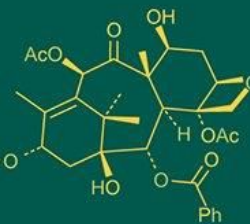


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Study of the effect of spraying high-potassium nitrogen-phosphorus-potassium (12-6-4+TC) fertilizer during the wet stage on the chemical properties of ten date palm varieties (*Phoenix dactylifera* L.) at the date palm station in Al-Mahawil, South of the city of Hillah

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Abstract

This study was conducted at the Date Palm Station in Al-Mahawil, Babil Governorate, during the 2024 growing season, with the aim of evaluating the effect of spraying high-potassium N-P-K+TC fertilizer (12-6-4+TC) during the wet phase on the chemical properties of ten date palm cultivars. Data were analyzed using Analysis of Variance (ANOVA), and the results are as follows:

- **Row Variation:** The results showed no significant variation between the rows (P-value = 0.063), indicating that there were no substantial differences in the chemical properties between the rows.
- **Column Variation:** A significant variation was observed between the columns (P-value < 0.05), indicating that different variables such as sugars, moisture, and dry matter significantly affect the chemical properties of the dates.
- **Error Variation:** The "SS" value for error variation was 2666.51, representing the unexplained variation due to other unstudied factors.

Key Results

- **Reducing Sugars:** 62.30%, reflecting the biochemical ripening stage of the dates.
- **Total Sugars:** 68.49%, indicating the significant contribution of total sugars to the nutritional value of the dates.
- **Moisture Content:** 29.51%, which is a key factor influencing shelf life and storage.
- **Dry Matter:** 71.14%, representing the non-water components in the dates.
- **Soluble Solids:** 60.97%, which contribute to the taste and nutritional value of the dates.

Conclusions: The results highlight the crucial role of both total and reducing sugars in determining the nutritional value of dates. Although no significant variation was found between the rows, the notable variation between columns emphasizes the impact of factors such as sugars, moisture content, and dry matter on the quality of dates. Therefore, improving these variables can enhance the nutritional quality of dates.

Keywords: Date palm, *Phoenix dactylifera*, high-potassium fertilizer, chemical properties

Introduction

The date palm (*Phoenix dactylifera* L.) is of significant economic importance in the Arab and Islamic worlds, playing a vital role in the national income of many date-producing countries. Despite this, Iraq, one of the leading date producers globally, faces a notable decline in date palm productivity. This decline is attributed to unfavorable environmental conditions, suboptimal use of available agricultural resources, limited application of modern agricultural techniques, inadequate agricultural services, and a lack of appropriate fertilization programs. These factors contribute to nutrient depletion in the soil, which remains unaddressed unless compensated for by fertilization.

Date palms require substantial amounts of various nutrients to ensure optimal growth and productivity. For instance, an annual intake of between 1.5 to 5 kg of nitrogen, 0.5 kg of phosphorus, and 2 to 3 kg of potassium is necessary for the proper growth of date palms (AL-Rawi, 1980) [5].

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The application of fertilization programs aims to improve the availability of essential nutrients to date palms, promoting optimal growth and enhancing yield. Nitrogen, phosphorus, and potassium are considered macronutrients that are crucial for the palm's development, with these nutrients typically supplied through fertilization.

Nitrogen plays a key role in regulating plant growth. It enhances the production of plant hormones such as auxins and cytokinins, which stimulate cell division in both the vegetative and root growth areas (Hussein Fathi *et al.*, 1977) [2]. Nitrogen also contributes to the growth of the vegetative parts of the palm and increases flower production. Improved root productivity, in turn, enhances the plant's ability to absorb water and essential nutrients. This contributes to the palm's resistance to harsh environmental conditions, such as water scarcity, and prolongs the plant's lifespan, delaying the onset of aging. Nitrogen directly influences plant growth by regulating the activity of plant hormones like auxins and cytokinins, leading to increased meristematic cell division, stimulation of vegetative growth, flower production, enhanced nutrient uptake, and improved resistance to environmental stressors (Al-Jabri *et al.*, 2009) [1]. Phosphorus, another essential nutrient, is required by plants in large quantities. It is a key component in the formation of important organic compounds such as DNA and proteins, as well as energy-producing compounds like ATP. Phosphorus enhances root growth and supports physiological processes vital for overall plant growth. It also plays a crucial role in strengthening the plant's resistance to diseases and pests. Potassium, on the other hand, is a vital nutrient involved in numerous physiological processes within plants. It helps regulate the water balance within plant cells, contributing to drought resistance. Potassium also plays a critical role in the opening and closing of stomata, a vital process affecting gas and water exchange within the plant. Furthermore, potassium activates various enzymes that enhance plant productivity and fruit quality. It is thus a significant indicator of fruit quality in many crops (Al-Akeidi, Hassan Khalid, 2020) [10]. Potassium is also essential for processes such as nitrogen transportation during photosynthesis, osmotic balance regulation in cells, and drought resistance, as well as enzyme activation, all of which contribute to improving fruit quality (Ibrahim & Khalifa, 2013) [15].

Materials and Methods

This study was conducted at the Date Palm Station in Al-Mahawil, Babil Governorate, during the growing season of 2024. The aim of the study was to investigate the effect of spraying the high-potassium N-P-K+TC (12-6-4+TC) fertilizer on the chemical properties of ten date palm cultivars during the wet stage. The results were analyzed in the laboratories of Al-Qasim Green University / College of Agriculture / Department of Horticulture.

Dry Matter Content (%)

The dry matter content was calculated for the same samples used to determine moisture content, according to the formula provided by (Sharaki, Mahmoud, *et al.* (1985):

$$\text{Dry Matter Content (\%)} = \frac{\text{Dry weight of the sample}}{\text{Fresh weight of the sample}} \times 100$$

A total of 40 date palm trees were selected, with four trees per cultivar. Two trees from each cultivar were treated by spraying their fruits during the wet stage using the high-potassium N-P-K+TC (12-6-4+TC) fertilizer. The cultivars studied included: Barhi, Khastawi, Mir Hajj, Saba' Azra'a (Seven Arms), Maktoum, Umm Dahan, Sultani, Ibrahimi, Shawafi, and Jamaluddin. The selected trees were homogeneous in terms of height, vegetative growth, and age. The trees were hand-pollinated using three male date palm inflorescences of the Ghnami green variety during the usual pollination period from March 21 to March 25. Six inflorescences were left on each tree to ensure uniformity of the experimental units. Necessary agricultural practices were implemented to ensure optimal tree growth. (Hopkins and Hanter, 2004) [13]

The following procedures were followed in the study

Pollination and Pollen Collection: Pollen was collected from male Ghnami date palms at the end of February. The mature pollen was collected in paper bags to prevent its spread.

Pollination Process: In March, the female inflorescence was pollinated after the flowers had opened. A slight difference in the timing of flower opening was observed among the trees, and the pollinated flowers were enclosed in paper bags to prevent random pollination and ensure good fruit set.

Manual Pollination: In April, unflowered inflorescences were manually pollinated.

Fruit Thinning: In May, fruit thinning was carried out to ensure healthy fruit development.

Ripening: In July and August, the fruits reached the wet stage.

Fertilization: In June, the fruits were sprayed with N-P-K+TE high-potassium fertilizer at a rate of 200 grams per 400 liters of water, applied at a rate of 20 liters per tree in three weekly doses. Random samples were collected from each tree to ensure proper representation in the stages of khalal, wet, and ripening. The samples were carefully cleaned to remove any foreign materials, placed in polyethylene bags with labels, and stored in the refrigerator until analysis (SALEM and Hegai 1971) [16]

Chemical Indicators

Moisture Content (%)

The moisture content in the wet stage was determined by taking 20 fruits for each treatment, removing the seeds, and measuring the fresh weight of the fruits. The samples were then dried in an electric oven at 70 °C until their weight became constant. The moisture content was calculated using the following formula (Al-Hamadi *et al.*, 1998):

$$\text{Moisture Content\%} = \frac{\text{Fresh weight of the sample} - \text{Dry weight of the sample}}{\text{Fresh weight of the sample}} \times 100$$

Total Soluble Solids (T.S.S.) (%)

The total soluble solids content was measured by taking 5 grams of the fruit pulp, adding 15 mL of distilled water, and grinding the mixture using a mortar (Ibrahima and Abow-Amer, 2013) [15]. The mixture was then filtered, and a few drops from the filtrate were placed in a hand refractometer to measure the total soluble solids.

Reducing Sugars (%)

The reducing sugars in the fruit pulp were measured based on the dry weight using the method described by Lin and Inon (Howritz, 1975) ^[14]. A 0.5-gram sample of dried fruit pulp from each replication was mixed with 50 mL of distilled water and shaken for 5 minutes. The mixture was then heated at 70 °C for 45 minutes in a water bath. After

filtering, lead acetate was added to the filtrate, followed by centrifugation. Potassium oxalate was then added to remove any remaining precipitate, and the volume was adjusted to 100 mL with distilled water. The reducing sugar content was calculated using the following formula): AL-Dulaimi .2006) ^[4]

$$\text{Reducing Sugars (\%)} = \frac{\text{mg of sugar (from the table, equivalent to the burette reading)} \times \text{dilutions} \times 100}{\text{Weight or volume of the sample} \times 1000}$$

2-5. Total Sugars (%)

The total sugars were calculated in a similar manner to reducing sugars, but 50 mL of the filtered solution was treated with hydrochloric acid (HCl) and phenolphthalein. The acidity was adjusted using sodium hydroxide (NaOH),

followed by the addition of acetic acid until the pink color disappeared. Total sugars were calculated as the sum of reducing sugars and sucrose, with sucrose being determined as the difference between total sugars and reducing sugars (Howritz, 1975) ^[14].

Table 1: Measurement of Sugars (Total, Reducing, Sucrose)

Cultivar	Sucrose Concentration % T ₁	Sucrose Concentration % T ₂	Reducing Sugars % T ₁	Reducing Sugars % T ₂	Total Sugars % T ₁	Total Sugars % T ₂
Barhi	10.02	11.4	69.35	62.4	79.9	74.4
Sultani	9.12	6.74	65.4	62.9	75	70
Maktoum	2.66	6.08	59.1	54.2	66.91	60.6
Seven Arms	7.6	7.98	57.0	54.3	65	62.7
Ibrahimi	5.84	6.22	64.3	59.7	70.5	66.9
Umm al-Dahan	3.32	4.7	63.5	56.9	67	61.9
Jamal al-Din	3.24	3.4	63.4	57.0	66.87	60.6
Khastawi	2.85	8.4	80.0	63.3	81	75
Hallawi	3.04	4.18	60.6	55.1	63.8	59.5
Shoufi	3.61	3.7	71.2	63.3	75	67.2

Table 2: Measurement of Moisture Content, Dry Matter, and Total Soluble Solids

Cultivar Name	Moisture Content (%) T ₁	Moisture Content (%) T ₂	Dry Matter (%) T ₁	Dry Matter (%) T ₂	Total Soluble Solids (%) T ₁	Total Soluble Solids (%) T ₂
Barhi Date	24	25.5	69.9	74.5	67	66
Sultan Date	33.6	34.3	64.4	64.6	56	54.5
Maktoum Date	27	29.2	70	70.9	60	58.6
Seven Arms Date	35.1	37.5	61.8	62.4	59.8	56.9
Ibrahim Date	22	24.4	78	61.8	57	55.8
Umm Dahn Date	36.0	37.3	62.9	78.3	60.3	58.8
Jamal Al-Din Date	30.5	32	66.5	80	59.8	57.9
Khustawi Date	29.8	31	66.2	75	78	77.8
Halawi Date	20.9	23	79.1	80	60.3	59.8
Shoufi Date	27	30	77	79	59	56

Discussion of Results

Summary Table

Variety	Count	Sum	Average	Variance
Barhi	6	320.17	53.36	832.01
	6	314.2	52.37	732.39
Sultani	6	303.52	50.59	608.72
	6	293.04	48.84	581.93
Maktoum	6	285.67	47.61	720.92
	6	279.58	46.60	586.58
Seven Arms	6	286.30	47.72	499.55
	6	281.78	46.96	449.55
Ibrahimi	6	297.64	49.61	838.18
	6	274.82	45.80	603.79
Umm Dahan	6	293.02	48.84	622.13
	6	297.90	49.65	656.04
Jamal El-Din	6	290.31	48.39	676.71
	6	291.40	48.57	727.45
Khestawi	6	337.85	56.31	1059.97
	6	333.50	55.58	838.61
Halawi	6	287.74	47.96	856.54
	6	281.58	46.93	776.84
Shoufi	6	312.81	52.14	907.62
	6	299.20	49.87	778.66

Concentration Summary

Parameter	Count	Sum	Average	Variance
Sucrose Concentration (%)	20	114.1	5.71	7.03
Reducing Sugars (%)	20	1245.95	62.30	40.13
Total Sugars (%)	20	1369.78	68.49	41.21
Moisture Content (%)	20	590.1	29.51	26.60
Dry Matter (%)	20	1422.8	71.14	47.68
Total Soluble Solids (%)	20	1219.3	60.97	42.89

ANOVA Table

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	968.17	19	50.96	1.65	0.0601	1.69707
Columns	68833.88	5	13766.78	445.28	2.82E-64	2.31023
Error	2937.16	95	30.92			
Total	72739.20					

Revised Discussion and Analysis of Results

The results of this study were analyzed using ANOVA (Analysis of Variance), which was employed to evaluate the influence of various date palm varieties and associated factors on key quality parameters such as sugars, moisture content, dry matter, and other properties. The objective was

to determine whether there were statistically significant differences in the physical and chemical characteristics of dates based on the fertilizers applied to different varieties.

Key Findings from the ANOVA Analysis

Effect of Varieties on Date Properties

The primary focus of the study was to examine the impact of different date palm varieties on key characteristics such as sugar content, moisture, and dry matter. The analysis of variance for rows (representing the date varieties) indicated that the differences between varieties were not statistically significant at the 0.05 significance level (p -value = 0.0601), as the p -value was slightly above the critical threshold (0.05). This implies that while some variation in the properties between varieties exists, it is not substantial enough to be attributed to the fertilizer treatment alone.

Interpretation

This result suggests that the differences observed between the varieties in terms of sugar and moisture content are not primarily due to the fertilizer used. While the varieties display some variation, it appears that factors other than fertilizer play a more significant role in determining the date quality. Therefore, fertilizers may not be the most influential factor in altering the studied properties of the date fruits.

Effect of Fertilizer and Other Variables (Sugars, Moisture, Dry Matter): In contrast to the variety effect, the ANOVA revealed that the columns (representing various properties such as sugar content and moisture) exhibited a highly significant effect (p -value = $2.82\text{E-}64$), far below the 0.05 significance level. This indicates that factors like total sugars, reducing sugars, moisture content, and dry matter are much more important in determining the variability in date quality.

Interpretation

This finding highlights the critical importance of these variables—especially sugars (both total and reducing sugars) and moisture content—in determining the quality and characteristics of date fruits. The fertilizer, while potentially influential in other aspects, does not significantly impact these key quality traits on its own.

Error Variance

The error variance, or unexplained variability, represents the portion of the variation in the data that could not be explained by the varieties or the factors included in the model. The error variance in this case was relatively small in comparison to the variation explained by the key factors such as sugar content and moisture. This suggests that the model was able to explain most of the variability observed in the data.

Interpretation

Although some variance remains unexplained, it is likely attributable to other external factors such as environmental conditions, soil types, and irrigation methods, which were not incorporated into this study. These factors might have influenced the properties of the dates but were outside the scope of the current analysis.

Main Conclusions

Fertilizer Effect on Date Varieties: The fertilizer did not show a statistically significant impact on the variation in

date characteristics between the different varieties. Fertilizer application alone does not appear to be a primary determinant of quality in the varieties studied.

Importance of Sugars and Moisture: The concentration of sugars and moisture content were found to be the key factors explaining the variation in date quality. These variables had a much stronger influence on the differences between varieties than the fertilizer treatment. **Variation in Data:** Most of the variation in date quality could be explained by sugars and moisture. However, unexplained variance suggests the influence of other factors, such as soil composition, climate conditions, or specific agricultural practices that were not measured in this study.

Recommendations for Future Research

Optimization of Agricultural Practices: While fertilizers did not exhibit a major effect in this study, improving overall agricultural practices, such as irrigation techniques and soil management, may help optimize factors that significantly affect date quality, such as sugar content and moisture levels.

Further Investigation of Environmental Factors: Future research should focus on the role of environmental conditions, including soil type, climate, and irrigation practices, in influencing the key factors that determine date quality. This would provide a more comprehensive understanding of the variables affecting date production.

Conclusion

This study highlights that fertilizer application alone does not sufficiently explain the variation in the characteristics of the date palm varieties tested. The most important factors influencing date quality appear to be sugars and moisture content, suggesting that agricultural improvements should focus on optimizing these parameters. Further studies should investigate additional environmental factors and their interactions with these key quality indicators.

In summary, although fertilizers play a role in agricultural practices, their direct effect on the critical attributes of date fruit in this study was minimal. Instead, attention should be given to other variables such as sugar and moisture levels to improve the quality of dates across varieties.

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