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The Moringa Leaf Caterpillar (*Noorda blitealis* Walker, 1859), a Major Pest of Moringa (*Moringa oleifera* Lam.) Worldwide

Bibata Ali Outani[1, 2*], Haougui Adamou[1], Basso Adamou[1], Ali Mahamane[2] and Patrick Delmas[3]

[1]Institut National de la Recherche Agronomique du Niger
[2]Université de Diffa (Niger)
[3]RECA-Niger

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***Corresponding author:** Bibata Ali Outani
Institut National de la Recherche Agronomique du Niger, Email: bibataali1984@gmail.com

Abstract **Review Article**

Moringa (*Moringa oleifera* Lam., Moringaceae) is one of the most widely consumed vegetables in Southeast Asia and West Africa. Throughout its range, it is attacked by the leaf caterpillar, *Noorda blitealis* Walker, 1859 (Lepidoptera: Crambidae). The latter is considered the most important insect pest because it is present throughout the year and causes significant damage to moringa. This document highlights its taxonomic position, its distribution, its bio-ecology, the damage inflicted on the plant as well as the control measures.

Keywords: *Moringa oleifera*, *Noorda blitealis*, biology, damage, control methods.

INTRODUCTION

Moringa, *Moringa oleifera* Lam, is a perennial shrub native to the Indian subcontinent. But it is now widely introduced and naturalized in several tropical and subtropical regions (Tsaknis and Lalas, 2002; Rajbhar et al. 2018). Its increasing commercialization and international trade are the basis for the very rapid spread of the species (Anwar *et al*., 2006; Fahey, 2005). It is grown for a variety of purposes, including human consumption, livestock feed, cosmetics and pharmacopoeia. In Niger, moringa is produced under irrigation in market gardening sites in pure or in association with crops s such as onion, lettuce, bell pepper, tomato, cabbage or squash (Haougui, 2015). The main production areas are located in the regions of Niamey and Maradi. Through its richness in trace elements (mainly calcium, iron and vitamins) and proteins, moringa contributes to the improvement of the nutritional quality of Nigeriens (Abasse *et al*., 2013; Republic of Niger, 2022). Like any other crop, moringa is attacked by several diseases and pests including insects. According to Tamraj and Gupta (2020), about 30 different species of insects have been reported in India on different organs of the plant. They mainly counted pod fly (*Gitona distigma*), defoliator caterpillar (*Noorda blitealis*), budworm (*Noorda moringae*), hairy caterpillar (*Eupterote mollifera*). On the stem they reported the attacks of *Indarbela tetraonis*, the leaf-eating weevil (*Myllocerus maculosus*), the whitefly (*Trialeurodes rara*), the mealybugs and the mites that are considered minor pests.

Other authors such as Kotikal and Math (2014), Math and Kotikal (2016) counted about 60 insect pests, mites and slugs that cause enormous damage to Moringa. The insects include stem and pod borers, defoliators, biting suckers and weevils.

In the Philippines, the hairy caterpillar, *Streblote siva* is known as a major pest. This insect also attacks several other plants such as *Acacia arabica*, cashew (*Anacardium occidentale* L), jujube (*Zizyphus jujuba*) and *Prosopis juliflora*. The larvae feed on the leaves in the early stages of development, and remain in groups on the tender shoots. Older larvae are usually at the base of the main trunk (Joshi *et al*., 2016).

Among the major pests of moringa is the moringa leaf caterpillar, *Noorda blitealis* Walker 1859 (Ratnadass *et al*., 2011; Halder *et al*., 2014; Math *et al*., 2014; Litsinger, 2014; Joshi *et al*., 2016; Sharjana and Mikunthan, 2018; Kabré, 2021). It can cause 100% defoliation and thus poses a threat to moringa production (Brunda *et al*. 2015).

The objective of this review is to provide an update on the knowledge and control of the this insect pest.

Taxonomic position and geographical distribution

The insect belongs to the Family Crambidae and to the Genus *Noorda* which was described by Walker, 1859. This genus includes in addition to *N. blitealis* Walter, 1859, *Noorda margaronialis* Hampson, 1912 and *Noorda moringae* Tams, 1938.

Noorda blitealis is a lepidopteran whose larva or caterpillar is the damaging stage on the moringa tree. Due to the significant expansion of moringa cultivation in the world, the pest is continuously expanding its area of distribution in recent years. It is reported as a pest of moringa in Asia where it originates and in several other tropical regions (Thumar *et al*., 2017). *Noorda blitealis* is also found in Australia and Africa. It occurs in Niger (Ratnadass *et al*., 2011; Chegou and Garba, 2019 ; Republic of Niger, 2022), Sudan, Burkina Faso, and Nigeria (Joshi *et al*, 2016). Taye *et al*., (2013) noted its presence in Ethiopia.

Biology

Oval to spherical, creamy-white eggs are laid in clusters on the underside of leaves. A female can lay between 10 and 150 eggs. However, Rachana *et al*. (2020) reports solitary egg laying. The eggs hatch only 2-4 days after oviposition (Selvi and Muthukrishnan, 2011; Rachana *et al*., 2020).

Larvae are transparent to creamy, light green and turn pink in the final stage with a body length of 2-20 mm. The larva goes through 5 instars separated by molts. The older larva is rather dark in color with two rows of striae on each flank and a clear dorsal line. It lacks a prothoracic shield and the body is bristling with setae. The aged caterpillar makes vertical movements each day from the ground to the foliage during the night, and descends into the sand during the warm hours of the day. The duration of the larval stage is 9-11 days (Ratnadass *et al*., 2011).

The caterpillar undergoes 4 successive molts before transforming into a pupa or chrysalis in the soil (Ratnadass *et al*., 2011) or in pods (Halder and Rai, 2014). During this transformation, it weaves a silk cocoon mixed with soil that becomes a protective structure. The pupa is black in color with a length of 8 mm.

The adults emerge 6 to 9 days after the beginning of chrysalidation. These are small moths with a dark brown abdomen and a wingspan of 19 to 22 mm. The forewings are usually dark in color, and the hindwings are transparent with wide margins.

Longevity of adult females and males is 10 and 7 days, respectively. The sex ratio, male to female is 1 : 1.3 (Sharjan and Mikunthan, 2019). The total life cycle is completed in about 16 to 26 days (Tamoghna *et al*., 2014) (Figure 1).

It is established that in the Sahelian zone, *Noorda blitealis* is most active at night and in the morning when temperatures are relatively low. The species is observed in both the dry and rainy seasons (Kabré *et al*., 2020). It is found in all seasons in moringa diversification countries too (Rachana *et al*., 2021).

Damage

The larvae of *N. blitealis*, as soon as it emerges from the egg, starts to attack the parenchyma of tender leaves by biting and absorbing the sap, leaving only the transparent epidermis and the veins bare. This causes drying, discoloration and necrosis. They feed almost exclusively on the leaves. Attack occurs throughout the year, although it is more severe in the dry season than in the winter (Walser, 2015). Early attacks can cause up to 100% leaf loss (Rachana *et al*., 2020). This defoliation gives the tree a skeletal appearance. The larvae devour any new leaves that form, and in the complete absence of leaves, the caterpillar can attack the apical buds and stems of young plants in which it digs galleries causing the feet to dry out. When the tree is pruned, the larvae feed on the bark of the tree. Under these conditions, they feed on the corky contents of the bark (Satti *et al*., 2013). During periods of severe damage, entire branches of the moringa tree become defoliated and cause vegetable shortages for rural and urban communities in semi-arid areas (Anjulo, 2009).

Halder and Rai (2014) reported that *N. blitealis* also attacks young and even old pods that are still green. These pods have circular holes. In this case, the seeds are attacked from the inside by old larvae that feed on the cotyledons.

Control methods

There are several methods of controlling the moringa leaf caterpillar, all of which tend to minimize its impact on production. However, the fact that moringa is a leafy vegetable makes control difficult.

- Prophylactic control

The first method of mitigating the effect of *Noorda* on moringa is to take preventive measures. The hygiene of the plots consists of destroying the residues of the crop, to proceed to a ploughing which could expose the chrysalids to the sun, to prune the attacked plants and to burn the cut branches. Indeed, it is known that chrysalidation occurs in the soil, and sometimes under dried leaves and debris (Sushil, *et al*., 2022). Also other good agricultural practices can be adopted for caterpillar management such as collecting caterpillars for destruction, using poultry to peck on the ground for caterpillars and chrysalids (Mamane *et al*., 2022).

Weekly monitoring allows to ensure the presence of the pest in the plots and to follow the evolution of its populations.

- Biological control

Biological and microbiological control is possible, with the existence of identified natural enemies on *Noorda blitealis*. These enemies include mainly larval parasites such as *Pristomeres* sp. (Ichneumonidae), *Bracon brevicornis*, *Chelonus* sp (Braconiae), *Elasmus hyblaeae*, *Perrilampus* sp. and *Stytasis* sp. (Chalcidoideea). The same is true of spiders that inhabit new growth in large numbers and exert natural control over the growing population (Tamoghna *et al*., 2014). In Ethiopia, Negusu (2005) identified ants of the genus *Myrmicaria* as well as the praying mantis as important predators. Several natural other enemies of the moringa leaf caterpillar have been identified. These include the ladybug, *Cheilomenes sexmaculata*, the pentatomid bug, *Eocanthecona*, the green lacewing, *Chrysoperla zastrowii sillemi*, the gitonid, *Cacoxenus* sp., a praying mantis, *Anaxarcha limbata*, a parasitoid spider, *Agathis* sp. (Math *et al.*, 2013).

- Use of biopesticides

Several microbial biopesticides have been tested against the moringa leaf caterpillar. Thus, it is possible to control the pest populations with applications of a product based on a bacterium, *Bacillus thuringiensis*. This is also the case for the microscopic fungus, *Bauveria bassiana*, which can be used to protect the crop against this caterpillar (Ricardo *et al*., 2000; Brunda *et al*., 2016; Moumouni and Mahamane, 2021). Another microscopic fungus, *Aspergillus flavus*, was isolated from *Noorda blitealis* larvae. Laboratory tests have shown that it induces 70-80% larval mortality when sprayed as a spore suspension (Kalia *et al*., 1996).

Plant-based biopesticides with insecticidal effects have been tested, with good results. The most widely used plant is the neem tree (*Azadirachta indica*). Sharjana and Mikunthan (2018) showed that the use of neem can reduce the *Noorda* populations by over 70% after only six hours of application. Under Niger conditions, Haougui *et al*., (2015) recommend the use of aqueous extracts based on neem almond powder at a rate of 500 g to be macerated in 10 liters of water for 24 hours.

Ragumoorthi and Arumugam (1992) found that application of neem cake and oil (1%) caused a significant reduction in larval populations of *Noorda blitealis* up to 21 days after treatment, compared to the control.

Recent work in Niger showed that aqueous neem seed extract was comparable to synthetic chemical pesticides with larval mortality rates of about 90%. Products based on *Melia azadirach* have been tested in the control of the caterpillar. Thus, aqueous extracts of the seeds of this plant at different concentrations have shown to have a harmful effect on the oviposition of butterflies and a repulsive activity against caterpillars (Negusu, 2005).

Aqueous extracts of garlic have been used against this insect, and have shown an efficacy of 75% (Kannan *et al*., 2018; Sharjana and Mikunthan, 2019a; Moumouni and Mahamane, 2021). Negusu (2005) showed efficacy of aqueous extracts of *Melia azadirach* on *N. blitealis* infesting *Moringa stenopetala* in Ethiopia.

Sharjana and Mikunthan (2019b) showed that several other plants were also tested, as well as other animal and mineral products compared to the aqueous neem extracts taken as a reference. In the same study, they showed that fermented cow urine and ash were 76% and 50% effective respectively.

In some parts of India, the application of biofertilizer (Meeno Amilam) based on putrefied fish, provides good control of *N. blitealis* on moringa. The efficacy can be achieved both in foliar and soil application (Kamaraj and Manisegaran, 2019).

- Agroecological control

Push-pull is increasingly used to control lepidopteran crop pests. It is a biological integrated pest management technique for crop pests, using a repellent plant ("Push") and an attractive plant ("Pull") that traps the pests. It is a natural method without chemical pesticides, which preserves the environment and humans. It was used against *Noorda blitealis* by Ratnadass *et al* (2010) in Niger. These authors tested jatropha and pigeonpea to protect moringa and other crops such as okra against the fruitworm (*Helicoverpa armigera*), and jujube against the fruit fly (*Carponya incompleta*).

- Use of varietal resistance

Several studies have been conducted in the moringa diversification area and 19 promising lines have been identified. These are M-26, M-63, M-19, M-46, M-54, M-66, M-1, M-125, M-86, M-13, M-79, M-93, M-89, M-95, M-39, M-120, M-97, M-98 and M-92. These genotypes have infestation levels between 0.2 and 5% (Tamraj and Gupta, 2020). They can be used in the breeding program for the development of varieties resistant to *N. blitealis*.

In West Africa, the two most widely grown *Moringa oleifera* varieties (PKM1, PKM2) and the single *M. stenopetala* variety are highly susceptible to the pest (Haougui, pers. obs.).

- Chemical control

This is the most widely used control method against *N. blitealis* populations. In Niger, Mamane *et al.*, (2022) showed that 80% of the producers in the large

moringa production basins of Niamey and Maradi systematically use synthetic pesticides to protect their crops. However, most of these pesticides are not registered and therefore of dubious origin. Some are even prohibited by regulation. Producers use these products without any respect of the decreed norms (unsuitable molecules, excessive applications, non-respect of the dose, pre-harvest delays, entry delays, etc.).

This exposes moringa farmers and consumers to certain poisoning, as these pesticides (even registered) are toxic to human beens, animals and the environment (Sadaane, 2018; Ngweme *et al.*, 2019; Tase, 1996). Chemical protection of moringa is problematic in the Sahel zone and indeed in all countries of the West African sub-region, due to the lack of actually registered insecticides on moringa. There is no such product in the catalog of the West African pesticide registration comitee, tested and validated on moringa. Furthermore, in mixed crop situations, moringa can be contaminated by careless applications of pesticides in the farmer fields (Satapornvanit, 2004; Dutta, 2020).

- Integrated pest management

All these control measures, applied individually, cannot control *Noorda blitealis* in a sustainable way. This is why it is wise to practice integrated pest management. Integrated Pest Management (IPM) is the joint use of several compatible strategies to maintain populations of one or more pests at acceptable levels in a production system, while protecting humans, animals, plants and the environment from all risks (Waheed and Kogan, 2002; Avetik, 2017; FAO, 2022). It has the advantage of being accessible to all producers without polluting the environment, with minimal use of pesticides (Haougui, 2021). Indeed, producers of all moringa producing sites carry out several treatments with unregistered and sometimes prohibited products (Abasse *et al*., 2013). It therefore promotes the growth of a healthy crop with minimal disruption of agroecosystems and encourages natural pest control mechanisms (FAO, 2022; Satyagopal *et al*., 2014).

CONCLUSION

The moringa leaf caterpillar is a very important pest that is even a limiting factor to the production of this leafy vegetable throughout its range.

Considering the economic and nutritional importance of the crop and the health problems caused by the immoderate use of pesticides in its protection, there is a need to identify appropriate techniques to manage the pest with more environmentally friendly, inexpensive and readily available methods.

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