

# Contribution to the Study of the Effect of Pollination Mode on Fruit Set Rate and Yield in the Date Palm (*Phoenix dactylifera* L.) in the Oases of Tozeur (Tunisia)

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**Abstract** – Palm trees are dioic plants, spontaneous pollination does not give well results, hence the need for human intervention. In Tunisia, the palm sector represents the main pillar of the economy in the oases of the South. Pollination is a crucial period for palm farmers because of its importance in the production of dates. Several researchers have tried to mechanize pollination due to several factors namely the scarcity and high cost of skilled labor and palm fall accidents that can go as far as death. The present work contributes to the introduction of mechanized pollination in the oases of Tozeur providing farmers with a new pollination technique. The machine consists of a compressor with a gun mounted at the head of a telescopic pole. To validate this device we realized two types of pollination, the first is a traditional pollination and the second is a mechanized pollination. The experiments were carried out in an experimental plot of the Regional Agricultural Development Commissariat of Tozeur. The yield obtained with mechanized pollination was more than double that obtained by the traditional method. We have determined the best pollen / talc percentage which is 1/8 and which ensures the best yield. This work offers an effective alternative, given the promising results obtained with this process economically, safely and time saving.

**Keywords** – Date Palm, Pollination, Mechanization, Pollen, Manpower, Yields.

## I. INTRODUCTION

Date palm cultivation occupies an important place in the agricultural production system in Tunisia and ranks second in terms of exports of agricultural products after olive oil. This sector constitutes a major resource for the majority of the inhabitants of the oasis regions of the country. Statistics reveal that there are more than 5 million palm trees occupying an area exceeding 40 thousand hectares (1). Tunisia is known for its production of “Deglet Nour”, a variety of dates originating from the region of Djerid and Nefzawa and which has great commercial value. This is mainly due to the Tunisian state during the 80s that favored cultivation of this cultivar, given the demand of the international market. The date palm is a dioecious plant with male feet (Dokkar) and female feet. For good date production, pollination is a crucial operation. Currently in the southern Tunisian oases, the operation is to attach two or three male spikelets with in female inflorescences. For taller palms, usually other varieties like 'Aligüe' pollination is harder to achieve given the high height of these cultivars

which exceeds 15 meters and the operator has to climb several times (up to three times) according to the opening of the spathes.

Several studies have been conducted to mechanize pollination given its importance and difficulty. In Iraq, for the first time in 1952, phoeniculturists used a dusting machine similar to that used for insects (Fly-Tox). During the same year, at the Ain-Ben-Noui experimental station (Algeria), a pollen dusting system was developed using a powder equipped with light alloy tubes and flexible (Cadmium) to which the pollen do not adhere. It is enough to handle the bellows lever so that the projection of pollen spreads on the female inflorescences. In the United States in 1963 Preston pollinated a plane palm air of 1964 palm trees in an oasis in California by adding a support (wheat flour). In Iraq, Ibrahim (2) developed a mechanical pollinator for the date palm, which they called Alnahreen Polinator, whose operating principle is the dusting of pollen grains on female in florescences. Also, Yahia (3) has designed a pollinator that consists of a 12V battery-powered electric motor, hopper and plastic vibrating drum, which runs at a slower speed than the electric motor. Published research on an electric pollinator (4). The latter consists of a telescopic pole, an air distributor, a pollen pipe, a nozzle and a remote control. According to the authors, the comparative study has shown that the use of this pollinator is more advantageous than the traditional method of fertility. From this framework, the present work contributes to the enrichment of this subject putting at the disposal of the farmers in the oases a new device of pollination. The experimental set-up is developed in collaboration with the Regional Commissariat of Agricultural Development of Tozeur. Experimentation was tested in southern Tunisia, more precisely at the plot 112 Ibn Chabbat II oases (Tozeur) in 2017.

## II. PROBLEMATIC

Several reasons led us to design this machine, firstly the difficulty of carrying out the pollination operation, the scarcity and high costs of skilled workers, the risk of accidents caused during manual pollination in addition to the slowness of the operation. Following the farmers' request, we made contact with an industrial company, which specializes in the design of agricultural machinery.

The goal is to achieve a pollination device adequate to the oasis system and easy to handle by the farmer. The test farm is an experimental plot of the Tozeur regional agricultural development station located at Ibn Chabbat II oasis, 11 km southwest of Tozeur. Tozeur has a desert climate, with hot, dry summers and mild winters with an average annual rainfall of 93mm / year. The average annual temperature is 21.1°C.

### III. MATERIALS AND METHODS

#### A. Plants materials

We chose the "Deglet Nour" variety as a female foot for carrying out pollination tests. This variety represents 65% of the existing biodiversity in the palmerais of Djerid and Nefzawa. This is the most requested by farmers saw its commercial value high value added variety. Six feet of the Deglet Nour variety were chosen to carry out the pollination according to both techniques (manual and mechanical). We made three repetitions (3 feet) for each method. The feet are chosen in a way to be furthest away, three feet at the beginning of the plot and 3 feet at the end of the plot to avoid pollination by the pollen clouds produced during the mechanized pollination. The pollen grains used in these trials are from the same pollinator "Daglawi", they were chosen for their high germination rate (85%) and viability (95%). The choice of using the same pollen source for both methods is to eliminate the metaxenic effect of pollen on fruit set rate and yield at the end of the harvest.

#### B. Pollen Harvesting Technique

The techniques involve picking male inflorescences at the time of maturity but before the flowers are too open and lose pollen. The inflorescences are cut into spikelets. The spikelets are then placed in the shade in a non-humid environment on Kraft papers for drying for 2 days. The spikelets are shaken manually, and then harvest powder is sifted to remove debris flowers. The pollen grains are stored in sealed glass boxes and placed in the refrigerator at 4 ° C.

#### C. Viability Test

This is a simple staining test that estimates pollen quality based on the calculation of the percentage of viability (colored pollen versus non-stained pollen). Acetocarmin was used as a cytoplasmic dye (5). This dye has the ability to interpose in the nucleus to give it a red color. The viable pollens are colored red and acquire a spherical shape. Non-viable pollens do not stain and have wrinkled appearances. The observation was carried out under a microscope at magnification 40. Counting is performed by observing 3 microscopic fields.

**Viability rate %** = (Number of viable grains / Total number of grains observed) \* 100.

#### D. In Vitro Germination Test

This test makes it possible to calculate the percentage of pollens capable of germinating in vitro. We used Brewbaker's Medium and Modified Kwack (BKM) (6) agar (1% agar). Sterilization of the medium is done by autoclaving at 120° C. for 20 minutes. The culture medium is then poured into petri dishes at the rate of 10 ml / dish. All operations are performed under aseptic conditions (in the presence of a bunsen burner). Fresh pollen seeding is

carried out using a spatula and a very fine sieve to disperse the pollens in a homogeneous manner in the petri dishes under the hood. The incubation is carried out for 24 hours in an oven set at 27° C. The enumeration of the pollens is carried out thanks to a microscope at a magnification of 40 X. The result corresponds to the average of three repetitions. A sprouted grain must emit a pollen tube greater than twice its diameter. The ungerminated seeds remain oval without emission of pollen tube. The percentage of germination is defined as the ratio between the number of pollen germinated and the total number of pollen germinated (7):

**Germination rate %** = (number of pollen sprouted / number of grain observed) \* 100.

#### E. Manual Pollination Technique

The pollination of the date palm has always been successful with the following success: The inflorescences are harvested from the male palms as soon as the spathe burst. These inflorescences are constituted by a thick spadix carrying many branches or spikelets on which the flowers are fixed. The spikelets detached from the spadix used immediately or left to dry on racks. The worker then climbs the female feet after opening the spathe, then he puts 3 to 5 male spikelets in the opposite direction (from the top of the spath downwards) on the female spikelet's. Then the worker attaches male and female spikelets with a quill to prevent their dispersal.

#### F. Semi-mechanical Pollination Technique

This technique does not require that the worker climbs the female feet; the operation takes place on the ground. The technique consists of a projection of the pollen cloud around the spathe when it is opened. The worker must make a projection with each spathe opening with a minimum of three passes per foot. The pollen is mixed with the inert support in a proper ratio and placed in the compressor gun. The compressed air will dabble the mixture (pollen/ talc) then he will bring it via the telescopic pole to the spaths in the heart of the palm tree. A cloud of pollen is formed at each projection. In this test we made three reports for the mixture (pollen / talc), (1/8), (1/12) and (1/16).

#### G. Statistical Analysis

These tests will be statistically processed using the software (STATISTICA) to obtain the average values for each repetition and each test performed.

## IV. RESULTS AND DISCUSSIONS

#### A. Physiological Characterization of Pollen

Before planting a dokkar, the value of its pollen will be taken into account as it influences the harvest and the maturation period according to Osman (8). In addition some dokkars seem to give better results than others in the fertilization of the same palms. So it will be to choose the extent possible dokkars whose physiological characters (rate of viability and germination) are high. In our case the pollen 'Daglawi' chosen as shown in Figure 1, represents remarkable physiological values with a viability rate of 95% and a germination rate of 85%. This pollen will be used for both types of pollination to avoid the metaxenic effect of pollen on female flowers (9). Indeed metaxemia is the

direct action of pollen on the morphology of fruits, nuclei and the tissue of the mother plant other than the endosperm. Under the direction of Single, R.W. Nixon began in 1925 the first research work on metaxemia in date palm. After his experiments in 1925, 1926, 1927 and 1928; Nixon (10) reports that the size of fruit and stones and the time of maturity show significant differences depending on the pollen used. The influence of the pollen is manifested: On the size of the fruit, size of the seed, ratio pulp nucleus, precocity of the ripening (5). So the only effect that will be concluded in our study is the effect of the pollination technique.

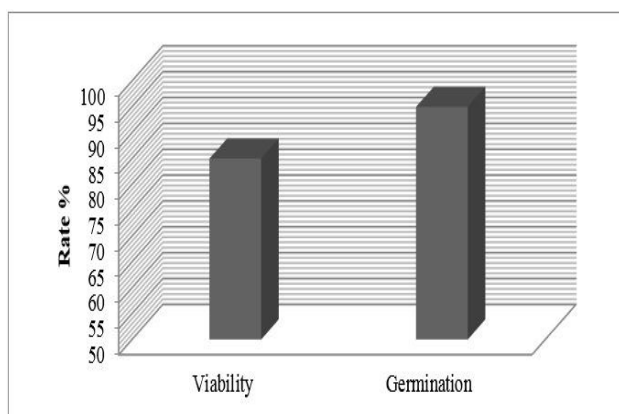


Fig. 1. Viability and germination rate in 'Daglawi' pollen.

### B. Effect of the Pollination Technique on the Fruit Set Rate

Percentage set is an indicator of compatibility between pollinator and variety (11). Fruit set is the result of fertilization. According to Nixon (12), the longer the crossing (that is, the male and female palms belong to different varieties) the poorer the setting. But for Pereau Leroy (13), fruit set depends much more on the female variety than on the origin of the pollen (14). Munier (15) cites that the percentage of fruit set in the date palm is all the higher as pollination is carried out as soon as the female inflorescences are bloomed because of floral receptivity. We tried to compare the fruit setting rate obtained with each pollination technique on the variety Deglet Nour. Figure 2 illustrates the effects of both methods on fruit set percentages.

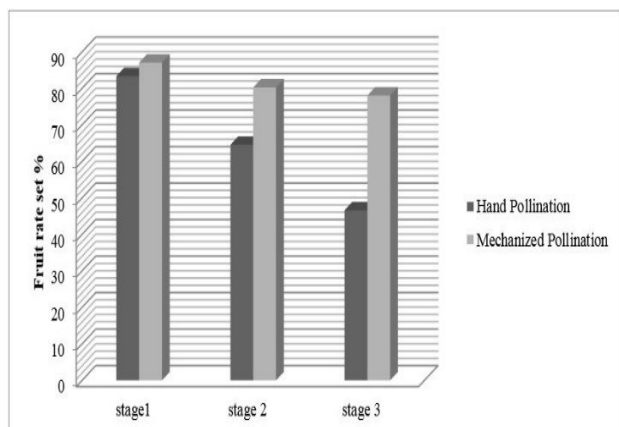


Fig. 2. Pollination-type effect on fruit set rate.

From the figure above, it is noted that the setting rate varies according to the emission stage of the bunch. Maximum setting rate was obtained for both techniques during the first stage of spath opening, with a slight superiority for mechanical pollination (87%). During the second phase of spath opening, there is a 25% reduction in fruit set in manual pollination (62%) compared to mechanical pollination (80%). This technique maintained a rate almost similar to that recorded in stage 1 (87%). During the second phase of spath opening, there is a 25% reduction in fruit set in manual pollination (62%) compared to mechanical pollination (80%). This technique maintained a rate almost similar to that recorded in stage 1 (87%). In stage 3, there is a remarkable drop of almost 40% fruit set rate in manual pollination (45%) compared to mechanical pollination (79%). Based on these results, the fruiting rate in mechanical pollination is almost constant and high (between 80 and 87%) in the three stages of spath



Fig. 3. Pollinated female spikelets at setting stage, T manually, M mechanically (S1: stage 1, S2: stage 2, S3: stage 3).

opening. However, in manual pollination a gradual decrease in fruit set rate is observed, ranging from 80% in the first stage to 45% in the last stage (figure 3). This is explained by a better dispersion of pollen grains provided by the powder. In addition the speed of pollination by the mechanical technique increases the rate of setting especially during the third stage, this stage is characterized by an increase of the daily temperature (month of April). Therefore more pollination is rapid after opening spathe, more the rate is high, which is not the case of manual pollination. Similar results were obtained (16, 17). Variance analysis shows that the pollination method has a significant effect on the setting rate with  $p < 0.05$ .

Table 1. Variance analysis (ANOVA) of the pollination mode on fruit set.

	SCE	DDL	CM	Test F	Prob (p)
<b>Total. Var</b>	3115	5	560		
<b>Factor Var.</b>	1978	3	2220	11.7965	0.01403
<b>Residual. Var</b>	1086	7	212		

### C. Effect of Pollination Technique on Yield

From a yield point of view, it can be seen from Figure 4 that the mechanized pollination yield is higher than that of the conventional one, and can wait up to three times (stage

3). From this figure it can be said that mechanized pollination has recorded an overall yield that is almost double that achieved by manual pollination. These results show the efficiency of this technique from a point of view of efficiency.

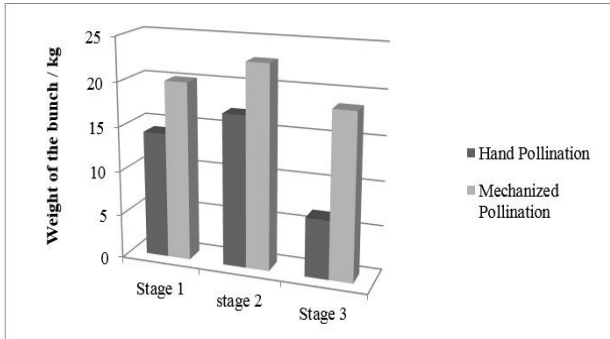


Fig. 4. Effect of pollination mode on yield.

As we have pointed out, mechanized pollination is more profitable (Figure 5) in the case of modern large-area plantations with aligned palms or at the scale of organized phoenicultural cooperatives; this is the case for plantations in the Gulf countries and California who have invested in these modern techniques since the 80s.



Fig. 5. Pollinated female spikelets at maturity stage, T manually, M mechanically (S1: stage 1, S2: stage 2, S3: stage 3).

For our case in Tunisia the introduction of these new techniques in the traditional and even modern oases becomes a necessity to improve the yield and assure the commercial competitiveness with the neighboring countries (figure 6). Variance analysis shows that the pollination method has a highly significant effect on yield with  $p < 0.05$  (Table 1).



Fig. 6. Variation in yield depending on the pollination mode (A: manual pollination); (B mechanical pollination).

Table 2. Variance analysis (ANOVA) of the pollination mode on yield

	SCE	DDL	CM	Test F	Prob (p)
<b>Total. Var</b>	2115	6	730		
<b>Factor Var.</b>	1698	2	1987	14.7965	0.02403
<b>Residual. Var</b>	1452	9	465		

#### D. Optimization of Pollen / Talc Mixture Dose

In this test we chose only spars belonging to the second stage, the pollinated spars are covered by a kraft paper after each operation of pollination to avoid cross pollination. The histograms below (figure 7) shows that fruit set rates vary according to the pollen / talc ratio.

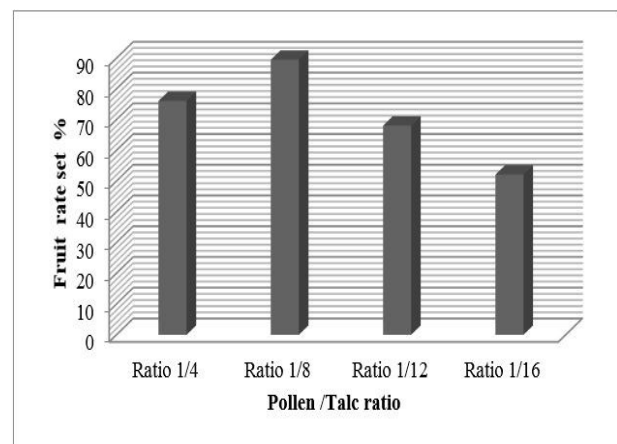


Fig. 7. Variation in the fruiting rate according to the pollen / talc ratio.

Overall it appears that 1/8 dose gives the best rate of fruit set (almost 90%), a 1/4 dose produced a lower rate. This may be due to the effect of talc which ensures homogenization and easier transport of pollen grains to the flowers. Beyond 1/8 ratio we notice a drop in the rate of setting, this is remarkable with a ratio of 1/16 this is explained by the dilution of pollen grains in talc. In conclusion we can say that the optimum ratio of pollen / talc mixture can range from 1/7 to 1/10 with an optimum of 1/8 (Figure 8). Analysis of the variance shows that the variation of the pollen dose has a very significant effect on the setting rate, with  $p < 0.005$  (Table 3).



Fig 8: variation in fruit set rate as a function of the pollen / talc ratio.

Table 3. Analysis of the variance (ANOVA) of the pollen / talc ratio

	SCE	DDL	CM	Test F	Prob (p)
<b>Total. Var</b>	1896	12	560		
<b>Factor Var.</b>	1320	5	420	5.4568	0.00609
<b>Residual. Var</b>	766	9	112		

## V. CONCLUSION

Pollination is a crucial operation in the life of the date palm. Nowadays, it turns out that many palm groves are abandoned due to a lack of qualified workers and lack of in-depth studies in this area. This research project offers an effective alternative to manual pollination, following the promising results obtained with the mechanical pollinator in terms of economy, safety and time saving. And when the function of this pollinator is based on pollen dispersal, we have determined that the best pollen / talc ratio is 1/8.

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**KADRI Karim** was born in Tunisia in 1978. He received the Diploma of engineering in Biotechnology science from the National Institute of Applied Science and Technology in 2003 and the Master degree on Genetic and molecular biology in 2005 and the PhD. degree in Biology in 2016 from the Faculty of sciences of Tunisia. He joined the National Institute of agronomic research of Tunisia, in 2004 as an engineer. Since 2007, he has been affected in the Regional Research Center of Oasis Agriculture, where he is currently member of laboratory of biotechnology and genetic resources. His main areas of research interest are conservation and improvement of Date Palm genetic resources. Dr. KADRI is a member of the Laboratory of Biotechnology applied to agricultural (INRAT), the Tunisian Association of Biotechnology (ATB) and the Date Palm Cluster.