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Date Moth Management in Date Palm: Current Status and Management Strategies in Algerian Arid Zones

Billal Nia

Center for Scientific and Technical Research on Arid Regions (CRSTRA), Mohamed Khider University Campus, RN 3, 07017 Biskra, Algeria

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Abstract: Dates have an economic and social importance in Algeria. Tremendous development has occurred in the production and the repartition of date palm during the last three decades. But this crop still suffers from several problems, in particular with phytosanitary issues such as bayoud disease (*Fusarium oxysporum f. sp. albedinis*), the date palm scale (*Parlatoria blanchardi*), the old world date mite (*Oligonychus afrasiaticus*) and the carob moth (*Ectomyelois ceratoniae*). The carob moth is a major pest of dates in stored places and date palm groves causing considerable losses. Integrated pest management program of carob moth should rely on diverse strategies. Several control methods were studied and they gave significant results however the main technique used currently by farmers is chemical control through the application of synthetic pesticides. Because of well reported issues with reliance on synthetic pesticides, practical alternatives are required.

Key words: Date moth, date palm, damages, control methods, Algeria.

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Vipin Chaudhary
K.S. Jadon
S.C. Meena

***Correspondence**

Billal NIA
bilalniadz@gmail.com

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Date palm (*Phoenix dactylifera* L.) has long been one of the most important fruit crops in the arid regions of the Arabian Peninsula, North Africa, and the Middle East (Chao and Krueger, 2007). In Algeria, the number of date palm trees is steadily increasing over the last few years. Pests such as date palm scale (*Parlatoria blanchardi* Targioni, 1892), old world date mite (*Oligonychus afrasiaticus* McGregor, 1939), black borer (*Apate monachus*), date moth (*Ectomyelois ceratoniae* Zeller, 1839) and root borer (*Oryctes Agamemnon*) have adverse and damaging impacts on date production (Dakhia *et al*., 2013). The carob moth, *Ectomyelois ceratoniae* Zeller (Lepidoptera: Pyralidae), also known in Algeria as the date moth (DM), is a major pest of date palm (Idder *et al*., 2009). It seriously threatens date exports by reducing the quality of dates. Damages caused to dates vary from 10% to 30% and could reach 70% in storage sites (Idder *et al*., 2015). The level of the DM infestation depends mainly on phytosanitary conditions of the date palm grove but also varies from one cultivar to another and also from year to year depending on climatic conditions (Idder, 2011). Roumani *et al*. (2018) reported two generations of DM in a year, the first generation developed from mid-March until late April and the second one from September to late October. More than

Table 1. Parasitoids used against date moth in Algeria.

Scientific name	Order /Family	Targeted life stage	References
Bracon hebetor Say	Hymenoptera/ Braconidae	Larva	Hamadene, 1979 ; Dehliz *et al.*, 2016
Phanerotoma flavitestacea Fisher	Hymenoptera/ Braconidae	Egg, Larva	Doumandji - Mitiche, 1983
Trichogramma embryophagum Hartig	Hymenoptera/ Trichogrammatidae	Egg	Idder, 1984
Trichogramma cordubensis Vargas and Cabellon	Hymenoptera/ Trichogrammatidae	Egg	Idder *et al*., 2009

85 million Algerian Dinar (AD)(~660,000 USD) have been granted by the Algerian Ministry of Agriculture, Rural Development and Fisheries for a preventive control operation against DM.

Four types of control techniques have been studied against DM and some are being applied by local farmers:

Biological control

Biological control or biocontrol is an ecological pest management strategy based on the use of natural enemies and biological pesticides. Currently, biological control is still evolving as an alternative method to fight against the DM. Four species have been studied and tested for their performance on the control of date moth (Table 1). *Bracon hebetor* Say and *Phanerotoma flavitestacea* Fisher (Hymenoptera: Braconidae) are two indigenous species used against DM (Dehliz *et al*., 2016). *B. hebetor* is a gregarious larval ectoparasitoid of several lepidopteran species that are associated with stored products. Females can use a broad range of lepidopteran hosts for paralysis and oviposition. Nevertheless, this parasitoid cannot necessarily develop and reproduce on all host species that it can paralyze and oviposit on, and optimum reproduction is on the stored-product pyralid hosts (Ghimire and Phillips, 2010). *Phanerotoma flavitestacea* Fisch. (Hymenoptera, Braconidae) is an important ovo-larval parasite of Lepidoptera species. It has been reported as a parasite of *Ectomyelois ceratoniae* Zeller, *Paramyelois transitella* Walker and *Ephestia kuehniella* Zeller (Moreno and Jiménez, 1993). Oviposition takes place first inside the egg of the host and then parasitoid larval development continues into different larval stages of DM (Hawlitzky, 1972). The parasitism rates obtained by *B. hebetor* and *P. flavitestacea* on date moth were 100% and 58.50% respectively (Ben Salah and Ouakid, 2013). Thus, these two auxiliaries could be used in combination, the first in the field and the second during the storage units (Dehliz *et al*., 2016). Egg parasitoids have long been an essential part of pest management strategies in crop protection (Roriz *et al*., 2006). The percentage of parasitism of *Trichogramma cordubensis* (Hymenoptera: Trichogrammatidae) on DM was 64% after release in date palm groves (Ouargla, Algeria) (Idder *et al*., 2009). *Trichogramma spp*. can be active in the field several days after being released (Pak and van Heiningen, 1985) and host preferences have been demonstrated for several species (Roriz *et al*., 2006). Therefore, further studies of *T. cordubensis* host preference need to be carried out to exploit it in biological control programs.

Microbiological control by using *Bacillus thuringiensis* var. Kurstaki (Btk) as an authorized biopesticide for organic agriculture was effective against the first larval stage of *E. ceratoniae*. Ben Salah (2016) has recorded 84% to 100% of mortality after exposing neonate larvae to Btk. Although Btk has acute toxicity against lepidopterous pests, the possibility that it has side effects on other non-targeted species such as hymenopterous cannot be excluded (Amichot *et al*., 2016).

Physical control

Heat treatment (HT) is an environmentally-friendly method to obtain effective insect pest control and its broad range of applications, especially as part of an integrated pest management strategy (Porto *et al*., 2017). HT at appropriate scales allows reduction in microbial proliferation, an elimination of all stages of insect development, an improvement in appearance, a complementary ripening for immature dates and partial dehydration allowing greater stability of the dates and an extension of their shelf life (Misbah *et al*.,

Table 2. Homologated pesticides using against date moth in Algeria (Anonymous, 2017)

Brand name	Concentration	Formulation
IAB -BT	32000 IU mg^{-1}	WP
Check 10 EC	100 g l^{-1}	EC
Panda 48 EC	480 g l^{-1}	EC
Medban®	480 g l^{-1}	EC
Chlorcyrine 220 EC	200 g l^{-1}+ 20 g l^{-1}	EC
Arrivo	10% and 25%	EC
Unidim	22.2% + 27.8%	EC
Insegar	25%	WDG
Lufox	75 g l^{-1}+ 30 g l^{-1}	EC
Arizonate	15%	SC
Zinad 15 SC	150 g l^{-1}	SC
Karate with Zeon technology	50 g l^{-1}	CS
Grand 5% EC	50 g l^{-1}	EC
Cypermethrine 10	10%	EC
Selene	25%	EC

WP: Wettable Powder; EC: Emulsifiable Concentrate; WDG: Waters Dispersible Granule; SC: Suspension Concentrate; CS: Capsule Suspension; IU mg^{-1}: International Units/milligrams; g l^{-1}: grams per liter.

2022). An exposition to 58°C for 15 minutes was sufficient to kill all larval stages of *E. ceratoniae* in dates (Ben Salah, 2016). However, HT could affect certain physical properties and biochemicals of the fruit. Thus, the effectiveness of this technique depends essentially on temperature and treatment duration (Hilal *et al*., 2005).

Radio frequency (RF) treatment is a promising physical insecticidal technique in postharvest grains (Hou *et al*., 2022). Compared to current procedures that are usually based on the application of chemicals, RF technology appears to be more convenient as a disinfestation method in date postharvest processing (Rosi *et al*., 2019). Nourani *et al*., (2017) had treated infested dates with RF at 60°C. All DM larvae were found dead and flattened after examination of all treated dates. Previous studies have highlighted that a six-minute RF application by heating the dates to approximately 60°C resulted in 100% mortality of the larvae, pupae, and adults of *Carpophilus hemipterus* without any negative effects on the quality of the dates (Pegna *et al*., 2015). Irradiation can be used as a safe method to control stored pests (Abbas *et al*., 2011).

The use of gamma radiation can cause the death or sterility of DM individuals (Belhout, 2012). Nevertheless, limited availability of the phytosanitary applications of irradiation resulted in lack of acceptance by the organic food industries. Another regulatory inconvenient is lack of an independent verification of treatment efficacy because pests may be found alive during commodity inspection, although they will not complete development or reproduce (Hallman, 2011).

Chemical control

Thirteen pesticides are approved in Algeria by the Department of Plant Protection and Technical Control (Table 2). A treatment of azadirachtin (24, 48, 96, 192, and 384 ppm) had caused first larval stage mortality of DM, reduced fertility of females and eggs hatching rate (Mehaoua *et al*., 2009). Nia *et al*. (2020) tested the aqueous extract of *Nerium oleander* (Apocynaceae) leaves and *Peganum harmala* (Zygophyllaceae) seeds. Toxicity by contact on larvae was not evident and the mortality percentage did not exceed 8%, regardless of the extract plant and concentration. Also, the fumigant effect of chinaberry leaf powder was tested on carob moth adults. The eggs hatching after four days were not affected by the aqueous extract with a rate of 55% of hatching eggs in both control and treated eggs. On larvae, more than 86% of mortality at 250 mg ml^{-1} was obtained. The lethal concentrations LC_{50} and LC_{90} were of 121.24 and 266.74 mg ml^{-1}, respectively. On adults, application of aqueous extract had caused 93% of mortality at 250 mg ml^{-1} after 24 hours with lethal concentrations LC_{50} and LC_{90} equal to 111.38 and 240.31 mg ml^{-1}, respectively. The fumigant effect of chinaberry powdered leaves did not affect this stage (Nia and Ben Salah, 2018).

Nonetheless, the topical application of essential oils of *P. harmala* on fourth instar larvae and adults caused 56.66% and 100% mortality after five days of treatment, respectively (Lebbouz *et al*., 2016). Hadjeb *et al*., (2016) found a toxic effect of spinosad on the first larval stage of DM at 100 ppm. According to Hertlein *et al*. (2011), 12 phytophagous species are susceptible to spinosad.

However, after consuming more than 1200 ppm spinosad active ingredient, individuals of two natural enemies [*Aleochara bilineata*

Gyllenhal (Coleoptera: Staphylinidae) and *Doru taeniatum* (Dohrn) (Dermaptera: Forficulidae)] suffered a high prevalence of mortality (Cisneros *et al*., 2002).

Moreover, hymenopteran parasitoids are significantly more susceptible to spinosad than predatory insects. Predators generally suffer insignificant sub-lethal effects following exposure to spinosad, whereas parasitoids often show sub-lethal effects including loss of reproductive capacity, reduced longevity, etc (Williams *et al*., 2003). Thus, spinosad could not be considered to have an environmental safety profile similar to most established biological insecticides.

Phosphine fumigation was efficient against all five larval stages of DM with an exposure time of 48 hours, and an average temperature between 17 to 19°C (Ben Salah, 2016).

However, particularly dangerous crop protection products intended for agricultural use as aluminum phosphide and methyl bromide may only be marketed or used with an authorization issued, on request, by the Algerian Phytosanitary Authority.

Cultural control

Cultural control practices have been employed for centuries. They represent one of the earliest methods applied in pest population management. It included tillage, fertilization, irrigation, pruning, bunch covering and bunch arrangement (Latifian and Rad, 2017). Bagging technique can prevent damage by insects and reduce pesticide use without interfering with fruit formation and color development (Leite *et al*., 2014). In Algeria, bunch bagging is used to prevent damages caused by DM. The percentage of infested dates recorded in a study testing this technique was low (4.6%) compared to non-bagged bunches (infestation rate exceeds 12%) (Açourene and Benchabane, 2001). Also, Krid *et al*., (2017) obtained during a study conducted in two years low infestation rates with bagged bunches (6.66 and 1.67%, respectively) whilst in witness bunches, infestation rates were 12.5 and 10 %, respectively. Moreover, bunch bagging often helps in overcoming some other problems, such as fruit set dropping, it improves fruit quality of dates and reduces compactness of bunch (Kassem and Marzouk, 2010).

In addition to bunch bagging, sanitation in the date palm grove play also an important role in protection of dates against DM attacks (Krid *et al*., 2017). Collecting fallen fruits and removing and destroying those infested, could help to reduce DM damages (Idder-Ighili, 2008).

Conclusion

This review provides an insight into the DM current status and management review in Algeria. The protection of date heritage in potential date producing areas against the damage caused by DM requires the combination of the efforts of academic and applied researches by the application of an integrated control program covering economic and environmental needs.

Disclosure statement

No potential conflict of interest was reported by the author.

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