-N أسيتيل-ثيازوليدين-٤-كربوكسيليك (AATC)على مورفولوجيا الأوراق ومحتوى الكلوروفيل في نخيل التمر صنف "البرحي *Phoenix dactylifera* L.,) " (cv. BARHIخلال فترة زمنية امتدت إلى ١٨ شهرًا. تم تطبيق سبعة معاملات شملت تركيزات مختلفة من SNP و AATC هى ٠,١ ، ١، ١٠ جزء في المليون بالإضافة إلى معاملة الكنترول للمقارنة. أظهرت النتائج تحسنًا معنوياً في طول وعرض الأوراق وكذلك محتوى الكلوروفيل، مع استجابات واضحة تعتمد على التركيز. سجلت معاملة SNP بتركيز ١٠ جزء في المليون أعلى طول للورقة، بزيادة قدرها ٣٧١% مقارنة بالكنترول. على الجانب الاخر، حققت المعاملتان SNP 0.1 جزء في المليون و AATC 0.1 جزء في المليون أعلى عرض للورقة على التوالي وأعلى محتوى للكلوروفيل. كما أظهرت معاملات AATCعلاقة عكسية بين التركيز وفعالية النمو والكلوروفيل، مما يشير إلى احتمال تثبيط مفرط لإنتاج الإيثيلين عند التراكيز العالية. هذا وتشير النتائج إلى أن المركبين يساهمان في تعزيز النمو الخضري بشكل سريع ومستدام، مما يعزز كفاءة عملية التمثيل الضوئي ونمو النبات. وتؤكد هذه النتائج أهمية الاستخدام لـ SNPو AATC في تعزيز النمو المبكر والإنتاجية طويلة الأمد في زراعة نخيل التمر.

الكلمات المفتاحية: نخيل التمر، التأقلم، التغذية، الأوكسين، منظم نمو النبات، خارج المعمل.