Growth and Physicochemical Responses of "Sakkoty" Date Palm to Soil and Foliar Application of Mineral Fertilizer Stimufol under Greenhouse Conditions

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Abstract

The acclimatization of micropropagated plants is a crucial stage to ensure their growth and adaptation under greenhouse and open field conditions. This study aimed to determine the fertilization requirements of nine-month-old "Sakkoty" date palm plantlets during the acclimatization stage. The effects of different application methods and concentrations of the mineral fertilizer Stimufol on vegetative and biochemical traits were evaluated after nine months of treatment. The fertilizer was applied either to the soil or as a foliar spray at concentrations of 0.5, 1.0, and 2.0 g/L, with additional combinations of soil and foliar application. Fertilization was conducted at two different intervals (every 2 or 4 days). The results revealed that the combined soil and foliar application of Stimufol at 2 g/L significantly increased total leaf number, pinnate leaf count, and overall plant vigor compared to other treatments. No significant differences in vegetative traits were observed between the two fertilization intervals. All fertilization treatments enhanced total and reducing sugar content, chlorophyll A and B, total amino acid content, and NPK percentage. However, extending the fertilization interval to four days reduced these biochemical parameters. Overall, soil fertilization alone or in combination with foliar application was more effective in promoting plant growth and nutrient accumulation than foliar application alone.

Keywords: Date palm, foliar application, soil application, NPK fertilization, Stimufol fertilizer

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Introduction

Date palm (*Phoenix dactylifera* L.), belonging to the family Palmaceae, is one of the most widely cultivated fruit crops in tropical and subtropical regions. Traditionally, date palm can be propagated through seeds or offshoots. However, seed propagation does not produce true-to-type plants due to high heterozygosity and requires approximately seven years before fruiting (Othmani *et al*., 2009). Moreover, traditional propagation methods often facilitate the transmission of diseases to newly cultivated areas. Therefore, tissue culture has emerged as an advanced and highly effective alternative for vegetative propagation, enabling the rapid production of a large number of desirable palm varieties in a relatively short time. Despite its

advantages, *in vitro*-grown date palm plantlets, like most micropropagated plants, require a specialized acclimatization and adaptation program to enhance survival and growth when transferred to open-field conditions (Hazarika, 2003; Kumar & Rao, 2012). Several techniques have been employed to improve the adaptation and growth of date palm plantlets under greenhouse conditions. The effectiveness of these techniques depends on factors such as environmental modifications (Hassan *et al*., 2014), fertilizer type, and fertilization rates (Abdi & Hedayat, 2010). Mineral nutrition (Abdel-Galeil *et al*., 2016; Hassan, 2017; Hassan *et al*., 2021), growth regulators such as gibberellins (Davies, 1995; Hassan, 2012) and cytokinins (Hall, 1973; Hassan, 2012, 2017), as well as optimized planting media and greenhouse conditions (Hassan *et al*., 2014), play a crucial role in plant growth and development during acclimatization. Other studies have examined the effects of transplanting methods and NP-fertilization rates on leaf length in female date palm offshoots (Isyaku *et al*., 2020). Additionally, foliar application of amino acids (Darwesh *et al*., 2014) and biological nutrition sources such as *Spirulina platensis* algae extract and biostimulants (Hasaballah *et al*., 2020) have shown positive effects on the growth of acclimatized date palm plants. Fertilizer application methods, whether soil and/or foliar application (Abdel-Galeil, 2010; Hassan, 2012), have also been studied as potential factors for improving date palm adaptation and productivity. The primary objectives of this research were to evaluate (1) the effect of chemical nutrition (Stimufol), a fertilizer containing NPK supplemented with copper, zinc, iron, manganese, and the amino acid lysine, at different application rates; (2) the impact of application method (soil and foliar application, either separately or in combination); and (3) the influence of application intervals on vegetative growth parameters and chemical composition of nine-month-old "Sakkoty" date palm plants grown under greenhouse conditions.

Materials and methods

A greenhouse experiment was conducted to evaluate the effect of different rates and application methods of mineral fertilizer (Stimufol) on the vegetative growth and chemical composition of acclimatized in vitro "Sakkoty" date palm plants (9 months old). The study was carried out over a period of nine months at the greenhouse of the Central Laboratory of Date Palm Research and Development, Agricultural Research Center, Giza, Egypt. Before the experiment began, all plants had 3-4 leaves and were uniform in growth parameters. The plants were cultivated in large bags filled with a peatmoss-perlite mixture (2:1 v/v). Stimufol, a nutritional fertilizer, was applied in two forms: soil injection and foliar application. It contains total nitrogen (24%), phosphorus (16%), potassium (12%), copper (0.08%), zinc (0.05%), iron (0.17%), manganese (0.08%), and the amino acid lysine (2%). Both soil and foliar applications were applied at intervals of every two and four days to assess the effect of fertilization frequency on "Sakkoty" plant growth and development. The control treatment in this study consisted of soil injection of Stimufol at a rate of 1 g/L every four days.

1. Fertilization treatments and application methods

The following table presents the different fertilization treatments applied during the experiment:

Table (1): Fertilization treatment and application methods of "Sakkoty" plants under greenhouse conditions

Treatment (g/L)	Application method
0.5	Soil injection
1.0	Soil injection
2.0	Soil injection
0.5	Foliar application
1.0	Foliar application
2.0	Foliar application
0.5, 0.5	Soil & foliar application
0.5, 1.0	Soil & foliar application
0.5, 2.0	Soil & foliar application
1.0, 0.5	Soil & foliar application
1.0, 1.0	Soil & foliar application
1.0, 2.0	Soil & foliar application
2.0, 0.5	Soil & foliar application
2.0, 1.0	Soil & foliar application
2.0, 2.0	Soil & foliar application

2. Data collection and calculations

At the end of the nine-month experimental period, data on the vegetative growth and chemical characteristics of "Sakkoty" date palm plants were collected. The parameters measured and calculation methods are as follows:

2.1 Vegetative measurements

2.1.1 Total leaf number

2.1.2 Leaf length (cm)

2.1.3 Plant growth vigor (assessed visually using a scoring system adapted from Pottino, 1981):

Growth Score	Description
1 (-)	Negative result
2 (+)	Below average
3 (++)	Average
4 (+++)	Good

2.2 Chemical analysis

Leaf chemical composition was analyzed as follows:

2.2.1 Chlorophyll a and b (µg/mL): measured according to Wellburn (1994).
2.2.2 Total sugar content (mg/100 g fresh weight): determined following Dubois *et al*. (1956).
2.2.3 Reducing sugar content (mg/100 g fresh weight): estimated using the method of Marsden *et al*. (1982).
2.2.4 N, P, and K content (% on dry weight basis): analyzed as described by Peach and Tracey (1968).
2.2.5 Total amino acid content (mg/g dry weight basis): determined using ninhydrin reagent following Rosen (1957).

3. Statistical Analysis

Each treatment included five replicates, with each replicate consisting of one plant. The collected data were analyzed using analysis of variance (ANOVA) in a randomized complete block design (RCBD) as described by Snedecor and Cochran (1980). The least significant difference (LSD) test at a 5% significance level (Steel & Torrie, 1980) was used to compare mean values among treatments.

Results and discussion

Data in Table (2) indicate the total number of leaves, leaf length (cm) and number of spines' leaves as affected by fertilizer treatment and fertilization period. It is clear that, increasing soil application and foliar application separately from 0.5, 1.0 to 2.0 g/L increased the vegetative growth expressed as total number of leaves, leaf length and number of spines' leaves as shown in (Fig.1 A, B). Whereas, combined treatments between soil applications at 2.0 g/L Stimufol + 0.5, 1.0 and 2.0 g/L Stimufol foliar application maximized significantly all parameters compared with other treatments without significant differences among them. This result is in harmony with the results of Hassan (2012) who studied the effect of soil and foliar application of Hoagland solution on date palm growth under greenhouse conditions and observed that, increasing plant soil nutrition application from 25 to 50% as well as the interaction between soil and foliar application had a significant effect on the vegetative parameters. Isyaku *et al.* (2020) also found that higher NP – fertilizer rate is necessary to enhance leaf length and produce greater leaves' dynamics of date palm offshoots. Moreover, Tagalsis *et al.* (2012) reported that application of nitrogen and phosphorus at higher levels increased leaf number and length as well as canopy cover in a mature date palm. Generally, data in Table 2 demonstrated that the soil application method and combined treatments are the most suitable to fertilize date palm plants than foliar application alone. This result is in agreement with the results of Hasaballah *et al*. (2020), who found that soil injection of different nutrient types was more effective than spray application in enhancing leaf number, shoot length and shoot thickness of date palm cv. Barhee. In regard to fertilizer period, no significant difference was observed in total numbers of leaves, leaf length and

number of spines' leaves of plants fertilized every 2 and 4 days. However, all studied parameters were increased with shortening the fertilizer period to 2 days. Interaction between the two application methods (foliar & soil) showed that, the highest mean values of total leave number, length of leaf and spines' leaves number were recorded with plants fertilized with 2.0 g/L Stimufol as soil application + 2.0 g/L Stimufol as foliar application every 2 days. However, the lowest significant values were noticed with plants fertilized every 4 days with 0.5 g/L Stimufol as foliar application.

Table (2): Effect of Stimufol application rates and fertilization period on the total number of leaves, leaf length (cm), and number of spines in Sakkoty date palm offshoots during the acclimatization stage

Treatment (A) (g/L)		Total number of leaves			Length of leaves (cm)			Spines' leaves number		
		Fertilization period (B)			Fertilization period (B)			Fertilization period (B)		
		2 days	4 days	Mean	2 days	4 days	Mean	2 days	4 days	Mean
1	**0.5**	5.33	5.00	5.17	44.00	38.33	41.16	1.00	0.67	0.84
2	**1.0**	7.67	6.33	7.00	45.66	39.33	42.50	1.67	1.00	1.38
3	**2.0**	8.33	7.67	8.00	47.66	41.66	44.66	2.33	1.33	1.83
4	**0.5**	4.67	3.33	4.00	34.00	31.66	32.83	0.33	0.00	0.17
5	**1.0**	5.33	4.33	4.83	37.00	33.66	35.33	0.67	0.33	0.50
6	**2.0**	6.67	5.00	5.84	39.66	35.66	37.66	1.00	0.67	0.84
7	**0.5+0.5**	6.00	5.33	5.67	44.00	38.66	41.16	1.33	1.00	1.17
8	**0.5+1.0**	6.33	5.67	6.00	46.00	39.33	42.66	1.67	1.33	1.50
9	**0.5+2.0**	7.00	6.33	6.67	47.00	40.00	43.50	2.00	1.67	1.84
10	**1.0+0.5**	7.67	6.67	7.17	46.00	41.00	43.50	1.67	1.33	1.50
11	**1.0+1.0**	8.67	7.00	7.84	47.00	42.00	44.50	2.00	1.67	1.84
12	**1.0+2.0**	9.00	7.67	8.34	48.66	43.00	45.83	2.33	2.00	2.17
13	**2.0+0.5**	8.67	8.00	8.34	48.00	42.66	45.33	2.67	1.67	2.17
14	**2.0+1.0**	9.00	8.33	8.67	49.00	45.00	47.00	3.00	2.00	2.50
15	**2.0+2.0**	9.67	9.00	9.34	51.00	46.66	48.83	3.33	2.33	2.83
Mean		**7.2**	**6.39**		**44.68**	**39.91**		**1.77**	**1.27**	
LSD at 0.05		A = 0.85			A = 6.41			A = 0.41		
		B = NS			B = NS			B = NS		
		AB = 3.39			AB = 9.23			B = 1.65		

NS: Not Significant

Data in Table 3 show the effect of Stimufol fertilizer application (both foliar and soil application) after 2 and 4 days on plant growth vigor. The data indicate that plant growth vigor values increased with 2.0 g/L soil application combined with 2.0, 1.0, and 0.5 g/L foliar application, with values of 3.66, 3.33, and 2.99, respectively. These values showed no significant differences among them when compared to the control and other treatments, as depicted in Figures 1 A, B, C, D, E, and F. In this regard, Hassan et al. (2021) found that using MS at full strength to fertilize date palm plants under greenhouse conditions had a stimulatory effect on plant length (cm), leaf number, growth vigor, and root system characteristics such as root number and thickness compared to ¾, ½, and ¼ strengths. El-Sharabasy and Zaid (2010) reported

that fertilizing date palm plants with N, P, K, and micro-nutrients during acclimatization and growth stages is crucial to obtaining vigorous and healthy plants. Regarding the effect of fertilization period, the data showed that Stimufol application was significantly more effective in stimulating growth vigor in plants fertilized every 2 days compared to those fertilized every 4 days (2.57 and 1.95, respectively). Additionally, data on the effect of combining application methods indicated that Sakkoty plants receiving 2.0 g/L Stimufol as soil application + 2.0 g/L Stimufol as foliar application every 2 days gave the highest significant mean value of growth vigor (4.0). On the other hand, using Stimufol at 0.5 g/L as foliar application after 2 and 4 days significantly reduced plant growth vigor compared to the control and other treatments.

Table (3): Effect of Stimufol application rates and fertilization period on the growth vigor of Sakkoty date palm offshoots during the acclimatization stage

Treatment (A) (g/L)		Growth vigor		
		Fertilization period (B)		
		2 days	4 days	Mean
1	**0.5**	1.33	1.00	1.16
2	**1.0**	2.33	1.66	1.99
3	**2.0**	3.33	2.33	2.83
4	**0.5**	1.00	1.00	1.00
5	**1.0**	1.33	1.00	1.16
6	**2.0**	2.00	1.66	1.83
7	**0.5+0.5**	2.00	1.33	1.66
8	**0.5+1.0**	3.50	1.66	2.58
9	**0.5+2.0**	2.66	2.00	2.33
10	**1.0+0.5**	2.66	2.00	2.33
11	**1.0+1.0**	3.00	2.33	2.66
12	**1.0+2.0**	3.33	2.66	2.99
13	**2.0+0.5**	3.33	2.66	2.99
14	**2.0+1.0**	3.66	3.00	3.33
15	**2.0+2.0**	4.00	3.33	3.66
Mean		**2.57**	**1.95**	
LSD at 0.05			A = 1.01 B = 0.53 AB = 1.41	

Moreover, the data on the chemical composition, including total sugar, reducing sugar, and non-reducing sugar of female date palm offshoots, revealed that plants fertilized every 2 days exhibited the highest total sugar content compared to those fertilized every 4 days, as shown in Table 4. Combined soil and foliar application of Stimufol at a rate of 2 g/L significantly enhanced the total sugar content, while the lowest significant values were observed in plants fertilized with foliar application at rates of 0, 0.5, 1.0, and 2.0 g/L, recording 3.78, 4.82, and 5.0 mg/100 g fresh weight, respectively. Data in Table 4 also revealed that the interaction between fertilizer treatment and fertilization period showed that plants receiving Stimufol as both soil and foliar applications at a rate of 2.0

g/L for both treatments, as well as those receiving 2.0 g/L soil application combined with 1 g/L foliar application every 2 days, recorded the highest total sugar contents (7.86 and 7.81 mg/100 g fresh weight, respectively). These results emphasize that a shorter fertilization period of 2 days was significantly more effective. Furthermore, the combination of 2.0 g/L Stimufol as soil application with foliar applications at 0.5, 1.0, and 2.0 g/L resulted in increased reducing sugar content (5.17, 5.31, and 5.46 mg/100 g fresh weight, respectively), with no significant differences among them. In contrast, fertilization with 2.0 g/L Stimufol without foliar application improved reducing sugar content, while using foliar application alone significantly reduced the reducing sugar level, especially when applied at 0.5 g/L, compared to the control treatment. These findings are consistent with those of Schroth *et al*. (2002), who reported that an increase in yield of peach palm was associated with higher fertilization rates. The highest mean values of reducing sugar content were recorded with 2.0 g/L Stimufol as soil application combined with 0.5, 1.0, and 2.0 g/L foliar application, when applied every 2 days. These treatments were followed by the application of 2.0 g/L Stimufol as soil application every 2 days, with significantly lower values of reducing sugar content. Regarding non-reducing sugar content, Table 4 shows that treatments including 2.0 g/L soil application combined with 2.0 g/L foliar application, as well as fertilization with 0.5, 1.0, and 2.0 g/L Stimufol as soil application, had a negative effect on non-reducing sugar levels, recording the lowest significant values compared to the control treatment. However, other treatments resulted in the highest values of non-reducing sugar content, with no significant differences. Data further revealed that non-reducing sugar levels were significantly higher with the 4-day fertilization period compared to the 2-day period. It was found that Sakkoty plants receiving 1.0 g/L Stimufol as soil application combined with 0.5 g/L foliar application had the highest non-reducing sugar content when fertilized every 4 days. Conversely, the 2-day fertilization period with 2.0 g/L Stimufol applied as both soil and foliar applications significantly reduced non-reducing sugar content to the lowest mean value. Furthermore, data in Table 5 showed the effect of fertilizer treatments and fertilization period on chlorophyll A and B contents in Sakkoty date palm leaves. Results revealed that the highest levels of chlorophyll A and B were obtained when Stimufol was applied at a rate of 2.0 g/L as both soil and foliar application. In contrast, the lowest chlorophyll contents were observed in plants fertilized with 0.5 g/L Stimufol as foliar application. Hassan (2012) reported that increasing the soil application of Hoagland solution from 25% to 100% and increasing foliar application from 0.0% to 100% significantly enhanced chlorophyll A and B contents in date palm leaves. Regarding the fertilization period, the results indicated that extending the fertilization period to 4 days resulted in a significant reduction in the photosynthetic pigments (chlorophyll A and B), with values of 0.65 and 0.75 µg/ml, respectively. Conversely, plants fertilized with combined soil and foliar application of 2.0 g/L Stimufol every 2 days exhibited improved chlorophyll A and B levels, with values of 1.28 and 1.25 µg/ml, respectively. Furthermore, when 0.5 g/L Stimufol was applied solely as foliar application every 4 days, the chlorophyll contents were significantly lower compared to the control treatment.

Table (4): Effect of Stimufol application rates and fertilization period on total sugars, reducing sugars, and non-reducing sugars in Sakkoty date palm leaves during the acclimatization stage

Treatment (A) (g/L)		Total Sugars (mg/100g FW)			Reducing Sugar (mg/100g FW)			Non-reducing sugars (mg/100g FW)		
		Fertilization period (B)			Fertilization period (B)			Fertilization period (B)		
		2 days	4 days	Mean	2 days	4 days	Mean	2 days	4 days	Mean
1	**0.5**	6.22	5.45	5.84	4.16	3.51	3.84	2.06	1.95	2.00
2	**1.0**	7.25	6.76	7.00	5.11	4.30	4.71	2.14	2.43	2.29
3	**2.0**	7.44	6.86	7.15	5.35	4.90	5.13	2.10	1.96	2.03
4	**0.5**	3.94	3.61	3.78	2.84	1.70	2.27	1.10	1.91	1.51
5	**1.0**	4.98	4.65	4.82	4.07	2.24	3.16	0.91	2.41	1.66
6	**2.0**	5.97	5.22	5.10	4.17	3.06	3.62	1.79	2.16	1.98
7	**0.5+0.5**	6.30	5.48	5.89	4.20	3.53	3.87	2.09	1.95	2.02
8	**0.5+1.0**	6.57	5.58	6.08	4.29	3.80	4.05	2.29	1.79	2.04
9	**0.5+2.0**	6.66	5.96	6.31	4.41	3.93	4.17	2.25	2.03	2.14
10	**1.0+0.5**	7.30	6.77	7.04	5.10	4.53	4.82	2.20	2.57	2.39
11	**1.0+1.0**	7.36	6.80	7.08	5.21	4.70	4.96	2.16	2.10	2.13
12	**1.0+2.0**	7.60	6.83	7.22	5.27	4.78	5.03	2.33	2.06	2.20
13	**2.0+0.5**	7.54	6.95	7.25	5.40	4.93	5.17	2.13	2.02	2.08
14	**2.0+1.0**	7.81	7.01	7.41	5.67	4.95	5.31	2.14	2.16	2.15
15	**2.0+2.0**	7.86	7.26	7.56	5.82	5.10	5.46	1.05	2.16	1.61
Mean		**6.71**	**6.11**		**4.72**	**4.09**		**1.93**	**2.11**	
LSD at 0.05		A = 0.051			A = 0.43			A = 0.39		
		B = 0.01			B = 0.15			B = 0.13		
		AB = 0.072			AB = 0.61			AB = 0.55		

Table (5): Effect of Stimufol application rates and fertilization period on chlorophyll A and B contents in Sakkoty date palm leaves during the acclimatization stage

Treatment (A) (g/L)		Chlorophyll A (µg/ ml)			Chlorophyll A (µg/ ml)		
		Fertilization period (B)			Fertilization period (B)		
		2 days	4 days	Mean	2 days	4 days	Mean
1	**0.5**	0.49	0.46	0.48	0.74	0.67	0.71
2	**1.0**	0.79	0.65	0.72	0.89	0.81	0.85
3	**2.0**	0.95	0.89	0.92	1.04	0.92	0.98
4	**0.5**	0.29	0.26	0.28	0.42	0.38	0.40
5	**1.0**	0.41	0.38	0.40	0.49	0.43	0.46
6	**2.0**	0.47	0.42	0.45	0.51	0.49	0.50
7	**0.5+0.5**	0.53	0.45	0.49	0.74	0.66	0.70
8	**0.5+1.0**	0.59	0.49	0.54	0.76	0.69	0.73
9	**0.5+2.0**	0.65	0.50	0.58	0.79	0.72	0.76
10	**1.0+0.5**	0.75	0.74	0.73	0.90	0.84	0.87
11	**1.0+1.0**	0.84	0.75	0.80	0.93	0.87	0.90
12	**1.0+2.0**	0.88	0.78	0.83	0.95	0.89	0.92
13	**2.0+0.5**	1.03	0.91	0.97	1.05	0.93	0.99
14	**2.0+1.0**	1.17	0.93	1.05	1.18	0.95	1.07
15	**2.0+2.0**	1.28	1.03	1.16	1.25	0.98	1.12
Mean		0.74	0.65		0.83	0.75	
LSD at 0.05		A = 0.072			A = 0.036		
		B = 0.025			B = 0.012		
		AB = 0.10			AB = 0.051		

Data presented in Table 6 indicated that the percentages of Nitrogen (N), Phosphorus (P), and Potassium (K) were influenced by both fertilizer treatments and the fertilization period. Observations in this study revealed that increases in N, P, and K percentages were associated with fertilizer treatments consisting of 2.0 g/L Stimufol applied as a soil treatment combined with foliar applications of 0.5, 1.0, and 2.0 g/L. However, plants receiving 0.5 g/L Stimufol applied as a foliar treatment alone recorded the lowest percentages of N, P, and K (1.99%, 0.11%, and 0.87%, respectively). Extending the fertilization period to 4 days, regardless of the treatment applied, resulted in decreased percentages of N, P, and K (3.79%, 0.21%, and 1.54%, respectively). In contrast, fertilization every 2 days resulted in the highest percentages of these elements. The highest concentrations of N, P, and K were observed in plants fertilized with the treatment consisting of 2.0 g/L Stimufol as soil application combined with 0.5, 1.0, and 2.0 g/L foliar application every 2 days. In particular, foliar application of Stimufol alone at 0.5 g/L every 4 days led to lower percentages of N, P, and K. These findings are consistent with those of Abdel-Galeil (2010), who reported that the application of NPK liquid fertilizer (10:10:10 + microelements) at 2.0 ml/l as a foliar spray and 20 ml/l as a soil drench significantly enhanced vegetative growth as well as the content of Chlorophyll A and B, carotenoids, and N, P, and K in the leaves.

Table (6): Effect of Stimufol concentrations and fertilization period on total NPK content in Sakkoty date palm leaves during the acclimatization stage

Treatment (A) (g/L)		N %			P %			K %		
		Fertilization period (B)			Fertilization period (B)			Fertilization period (B)		
		2 days	4 days	Mean	2 days	4 days	Mean	2 days	4 days	Mean
1	**0.5**	3.52	3.10	3.31	0.18	0.15	0.17	1.50	1.36	1.43
2	**1.0**	4.48	3.55	4.02	0.26	0.23	0.25	1.82	1.75	1.79
3	**2.0**	4.84	4.69	4.77	0.29	0.26	0.28	2.17	1.85	2.01
4	**0.5**	2.13	1.85	1.99	0.12	0.10	0.11	0.99	0.75	0.87
5	**1.0**	3.22	2.85	3.04	0.15	0.12	0.14	1.16	0.93	1.05
6	**2.0**	3.54	3.15	3.35	0.17	0.15	0.16	1.39	1.06	1.23
7	**0.5+0.5**	3.57	3.19	3.38	0.19	0.16	0.18	1.54	1.36	1.45
8	**0.5+1.0**	3.70	3.32	3.51	0.20	0.17	0.19	1.60	1.39	1.50
9	**0.5+2.0**	4.09	3.49	3.79	0.22	0.18	0.20	1.72	1.45	1.59
10	**1.0+0.5**	4.57	4.17	4.37	0.26	0.23	0.25	1.82	1.76	1.79
11	**1.0+1.0**	4.74	4.41	4.58	0.28	0.25	0.27	1.85	1.77	1.81
12	**1.0+2.0**	4.80	4.75	4.78	0.29	0.26	0.28	1.89	1.79	1.84
13	**2.0+0.5**	4.95	4.78	4.87	0.30	0.27	0.29	2.17	1.86	2.02
14	**2.0+1.0**	5.12	4.81	4.97	0.31	0.28	0.30	2.19	1.90	2.05
15	**2.0+2.0**	5.21	4.92	5.07	0.33	0.30	0.32	2.20	1.95	2.08
Mean		4.13	3.79		0.23	0.21		1.74	1.54	

Data presented in Table 7 revealed significant variation in amino acid content among the different Stimufol treatments and fertilization periods. The highest increase in amino acid content was observed with the combined treatment of 2.0 g/L Stimufol applied both as soil and foliar application. However, foliar application alone at different concentrations (0.5, 1.0, and 2.0 g/L) significantly reduced amino acid content compared to the control treatment. Fertilizer treatments applied every 2 days significantly enhanced

amino acid content compared to those applied every 4 days. The combined application of Stimufol, with 2.0 g/L as soil application + 2.0 g/L as foliar application every 2 days, resulted in the highest amino acid content. In contrast, foliar applications at different concentrations applied every 4 days decreased amino acid levels when compared to the control and other treatments under investigation.

Table (7): Effect of Stimufol concentrations and fertilization period on amino acid content in Sakkoty date palm leaves during the acclimatization stage

Treatment (A) (g/L)		Amino acid content (mg/g DW)		
		Fertilization period (B)		
		2 days	4 days	Mean
1	**0.5**	2.48	2.23	2.36
2	**1.0**	3.85	3.50	3.68
3	**2.0**	4.50	4.20	4.35
4	**0.5**	1.61	1.33	1.46
5	**1.0**	1.74	1.40	1.57
6	**2.0**	2.20	1.90	2.05
7	**0.5+0.5**	2.96	2.43	2.70
8	**0.5+1.0**	3.33	2.73	3.03
9	**0.5+2.0**	3.44	2.90	3.17
10	**1.0+0.5**	4.00	3.70	3.85
11	**1.0+1.0**	4.27	3.97	4.12
12	**1.0+2.0**	4.57	4.27	4.42
13	**2.0+0.5**	4.67	4.40	4.54
14	**2.0+1.0**	4.97	4.70	4.82
15	**2.0+2.0**	5.13	4.90	5.02
Mean		3.55	3.23	
LSD at 0.05		A = 0.318		
		B = 0.112		
		AB = 0.449		

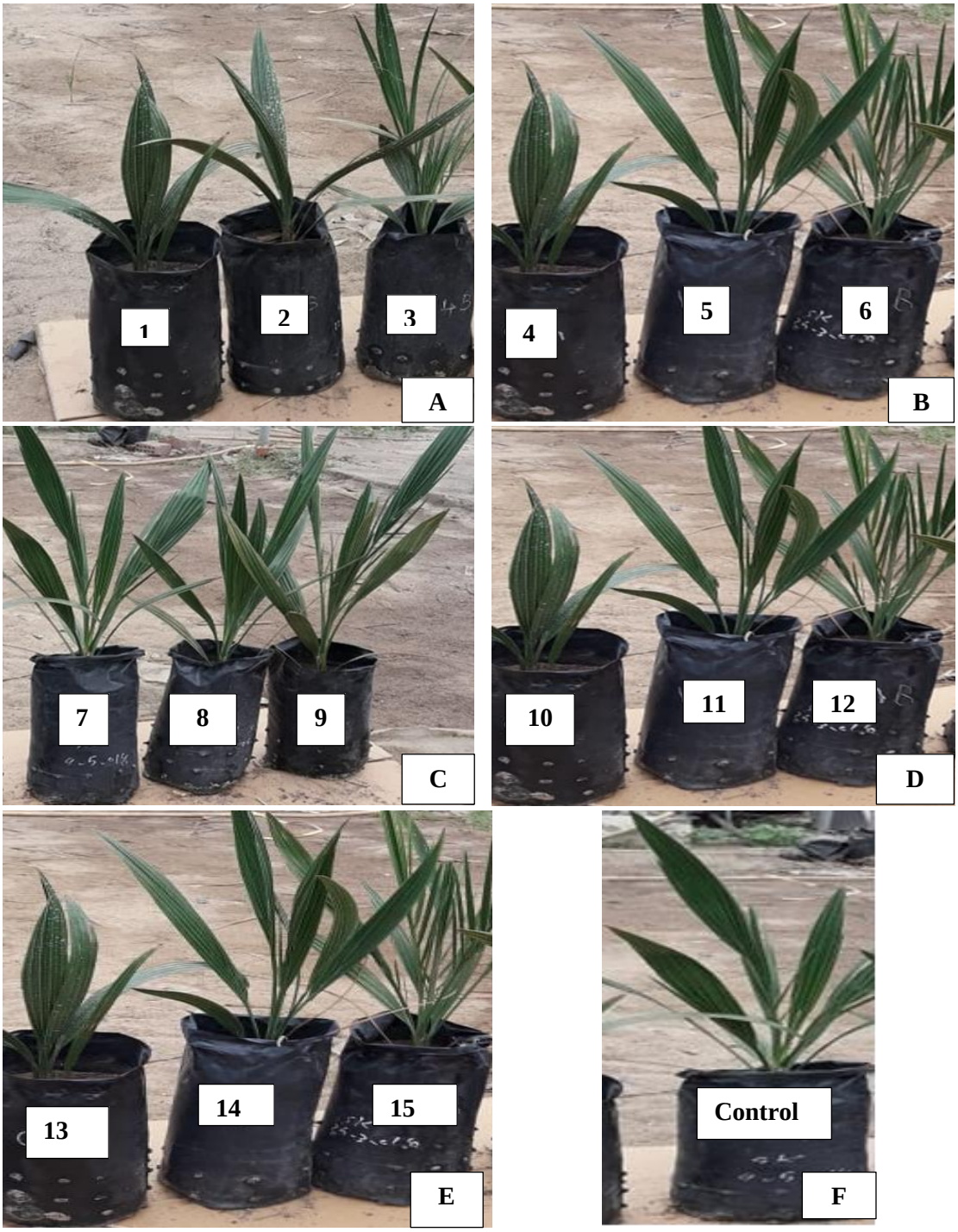

Fig.1. Effect of soil and foliar application of Stimufol (applied every 2 days) on growth and development of Sakkoty date palm.(A) Soil application of Stimufol at 0.5, 1.0, and 2.0 g/L, respectively; (B) Foliar application of Stimufol at 0.5, 1.0, and 2.0 g/L, respectively; (C) Soil application of Stimufol at 0.5 g/L + foliar application at 0.5, 1.0, and 2.0 g/L, respectively; (D) Soil application of Stimufol at 1.0 g/L + foliar application at 0.5, 1.0, and 2.0 g/L, respectively; (E) Soil application of Stimufol at 2.0 g/L + foliar application at 0.5, 1.0, and 2.0 g/L, respectively; (F) Control treatment: 1.0 g/L Stimufol soil application every 4 days.

Conclusions

This study demonstrated that the combined application of 2.0 g/L Stimufol as both soil and foliar treatments every 2 days significantly improved the growth, nutrient content, and biochemical composition of Sakkoty date palm offshoots. Plants treated with this combination showed higher growth vigor, leaf length, and number of leaves. Additionally, total sugars, chlorophyll A and B, nitrogen (N), phosphorus (P), potassium (K), and amino acid content were enhanced with this treatment, while extending the fertilization period to 4 days decreased these parameters. Foliar application alone, especially at lower concentrations, resulted in lower nutrient and biochemical values. The findings indicate that frequent fertilization (every 2 days) with combined soil and foliar applications of Stimufol optimizes the growth and quality of date palm plants, providing valuable insights for improved cultivation practices.

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النمو والاستجابات الفيزيائية والكيميائية لنخيل التمر "سكوتي" للتسميد الأرضي والرش الورقي باستخدام السماد المعدني ستيموفول تحت ظروف البيوت المحمية

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الملخص العربي

تعد أقلمة النباتات الناتجة من الإكثار المعملي مرحلة أساسية لضمان نموها وتكيفها تحت ظروف البيوت المحمية (الصوبة) والحقل المفتوح. هدفت هذه الدراسة إلى تحديد الاحتياجات السمادية لنباتات النخيل صنف السكوتي بعمر تسعة أشهر خلال مرحلة الأقلمة. تم تقييم تأثير استخدام السماد المعدني "ستيموفول" بمعدلات مختلفة على بعض الصفات الخضرية والكيميائية بعد تسعة أشهر من المعاملة. تم تطبيق السماد عن طريق التربة والرش الورقي بتركيزات ٠,٥، ١,٠، و٢,٠ جم/لتر، بالإضافة إلى التوليفات المختلفة بين التسميد الأرضي والرش الورقي. كما تم تنفيذ التسميد على فترتين (كل يومين و كل أربعة أيام. أظهرت النتائج أن التسميد الأرضي مع الرش الورقي بمعدل ٢ جم/لتر "ستيموفول" أدى إلى زيادة معنوية في عدد الأوراق الكلية، وعدد الأوراق الريشية، وقوة نمو النباتات مقارنة ببقية المعاملات. ولم تُلاحظ فروق معنوية بين فترتي التسميد (كل يومين مقابل كل أربعة أيام) من حيث الصفات الخضرية. كما أدت جميع معاملات التسميد المختلفة إلى زيادة في محتوى السكريات الكلية والمختزلة، والكلوروفيل أ و ب، والأحماض الأمينية الكلية، ونسبة NPK في الأوراق. إلا أن زيادة الفترة بين مواعيد التسميد إلى أربعة أيام خفضت من هذه القيم الكيميائية. بشكل عام، كان التسميد الأرضي منفردًا أو عند دمجه مع الرش الورقي أكثر كفاءة في تحسين نمو النباتات مقارنةً بالرش الورقي وحده.

الكلمات الدالة: نخيل التمر، التسميد الورقي، التسميد الأرضي، التسميد بالنيتروجين والفوسفور والبوتاسيوم(NPK)، سماد ستيموفول