*Asian Journal of Agricultural and Horticultural Research*

*7(2): 16-25, 2020; Article no.AJAHR.63044*
*ISSN: 2581-4478*

# Comparison of Locally Developed Date Palm Pollination Machine with Manual Pollination under Shambat Condition – Sudan

**Mohamed Hassan Dahab[1*], Mona Shahin Osman[2] and Omer Ahmed Abdalla[1]**

*[1]Faculty of Agricultural, University of Khartoum, Shambat, Sudan.*
*[2]Ministry of Agriculture and Natural Resources, Khartoum State, Sudan.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. Author MHD designed the study, wrote the protocol and wrote the first draft of the manuscript. Author MSO performed the field work and the statistical analysis and managed the analyses of the study. Author OAA managed the literature searches. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/AJAHR/2020/v7i230091
Editor(s):
(1) Dr. Magdaléna Valšíková, Slovak University of Agriculture (SUA), Slovakia.
Reviewers:
(1) Oyelakin K. Akinloye, Federal University of Technology, Nigeria.
(2) Braimah Joseph Oduayo, Ambrose Alli University, Nigeria.
Complete Peer review History: http://www.sdiarticle4.com/review-history/63044

***Original Research Article***

***Received 05 September 2020***
***Accepted 10 November 2020***
***Published 28 November 2020***

## ABSTRACT

The main objective of the research study was to compare a locally developed date palm pollination machine to manual pollination during two successive seasons. Two pressures were used to operate the machine. The parameters measured were, rate of work, pollen application rate, crop yield and cost of pollination. The results indicated that the field capacity (rate of work) of the pollination machine was 18 tree/hr, while for the manual pollination it was 5 tree/hr. The machine pollen application rate was 0.5-1 gm/tree as compared to manual pollination which consumed higher amount of pollen 8 gm/tree. There was no significant difference between the effect of using the three methods of pollination on physical and chemical characteristics of date fruits. There was significant effect of treatments on quantity of date yield in the two seasons for the three methods of pollination at 5% level of significance. The pollination machine at high pressure produced higher yield than other treatments which were 605 kg, 1206 kg for the two seasons respectively, while the lowest yield was recorded by manual pollination as 233 kg and 818 kg for the two seasons in sequence. The pollination cost of the machine was 9.1 SDG /tree which was less than the manual

**Corresponding author: Email: mhdahababahmed55@yahoo.com;*

pollination that costs 60 SDG /tree. The manual pollination needed two labors to pollinate 200 trees per season, while mechanical pollinator needed one operator to pollinate 760 trees per year. The pollination machine reached up to 10 meters in height. In addition, considerable reduction of time requirements, and pollination cost were observed.
It was concluded that the pollination machine is highly reliable and efficient in control over pollen application rate, thus reducing pollen loss to minimum, saving cost and time and overcoming defects associated with manual pollination.

*Keywords: Pollination; machine; manual; date palm; Shambat.*

## 1. INTRODUCTION

The date fruit, which is produced largely in the hot arid regions of South West Asia and North Africa, is marketed all over the world as a high-value confectionery and fruit crop and remains an extremely important subsistence crop in most of the desert regions. The major date producers in the world are situated in the Middle East and North Africa. With an annual production of about 330,000 tons and a date palm population of about 8 million trees, Sudan ranks number 8 in the list of top date producing countries of the world. However, Sudan has available irrigation water and suitable climate for date production. History shows the date palm is a traditional crop in northern Sudan so it is providing all varieties of dates to the local markets, and it is economic crop to northern people. According to [1] the five leading exporting countries since 1991 have been Iran, Pakistan, Tunisia, Algeria and Saudi Arabia. The major date producers in the world are situated in the Middle East and North Africa. On average over the period 1999-2001, Iran, Saudi Arabia and Iraq had almost half of the harvested area of the world. Trade figures indicate that about 93 percent of the date harvest is consumed locally and that by far the majority of these palms are not of the well-known export varieties. It was explained that natural pollination by wind, bees and insects is found to yield affair fruit set in various areas of the date growing countries (Marrakech, Morocco; Elche, Spain; San Ignacio , Baja – Mexico; Ica, Peru, etc.) [2]. All these regions are characterized by their 100% seedling composition with about 50% males. In the absence of such natural pollination, female flowers are not fertilized. Artificial pollination ensures good fertilization and there are three types of artificial pollination [3]. It was reported that artificial technique of pollination is to cut the strands of male flowers from a freshly opened male spathe and place two to three of these strands, length wise and in inverted position, between the strands of the female inflorescence [4]. It was mentioned that a man must climb a date palm eight to ten times from the time of pollination through to crop harvesting [5]. It was stated that experiments with pollinating of dates with aircraft were conducted in the Coachella valley of California on Deglet Nour [6]. Results showed that even though temperatures and weather conditions were favorable both the helicopter and fixed – wing methods of application yielded less fruit sets than the manual pollination method. [7], and [8], showed that mechanical pollination was developed mostly in new world of date palm (USA) where labor is expensive and not always available. Mechanical pollination has been one of the most important alternatives when the labor being reduced by 50 - 70% [9]. There are many pollination machines were developed and investigated to explain the good conditions for using mechanical pollination in many countries in the world [10,11,12,13, 14,15,16]. The results of these studies showed few or no differences between mechanical pollination and manual pollination, according to quantity of crops harvested, but were efficient and saving cost and time. [8] and [17] showed that the research workers in Irag were interested to use mechanical pollination because the yield of good mechanical pollination for date palms were found to be equal to/or better than manual pollination. It was explained that in general the technique of pollination in different area of date palm cultivation in Sudan is almost the same with some difference pollination technique [18]. It is to cut the strands of male flowers from a freshly opened male spathes to tie three to four strands together, or cut the strands to small pieces with length (10 -12) cm and tied (3 - 4) strands or pieces in form of package and gathered into bag that the polliniferous hang on his neck to climb the female palm to the strands in mid of female spathe. Therefore, pollination is manually carried out, difficult, time consuming and costly. The main objective of the present study was to compare a locally developed date palm pollination machine with manual pollination under field condition using two operation pressures.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The pollination machine was designed and manufactured at the workshop of the Department of Agric Engineering, University of Khartoum, while the application carried out at the experimental Orchard farm, Faculty of Agriculture, University of Sudan, as shown in Fig. 1.

### 2.2 The Component of the Developed Pollination Machine

The mechanical pollinator consisted of an air compressor type SHIMGE (R), capable of producing a maximum air pressure of 180 psi or 12 bar (1034 pa), Medium cylinder size, its volume 50 liter. The gearbox and compressor were connected by means of two iron pulleys with v-belt. The power derived from the PTO of a two-wheel drive tractor of 75 hp. The gearbox and compressor were mounted on iron frame with three telescopic trivets. The PTO shaft rotates the big conical gear which inside the gearbox then it rotates the small conical gears set which are connected with the pulley shaft when the big gear rotates one cycle the small gears rotate five cycle. The important part of the machine is the pollen tank; the capacity of the tank is 250 g for pollen mixture. Pollen tank consists of two cylinders, upper cylinder and bottom cylinder in pyramidal shape, it consisted of air vacuum device (adapter) which created a pressure drop into small tube (length is 4 cm), that forces the pollen mixture up through a small metal tube (length is 10 cm) and into the air stream (length is 10cm), as shown in Fig. 2.

**Fig. 1. The study date palm field**

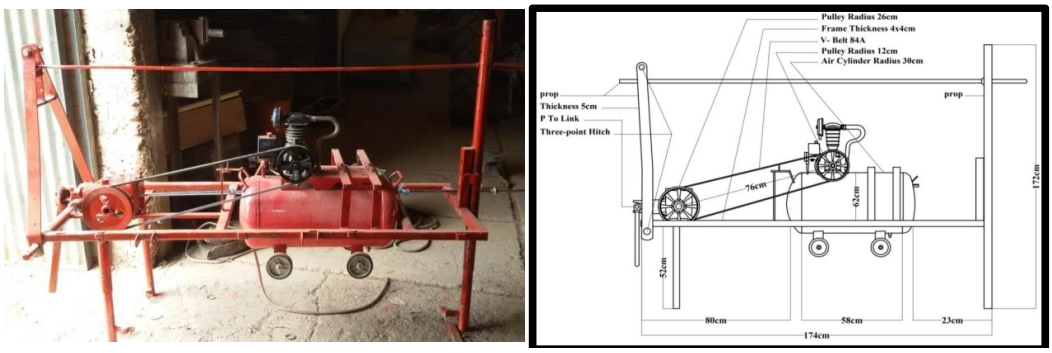


**Fig. 2. The pollination machine**

## 2.3 Treatments

Fifteen date palm trees were selected; with an average height of 8-10 meters. Each tree was pollinated once during a pollination season that extended for 4 weeks. The pollen mixture used consisted of 1:9, one pollen to 9 flour. The palm trees were divided into three groups, each one had 5 trees, and the first group was pollinated manually by inserting three male strands /female spathe, the second with the machine by dusting mixture 1.0 g pollens/9.0g flour using high pressure 5 – 8 bar. and the third with machine by dusting mixture 1.0 g pollens/9.0g flour using low pressure 1 – 4 bar.

## 2.4 Field Performance Measurements

1. Field efficiency (E)

$$E = T1 / (T1 + T2 + T3 + T4) \times 100 \quad (1)$$

2. Actual field capacity

The field capacity or work rate was calculated using the following equation.

$$FC = N / (T1 + T2 + T3 + T4) \quad (2)$$

Where:

FC: Field capacity (no. of pollinated trees/hr)
N: Number of pollinated trees
T1: Time for actual pollination (hr)
T2: Time for adjustment and filling the pollen tank (hr)
T3: Time for travel between trees and turnings (hr)
T4: Functional time losses (hr).

3. Amounts of pollens used per tree (gm/tree)

4. Number of labour required (labour/season)

5. Cost of pollination operation (SDG/tree)

The total mechanical pollinator operating cost per hour is the sum of the cost components per hour=

Depreciation+ Interest+ Housing+ Repair and maintenance + fuel and oil +Labor

The pollination cost per tree is obtained by dividing the total operating cost by machine field capacity and multiplying by 4(number of pollen application/season) as follows:

The pollination cost per tree (SDG/tree) was calculated as =

$$\frac{\text{Total operation cost per hour} \times 4\ (\text{number of pollen application/season})}{\text{Machine field capacity (trees/hour)}} \quad (3)$$

The manual pollination cost per tree was determined as=

labour total cost/ number of trees pollinated (4)

6. The Yield of manual and mechanical pollination

The yield of manual pollination was estimated as:

$$\text{The average weight of bunches} \times \text{number of bunches of each date palm tree} \quad (5)$$

The yield of mechanical pollinator pollination was estimated by the same method used for the manual pollination

7. Some physical and chemical characteristics of the date fruits

Thirty fruits from each bunch were randomly selected to determine the average fruit weight (kg) and dimensions (length and width in cm) as in Fig. 3, and also chemical analysis for total and reducing sugars.

Statistical analysis was carried out to compare between treatments and parameters measured using ANOVA (analysis of variance) table and Duncan multiple range test (DMRT).

## 3. RESULTS AND DISCUSSION

### 3.1 Pollinator Preparation and Manufacturing

The mechanical pollinator was component of five parts which were gearbox, compressor, application control system, pipes, and frame with hitch. The mechanical pollinator mounted behind the tractor by the three-point hitch. The power produced from PTO (50 hp) of a two-wheel drive tractor to the compressor to fill air tank. The system is equipped with pollen application control system which pollinated by using sufficient pressure, and equipped with aluminum pipes to convey the pollen mixture to the bloom area.

### 3.2 Manual and Mechanical Pollinator Field Performance (FC)

Result of field performance of the three pollination treatments is shown in Table 1. The

time ratio of each activity involved in field operation to total field time provides guidelines for time analysis. This is considered as a reliable means for evaluating the machine pollinator field performance. Data analysis indicated that the actual pollination time to total field time represents the pollinator field efficiency which was replicated for two seasons with two pressures; high and low. The same result of efficiency as 28% was obtained. When compared to other developed ground level pollinators like Alnahreen pollinator [15] which had higher field efficiency (39%), but manual pollination consumed long total field time which was about one hour and the actual productive time was about (25%). The functional time losses as with other ground level pollinators, was (17%) which was higher than manual pollination (8%). The field capacity of the mechanical pollinator as calculated was found to be 18 tree/hr. This was considerably lower than other reported ground pollinators (43-89 tree/hr), but was considerably higher compared to manual pollination (5 tree/hr) (Table 2).

### 3.3 Effect of Treatments on Amounts of Pollens Used

Data analysis showed in Table 2 indicated that the mechanical pollinator had a considerably low pollen application rate (0.5,1 gm/tree) as compared to the manual pollination which used higher amount of pollens as 8 gm (Fig. 4). Studies reported similar outputs e.g. Babil pollinator (3gm/tree) [10], Alnahreen [15] and Hamorabi pollinators which used 0.6 and 1 gm/tree respectively. Mechanical Pollinator operated with low pressure used significantly few amounts of pollen application as 0.5 gm compared to the higher pressure one (1 gm/tree).

.

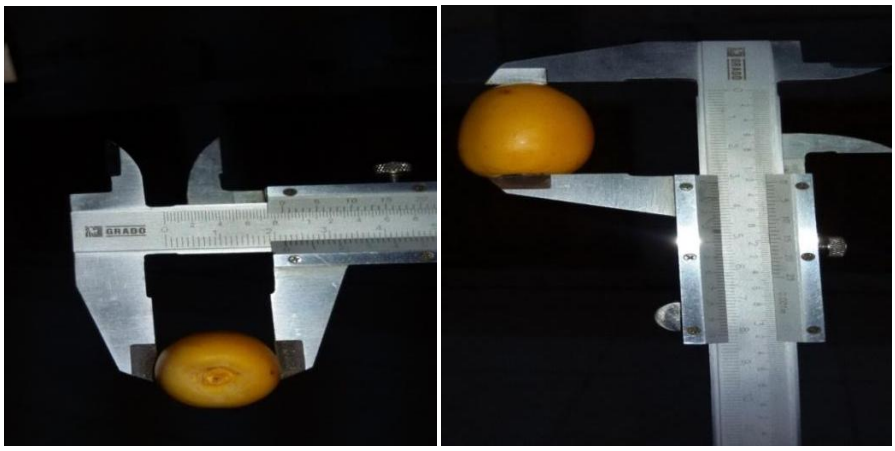


**Fig. 3. The measurement of both length and width of date fruits**

**Table 1. Field performance test of the pollinator (average of two seasons)**

| Items | Manual pollination | | Mechanical low pressure | | Mechanical high pressure | |
|---|---|---|---|---|---|---|
| No. of Trees | 5 | - | 5 | - | 5 | - |
| Total Field time(min) | 60 | 100% | 18 | 100% | 18 | 100% |
| T1 (min) | 15 | 25 % | 5 | 28% | 5 | 28% |
| T2 (min) | 20 | 33.33 % | 6 | 33% | 6 | 33% |
| T3 (min) | 20 | 33.33 % | 4 | 22% | 4 | 22% |
| T4 (min) | 5 | 8.33 % | 3 | 17% | 3 | 17% |
| Pollen dusted (gm/tree) | 8 | 100% | 0.5 | 6.3% | 1 | 13% |
| Fuel consumption (gal/hr) | - | - | 1 | 0.3 | 1 | 0.3 |

**Each number is the mean of 5 readings.*
*T1: Time for actual pollination (min)*
*T2: Time for adjustment and filling the pollen tank (min).*
*T3: Time for travel between trees and turning at row ends (min).*
*T4: Functional time losses (min) (manufacture defect)*

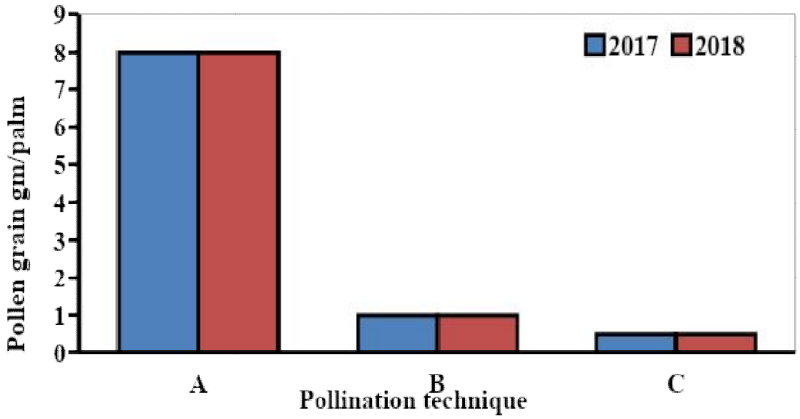


**Fig. 4. The amount of pollen application for the different treatment**

### 3.4 Effect of Treatments on Number of Pollinated Trees /Seasons

Table 2 indicated that the maximum number of trees that can be pollinated per season could be estimated by multiplying the effective time available for pollination (160 hr/year) by machine field capacity (18 trees/hr) and dividing by the number of pollen applications (4 application/year). Accordingly, the maximum number of trees/seasons that can be pollinated by the mechanical pollinator was found to be 720. And also, the maximum number of trees/season that can be pollinated by hand pollination is estimated by multiplying the effective time available for pollination (160 hr/year) by field capacity (5 trees/hr) and dividing by the number of pollen applications (4 application/ year) was found to be 200 (Fig. 5). The mechanical pollinator pollination was considerably higher than hand pollination and lower than that for Babil [10] Hamorabi pollinators [15].

**Table 2. Effect of using manual and mechanical pollination techniques on efficiency yielding and number of date palms during 2017 and 2018 seasons**

| Parameter | Pollination technique | | | | | | P-value | $Lsd_{0.05}$ |
|---|---|---|---|---|---|---|---|---|
| | A | | B | | C | | | |
| | Season | | | | | | | |
| | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | | |
| Cost of labour (SDG/day) | 150.00$^{a}$ ±0.42 | 150.00$^{a}$ ±0.42 | 100.00$^{b}$ ±0.31 | 100.00$^{b}$ ±0.31 | 100.00$^{b}$ ±0.31 | 100.00$^{b}$ ±0.31 | 0.002$^{**}$ | 29.571 |
| Palm tree height (m) | 8-10 | 8-10 | 8-10 | 8-10 | 8-10 | 8-10 | - | - |
| Polen grain weight (gm/palm) | 8.00$^{a}$ ±0.14 | 8.00$^{a}$ ±0.14 | 1.00$^{b}$ ±0.07 | 1.00$^{b}$ ±0.07 | 0.50$^{c}$ ±0.02 | 0.50$^{c}$ ±0.02 | 0.0301$^{*}$ | 0.042 |
| Pollination time (min/tree) | 12.00$^{a}$ ±0.19 | 12.00$^{a}$ ±0.19 | 3.00$^{b}$ ±0.11 | 3.00$^{b}$ ±0.11 | 3.00$^{b}$ ±0.11 | 3.00$^{b}$ ±0.11 | 0.0$^{*}$ | 6.531 |
| Pollination repetition | 4.00$^{a}$ ±0.00 | 4.00$^{a}$ ±0.00 | 4.00$^{a}$ ±0.00 | 4.00$^{a}$ ±0.00 | 4.00$^{a}$ ±0.00 | 4.00$^{a}$ ±0.00 | >0.05$^{NS}$ | 0.964 |
| Number of laborers | 2.00$^{a}$ ±0.0 | 2.00$^{a}$ ±0.0 | 1.00$^{b}$ ±0.07 | 1.00$^{b}$ ±0.07 | 1.00$^{b}$ ±0.07 | 1.00$^{b}$ ±0.07 | 0.049$^{*}$ | 0.876 |
| Number of pollinated date palms per hour | 5.00$^{b}$ ±0.17 | 5.00$^{b}$ ±0.17 | 18.00$^{a}$ ±0.25 | 18.00$^{a}$ ±0.25 | 18.00$^{a}$ ±0.25 | 18.00$^{a}$ ±0.25 | 0.0$^{*}$ | 10.599 |

*Mean value(s) bearing different letters within a row are significantly different (P0.05) according to DMRT (Duncan multiple range test).*

*** = highly significant different at 1% level, * = significant different at 5% level, ns = insignificant*

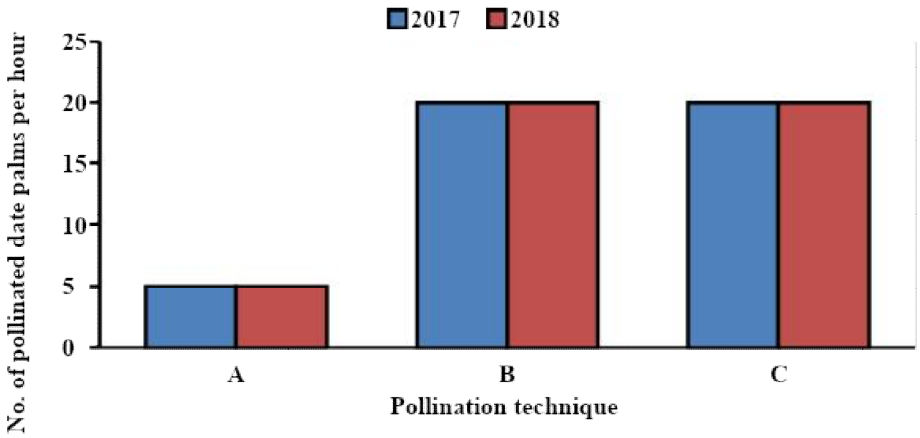


**Fig. 5. Number of pollinated date plams per hour for the different treatment**

### 3.5 Effect of Treatments on Dates Yield

Table 3 showed that there was significant effect of treatments on quantity of date yield at two seasons. For the two seasons, mechanical pollinator pollinated produced significantly higher yields for the two pressures as compared with manual pollination. The mechanical pollinator pollinated by high pressure was superior to other treatments (low pressure and manual pollination) at the two seasons; it recorded 605 kg, 1206 kg respectively while the lowest yield was recorded by manual pollination as 233 kg and 818 kg for the two seasons respectively (Fig. 6). The highest percentages losses of dates (un pollinated dates) was recorded by manual pollination as 6%, 3.7%, while the mechanical pollinator with high pressure recorded lowest percentages 2.0% and 1.4% (Fig. 7). With regard to spathes weight at the two seasons, the mechanical pollinator pollinated with high pressure was superior to other treatments, low pressure and manual pollination and recorded for the two seasons 9.2 kg and 14.2 kg respectively while manual pollination produced lowest weight 6.2 kg and 10 kg respectively.

### 3.6 Effect of Treatments on Quality of Dates

The data analysis in Table 3 showed that there was no significant effect of pollination methods on dates weight and width at the two seasons. Generally, dates fruit length at the second season was longer and the manual pollination produced significantly longer fruits as compared with mechanical pollinator pollinated with high pressure, but there were no significant different as compared with mechanical pollinator pollinated with low pressure. Table 3 also showed no significant effect on chemical characters (total and reducing sugars) of fruit at the two seasons for the three methods of pollination. The total sugar at first season, mechanical pollinator pollinated with high pressure produced significantly highest percent

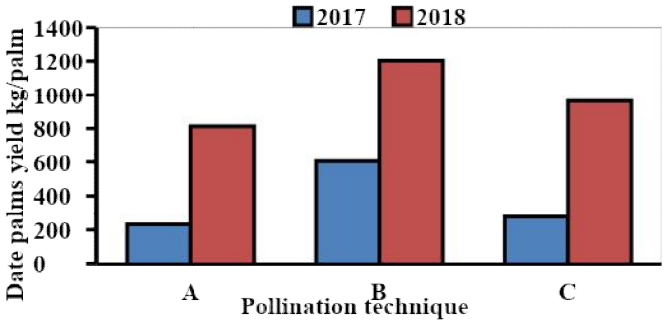


**Fig. 6. Yield of date plams for the different reatments**

(51.18%) and mechanical pollinator pollinated with low pressure recorded the lower percent (50.33%). At second season manual pollination produced significantly higher percent (50.61%) compared to the other treatments. With regard to reducing sugar manual pollination produced significantly higher percent at the two seasons (Fig. 8).

**Table 3. Effect of different methods of pollination on the percentages of un-pollinated date, yield, physical characters and sugar content of date palm during 2017 and 2018**

| Parameter | Pollination technique | | | | | | P-value | $Lsd_{0.05}$ |
|---|---|---|---|---|---|---|---|---|
| | A | | B | | C | | | |
| | Season | | | | | | | |
| | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | | |
| Un pollinated dates (%) | 6.00$^{a}$ ±0.15 | 3.70$^{bc}$ ±0.09 | 2.00$^{c}$ ±0.05 | 1.40$^{d}$ ±0.03 | 4.00$^{b}$ ±0.11 | 2.40$^{c}$ ±0.07 | 0.01$^{*}$ | 0.581 |
| Yield palm (kg) | 233.00$^{f}$ ±9.31 | 818.00$^{c}$ ±17.62 | 605.00$^{d}$ ±13.27 | 1206.00$^{a}$ ±35.29 | 278.00$^{e}$ ±10.25 | 967.00$^{b}$ ±24.11 | 0.0$^{**}$ | 43.29 |
| Fruit weigh (kg) | 0.01$^{a}$ ±0.00 | 0.03$^{a}$ ±0.02 | 0.01$^{a}$ ±0.00 | 0.03$^{a}$ ±0.02 | 0.01$^{a}$ ±0.00 | 0.03$^{a}$ ±0.02 | 0.06$^{NS}$ | 0.04 |
| Fruit length (cm) | 3.00$^{a}$ ±0.08 | 2.70$^{ab}$ ±0.05 | 3.00$^{a}$ ±0.08 | 2.60$^{b}$ ±0.04 | 3.00$^{a}$ ±0.08 | 2.70$^{ab}$ ±0.05 | 0.05$^{*}$ | 0.36 |
| Fruit width (cm) | 2.20$^{a}$ ±0.08 | 2.08$^{a}$ ±0.06 | 2.00$^{a}$ ±0.01 | 2.04$^{a}$ ±0.03 | 2.20$^{a}$ ±0.08 | 2.08$^{a}$ ±0.06 | 0.07$^{NS}$ | 0.61 |
| Total sugars (%) | 50.91$^{a}$ | 50.61$^{b}$ | 51.18$^{a}$ | 50.48$^{bc}$ | 50.33$^{c}$ | 50.49$^{b}$ | 0.04$^{*}$ | 0.19 |

*Mean value(s) bearing different letters within a row are significantly different (P0.05) according to DMRT (Duncan multiple range test).*

*** = highly significant different at 1% level, * = significant different at 5% level, ns = insignificant*

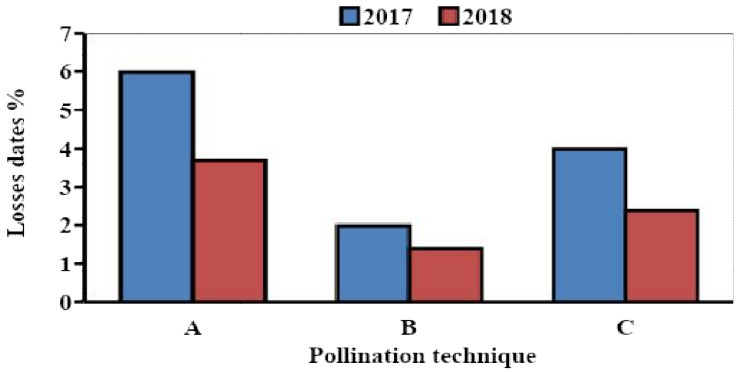


**Fig. 7. Losses dates (un pollinated dates) for the different treatments**

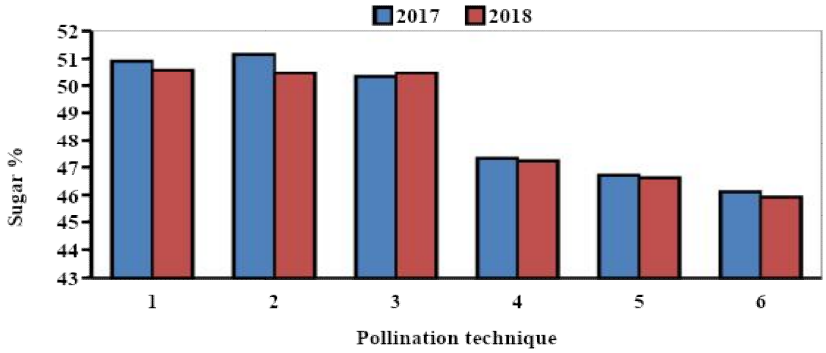


**Fig. 8. Suger content for the different treatments**

### 3.7 Effect of Treatments on Labor Requirements and Cost of Pollination

Labor requirements was compared between the pollination of the same number of trees by hand and mechanical pollination. Two labors were needed to pollinate 200 trees per year by hand pollination while only one operator was used to pollinate 720 trees by the mechanical pollinator (Table 2). This means that, eight labors will be required to pollinate 720 trees by using hand pollination. As compared with Alnahreen pollinator [15] which needed two operators per system whereas the present mechanical pollinator required only one operator. The pollination cost of the mechanical pollinator was the average of the two seasons and it was 9.1 Sudanese pound /tree. Based on prevailing rates, the manual pollination cost was 60 SDG/tree for 4 pollen applications per season. This means the mechanical pollinator was less than hand pollination cost many times. The feasibility of adopting a mechanical pollination system as a replacement for manual pollination was based on its impact on increasing the maximum number of pollinated trees/ seasons, reduction of labor requirements and pollination cost, in addition to its suitability to palm plantations.

## 4. CONCLUSION

Results of field tests showed that the mechanical pollinator recorded higher field efficiency, field capacity and reliability as compared to some existing mechanical pollinators and manual pollination. The mechanical pollinator increased the productivity of dates compared to manual from 233 kg to 605kg at the first season and from 818 kg to 1206kg at the second season. The mechanical pollination also increased the pollinated date palm trees from 200 trees to 720 trees per seasons and reduced the labor requirements to 50% and the cost of pollination was reduced from 60 SDG/tree to 9.1SDG/tree. For the two seasons, the mechanical pollinator showed highly significant difference for all measured parameters as compared with manual pollination.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES


1. Abdelouahhab Zaid. Food and agricultural organization of the United Nations, Rome, UNOPS - Date Palm Research & Development Programme, United Arab Emirates, Crop and Grassland Service, FAO Plant Production and Protection Division. 2002;2-56.
2. Abdellouahhab Zaid. Date palm cultivation. 1999;144-149.
3. Enaim JH, Jafar A. La Physiologie du palmier dattier (*Phoenix dactyliferal*); 1980.
4. Dowson VHW. Date Production and protection with special reference toNorth Africa and the Near East. FAO Technical Bulletin No. 1982;294.
5. Perkins RM, Burkner PF. Mechanical pollination of date palms. Ann. Date Grower's Inst. Rept. 1973;50:4-6.
6. Brown RM, Perkins EGV. Experiments with aircraft methods for pollinating dates. The Punjab Fruit J. 1972;119:116–127.
7. Nixon RW, Carpenter JB. Crowing dates in the United States. U.S. Dept. of Agriculture, Agrivulture, Agric. Information Bulletin; 1978.
8. Galeb HH, Mawlood EA. Effect of different Pollinators on fruit set yield of Sayer and Hallawy date palm cultivars under Basrah conditions. Date Palm J. 1987;5(2):155-173.
9. Sail FS, Khalid M. Appropriate date mechanization technology for Arabian Oses (Suitable for small Grower's). Amer. Soci. Engin. 1983;84–1570:24.
10. Fathi HA. Date palm, the tree of life between past, present and future of planting (in Arabic). 2005;423-433.
11. Al-Wusaibai NA, Ben Abdallah A, Al-Husainai MS, Al- Salman H, Elballaj M. A comparative study between mechanical and manual pollination in two premier Saudi Arabian date palm cultivars, National Date palm Research Centre-Al-Hassa-Saudi Arabia. FAO-Project (UTFN/ SAU/ 015/SAU); 2012.
12. Haffar I. Design and performance testing of amicro*duster for date palm pollination. Date palm, phoenix dactylifera, Machanical Pollination, pollen, Dusters; 2013.
13. Saeed Hajian. Fundamentals of pollination in date palm plantations In Iran. Date Palm and Tropical Fruits Research Institute of Iran; 2005.
14. Cini E. Mechanical date palm pollination in Tunisian Oases. Journal, Rivista di

Agricoltura Subtropicale E Tropicale. 1990; 84(2):309-320.

15. Ibrahim AAKJ. Al-Shaikhly YG. Yousif. Development of a new ground level pollinator for date palm. Palms and Dates, Agric Water Reso. Res. Center, Sci. Res. Council, P.O. Box 2416, Baghdad, Iraq; 1987.
16. Adel Ahmed Abul-Soud. Date palm in Pakistan, Current Status and Prospective. Shah Abdul Latif University, Khairpur, Sindh, Pakistan; 2011.
17. Hamood HH, Mawlood EA. The effect of, mechanical pollination on fruit set, yield and fruit characteristics of date palm (*Phoenix dactylifera L.*) Zahdi cultivar. Date Palm J. 1986;4(2):175–184.
18. Abdel Gabbar E. Date Palm, past, present and the new in its planting and processing and trading, (in Arabic). 1972;341-345.



*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*http://www.sdiarticle4.com/review-history/63044*