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EFFECT OF NPK FERTILIZATION AND LEAF/BUNCH RATIO ON FRUIT YIELD AND QUALITY OF KHASTAWI DATE PALM

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SUMMARY

This study conducted in 2020–2021 sought to determine the impact of NPK fertilizer with three levels (F_0: 0, F_1: 900 g, F_2: 1300 g) and three levels of pruning at the ratio of P_1: 5, P_2: 7, and P_3: 9 leaves/bunch, to improve the fruit and quality of the date palm (*Phoenix dactylifera* L.) cv. "Khastawi," held at the Al-Zahfaraniah Palm Station, Baghdad Governorate, Iraq. Executing the study as a factorial experiment (3 × 3) within a randomized complete block design (RCBD) had three replications. Every two date palms as an experimental unit setup came from 54 trees aged 16 years and, as much as possible, homogeneous in growth characteristics. The experimental results showed that NPK fertilization at the F_2 level was superior in all studied traits, including fruit set, weight, width, length, volume, seed and bunch weights, and total yield. The pruning treatment (P3) was significantly superior by giving the highest fruit set, width, and length values, whereas F_0 and P_2 treatments gave the lowest average for these traits. Furthermore, the interaction of F_2P_3 provided the highest rates in fruit weight, length, volume, seed, and bunch weights, and total yield, while the F_0P_1 treatment gave the lowest values.

Key words: Date palm (*Phoenix dactylifera* L.), NPK fertilization, pruning, fruit trait, fruit yield, fruit quality

Key findings: The studied traits increased significantly, especially the qualitative fruit traits and the yield of the date palm Khastawi cultivar, especially when adding the NPK fertilizer at a concentration of 1300 g and keeping nine leaves for each bunch.

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INTRODUCTION

The date palm (*Phoenix dactylifera* L.) belongs to the palm family Arecaceae, one of the most valued evergreen and oldest fruit trees known in Mesopotamia. Its cultivation spreads in the tropics between latitudes (10° and 30°) north of the equator and extends to latitude 20° south (Al-Bakr, 1972). Palm trees are distinct for their economic importance, as they comprise an integrated food system because they contain numerous mineral elements, proteins, vitamins, fiber, and many substances for easy digestion and absorption (Al-Jubouri, 2002; Kshash and Aubied, 2016).

The number of date palm trees in the world estimates at 105 million, 62.5 million of which locates in the Arab world (FAOSTAT, 2021). Iraq produces 735,000 tons of dates annually, placing it sixth in the world. The number of palm trees totals 17,348,741 palms, each yielding an average of 68.2 kg palm^{-1} (CSO, 2021). Khastawi is a traditional cultivar, and its production has a good market globally, thus could bring considerable income to the native farmers. Furthermore, compared with other varieties, Khastawi palm groves of mentioned regions have traditional management (Al-Jubouri, 2002).

Fertilization treatment plays a very indispensable role in improving the quantity and quality of date palm fruits because of nutrients' chief function in enhancing the growth of trees since providing essential nutrients leads to completing the formation of fruits and their good growth (Al-Rawi, 1998). Al-Hamadani *et al*. (2015) indicated that adding fertilizer combinations (300 g Urea + 150 g Phosphate Diammonium + 200 g Potassium Sulfate) achieved the best significant results in the growth of three date palm cultivars. Al Katila (2021) refers to a noteworthy effect of chemical fertilizer on the Khastawi cultivar at 10 years that increased fruit set, weight, size, length, and total yield. Khan *et al*. (2022) investigated the possible role of potassium and urea in reducing fruit drop and improving the fruit quality of "Dhakki" date palms. They discovered that a bunch sprayed with potassium significantly affected all the traits, such as decreased fruit drop, enhanced fruit quality, and other improved physicochemical characteristics.

One of the most pertinent practices influencing fruit quality and bunches size is the leaf/bunch ratio (Hussein and Abdalla, 1973). Old leaves on palms do not provide palm trees with the same nutritional efficiency (Khalifa *et al*., 1987). Therefore, leaving a sufficient number of fully expanded green leaves per bunch by removing some old leaves on palm trees is a crucial practice. Al-Salman *et al*. (2012) found that 12 leaves/bunch was sufficient to obtain a suitable yield for the "Khlass" date palm cultivar. Ibrahim and Mohamed (2021) studied the influence of the leaf/bunch ratio in the date palm cv. "Zaghloul" found that 10 leaves per bunch resulted best for yield and fruit qualities. This study aimed to determine the optimal levels of NPK fertilizer, pruning ratios, and their interactions to increase harvest and achieve desired fruit quality in the date palm "Khastawi" cultivar.

MATERIALS AND METHODS

The research ran in the Al-Zahfaraniah Palm Station located in Baghdad Governorate, during the 2020–2021 season to study the effect of NPK (20:20:20) fertilizer at three levels (F_0: 0, F_1: 900 g, F_2: 1300 g) and three levels of pruning at a ratio of P_1: 5, P_2: 7, and P_3: 9 leaves/bunch to increase and improve the yield and fruit quality of the date palm, cv. Khastawi. Choosing 54 16-year-old trees that were as uniform in their growth traits as feasible ensued. Irrigation used a drip system, and pollination was according to the regional custom by using pollen grains of the "Ghanmi akhder" cultivar. Foliar application has proceeded with various insecticides and weeding. The addition of organic manure as one of the agricultural service applications for palms took place in December, at an average of 25 kg for each palm (Elamin *et al*., 2017). Adding NPK chemical fertilizers progressed on three dates; the first on 20 February, the second on 20 April, and the third on 20 May, adding at a depth of 60 cm. Using basins with a diameter of 1.5 m and deeply turning the soil surface 25 cm around the selected palm trees

Table 1. Soil sample analysis of experimental site.

Texture	Texture (g kg^{-1})			Macro elements: Mmol L^{-1}						Ec.	pH
Loamy sand	Sand	Silt	Clay	HCO_3	N	P	K	Mg	Ca	$Ds.m^{-1}$	7.4
	130	860	10	1.15	50.0	7.11	217	10.75	20.95	5.30	

facilitated the adding process. As for pruning treatments, their execution was during the pollination period in March. Table 1 shows the results related to soil analysis before starting the experiment (A.O.A.C., 2006).

Study factors

The first factor of adding NPK fertilizer included three concentrations (0, 900, and 1300) at g $tree^{-1}$, and its symbols are F_0, F_1, and F_2, respectively. The second factor is pruning, with trees pruned in conjunction with pollination treatments. This factor included three levels: P_1: 5, P_2: 7, and P_3: 9 leaves $bunch^{-1}$.

Statistical analysis

This research, accomplished in a factorial experiment (3 × 3), continued on a randomized complete block design (RCBD), with every two palms considered an experimental unit and each treatment represented in three replications (Al-Mohammedi and Al-Mohammadi, 2012). The obtained data analysis was according to the GenStat software program. Means comparison employed the least significant difference test (L.S.D. $_{0.05}$) widely used to compare the arithmetic average.

Studied traits

Fruit set (%): (one 25 day after pollination) according to the equation:

$$\text{Fruit set \%} = Ns/Nt \times 100,$$

where:
Ns: Number of setting fruits $strand^{-1}$, Nt: Total number of flowers $strand^{-1}$

For all treatments, the picking of bunches occurred at the harvest date (when dates reached the rutab stage), where the weight of fully developed fruits per bunch's determination was by calculating yield (kg $palm^{-1}$) and bunch weight. Consequently, randomly taking 25 date fruits from each treatment of each replicate helped determine fruit and seed weight. The fruit diameter, and length measurement in fruits of each replicate used a vernier caliper.

RESULTS AND DISCUSSION

Fruit set

Table 2 shows the significant effect of NPK treatments on the fruit sets percentage of date palm cv. Khastawi, with the F_2 treatment, gave the highest fruit set rate at 74.00%, while the F_0 treatment with the lowest at 69.37%. The results revealed significant differences as effects of the leaf/bunch ratio. The P_3 treatment gave the highest set fruit percentage of 72.16%, whereas the P_1 treatment was the lowest at 71.86%. The outcomes on the same table indicated significant differences resulting in the interaction of treatment F_2P_2 as excellent, which achieved the foremost percentage of 74.21%; however, the F_0P_2 treatment gave the lowest percentage of 69.32%.

Fruit weight

Table 3 displays the significant effect of chemical fertilization treatments on the fruit weight, as the F_2 treatment gave the highest fruit weight at 6.242 g, while the F_0 treatment with the lowest value at 5.638 g. The results presented significant differences for pruning levels, while the ratio of leaf/bunch did not show a meaningful effect in this trait. The findings disclosed noteworthy differences in interaction between NPK^{TC} chemical fertilizer

Table 2. The effect of NPK fertilizer, leaf/bunch ratio, and the interaction between them in the percentage of fruit set of date palm cv. Khastawi.

NPK Fertilizer (F)	Leaf/Bunch ratio (P)			Means (F)
	P_1	P_2	P_3	
F_0	69.42	69.32	69.37	69.37
F_1	72.52	72.89	72.97	72.79
F_2	73.64	74.21	74.13	74.00
Means (P)	71.86	72.14	72.16	
$LSD_{0.05}$ F= 0.824	$LSD_{0.05}$ P= 0.824		$LSD_{0.05}$ FXP= 1.427	

Table 3. The effect of NPK fertilizer, leaf/bunch ratio, and the interaction between them in the fruit weight (g) of date palm cv. Khastawi.

NPK Fertilizer (F)	Leaf/Bunch ratio (P)			Means (F)
	P_1	P_2	P_3	
F_0	5.743	5.463	5.707	5.638
F_1	5.913	5.890	5.900	5.901
F_2	6.130	6.290	6.307	6.242
Means (P)	5.929	5.881	5.971	
$LSD_{0.05}$ F= 0.184	$LSD_{0.05}$ P= NS		$LSD_{0.05}$ FXP= 0.319	

Table 4. The effect of NPK fertilizer, leaf/bunch ratio, and the interaction between them in the seed weight (g) of date palm cv. Khastawi.

NPK Fertilizer (F)	Leaf/Bunch ratio (P)			Means (F)
	P_1	P_2	P_3	
F_0	0.550	0.556	0.553	0.553
F_1	0.576	0.573	0.580	0.576
F_2	0.596	0.597	0.610	0.601
Means (P)	0.574	0.575	0.581	
$LSD_{0.05}$ F= 0.012	$LSD_{0.05}$ P= NS		$LSD_{0.05}$ FXP= 0.021	

and pruning, with the treatment F_2P_3 giving a maximum value of 6.307 g and the F_0P_2 treatment giving a minimum value of 5.463 g.

Seed weight

Significant effects of NPK fertilization treatments on the average seed weight resulted, as the F_2 treatment gave the highest average of 0.601 g, while the F_0 treatment gave the lowest rate of 0.553 g (Table 4). In contrast, the pruning treatments showed no remarkable influence on seed weight. The results of the same table implied a substantial disparity in average seed weight as a result of interactions between NPK fertilization and pruning, where the treatment F_2P_3 provided the foremost average of 0.610 g; however, the control treatment gave the least seed weight of 0.550 g.

Fruit diameter

Table 5 shows the sizable effect of NPK fertilization treatments on the average fruit diameter, with the F_2 treatment having the maximum average of 1.775 cm and the F_0 treatment giving the lowest median of 1.671 cm. The results showed significant differences in leaf/bunch ratio, as the P_3 treatment provided the highest mean of 1.741 cm, while the P_2 treatment gave the lowest rate of 1.712 cm. The results further indicated considerable differences in the average diameter of the fruit as an outcome of the interaction between NPK fertilization and pruning, with the F_2P_3

Table 5. The effect of NPK fertilizer, leaf/bunch ratio, and the interaction between them in the average of fruit diameter (cm) of date palm cv. Khastawi.

NPK Fertilizer (F)	Leaf/Bunch ratio (P)			Means (F)
	P_1	P_2	P_3	
F_0	1.686	1.656	1.670	1.671
F_1	1.730	1.710	1.753	1.731
F_2	1.756	1.770	1.800	1.775
Means (P)	1.724	1.712	1.741	
$LSD_{0.05}$ F= 0.016	$LSD_{0.05}$ P= 0.016		$LSD_{0.05}$ FXP= 0.028	

Table 6. The effect of NPK fertilizer, leaf/bunch ratio, and the interaction between them in the average of fruit length (cm) of date palm cv. Khastawi.

NPK Fertilizer (F)	Leaf/Bunch ratio (P)			Means (F)
	P_1	P_2	P_3	
F_0	3.343	3.283	3.403	3.343
F_1	3.533	3.456	3.513	3.501
F_2	3.653	3.590	3.636	3.626
Means (P)	3.510	3.443	3.517	
$LSD_{0.05}$ F= 0.044	$LSD_{0.05}$ P= 0.044		$LSD_{0.05}$ FXP= 0.077	

Table 7. The effect of NPK fertilizer, leaf/bunch ratio, and the interaction between them in the fruit volume (cm^3) of date palm cv. Khastawi.

NPK Fertilizer (F)	Leaf/Bunch ratio (P)			Means (F)
	P_1	P_2	P_3	
F_0	5.923	5.927	5.937	5.929
F_1	6.163	6.150	6.147	6.153
F_2	6.397	6.413	6.477	6.429
Means (P)	6.161	6.163	6.187	
$LSD_{0.05}$ F= 0.079	$LSD_{0.05}$ P= NS		$LSD_{0.05}$ FXP= 0.137	

treatment revealing the topmost average of 1.800 cm and the F_0P_2 treatment with a minimum mean of 1.656 cm.

Fruit length

The significant effect of NPK fertilization treatments on fruit length appeared as the F_2 treatment displayed the highest fruit length amounting to 3.626 cm, while the F_0 treatment gave the lowest, reaching 3.343 cm (Table 6). The results showed substantial differences for pruning, as the P_3 treatment gave the superior average of 3.517 cm, whereas the P_2 treatment had the lowest median of 3.443 cm. Further findings indicated noteworthy variances in the average of fruit length from interactions between NPK fertilizer and leaf/bunch ratio. The F_2P_1 treatment recorded the highest average of 3.653 cm, but the F_0P_2 treatment gave the lowest at 3.283 cm.

Fruit volume

Table 7 shows the influential effect of NPK fertilization treatments on the average fruit volume, as the F_2 treatment gave the highest average at 6.429 cm^3, and the F_0 treatment provided the lowest average at 5.929 cm^3. Contrastingly, the leaf/bunch ratio showed a nonsignificant effect in this trait. The results further indicated notable differences in the average fruit volume as a result of the interaction between NPK fertilizer and pruning, with the F_2P_3 treatment exhibiting the highest value of 6.477 cm^3, whereas the F_0P_1 treatment with the lowest value of 5.923 cm^3.

Table 8. The effect of NPK fertilizer, leaf/bunch ratio, and the interaction between them in the bunch weight (kg) of date palm cv. Khastawi.

NPK Fertilizer (F)	Leaf/Bunch ratio (P)			Means (F)
	P_1	P_2	P_3	
F_0	8.420	8.370	8.500	8.430
F_1	8.717	8.693	8.757	8.722
F_2	9.320	9.270	9.420	9.337
Means (P)	8.819	8.778	8.892	
$LSD_{0.05}$ F= 0.149	$LSD_{0.05}$ P= NS		$LSD_{0.05}$ FXP= 0.286	

Table 9. The effect of NPK fertilizer, leaf/bunch ratio, and the interaction between them in the weight of total yield (kg) of date palm cv. Khastawi.

NPK Fertilizer (F)	Leaf/Bunch ratio (P)			Means (F)
	P_1	P_2	P_3	
F_0	41..94	41.85	42.50	42.10
F_1	43.56	43.47	43.77	43.60
F_2	46.55	46.33	47.11	46.67
Means (P)	44.02	43.88	44.46	
$LSD_{0.05}$ F= 0.747	$LSD_{0.05}$ P= NS		$LSD_{0.05}$ FXP= 1.294	

Bunch weight

NPK fertilizer treatments significantly influenced the bunch weight (Table 8), with the F_2 treatment causing the highest average bunch weight at 9.337 kg. Meanwhile, the F_0 treatment gave the lowest average, reaching 8.430 kg. The findings showed that none of the pruning treatments had significant effects on the bunch's weight. Results in Table 8 also indicated weighty differences in the average bunch weight, as a result of the interaction between NPK fertilizer and pruning, as the F_2P_3 treatment gave the maximum average of 9.420 kg and the F_0P_2 treatment had the lowest average of 8.370 kg.

Total yield

Table 9 details the paramount effect of NPK fertilization treatments on total yield, showing the F_2 treatment with the highest yield average of 46.67 kg and the F_0 treatment with the lowest yield average of 42.10 kg. However, the pruning treatments caused no significant impact on total yield. The same table showed notable differences in the total yield resulting from the interaction between NPK fertilizer and leaf/bunch ratio, where the F_2P_3 treatment gave the foremost value at 47.11 kg, and the F_0P_2 treatment displayed the minimum value at 41.85 kg.

The increase in fruits' productivity when raising the levels of NPK fertilizer is due to the effect of this fertilizer in augmenting the percentage of fruit set, hence, amplifying their weight (Tables 2 and 3). At the same time, the increase in fruit set might be due to the role of the elements to stimulate the initiation and development of flowers, as nitrogen involves in the synthesis of nucleic acids, amino acids, proteins, co-enzymes, and other organic compounds in the living cell (Marschner, 2012). As for phosphorus, the element stimulates cell division and the formation of energy compounds, participating in carbohydrate metabolism (Hawkesford *et al*., 2012).

Potassium is necessary for stimulating many enzymes, pH and osmotic regulation, and regulating the cell membrane permeability, which facilitates the transfer of water and transport of metabolites and their accumulation in the fruits and seed tissues (Havlin *et al*., 2005; Taiz and Zeiger, 2006). The increase in the weight of fruit and bunch may refer to the fact that the increase in the N, P, and K concentrations led to a state of

activity and rapid growth of the fruit tissues due to cell division and their expansion during the different growth and maturity stages, which reflected positively on the fruits' physical characteristics (Tables 4, 5, 6, 7, and 8). These outcomes correspond with those of Al-Qurashi *et al*. (2015), Al-Qurashi *et al*. (2016), Elsadig *et al*. (2017), and Al-Fahdawi and Al-Janabi (2022).

As for the leaf/bunch ratio, the third level of pruning increased source productive units, which enhanced the efficiency of the photosynthesis process, intensifying its manufacture and accumulation in the sink unit (fruits) (Zufferey *et al*., 2015). It reflected positively on the growth of the fruits, significantly increasing the fruit set, diameter, and length. According to Gifford and Jenkins (1982), enhanced cultural practices that influence photosynthetic efficiency determine yield and plant characteristics. Heuvelink (2005) and Lombardine *et al*. (2009) reported that shaded tree canopies receive a little sunlight on the bottom leaves of the tree, which manifest in photosynthesis accumulation. Hence, ensuring high fruit quality requires appropriate light distribution within the tree canopy. These outcomes are generally consistent with investigations on other date palm cultivars, with similar reports from Omar *et al*. (2013) on the Barhi cultivar, El-Salhy *et al*. (2017) on the cultivar of Sewy, and Ibrahim and Mohamed (2021) on Zaghloul date palms.

CONCLUSIONS

The results obtained concerning the NPK fertilization and leaf/bunch ratio application in the "Khastawi" date palm orchard, located in Al-Zahfaraniah Palm Station, Baghdad Governorate, Iraq, indicated that adding 1300 g of NPK fertilizer and keeping nine leaves per bunch was responsible for improving the yield and the fruit's physical quality of dates.

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