Journal of Entomology and Zoology Studies
Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(4): 984-991

Received: 06-05-2017
Accepted: 07-06-2017

Meddich Abdelilah
Laboratoire Biotechnologie et Physiologie Végétale, Faculté des Sciences Semlalia, Université Cadi Ayyad Marrakech, Maroc

Boumezzough Ali
Laboratoire Ecologie et Environnement, Faculté des Sciences Semlalia, Université Cadi Ayyad Marrakech, Maroc.

Correspondence
Boumezzough Ali
Laboratoire Ecologie et Environnement, Faculté des Sciences Semlalia, Université Cadi Ayyad Marrakech, Maroc

First detection of *Potosia opaca* larva attacks on *Phoenix dactylifera and Phoenix canariensis* in morocco: focus on pests control strategies and soil quality of prospected palm groves

Meddich Abdelilah and Boumezzough Ali

Abstract
The present study illustrated the impact of *Potosia opaca* larva as devastating of two species *Phoenix Canariensis* and *Phoenix dactylifera*. We examined the possible relationship between the health status of palm trees and the soil quality of plantations. This study was performed on oases of Marrakech and Errachidia during the period of 2014-2016. The present study results showed that the larvae found belong to *Potosia opaca var.* cardui Gyllenhal. Chemical and mineral analyses showed that the level of organic matter was higher in soil of Marrakech palm grove (2.06-3.62%) than in Errachidia (1.51%). Levels of available phosphorus (6.98 ppm) and total nitrogen (0.05%) were very low in soils of Errachidia palm groves. K, Cl, Fe, Zn and Cu contents were high in the planting soils of *P. Canariensis* without exceeding the anomaly thresholds. Lead concentration was found to be low in the studied soils (< to 16 ppm). Phytopahtological analyses show the presence of saprophytic fungi in particular the Dimaties and genus *Fusarium* with a non-virulent strain. Finally, the present study proposed a strategy to control the larvae of *Potosia Opaca* to limit its risk of contamination of Moroccan oases.

Keywords: *Potosia opaca,* devastating, *palm trees, mineral and trace metallic, Marrakech* and Errachidia palm groves

1. Introduction

Phoenix canariensis is a species of flowering plant in the palm family Arecaceae, native to the Canary Islands [9]. It is a relative of *Phoenix dactylifera*, the true date palm. *Phoenix Canariensis* was one of the first palm trees introduced. It has since become widely acclimatized [8, 10]. Currently, this species is threatened both in its area of origin and in its peri-mediterranean culture zone [33]. The diversity and genetic structure of the species in its natural environment remain unknown. The integrity of spontaneous populations is endangered by hybridization with introduced species, particularly *Phoenix dactylifera* [33]. Besides theses problems, *P. canariensis* is affected by several factors of disturbance such as several pests (like the weevils *Rhynchophorus ferrugineus* and *Diocalandra frumenti*), infections (especially that caused by the fungus *Fusarium oxysporum*) and hybridization with the congener *Phoenix dactylifera* [26]. The red weevil causes millions of dollars in economic losses each year, in terms of agricultural production or costs related to pest control [24]. In the Gulf countries and the Middle East, $ 8 million is spent every year to cut down contaminated trees [22, 24]. In Italy, Spain and France, costs related to pest management, eradication and replacement of contaminated palms were estimated at 90 million euros in 2013 [24]. In Spain, red palm weevil has appeared since 1999 and damaged almost 20 000 palms of *P. dactylifera* [37]. In the North of Morocco and more precisely in Tangier, the number of *P. canariensis* prospected during 2009-2016 is 244 393 [4]. The number of *P. canariensis* infested with *Rhynchophorus ferrugineus* is 904, which 896 were incinerated [4]. Also despite the importance of the species and the potential reduction in population viability posed by fragmentation and other human-induced disturbances, there are few studies about the genetic structure and reproductive biology of *P. canariensis*, and none about Pest or devastating that would be instrumental to understand and manage plantation and conservation of this plant [4, 10]. Otherwise, the date palm plantations (*P. dactylifera*) play important roles in the development of oasis ecosystems. They are rich in varied genetic stocks and promote the creation of a favorable microclimate for the development of the underlying crops. It allows stabilizing the living of human populations in arid regions where natural resources are limited and the living conditions are difficult [16]. Date palms are a resource for many communities in the Middle East and North Africa, and for centuries, dates have become a staple food and are now among the major food crops. More than seven million tons of dates are produced each year and nearly 100 million date palms are grown today with 60% in the Arab countries [23]. In North Africa and in Morocco, the oases are facing several constraints related to urbanization, drought, salinity, desertification, poor soils in organic matter and nutrients, genetic erosion, aging and diseases like Bayoud palm caused by *Fusarium oxysporum f albidinis* [3, 30, 31, 43]. Whereas in Morocco no *P. dactylifera* has been infested with *Rhynchophorus ferrugineus*. Also, we noted the lack of accurate diagnoses in date palms. Poor management like no pruning, lack or excess of irrigation and fertilization will predispose the date palm tree to infestation by insect and mite pests [20]. In this context, we realized a diagnosis of palm trees planted in palm grove of Marrakech, Ouarzazate, Zagora, Errachidia and Casablanca. In our study, the diagnosis will concern palm trees which present a weak state. Thus, we examined the health status of palm trees of genus *phoenix* of two species *dactylifera* and *canariensis* and soil quality of these plantations. In addition, we will recommend strategies to control new larvae identified to limit oasis contamination.

2. Materials and Methods

2.1 Study Area and Plant Material

This study was conducted during the period of 2014-2016 in the oasis of Marrakesh located in the central region of Morocco and the oasis of Errachidia situated in the south-eastern part of the country. The majority of their territory presents arid climate, hot in summer and cold in winter.

Palms (*Phoenix*) constitute one of the important botanical families, and include some of the world's most important economic plants. In North Africa regions, dates production provides jobs for estimated 50 million people [17]. It plays by now an undeniable role in maintaining human populations in arid regions where natural resources are limited and living conditions are difficult [16, 17]. Like in Zagora, Errachidia, Ouarzazate are located between the Tafilalet and Draa. It is built on terraces, crowned by an old Glaoui kasbah of a hill and surrounded by a major oases of palm grove. The region includes the biosphere reserve oases of south eastern Morocco [19] and forms an agglomeration of ksours (Berber architecture in the form of small castles). It is surrounded by an area devoid of vegetation; dunes give way to regs (vast expanse of stones) where khetaras (structures related to the ancient local irrigation system) are still visible. As Marrakesh city, the area is under a semi-arid climate regime characterized by relatively cold and humid winters and hot and dry summers with a large diurnal temperature range [39]. This study was performed on *P. dactylifera* and *P. canariensis*. 60-year-old trees with a diameter of 70–90 cm were selected for larvae sampling (Fig. 1). Analyzed leaves were 4–5 m long with 80–100 segments on each side of the spine. No specific permissions were required for these locations and activities. The field studies did not involve endangered or protected species. The pathogen presence was visually confirmed. No plants were available at very early stage of infection.

Fig 1: Picture of *Phoenix canariensis* in Marrakesh city.

2.2 Physico-chemical analyzes of palm planting soil

The current study analyzed the mineral elements and metallic trace elements for palm plantation soils (*P. Canriensis* and *P. dactylifera*) in Marrakech and Errachidia palm groves. Soil sampling was conducted in April 2015.Three samples of rhizospheric soil were collected at the base of *P. canariensis* and *P. dactylifera* which have an average health status to puny. These soil samples are taken at 0.5 m of the trunks *P. canariensis and P. dactylifera*, the distance between two successive points is included between 50 and 80 meters and has 10 to 40 cm of depth. Soil samples are then homogenized to obtain a homogenous and representative sample of the entire site of *P. canariensis and P. dactylifera*. For each point, we collected 0.5 kg, and mixed all the samples to get a representative sample of the area. Analyzes of mineral elements and metallic trace elements were developed on 3 replicates, each obtained from the mixture of eight samples taken at random in the palm investigation site. A total of twenty-four (24) rhizospheric soil samples were collected from each site in order to obtain consistent results. Subsequently, we proceeded to the laboratory for established various analyze. Thus, the pH measurement is performed by electrometrically using a pH meter. The electrical conductivity defines the total amount of soluble salts corresponding to the overall salinity of the soil, it depends on the content and nature of the soluble salts present in the soil. It is determined using conductivity. Analyzes of mineral content and metal trace elements (Etm) of soils are carried out by a Delta portable XRF analyzer equipped with specialized calibrations, specifying the concentrations of these identified elements. The available phosphorus is determined by the Olsen method [27]. The measurement of total nitrogen is based on the conversion of organic nitrogen to ammonia nitrogen. The sample is mineralized with concentrated sulfuric acid in the presence of the Kjeldahl catalyst and then the ammonia formed is displaced by NaOH (40%). The ammonia entrained by the steam is fixed by boric acid and titrated with sulfuric acid. The NTK content is determined by the Velp-UDK132 distillation unit [36].

2.3 Phytopathological analysis and fungi isolation

The present study used augers to levy excerpts localized and perform microbiological isolates. To deepen the diagnosis of *P. canariensis*, we made levies of rachis, leaflets palms, dry and green leaf bases at the crown. We have carried out cultures and incubation of extracts of rachis (1cm) and palm leaves puny on selective media and non-selective.

2.4 Sampling techniques and prospecting the crown of Palm

During the exploration of the palm crown, using a scaffold (Fig. 2A), a number of larvae (white grubs) sluggish and arched with strong mandibles were harvested at the base of the green rachis and/or dead. Similarly, insect larvae were removed from the base of live palms and dried for laboratory breeding in incubators with controlled conditions of temperature, humidity and photoperiod.

Dead rachis (Fig. 2B) were brought back to the laboratory to explore them further and also put them in terrariums to ensure the follow-up and development of the larvae trapped inside in the hope of having imagos (adult forms). Identification of larvae was performed according to the key proposed by Mico and Galante [32].

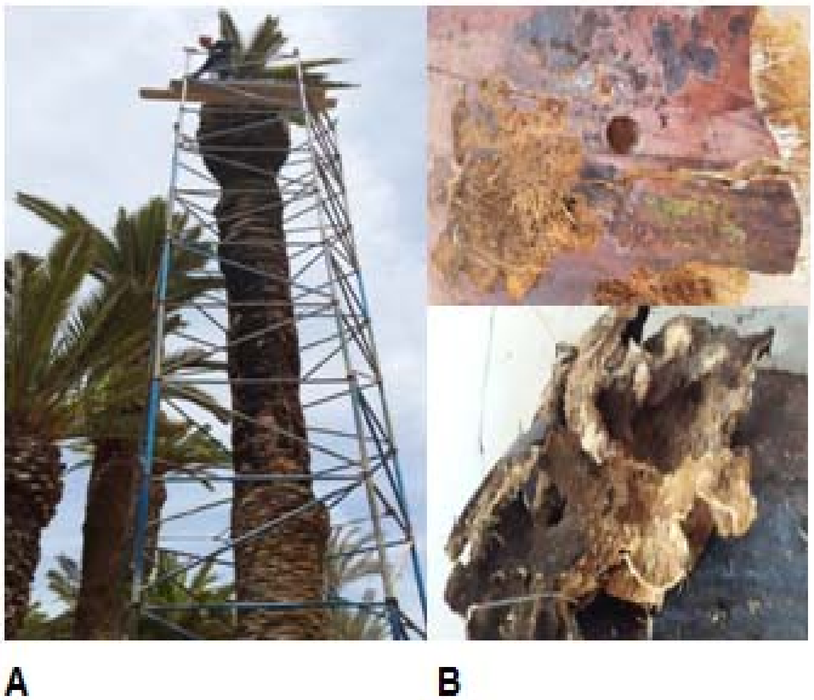

Fig 2: Exploration of the *P. canariensis* palm crown using a scaffold (A); Base of leaves (B).

2.5 Breeding of larva and nymphs

The larvae collected were immediately placed into breeding boxes; transparent, with openings in lateral side and on the top of the boxes to ensure oxygenation and avoid asphyxiation. The openings on the boxes are closed with a fabric scrim (muslin type). Rectangular boxes were used for rearing larvae harvested from *P. canariensis* and *P. dactylifera*. The breeding substrate was composed of a mixture of untreated natural soil and debris of dead wood, rotted wood, and sawdust. Care was taken not to import diseases on bringing boxes of dry dung in breeding substrate in order to increase its acidity which disadvantages the development of diseases. The breeding substrate was constantly renewed as soon as the feces of larvae appear in large quantities on the surface and more debris and wood in the rearing environment was observed. This breeding operation continued in incubators refrigerated and illuminated with controlled temperature and humidity. However larvae are lucifugous (escape behavior of light); the optimum temperature is between 25 and 30 °C.

The nymphal hulls were placed in boxes with slightly damp peat. The duration of pupation varies according to the temperature supported by the larvae and also the male or female sex. The infected nymphal hulls were removed as soon as possible from the breeding environment to avoid pathological contamination of the rest of the cocoons.

2.6 Statistical analysis

All results were analyzed statistically with the CO-STAT software (Statistical Software, New Style Anova). The study includes an analysis of variance followed by the Newman and Keuls test at the 5% threshold.

3. Results and Discussion

The results of physicochemical and Etm analyses at palm plantation soils in Marrakech and Errachidia palm groves are presented in Table 1. The soils of *P. dactylifera* in Errachidia palm grove were more alkaline (9.54) compared to the soils of Marrakech palm grove (8.2). Their electrical conductivity is between 0.46 and 0.74 ms / cm for Errachidia and Marralech soils respectively. According to the interpretation of salinity standards, these soils are moderately saline. The level of organic matter was higher in soil of Marrakech palm grove than in Errachidia. The soils of *P. canariensis* benefit more from fertilizers than the soils of *P. dactylifera.* According to the interpretation standards of available phosphorus [13], the contents of this element were very low in soils of *P. dactylifera* than soils of *P. Canariensis* (42 ppm) and especially in palm grove of Errachidia (7 ppm). Also, the soils of Errachidia palm grove were poor in total nitrogen (0.05%); while those in Marrakech palm grove were moderately rich in this element (0.13-0.25%), based on the interpretation standards given by Calvet and Villemin [6]. Similarly K, Cl, Fe, Zn and Cu contents were high in the planting soils of *P. Canariensis* without exceeding the anomaly thresholds [12, 41].

Table 1: Physico-chemical parameters, mineral and metallic trace-elements in Marrakech and Errachidia palm groves.

	Samples of *P. Canariensis* plantation soils in Marrakech palm grove	**Samples of *P. dactylifera* plantation soils in Marrakech palm grove**	**Samples of *P. dactylifera* plantation soils in Errachidia palm grove**
pH	8.24±0.0141	8.19±0.0212	9.54±0.0282
Electrical conductivity in ms/cm	0.74±0.0004	0.71±0.0031	0.46±0.0002
Organic matter in %	3.62±0.30	2.06±0.28	1.51±0.22
Elements	Concentrations by % (g / 100g)		
Cl	4.61%±0.05	3.55±0.05	3.94±0.06
Fe	4.22%±0.06	0.98±0.01	0.98±0.01
Ca	2.48±0.02	5.94±0.03	6.01±0.03
N Total	0.25±0.05	0.13±0.02	0.05±0.012
Elements	Concentrations by ppm (mg/kg)		
K	3228±43.46	782±31.74	823±34.49
P assimilable	42.30±6.35	30.98±7.26	6.98±1.67
Si	941±91.01	4946±145.67	5036±153.94
Al	2626±425.04	2609±424.91	3291±640.03
S	223±27.82	547±31.07	601±33.40
Sr	196±2.37	196±2.33	259±2.86
Zr	135±2.09	139±2.08	136±2.19
Zn	56±3.53	30,9±3.04	29,2±3.13
Cu	20±4.34	14,4±4.19	15,6±4.44
Pb	7±2.06	13.3±2.15	15,68±2.31
Y	17±1.17	14.2±1.20	11,92±1.13

On the other hand, Ca, Si and S concentrations were elevated in *P. dactylifera* soils. The three soils were characterized by similar levels of Zr with high Sr and Al contents in soil of Errachidia palm grove. The concentration of Pb and Y elements remained low in the studied soils compared to standards [14]. Pb was more represented in *P. dactylifera* soils than in *P. canariensis* (Table 1). In Laboratory the phytopathological analyzes, showed fungal formations (blackish, whitish and greenish spots) observed on the inoculated Petri dishes. After observation under the microscope, it has been found as saprophytic fungi in particular the Dimaties, with blackish spots; those take advantage of the damage already noted and the genus *Fusarium* with a non-virulent strain developed in whitish and pinkish spots with some conidia. The genus *Trichoderma* is widespread, in greenish spots and is often a key fungus in symbiosis and in biological control.

Date palms are afflicted with many diseases and pests [20, 28]. Carpenter and Elmer [7] reported more than 50 species of insects and mites as pests of date palms in various countries. During the exploration of the palm crown (*P. canariensis and P. dactylifera*), a number of larvae (grubs) soft arched with strong mandibles were harvested at the base of the green spine and / or dead (Fig. 3).

Fig 3: Larvae founded in the palm crown (*P. canariensis*) (A and B larvae), (C) Leaf base.

The first diagnosis of these larvae showed that they have a powerful mandibles, form "melolonthoides", sub-cylindrical strongly arched, whitish, with head, stigma and brownish legs; the head was always perpendicular to the body axis, with blackish posterior end; related to the larvae of beetles Scarabeidae (3 pairs of legs, antennae with 3 items). Maximum width of head capsule 4.6-4.9 mm.Cranium; Colour light yellow. Dorsoepicranium with 2 groups of short setae more or less arranged in 2 rows on each side; Clypeus with 2 anterior setae and 2 external setae on each side. Labrum; Trilobed, narrower than clypeus; clithra present. Epipharynx. Plegmatium absent. Corypha with 4 long setae flanked by 2–3 sensilla on each side. Haptomeral region with slightly curved, transverse row of 15–18 heli above which are 7–9 sensilla. Acanthoparia with 7–9 short and stout setae, decreasing in size posteriorly. Chaetoparia well-developed, covered with longitudinal rows of long, stout setae and many smaller and finer setae near the gymnoparia. Haptolachus with 4 sensilla (2 on the base, 2 on left margin). Sensorial cone present Antenna. 4-segmented.Apical segment with 2 dorsal and 3 ventral sensory spots (1 lateroexternal, and 1 laterointernal). Legs. Tarsungulicylindrical bearing 10–11 setae.Antenna.4-segmented. Apical segment with 2 dorsal and 3 ventral sensory spots (1 lateroexternal, and 1 laterointernal). Tegilla composed of short, acute setae and sparse long setae. Legs. Tarsunguli cylindrical bearing 10–11 setae. Larvae of the Scarabeidae Coleoptera live normally and develop on decomposing organic matter such as manure, compost being degraded and mated. These larvae were either rhizophagous (melolonthoids) or saprophytophagous or saproxylophagous (Cetoniidae). Initial research has shown that in the forms of phytophagous and saproxylophagous larvae, egg-laying can include about one hundred eggs placed directly in the soil or in the wood, sometimes with the aid of an auger [40]. According to field investigations, the present study observed the theft of a number of Scarabeidae beetles from the Cetoniidae family, but linking the larvae harvested at the level of the palm crown and the adults captured on the flight seems to be an illusory thing especially since all the larvae of Coleoptera Scarabaeidae were similar and that the systematic identification at the generic and specific level requires a rearing of the larvae under appropriate conditions of temperature and humidity for obtaining the adult, The ultimate stage of development of this Scarabeidae and whose characteristics were indispensable for the identification of specimens. The evolution of the larvae is carried out at the base of the palms and rachis weakened and attacked by saprophytic fungi which can lead to the appearance of rot and the dieback of the weakened palm. Their presence at the top of the palm can also be explained by the fact that this beetle found an ideal biotope for the proliferation of larvae. Probably the adult manages to lay his eggs at the base of the weakened rachis and continues its development process while damaging the foliar bases as well as the heart of the palm. The larvae of this insect developing in the crown of the stem can infect the whole leaf mass and cause the crown tilt, which can be fatal to the palm. It should be noted that important attacks are observed at the palms base, at the crown; Attacks marked by the formation of galleries with a rejection of sawdust and dejections of white grubs (Fig. 3). After one month of larval rearing, the majority of stage III (L3) larvae are transformed into nymphs (the last stage before adult release). At the end of the last stage of development, the larva becomes more yellowish (accumulation of adipose tissue to the detriment of the stercoral volume of the rectal sac).

The premymphal phase lasts a few days during which the elderly larva (L3) no longer feeds and migrates to the bottom of the substratum to build a pupal cocoon which it generally chooses to make against a support (Fig. 4).

Fig 4: Observed cocoons (A) and nymphs (B).

Pupation occurs in the dorsal position since the larvae move on the back, which distinguishes them from Oryctes larvae (Rhinoceros). In general, its cycle development from the egg to the imago known to be set on one year [40]. However, its metabolic activity is closely related to the ambient temperature, the low temperatures slow down this passage which may last 2 years [40]. The oases, Moroccan as already said are relatively warm, which could privilege this passage.

The nymph of brown-orange color has appendages entirely free and folded down on its ventral surface. During this critical phase of development, the insect does not feed, its mobility is very limited and it is very dependent on the conditions of the environment (temperature, humidity and predation). During this passive stage of development, the nymph gradually acquires a darker color. This pigmentation is perfected in the days before the moult. On the occasion of this final metamorphosis, the insect takes a ventral position, in order to facilitate the deployment of wings and elytra. Its tissues harden progressively in the presence of oxygen from the air. After gaining greater rigidity, the adult perforates its cocoon and migrates to the surface of the substrate in order to begin its phase of aerial life. The adult that has just hatched is sometimes still a little soft and often presents colors less sustained and clearer than its older congeners (Fig. 5).

(A) **(B)** **(C)**

Fig 5: Adult observed in his damaged cocoon (A), B and C Free adults.

Examination of adults under binocular loupe and using a dichotomous key and reference collections from the laboratory led us to the species of Coleoptera Scarabeidae: *Potosia opaca* var. cardui Gyllenhal. This species varies greatly in size (from 14 to 24 mm), its morphology with the sides of the pronotum which can be weakly indented before the posterior angles, or not indented. Its coloring; On the top, the general color black or dark, passes more rarely to the dark green (typical form) and even to bronze and green with coppery metallic reflection; On the underside, the color is sometimes black, sometimes bluish, or sometimes greenish or white.

Systematic

Hexapoda (Insecta)

Coleoptera,

Scarabeidae

Cetoniini

Potosiaopaca Fabricius

Tauzine [40] indicated the presence of this species in Anti-Atlas (Ifni, Tiznit), middle and southern of Morocco. The presence of *Potosia opaca* in the crown of the *P. canariensis* and *P. dactylifera* palm can be explained only by the fact that adults have found an ideal biotope for egg laying and larval development. The present study showed that *P. opaca* occured in decaying wood of and *Phoenix dactylifera* L., also, where they consumed the wood and promote more rapid decay and laid their eggs in the hollows of branches. The present finding was supported by Mico and Galante [32]. Besides, adults of the Cetoniidae fly above the vault of the trees (including the palm tree) and feed on nectar plants and fruit trees and probably the inflorescences of the palm trees. In this way, it can be assumed that this species has undergone a mutation by changing biotope and passing from saprophagous larvae (dead organic matter, compost) to saproxylophagous larvae (dead woods, rachis and dead and / or alive palms of the *P. canariensis* and *P. dactylifera*). However, we note that the prospected and infected *P. canariensis* palms were planted and located in the north-east palm grove of Marrakech. This will allow exchanges of contamination between the two palm species studied. For the oasis one, the problem will cause a lot of damage and a serious socio-economic problem. The date palm (*Phoenix dactylifera* L.) is a former species which constitutes the pivot of the oasis agriculture in the south of Morocco. Out of an overall area estimated at 84 500 ha in 1948, the Moroccan palm groves in 1994 covered an area of 44 450 ha occupied by a total of 4.42 million palm trees [22].This population is currently estimated at 5.12 million palms on an area of 48 000 ha. The importance of the palm by province, given in Table 2, showed that the provinces of Ouarzazate, Errachidia and Tata (Bani) were the most important and thus constitute the largest phoenicultural areas (quoted by Sedra [38] and updated by Meddich) [29].

Table 2: Importance of date palm by province or prefecture in Morocco.

Province	Number	Percentage %
Ouarzazate	1 873 000	36,55
Errachidia	1 250 000	24,39
Tata	800 000	15,61
Marrakech	799 000	15,59
Tiznit	139 140	2,72
Guelmine	138 000	2,69
Figuig	125 500	2,45
Total	5 124 640	100

As finding of this study, *Potosia opaca* larva was found of all studied sites. The phytophagous species (Scarabeidae) were active at night. In the broad sense, saproxylophages cause damage by attacking either roots or leaves. Larvae (white worms) were generally the most harmful to palms. So, we can conclude that the degradation of the Moroccan palm grove may be linked to the attack of *Potosia opaca* larvae. We observed that the frequency of palms prospected and infected with *Potosia opaca* remains higher in the Marrakech palm grove than in the south of Morocco. Date palm grove of Marrakech is more confronted with anthropogenic constraints such as urban extension and air pollution by dust exceeding the tolerance threshold [29, 35]. Suspended particle concentrations in certain areas of Marrakech are slightly above the limit value for health protection in Morocco [35]. This may favor the creation of biotopes necessary for the development of larvae of *Potosia opaca* in this city. The soil quality analysis revealed that Errachidia palm grove was less fertilized and poor in organic matter than Marrakech palm grove. We can't, however, establish direct relations between the frequency of insect attacks and the quality of soil studied. According to INRA reports, Moroccan palms suffer from invasions by larvae and adults of Rhinoceros Borer (Coleoptera: Scarabaeidae), as the case in Tunisia, Middle East or Iran [11, 15, 16, 18].

The present study concluded that no Rhinoceros Borer (*Coleoptera: Scarabaeidae*) larvae or adults were found. Also, the colonization of the wounds by the saprophytic fungi can lead to the appearance of rot and the dieback of the weakened palm. Control of these insect pests involves spreading chemicals (in the form of toxic pellets) as uniformly as possible in areas where the larvae are causing damage. The elimination of diseased palms (attacked by larvae) can reduce the spread of the pest and consequently limit the damage.

Many researches carried out in other countries have highlighted the danger of the red palm weevil for both species *P. dactylifera* and *P. canariensis*. In the Arab countries, the efforts deployed to control *R. ferrugineus* were based mainly on modified cultural practices, the application of traditional insecticides and recently traps that uses pheromones to lure *R. ferrugineus* [1]. Efforts now focus on the development of integrated pest management methods based on biological control and pheromone traps rather than on conventional insecticides [34]. Since it is an internal tissue borer, *R. ferrugineus* is difficult to control in the early stage of attack [1, 25]. Initial efforts to control red palm weevil in the Kingdom of Saudi Arabia using chemical insecticides were failed [5]. Recently, an integrated pest management strategy, developed in India, has successfully suppressed the pest in the date plantations in the Kingdom of Saudi Arabia [1]. The strategy is modeled on the lines of tackling the pest on coconut. The pheromone traps has been used successfully to monitor and mass attract the pest, and it could be considered as the core of in any integrated pest management [2, 21, 42].

Nevertheless, we believe that it is also necessary to target the larval stage which is more dangerous. Further studies are needed to develop an effective integrated biological treatment.

4. Conclusion

This study reveals that Palm trees in Moroccan oasis are facing a new threat which is *Potosia opaca* larvae. Phytopahtological analyses show the presence of saprophytic fungi and genus *Fusarium* with a non-virulent strain. The soils of Errachidia palm grove were poor in phosphorus, total nitrogen and organic matter than in Marrakech. The soils of *P. canariensis* benefit more from fertilizers than the soils of *P. dactylifera*. The content of metallic trace elements remained low in prospected soils without exceeding the anomaly thresholds. On the other hand, we can't establish direct relations between the frequency of insect attacks and the quality of soil studied.

5. Recommendations

One of the causes of the high rate of spread of this pest is human intervention, by transporting infested young or adult date palm trees from infested to clean areas. Also, prophylaxis remains very important; it consists in increasing the resistance of the palm tree by the use of the recommended cultural methods in phoeniculture, among others:

1. Clean the stipes by the entire removal of the old foliar bases on the trunk of the palms from the base of the trees to the crown. Proceed as follows:
   Maintain only between 10 and 14 fins that surround the heart of the palm at the level of the crown;
   Remove, burn and release off-site dead palm trees;
   Eliminate the larvae at the base of the leaves and rachis by cultural methods.
2. Providing showers, by spraying water, at the crown to clear all dust, "suspended soils" at the base of the leaves,

organic matter resulting from decomposition of leaves and base Dead spines;
3. well work the soil to bury organic matter and superficial plant debris which can become egg-laying sites for this scarabeidae beetle whose larvae grow in the soil rich in decomposing organic matter and / or compost.

For preventive treatments of the aerial parts and the crown of the palm:

- Use Imidacloprid (200 g / l) by spraying at the crown (stipe, palm and heart) 2 to 3 times. It is a systemic insecticide for the selective control of scarabeidae beetles.
- Spray acetamiprid 100g / l at 2-3 times / year.
- Also use entomo-pathogenic nematodes with a dose of 180 million nematodes per 100 L of water, which act by reducing the size of the larvae and consequently affect the number of female adults capable of laying the eggs.
- Trapping control using pheromones. The use of such specific substances for sexual confusion may be a means to attract one of the two sexes and to minimize the fertilization operation.

For curative treatments

- Use Imidacloprid 200G / l.
- Sanitation of infested palm trees:
- Remove contaminated tissue,
- Ensure proper crown size,
- Clearing and pruning the foliar bases along the stem, especially in winter when the beetles are immobilized by cold and the palms themselves are in a period of vegetative rest.

It is important to determine the propitious time to ensure the protection of palm trees and therefore to plan for better control of invasions of larvae whose damage is dreadful in palm trees. In this context, we propose a control strategies illustrate in Table 3.

Table 3: Proposed Control Strategies.

	First year strategy	Second year strategy
From 01 March to 30 June	5 Applications of entomopathogenic nematodes (Rhabditisblumi or Steinernemacarpocapsae) (spacing of 21 days) + Spraying of Benomyl (0.5%)	4 Applications of entomopathogenic nematodes (Rhabditisblumi or Steineremacarpocapsae) alternating with application of insecticide treatment (spaced from 21 days to 01 months) + Spraying of Benomyl (0.5%)
From 01 July to 31 August	2 Applications of insecticides (Imidacloprid) (200g / l) (21 days apart) + Spraying of Benomyl (0.5%)	None Application of nematodes and insecticides Spraying of Benomyl (0.5)
From 01 September to 15 November	5 Applications of entomopathogenic nematodes (Rhabditisblumi or Steineremacarpocapsae) (spaced 21 days apart).	4 Applications of entomopathogenic nematodes (Rhabditisblumi or Steineremacarpocapsae) alternating with application of insecticide treatment (spaced from 21 days to 1 month)

6. Acknowledgments

The authors would like to thank Mr. Zenjali Tariq for linguistic consultation. We also thank the Mohammed VI Foundation for the Protection of the Environment in charge of the project to preserve the palm grove of the City of Marrakesh.

7. References

1. Abraham VA, Al Shuaibi M, Faleiro JR, Abozuhairah RA, Vidyasagar PSPV. An integrated management approach for red palm weevil, *Rhynchophorus ferrugineus* Oliv. A key pest of date palm in the Middle East. Agricultural Science. 1998; 31:77-83.
2. Al-Saoud AH. Effect of ethyl acetate and trap colour on weevil captures in red palm weevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) pheromone traps. International of Tropical Insect Science. 2013; 33(3):202-206.
3. Awad MA. Water spray as a potential thinning agent for date palm flowers (*Phoenix dactylifera L.*) c.v. 'Lulu'. Scientia Horticulturae. 2006; 111:44-48.
4. Ben Ayad A. Presentation of the status of infestations by the red weevil in Morocco. Notions on the biology of the pest. A strategy for the control of the disease. Workshop on the technique of endotherapy applied in the framework of the strategy against the red palm weevil. Training organized by the Ministry of Agriculture and Maritime Fisheries (National Office of Food Safety of the Regional Directorate and the company Fertileader. Tangier, Morocco, 27 March 2017.
5. Bokhari UG, Abozuhairah RA. Diagnostic tests for red palm weevil. *Rhynchophorus ferrugineus* infested date palm trees. Arab Gulf Journal Science Research. 1992; 10(3):93-104.
6. Calvet G, Villemin P. Interprétation des analyses de terre, IPAS, SADEF- Ed. SCPA, Aspach le Bas, France, 1986, 25.
7. Carpenter JB, Elmer HS. Pests and diseases of the date palm. United States Department of Agriculture. Agric. Hand Book. 1978; 527:1-42.
8. Castellana R. Le palmier des îles Canaries (*Phoenix canariensis*). Histoire comptemporaine d'une diaspora emblématique. CRP Ed (Passionsvegetales). 2014, 13.
9. Chabaud B. «*Le Phoenix canariensis*» dans Provence agricole et horticole illustrée. 1982; 19:293-297.
10. Chabaud B. Les palmiers de la côte d'Azur : distribution géographique, culture, description des genres et espèces, Paris, Librairie agricole de la maison rustique (Bibliothèque horticole), 1915, In-8, 208.
11. Chao CCT, Krueger RR. The date palm (*Phoenix dactylifera L.*): overview of biology, uses and cultivation. Horticultural Science. 2007; 42:1077-1082.
12. Ctifl. Les analyses de sol « extraits à l'eau » en culture légumières : d'un référentiel à l'autre. Info-Ctifl n°189, 2003, 47-49.
13. Delaunois A, Ferrie Y, Bouche M, Colin C, Rionde C. Guide pour la description et l'évaluation de la fertilité des sols destinés aux agriculteurs et aux agronomes. Chambre d'Agriculture du Tarn 81, INRA de Montpellier, France, 2008, 37.
14. Denayer FO. Ecotoxicité des éléments traces métalliques chez les bryophytes. Thèse de Doctorat. Université de Metz. France, 2000, 253.
15. Ehsine MM, Belkadhi S, Chaieb M. Bio-ecologic observations on rhinoceros beetle Oryctes agamemnon (Burmeister 1847) on the palm dates Oasis of Rjim

Maatoug in South-Western Tunisia. Journal of Arid Land Studies. 2009; 19:379-382.

16. Ehsine M, Belkadhi MS, Chaieb M. Seasonal and Nocturnal Activities of the Rhinoceros Borer (Coleoptera: Scarabaeidae) in the North Saharan Oases Ecosystems. Journal of Insect Science. 2014; 14(256):1-5.
17. El Hadrami I, El Hadrami A. Breeding date palm, in S. M. Jain and P. M. Priyadarshan (eds.), Breeding plantation tree crops: tropical species. Springer, New York, 2009, 191-216.
18. El Hadrami A, Al-Khayri JM. Socioeconomic and traditional importance of date palm. Emirates Journal of Food and Agriculture. 2012; 24:371-385.
19. El Rhaffari K, Hammani M, BenlyasZaid A. Traitement de la leishmaniose cutanée par la phytothérapie au Tafilalet. Biologie and Santé. 2002; 1(4).
20. El-Shafie HAF. Review: list of arthropod pests and their natural enemies identified worldwide on date palm, *Phoenix dactylifera L*. Agriculture and Biology Journal of North America. 2012; 3:516-524. ISSN Print: 2151-7517, ISSN Online: 2151-7525, doi:10.5251/abjna.2012.3.12.N.
21. Faleiro JR, Ashok Kumar J, Rangnekar PA. Spatial distribution of red palm weevil *Rhynchophorus ferrugineus* Olivier in coconut plantations. Crop Protection. 2002; 21:171-176.
22. FAO. Données statistiques de production végétale, site FAOSTAT Database. Site web : Foa.org.com, 2003.
23. FAO. FAOSTAT. FAO, Rome, Italy, 2014.
24. FAO 2017. Palmiers: Un plan d'action international contre le charançon rouge. APS. Communication publiée le 30/03/2017. APS. www.huffpostmaghreb.com/2017/03/30/palmiers-protection-chara_n_15705940.html.
25. Ferry M, Gomez S. The red palm weevil in the Mediterranean area. Palms. 2002; 46(4):172-178.
26. Gonzalez-Perez MA, Caujape-Castells J, Sosa PA. Molecular evidence ofhybridisation between the endemic *Phoenix canariensis* and the widespread *P. dactylifera* with Random Amplified Polymorphic DNA (RAPD) markers. Plant Systematics and Evolution. 2004; 247:165-175.
27. Hafidi M, Badri W, Kaemmerer M, Revel JC. Comparaison des méthodes d'extraction chimique et biologique pour la détermination du phosphore assimilable. Actes Institut Agronomique et Vétérinaire, Maroc. 1994; 14(3):43-48.
28. Howard FW. The animal class Insecta and the plant family Palmae, In F. W. Howard, D. Moore, R. M. Giblin-Davis, and R. G. Abad (eds.), Insects on palms. CABI Publishing, New York, 2001, 1-32.
29. Meddich A. Program for the Safeguarding and Development of the Marrakech Palm Grove. National workshop on the palm grove and the gardens of Marrakech state of progress and assessment, organized by the Marrakech Palm Grove Observatory. Congress palace, Marrakech, Morocco, 2014.
30. Meddich A, Oihabi A, Jaiti F, Bourzik W, Hafidi M. Role of arbuscularmycorrhizal fungi on vascular wilt and drought tolerance in date palm (*Phoenix dactylifera L.*). Canadian Journal of Botany. 2015a; 93(6):369-377.
31. Meddich A, Jaiti F, Bourzik W, El Asli A, Hafidi M. Use of mycorrhizal fungi as a strategy for improving the drought tolerance in date palm (*Phoenix dactylifera L.*). ScientiaHorticulturae. 2015b; 192:468-474.
32. Mico E, Galante E. Larval morphology and Biology of four Netocia and Potocia species (Coleoptera: Scarabaeoidea: Cetoniidae: Citoniinae). European Journal of entomology. 2003; 100:131-142.
33. Morici C. La PalmeraCanaria: Phoenix canariensis, Spain, Rinconesdel Atlantico. 2006; 3:134-143.
34. Murphy S, Briscoe B. The red palm weevil as an alien invasive: biological and prospects for biological control as compone Briscoe B. The red palm weevil as an alien invasive: biological and prospects for biological control as component of IPM. Biocontrol News and Information. 1999; 20(1):35-46.
35. OREDD. Rapport sur l'Etat de l'Environnement de la Région de Marrakech. Observatoire Régional de l'Environnement et de Développement Durable. Ministère Marocain de l'Energie, des Mines, de l'Eau et de l'Environnement, 2013, 73.
36. Rodier J. L'analyse de l'eau: eaux naturelles, eaux résiduaires, eau de mer. 7ème édition. Dunod, Paris, 1984, 1365.
37. Sanchez CS. Status of infestations by the red weevil in Spain. Presentation of the endotherapy technique as a method of pest control. Workshop on the technique of endotherapy applied in the framework of the strategy against the red palm weevil. Training organized by the Ministry of Agriculture and Maritime Fisheries (National Office of Food Safety of the Regional Directorate and the company Fertileader. Tangier, 2017.
38. Sedra MYH. Le palmier dattier base de la mise en valeur des oasis au Maroc. Techniques phoénicicoles et Création d'oasis. INRA Maroc, 2003, 265.
39. Tahraoui A, El-Hilaly J, Israili ZH, Lyoussi B. Ethnopharmacological survey of plants used in the traditional treatment of hypertension and diabetes in south-eastern Morocco (Errachidia province). Journal of Ethnopharmacology. 2006; 110:105-117.
40. Tauzine P. Chorologie de Protaetia (Potosia) *opaca* en France. CETONIIMANIA. Volume N1, Juin 2007.
41. Tóth G, Hermann T, Da Silva MR, Montanarella L. Heavy metals in agricultural soils of the European Union with implications for Food Safety. Environment International. 2016; 88:299-309.
42. Vidhyasagar PSPV, Haji M, Abozuhairah RA, El Mohanna O, Al Saihati A. Impact of mass pheromone trapping on red palm weevil : Adult population and infestation level in date palm gardens of Saudi Arabia. The Planter; Kuala Lumpur. 2000; 76(891):347-355.
43. Ziouti A. Biochemical aspects of interaction Phoenix dactylifera L.-*Fusariumoxysporum f. sp. albedinis*, role of phenolic compounds. 3rd cycle thesis, Faculty of Science Semlalia, Cadi Ayyad University of Marrakech, 1998, 123.