COMPARISON OF TWO CUTTING SAWS ON CUTTING FRONDS IN FIVE DATE PALM VARIETIES

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ABSTRACT

Management of date palm is laborious andcostly, thus this work intended to study the two types of frond cutting saws (reciprocating saw andvibrating saw) investigated on three cutting parameters (noise intensity result from frond cutting, surface regularity or flatness of the cut region, andsome mechanical characteristics of the cutting process including longitudinal andradial compressive strength andstress measurement) applied on field grown five date palm varieties (Barhi, Bream, Khestawi, Tebarzal andZahdi). Nested r&omized complete block design was implemented which included five date palm varieties as the main plot andthe type of saw as a sub-plot. Results indicated that both saws caused noise intensity y in accordance with st&ard permissible noise intensity. The highest was in Tebarzal variety while the lowest noise intensity occurred in Bream andthus this variety caused significantly lower noise intensity during cutting fronds than Tebarzal andBarhi. Vibrating saw achieved significantly better cut surface flatness than reciprocating saw. The least frond cut uniformity was reported in Tebarzal variety during using reciprocating saw, whilst the highest was recorded during cutting Bream fronds using vibrating saw. Concerning the radial compressive strength andstress, after the laboratory test it was noticed that the Tebarzal variety resulted in a significantly higher diagonal compressive andstress strength than others except Khistawi, Tebarzal variety recorded the highest radial compressive strength andlongitudinal compressive stress resulted in a significant difference with other varieties except Khistawi. Bream reported the lowest mechanical properties among other varieties, in contrast to Tebarzal which recorded the highest properties. From previous results, it is concluded that the above studied varieties retains mechanical properties differ from each other, which cause different performance of the pruning process.

Keywords: date palm, reciprocating saw, vibrating saw, frond cutting, noise intensity, surface regularity, radial compressive andstress strength.

مقارنة نوعان من مناشير قطع الكرب في تكريب خمسة اصناف من نخيل التمر

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المستخلص

خدمة اشجار النخيل مجهدة ومكلفة, لذا هدف البحث الحالي لدراسة نوعين من مناشير قطع كرب النخيل (الترددي والاهتزازي) تم تطبيقهما في التقصي عن ثلاثة معايير في خواص القطع (شدة الضوضاء الناتجة عند قطع الكرب, درجة استواء وانتظام منطقة قطع قاعدة الكربة, بالاضافة الى الصفات الميكانيكية لعملية التكريب والتي شملت قياس قوة الانظغاط والاجهاد الطولية والقطرية). طبقت حقلياً على خمسة أصناف من نخيل التمر شائعة الزراعة في العراق (برحي, بريم, خستاوي, تبرزل, وزهدي). صممت التجربة الحقلية وفق تصميم القطاعات العشوائية الكاملة وفق النظام المعشعش والذي شمل أصناف النخيل الخمسة كعامل رئيسي ونوعين من مناشير القطع كعامل ثانوي. أشارت النتائج بان كلا المنشارين سببا في ضجيج يتطابق مع المعايير العالمية عند قطع الكرب وحصل أعلى ضجيج في صنف التبرزل والادنى في صنف البريم والتي انخفضت معنوياً في صنفي التبرزل والبرحي. حقق المنشار الاهتزازي استواءاً منتظما لمنطقة القطع في قواعد الكرب عند تجريبه على اصناف النخيل الخمسة مقارنة بالمنشار الترددي. كما تم تسجيل أقل استوائية لمنطقة القطع في قواعد كرب صنف التبرزل عند استعمال المنشار الترددي في الوقت الذي سجل المنشار الاهتزازي أعلى انتظام لسطح القطع في صنف البريم. بعد اجراء الفحوصات المختبرية, لوحظ بان كرب صنف التبرزل قد تسبب في اعلى قيم الانضغاط والاجهاد القطريان مقارنة بالاصناف الاخرى ماعدا صنف الخستاوي اذ سجل الاخير أعلى قوة انضغاط واجهاد طوليان مما نتج فرقاً معنوياً أعلى من باقي الاصناف عدا الخستاوي. حقق صنف البريم أدنى خواص ميكانيكية بين الاصناف الاخرى على العكس من صنف التبرزل والذي سجل أعلى القيم في هذه الصفة. يستنتج من أعلاه بان أصناف النخيل الخمسة ذات مواصفات ميكانيكية تختلف عن بعضها عند تكريبها.

الكلمات المفتاحية: نخيل التمر, المنشار الترددي، المنشار الاهتزازي، قطع الكرب، شدة الضوضاء، الانتاجية، انتظام سطح القطع، قوة الانضغاط القطرية والطولية والاجهاد.

Received:22 /01/2023, Accepted:19/04/2023, Published: August,2025

INTRODUCTION

Date palms (*Phoenix dactylifera* L.) are monocots, evergreen flowering trees (25). Date palms withstandharsh environmental conditions (2). Many products are produced from date palm in general andfronds in particular (11, 14, 13). In developing countries, date palm oil is used as a high quality cooking oil (24). The mechanical resistance of the fibers, particularly in fronds, refers to the stiffness andthe dimensional firmness of fibers depending on lignin content andother components (7). Mechanical properties also depend on the fiber density of wood (6). Tree management is costly andlabor-intensive; thus, new technology has to be introduced. The process of pruning date palm is practically removing leaves andfronds, along with the fibers surrounding fronds (15,16). Although, it is considered a routine work done annually or biannually (9), frond pruning is crucial management in date palm groves since it avoids diseases andpests (26, 1). When the frond is too hard to cut, it causes worker fatigue due to vibration andresistance (12), leading to a reduction in productivity. Aminuddin *et al*. (5) manufactured andtested a motorized date palm fronds cutter equipment used to cut palm fronds. They indicated that Increasing the number of blades improved the machine's effective capacity by 14.22%. Results also showed that the size of waste palm fronds andleaves was decreased, leading to more efficient operation. Some varieties entail much more human effort than others since the higher cutting resistance, the higher energy input, andtake more time to prune. Rottensteiner (29) suggested high-speed cutting tools ranging between 20-1000 Hz to avoid risk imposed on the labor body so that a smooth cutting surface can be obtained to avoid water drops accumulation andthus fewer diseases may invade the trunk fibers. Fadel (12) developed andtested an experimental prototype of a h&held pruner under laboratory conditions. The developed pruner can be operated using various types of prime movers such as drills, hydraulic motors, pneumatic actuators, or mechanical drivers. A cordless drill drive was used to drive the pruner, andlow feed rates produced a flat andcleaner cut surface. Although manual andmechanically driven pruning shears andsaws are widely used in horticulture, the available tools for date palm pruning are still very basic andwasteful of power. Some variables andfactors as defects, microfibrillar angle, chemical composition, cell dimensions, andstructure affect mechanical characteristics (8,10,19,30). The microfibrillar angle which is the angle confined between the micro-fibrils andfiber axis is responsible for the fibrils mechanical properties. The higher stiffness andstrength can be attributed due to a smaller angle (3). Increased cell walls in volume unit andcellulose content improve some of the mechanical properties, such as Young's modulus andtensile strength (20,23). The current research aimed to compare three cutting characteristics (noise intensity, regularity of the frond cutting surface, andmechanical characteristics of frond) using two electrical-powered cutting saws examined on cutting fronds of five date palm varieties very commonly grown in Iraq.

MATERIALS and METHODS

The experiment was conducted in a date palm orchard belongs to the ministry of agriculture, Zufrania Horticulture station, south Baghdad. Two cutting machines were used, a reciprocating saw anda vibrating saw. Their description andproperties are shown in table 1. Both were bought from a local market. The experiment required a well-trained worker to use both saws after installation as described previously (4). The experimental was designed according to nested r&omized complete block design (NRCBD) with three replications was used for each parameter. Genstat, version 12.1 program was used for the statistical analysis. Reciprocating andvibrating saws were used for the studied parameters on five date palm varieties (Tebarzal, Khestawi, Bream, Zahdi, andBarhi). The studied parameters were noise intensity, frond cut uniformity, mechanical properties of fronds including longitudinal compressive strength andstress measurement. The frond-cutting process was performed by moving the reciprocating saw from the right to the left at the base of frond at one time, while the vibrating one required repeating three times to complete the cut as in using the traditional knife (curved chisel).

Table 1. Description andproperties of the experimental saws (15)

Description	Reciprocating saw	Vibrating saw
Manufacture	Dewalt	Dewalt
Device length	54 cm	35 cm
Device width	10 cm	8 cm
Device weight	3215 g	1510 g
Operating power	1100 W	300 W
Cutting knife shape anddimensions	Semi-triangle 127 mm length 2-19 mm width 1.1 mm thickness	Semi-circle 50 mm radius 0.4 mm thickness

Noise was measured by using a Noise meter (Onsoku, Japan). It was fixed nearby the worker ear andnoise intensity was measured according to the manufacturer instructions. Surface uniformity was measured with Surface Roughness SRF 6210 (UK) device according to the manufacturing company instructions. Longitudinal compressive strength andstress were measured according to Hiziroglu (21) as below:

σL=F/A =F/2500 , $N/(mm)^2$ =MPa

since:

σL: Longitudinal stress imposed on the wood surface

F: Power imposed on the wood sample

A: Sample area in contact with imposed power

The criterion for penetration tolerance is the power by which penetration occur suddenly. Data were recorded depending on the following equations:

$$\sigma r = \frac{Bx + Tool\ weight\ reaction\ force}{Pin\ cross\ section\ Area}$$

since:

σ r: Radial stress strength for a frond

Bx:The reaction of the frond on the device

The area of penetration section (circular shape) = $A = \pi r^2$

Area of penetration pin= $A = \frac{22}{7} \times (2)^2$= 12.57 mm^2

The reaction strength of the device was measured directly with a device. To find out Bx, the following equation was applied:

$$\sum MA = 0 = 565F - 250Bx$$

$$Bx = 2.16F$$

After the compensation of the measured tree trunk reaction (48.35 N) with bearing cell then dividing by area of penetrating pin, the equation will be: $\sigma r = 3.85 + 0.18F$

The above equation was exploited to convert the normal force (N) which is equivalent to 10^6 N.m.· Finally, compensating F value in the last equation with the obtained readings. Experimental design andstatistical analysis: A field experiment was designed according to the nested r&omized complete block design, including date palm varieties as the main plot andtype of saw as a sub-plot. Means were compared using the least significant differences test (LSD 0.05). The statistical analysis was conducted using Genstat, version 12.1.

RESULTS andDISCUSSION

Noise intensity: Results revealed that Bream variety caused the minimum noise intensity (Table 2) recording 93.5 db andthus decreased significantly than means of Tebarzal, Barhi which recorded 9.4 and97 db respectively, whereas Khestawi andZahdi exhibited no significant difference. Meanwhile, reciprocating saw caused maximum noise intensity (97.9) dp compared with the vibrating saw (94.2) db. Additionally, the interaction between date palm variety andthe type of saw displayed no significant differences, andthe minor reduction in reciprocating saw can be negligible.Results of the current study are within the limits reported by Owoyemi (27) who revealed a noise intensity 80-120 db during cutting surfaces then they recommended 100 db for 15 minutes to be relevant to the human ears, since it increases with increasing wood stiffness andnoise can be minimized by using low speed pruning saws. Accordingly, it is not necessarily that noise intensity rises as the date palm variety increases its resistance to cutting, since a variety with high rigidity will lessen the saw speed. The variability indicated in the above table between Tebarzal andBream may due to the variability in the anatomy of the fronds in those varieties particularly the fibers. Jasim (18) mentioned that low noise intensity during cutting Barhi fronds is due to the low resistance compared with Maktoom variety. Thus, noise intensity is considered suitable for human health in the current study.

Table 2. Effect of two types of cutting saws, date palm variety, andtheir interaction on noise intensity (db).

Variety	Type of saw		Mean of variety
	Reciprocating	Vibrating	
Khestawi	97.5	94.5	96.0
Tebarzal	100.0	96.8	98.4
Bream	95.0	91.9	93.5
Barhi	98.5	95.4	97.0
Zahdi	98.2	92.4	95.3
LSD 0.05	3.9^{NS}		LSD 2.7
Mean of cutting saw	97.9	94.2	
LSD	2.0		

Cutting uniformity

Results illustrated in table 3 reported that Barhi variety was the highest with frond cut surface roughness with a mean value of 7.25 micron so, it exceeded significantly other varieties. Meanwhile, reciprocating saw recorded 8.68 micron which was significantly higher than this recorded after cutting fronds with the vibrating one (5.68) micron. The results is in accordance with that reported by Jankowska (17) who mentioned that the cutting uniformity depends on the geometric shape of the cutting knife, sharpness, speed in addition to some other anatomic characteristics of the wood. The more speedy the cutting knife the more surface uniformity, thus the vibrating saw was more speedy andresulted in almost uniform frond cut base. The interaction between the two saws anddate palm variety exhibited the superiority of vibrating saw in cutting Bream frond with a uniformity of 5.89 micron while the reciprocating saw enlarged coarseness of the cut frond surface andthe highest value was recorded in Tebarzal fronds reached 8.87 micron andthe least was chronicled in Bream (8.44) micron. The table refers that reciprocating saw augmented the coarseness of the cut frond surface recording maximum coarseness in Tebarzal variety (8.87) micron andthe least in in Bream (8.44) micron. No significant differences were reported in the variety effect on roughness of the cut surface, in other words, the coarseness between varieties was not affected after cutting with both saws. Notably, the vibrating saw exhibited better surface regularity than reciprocating one, but such alteration in a few microns is very minor andnot practically significant since the advantage of smooth surface is to ease tree climbing andreducing pest invasion andnot advantageous for industrial purposes.

Table 3. Effect of two types of cutting saws, date palm variety, andtheir interaction on frond cut uniformity (micron)

Variety	Type of saw		Mean of variety
	Reciprocating	Vibrating	
Khestawi	8.77	5.60	7.22
Tebarzal	8.87	5.62	7.24
Bream	8.44	5.53	6.99
Barhi	8.84	5.67	7.25
Zahdi	8.46	5.89	7.18
LSD (0.05)	$0.48^{N.S}$		LSD 0.28
Mean of cutting saw	6.68	5.68	
LSD	0.77		

MECHANICAL PROPERTIES

Results reported in table 4 indicate that Tebarzal variety recorded the highest radial compressive strength (101.37) N so it differed significantly with Barhi, Bream, andZahdi which recorded 68.88, 48.6, and78.95 N respectively. After the laboratory examination, it was found that the Tebarzal variety had a significantly higher longitudinal compressive strength andradial compressive stress (22.09 Mpa, 8827 N) than other varieties except the Khestawi while the same variety recorded the highest compressive strength andlongitudinal stress with a significant difference from other varieties. Bream had the lowest mechanical properties among the other varieties, in contrast to Tebarzal, which recorded the highest properties ever. Tebarzal requires more compressive power to cut the frond, while Bream variety needed the lowest andradial stress (12.59) Mpa because it needed low diagonal compressive strength than other varieties except the Khistawi while Tebarzal variety recorded the highest compressive strength andlongitudinal stress, with a significant difference compared with other varieties.

Table 4. Some mechanical characteristics of frond wood in five date palm varieties

Date palm variety	Radial compressive (N)	Radial stress (Mpa)	Longitudinal compressive (N)	Longitudinal stress (Mpa)
Barhi	68.88bc	16.25bc	6925c	2.77c
Bream	48.60c	12.59c	3372e	1.35e
Kestawi	78.95ab	18.06ab	8078b	3.23b
Tebarzal	101.37a	22.09a	8827a	3.53a
Zahdi	55.76bc	13.88bc	4723d	1.88d
LSD 0.05	25.65	4.62	708.8	0.29

varieties, in contrast to Tebarzal, which recorded the highest properties ever. From previous results, it is concluded that each of the studied date palm variety possesses mechanical properties differ from others, which is behind the different performance of the pruning process. It is recommended to use a reciprocating saw for this purpose due to its speed with minimal effort by the worker. The current results are not in accordance with those of Shamsi et al. (22) who reported that radial compressive ranged 27-40 N andthe radial stress ranged 5.45-7.79 Mpa. when they examined the frond properties in some date palm varieties grown in Iran. This may due to the variability in climatic circumstances between the two regions particularly the hot anddry weather in Iraq during summer season. Peng (28) explained the differences in wood mechanical characteristics as a result of humidity in the atmosphere since Iraq is known for low humidity, especially in the middle regions.

Conclusion

Variability among varieties is due to the mechanical properties of fronds according to the variety which causes different performance of the pruning process. Thus, using a relevant saw for this purpose can achieve minimal noise intensity, uniform frond cut surface andbetter mechanical cut properties when other parameters concern the pruning process are studied.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

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