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A Study on Biology and Management of Spotted Pod Borer, *Maruca vitrata* (Geyer) in Legumes

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ABSTRACT: The spotted pod borer is a major biotic impediment to pulse growth, causing damage to economically valuable plant parts such as flower buds, flowers, and pods. Flower buds (highest) > open flowers > mature pods > immature pods had the highest abundance and degree of *M. vitrata* infection (lowest). As hosts, the larvae consume 39 different varieties of legume crops. The spotted pod borer's presence varied from crop to crop and season to season. In contrast, the peak incidence of larvae was observed during flowering and pod development in various pulse crops. Female moths lay flat scaly eggs on flowering flowers, seeds, roots, leaf axils, terminal shoots, and tender pods. The larval period ranged from 11 to 21 days, with a typical life cycle of 27 to 36 days depending on the host. The larval period ranged from 11 to 21 days, and the larvae were translucent with dark brown spots on each segment. The effectiveness of various organic insecticides against the spotted pod borer. On a variety of pulse crops, it was well-established. Biocides, such as *Bacillus thuringiensis*, and neem seed kernel extract (NSKE) or neem oil are two examples of neem products, as are neem seed kernel extract (NSKE) or neem oil showed differing degrees of efficacy on different crops. Entomopathogenic fungi have recently gotten a lot of attention and have proved to be successful. Furthermore, the use of sex pheromones and traps, as well as cultural management methods like intercropping, weeding, and planting time and density, are both highly effective and complement each other. More details on the genetics of *M. vitrata*, population ecology, pesticide resistance methods, and natural enemies, as well as their incorporation, would aid in the development of a tough management system and improved legume crop productivity.

Keywords: Pulses, Spotted pod borer, *Maruca vitrata*, Pest, NSKE, Management

INTRODUCTION

Pigeonpea, *Cajanus cajan* (L.) Millsp is a major grain legume in Asia, Eastern Africa, and the semi-arid tropics of the Caribbean. For millions of people who live in these countries, it is a source of protein (Shejulpatil *et al.,* 2020). It is grown on approximately 4.6 million hectares in India, with an annual production of 2.5 million tons. It's normally intercropped with grain and fiber crops on marginal lands, with little or no fertilizer and pesticide inputs. After the main crop is harvested, pigeonpea plants are normally left in the field to take advantage of any available moisture and nutrients. A pigeonpea crop produces two to three flushes of flowers during a season, but only one of them contributes significantly to the overall grain harvest; the others are either destroyed by insects or suffer from other biotic and abiotic factors that cause poor flower and pod retention. Pigeonpea cultivation in India increased by 2% per year between 1970 and 1990 (Randhawa *et al.,* 2015). On the other hand, productivity has only increased at a 0.33 percent annual rate. High-yielding cultivars, especially short-duration (150 days to maturity) pigeon peas, have made significant progress, and have a lot of potential for increasing pigeon pea production as a mono-crop of high-density planting. (Sahoo *et al.,* 2002)

In the conventional rice-wheat cropping method practiced in the northern Indian plains, as well as in Southeast Asian rice or rice-fallow regimes, short-duration pigeonpea may play an important role in crop rotations. Short-duration pigeonpea cultivars are less photoperiodic and temperature-dependent and can be adapted to a variety of newer conditions (Singh *et al.*,1988). Due to substantial losses due to insects, pests, and moisture stress, the genetic potential of high-yielding pigeonpea cultivars has not been completely realized. Short-duration cultivars lose more than intermediate and long-duration cultivars due to the shorter growth cycle and less time available to the plant to compensate for insect damage.

Insects damaging the reproductive sections of the pigeonpea cause the greatest reduction in grain yield. A pod borer is *Helicoverpa* (Heliothis) *armigera* (Hubner). *Exelastis atomosa* (Walsingham), seed fly *Melanagromyza obtusa* (Malloch), legume pod borer, or spotted caterpillar *Maruca* (testulalis) *vitrata* (Geyer). Blister beetles *Mylabris* spp., pod sucking bugs *Clavigralla* spp., and bruchids *Callosobruchus* spp. are the most destructive pests of pigeonpea. The relative value of different plants, on the other hand, differs depending on the place, season, and period of flowering of various cultivars.

Maruca vitrata has emerged as an important pest since the flowering of short-duration pigeonpea cultivars occurs during periods of high humidity and mild temperatures in Sep-Oct in India. It is a significant impediment to the introduction of pigeonpea into new areas/cropping systems, such as in Sri Lanka, where humidity is high during flowering and regulation is difficult. (Sujithra *et al.*, 2016) Because of the exponential growth of its population, as result, it's vital to examine basic information on genetics, population dynamics (Chaitanya *et al.*, 2012). Relationships between insect density and yield loss, artificial rearing, resistance screening methods, resistance sources, and mechanisms, the impact of biotic and abiotic factors on population variability and the role of cultural norms in mitigating harm and ensuring equal use of insecticides in integrated insect management (Rachappa *et al.*, 2017).

A. Taxonomy

This legume flower and pod borer are scientifically known as *Maruca vitrata* Fabricius, but it is also known as *Maruca testulalis* Geyer and *Croshipora testulalis* Geyer. It is a member of the Crambidae family and order Lepidoptera which is formally classified as Pyralidae and has only one L seta on its ninth abdominal segment. (Gopali *et al.*, 2010)

B. Host range

Cowpea, pigeonpea, black gram, green gram, rice, and soybean all are serious pests in India. Although host plants are sparse during the off-season, it survives on alternate hosts such as wild leguminous shrubs and trees, as well as weed hosts. The most common host plants are *Cajanus cajan, Vigna unguiculata, Phaseolus lunatus, and Pueraria phaseoloids.* Pigeonpea larvae have a 4.14 growth index, cowpea larvae have a 4.63 growth index, and hyacinth bean larvae have a 5.17 growth index. (Ramasubramanian *et al.*, 1988). The larva feeds on 39 different host plants, the bulk of which are Leguminosae and has been found in every legume-growing state in India. (Sharma *et al*., 1998).

C. Seasonal incidence

The spotted pod borer's seasonal occurrence differed based on the crop and season in various areas. *M. testulalis* reaches its highest activity in July, August, and October (Lalasangi *et al*., 1988). In moth captures from light traps at ICRISAT, Hyderabad, two population peaks have been observed: the first peak in September and the second peak in early November to mid-December, it is between the middle of September and the middle of October in Hisar (Srivastava *et al*., 1992). In pigeonpea, the occurrence was observed from mid-October to late November, with a peak in Dholi, Bihar, at the end of November and from early September to mid-October at Pant Nagar (Akhauri *et al*., 1994, Bajpai *et al.*, 1995). It occurs in field beans in Karnataka from the second fortnight of September to the first fortnight of February, with a peak occurrence from the second fortnight of November to the first fortnight of December (Tejaswini *et al*., 2012). Though confirmed that the occurrence is bimodal, with early infestation beginning in September and Pigeonpea in Karnataka peaks in the middle of October, with the second season in December (Gopali *et al*., 2008, Shivaraju *et al.*, 2011, Chittibabu *et al.*, 2009, Sonune *et al*., 2010) found that peak larval activity coincided with peak flowering stage in black gram.

Table 1: Distribution of spotted pod borer in India.

State	Major host	Reference
Karnataka	Pulses	Krishnamurthy (1936)
Uttar Pradesh	Pigeonpea	Patel and Singh (1977)
Bihar	Legumes	Saxena (1978)
Madhya Pradesh	Legumes	Saxena (1978)
Delhi	Legumes	Saxena (1978)
Tamil Nadu	Grain Legumes	Sundara Babu and Rajasekaran (1984)
Gujarat	Greengram	Venkaria and Vyas (1985)
Andra Pradesh	Pigeonpea	Rao *et al.* (1986)
Orissa	Pigeonpea	Prasad *et al.* (1989 a, b)
Haryana	Pigeonpea	Srivastava *et al*. (1992)

According to (Umbarkar *et al*., 2010), the population of *Maruca* pod borer began to emerge in green gram at Junagadh from the 5th week after sowing and peaked at the 7th week after sowing.

D. Nature of damage

Adults prefer flower buds, seeds, terminal shoots, and tender pods to lay their eggs on (Taylor *et al.*, 1963). Young larvae (1st, 2nd, and 3rd instars) injure the terminal shoots and flower buds the most after hatching, while older larvae (4th and 5th larval instars) injure the open flowers and pods the most. The larvae eat from a webbed mass of leaves, flowers, vine buds, and other plant parts. The larvae are protected from natural enemies and insecticides since they eat in secret. Older larvae are extremely agile, feeding constantly on flowers and freshly shaped pods and wreaking havoc all over the place. period of crop reproduction (Singh *et al.*, 1988). Normally, larvae eating on the anthers, filaments, styles, stigma, and ovaries of flowers and move from flower to flower, consuming 4-6 flowers before reaching adulthood. Larvae in the third to fifth instars will bore into pods and, on rare occasions, peduncles, and stems (Taylor *et al.*, 1967). Later, (Jackai *et al*., 1982) recorded that the infestation begins 21 days after planting in cowpea terminal shoots and then spreads to reproductive sections, with flower buds, terminal shoots, and pods showing the highest severity. Flowers (52.3 percent) have a higher frequency than pods (37.8%) and leaves (37.3 percent) (9.9 percent). (Karel *et al*., 1985). The stems of a black gram are eaten by young larvae from the leaf axils of roots, causing the plant to wilt (Goud *et al.*, 1992). By spinning, webbing, and feeding inside the rolled leaves, the larvae weakened the pigeonpea leaves. During the flowering and seed-forming cycles, larvae ate seeds, flowers, and pods by webbing them. Pods are preferred by third instar larvae over flowers and leaves, while flowers are preferred by first instar larvae (Sharma *et al.*, 1998). Though female moths lay eggs during the growing season, the damage is concentrated during the flowering and podding periods, young larvae eat flowers, while mature larvae eat the fruits and pods of beans (Rekha *et al.*, 2007).

E. Biology of spotted pod borer

Egg: Flat, somewhat elongated, on tiny and fragile chorion, pale yellowish eggs with faint reticulate sculpturing (Vishakantaiah *et al.*, 1980). The undersides of stems, terminal shoots, and flower buds are glued with eggs (Goud *et al.*, 1992). Eggs are laid singly or in batches of 2-6 and are milky white, flattened dorsoventrally, and oval on the underside of stems, terminal shoots, and flower buds. When they are freshly laid, the eggs are milky white, oval, dorsoventrally flattened, and fixed to the substrate. The number and duration of egg-laying were affected by temperature, with up to 400 eggs laid in batches of 2-16 and an incubation time ranging from 0.04 to 2.54 days. (Naveen *et al.*, 2009)

Larva: Mature larvae have a translucent body with two dark brown spots on each segment and are 17-20 mm long. The amount of spotting depends depending on the host, and some larvae were discovered without spots. In the larval stage, there were five instars. The head capsule is light to dark brown, and the prothoracic plate is dark brown and broken dorsally. Until pupation, the spots become indistinct. The larvae are photonegative and active in the evenings, feeding on the plant all night (Singh *et al.*, 1978). On pigeonpea, the larval cycle is between 12.7 and 16.4 days (Vishakantaiah *et al.*, 1980) and 16.4 days (Jackai *et al.*, 1982). Cowpea has a short larval period (7.3 days), while sun hemp has a long larval period (21 days). (Jackai *et al.*, 1983) In Southern India, the average larval time on cowpea is about ten days (Ramadas *et al.*, 1983). Cowpea larval period is 13.9 days, pigeonpea larval period is 13.3 days, and hyacinth bean larval period is 12.9 days, (Ramasubramanian *et al.*, 1988). When compared to cowpea flour diets (16.5 days) and soybean flour diets (14.4 days), the larval time on cowpea (11.1 days) is shorter.

There are five larval instars, each lasting 8-10 days or depending on the atmosphere and host species, it can take up to 16 days. Many that fed the larvae artificial food had a reduced lifespan. The insect's biology is also affected by the larval feed portion, which preferentially feeds on the host plant's reproductive organs for around three weeks before migrating to the pods to pupate. Until pupation, the larval body is semitransparent and spotted on each segment, with the severity of the spotting varying and the spots fading. In Southern India, the average larval time on cowpea is about ten days (Ramadas *et al.*, 1983). Cowpea larval period is 13.9 days, pigeonpea larval period is 13.3 days, and hyacinth bean larval period is 12.9 days, (Ramasubramanian *et al.*, 1988). When compared to cowpea flour diets (16.5 days) and soybean flour diets (14.4 days), the larval time on cowpea (11.1 days) is shorter.

Pupa: The pupal period lasted eight to ten days on pigeonpea, 11.6 days on sun hemp, 11.1 days on pigeonpea, and 5.6 days on cowpea (Vishakantaiah *et al.*, 1980). The pupae are elongated and have a shoulder-like shape, measuring about 13 mm in length. The early pupal stage is greenish, but when fully grown, it turns brown and is hidden in a cocoon made of dry leaves, flowers, and other dead plant matter. Normally, the pupal cycle lasts one to two weeks. During the dry season, there is no evidence of diapause (Jackai *et al.*, 1982).

Table 2: Larval duration (Rachappa *et al.*, 2016).

Larval Stages	Minimum Period (days)	Maximum Period (days)
1st instar	1.75	2.25
2nd instar	2.50	3.00
3rd instar	2.75	3.50
4th instar	3.50	3.75
5th instar	3.75	4.00
Total larval duration	13.5	16.5

Table 3: Pupal Stages (Rachappa *et al.*, 2016).

Stages of pupa	Minimum Period (days)	Maximum Period (days)
Prepupal	2.50	3.00
Pupal	7.00	8.50
Total	9.5	11.50

Adults: Moths have medium size of fuscous brown forewings and a lunulate black-edged white dot at the cell's end. A black-edged, semi-hyaline band protruded beyond the cell from beneath the costa. With a fuscous mark at the base and a spot at the cell's upper angle, the hind wings were semi-hyaline white. From costa to vein 1c, a marginal fulvous brown fuscous band with an inner irregular edge ran. Both sexes had identical morphology (Hampson *et al.*, 1976). On different hosts, the average lifespan of the sexes differed. Adult lifespan was found to vary between 8.6 and 5.9 days 8.5 to 6.1 days for Cowpea takes 8.5 to 6.1 days to mature, pigeonpea takes 8.5 to 6.1 days, and lab-lab takes 10.0 to 6.1 days to mature. On soybean flour diets, female and male moths lived for 8.3 and 5.8 days, respectively, while on cowpea flour diets, both sexes lived for 9.0 and 6.1 days. Adults are medium-sized, and all sexes are morphologically similar. Gray with a white spot and black margins on the forewings, and semi-hyaline on the hind wings.

Table 4: Adult longevity.

Stages	Minimum (days)	Maximum (days)
Male	8.00	10.00
Female	8.25	12.00
Pre-oviposition	3.25	4.00
Oviposition	3.75	5.70
Post oviposition	2.50	3.00
Fecundity (No. of eggs/female)	21	36
Hatching Percent	77.75	88.75

Table 5: Total life span.

Stage	Minimum Period (days)	Maximum Period (days)
Male	31.5	41.00
Female	32.5	42.50

The maximum proportion of mating and oviposition happens within the first four to five nights of pairing, and the ideal temperature range for this is between 20 and 25°C with a humidity of 80 percent or higher. Males have a lifespan of 7-10 days, while females have a lifespan of 5-6 days (Ramasubramanian *et al.*, 1988).

Life cycle: Pigeon peas have a 27-day life cycle (Vishakantaiah *et al.*, 1980), with males having a 30.2-day life cycle and females having a 32.6-day life cycle (Ramasubramanian *et al.*, 1988). On cowpea, the complete life cycle lasted between 31 and 36 days (Naveen *et al.*, 2009).

F. Economic importance

M. vitrata has been identified as the most damaging insect pest, causing low yields and significant losses of cowpea around the world, according to several studies. The larval stage does the most harm when it enters the buds and seed pods. Damaged pods are entirely or partly eaten out, and the entrance lets water into the pod, straining the seeds left behind.

The buds, flowers, and leaves are also damaged, and the larvae can eat them or bind them together. The young larvae normally feed on and cause harm to the environment. The younger ones eat the flower, while the older ones eat the pod.

G. Management practices of spotted pod borer in legumes

Farmers use a variety of approaches to control *M. vitrata* and other insect pests, depending on their experience and financial situation. Despite the high cost and other drawbacks of chemical insecticides, extensive research has shown that they are the most used. According to recent studies undertaken in Thailand, more than 90% of the growers polled used chemical pesticides. Two-thirds of those who used it once a week did so. Similarly, using insecticides once during the flowering and podding periods significantly increases crop yield. Methomyl, cypermethrin, endosulfan, dimethoate, carbaryl, lambda-cyhalothrin 5 EC, beta-cyfluthrin, and monocrotophos have all been shown to be effective against *M. vitrata* when sprayed daily. Deltamethrin and lambda-cyhalothrin mixed with dimethoate have also been shown to be effective against this insect pest, particularly when used before pod infestation. Chemical pesticides have substantial leverage, improved yields, immediate impact, and plant health improvement in the short term, all of which are attractive to less-literate growers. However, in the long run, it has significant long-term consequences, such as insecticide resistance and a poor tolerance level in *M. vitrata*, which has already been established. Resistance to cypermethrin, endosulfan, and dimethoate, for example, was discovered, and non-chemical regulation or use only when appropriate was recommended. Other consequences include the extinction of natural enemies, poisoning of the atmosphere, and the extinction of natural enemies, toxicity to living creatures, growers, and consumers, as well as being expensive.

Biological control: Biological management methods, an alternative to chemical pesticides, have gained popularity in the fight against insect pests in recent years, and be a safer control approach to some degree. Natural enemies (parasitoid e.g., *Phanerotoma leucobasis*, *Pristomerus* sp., *Testudobracon* sp. *Apanteles taragamae*) of *M. vitrata* eggs and larvae are included in this procedure. *M. vitrata* Multi Nucleopolyhedroviral and entomopathogenic fungi are examples of entomopathogenic viruses and fungi. Isolates of *M. anisopliae* and *B. bassiana Bacillus thuringiensis* sub sp has also been found to be very useful. *M. vitrata* has previously been shown to be susceptible to *Bacillus thuringiensis*-endotoxins in tropical and subtropical environments. Most of these approaches have shown promising results, but others have yet to be adopted, and further population-level trials are needed for effective biocontrol implementation (Sunitha *et al.*, 2008).

Botanical control: Botanicals have a lot of potential against *M. vitrata* It has only recently been discovered that vitrata exist. It has been recorded that a neem concentration of 50,000 ppm causes 90 percent larval mortality. In a similar study, *Allium sativum bulb, Piper guineense, and Azadirachta indica* seed extracts were found to be effective in reducing egg hatch, with black pepper and garlic bulb having the highest reduction of all levels of concentration Another research looked at the effectiveness of Neem, papaya, and Hyptis species against *Maruca* and other pests like Thrips, with neem coming out on top. Other research on neem oil in India and Africa showed that it is effective against *M. vitrata*. Similarly, researchers discovered that combining neem seed kernel extract (5%) with Dichlorvos (0.5 ml per liter of water) yielded excellent results. (Akhauri *et al.*, 1994) and (Prajapati *et al.*, 2003)

Cultural Control: Cowpea damage is reduced by cultural activities such as intercropping, weeding, planting time, and density. Planting at 30×20 cm^2 or 60x20 cm^2 at the start of the rain will help minimize *M. vitrata* infestation and most other yield-limiting insect infestation, and planting at 1.0–1.5m will help reduce *M. vitrata* infestation (Karungi *et al.*, 2000) and most other yield-limiting insect infestation. (Asiwe *et al.*, 2005) Furthermore, a rise in bird perching was recorded Intercropping of sorghum seeds and plowing in the Summer reduces pod borer by 85 percent, raising the efficiency of legume fields. When there are few seeds, regular inspections and handpicking of *M. vitrata* eggs and larvae are much superior to the use of synthetic chemicals.

Sex Pheromones and Traps: In recent years, the use of sex pheromones and in the control of *M. vitrata* populations, traps have proven to be extremely useful and complementary. Many studies on the sex pheromone of insect pests of legumes using *M. vitrata*. According to the literature, (E, E)-10,12-hexadecadienol and (E)-10-hexadecenal are minor components (Schlager *et al.*, 2012), while (E, E)-10,12-hexadecadienal is a major component (Kar *et al.*, 2007). Several sex pheromones are both effective and common. (E)-10-hexadecenol and (Z, Z, Z, Z, Z)-3,6,9,12,15-tricosapentaene are two more elements. were also found to have a higher capture rate. Many of these moths (up to 1500 in a single night) were captured using light traps during the pigeonpea growing season in Kano, Nigeria, indicating that it can be used in conjunction with other methods to mitigate *M. vitrata* damage to pigeonpea (Zakari *et al.*, 2019). *M. vitrata* is becoming a possible danger to dwindling global cowpea and other legume supply, based on its recent distribution and emergence of resistance to certain chemical pesticides. As a result, *M. vitrata* necessitates a lot of attention. More detailed, diverse, and up-to-date data on its biodiversity, diversity, migration patterns, and other topics to understand it better and scan for the most effective management methods, pesticide resistance techniques, and off-season incidence are required. Identifying more natural enemies' resources would be a more productive and effective management technique of this pest and integrate them with cultural traditions and other biocontrol techniques. Sex pheromones and traps can also help in population control Put some strain on this pest. To fine-tune the pheromone-based regulation of *M. vitrata* species, further research into the components of this insect pest's sex pheromone in different geographical regions is also required. Crop development efforts should concentrate on providing local farmers with resistant and genetically transformed pigeonpea and other legume seeds.

Chemical insecticides: Several studies on spotted pod borer insecticidal control in various crops and locations were available. Monocrotophos and endosulfan, both at a weight of 0.5 kg a.i. The strongest was discovered to be ha-1 in controlling pigeonpea pod borers, according to (Samolo *et al.*, 1986). Two sprays of 0.05 percent dimethoate and 0.05 percent monocrotophos were safe, according to Lal *et al.*, (1988). Rahman *et al.*, (1989) found that four sprays of 0.008 percent cypermethrin (1st at flower initiation, 2nd at 50% flowering, 3rd at 100% flowering, and 4th at 100% pod set) were effective against *Maruca*, with a maximum benefit-to-cost ratio of 6.23 in pigeonpea. Triazophos, endosulfan, and monocrotophos effectiveness (Sundara *et al.*, 1984). The use of cypermethrin, deltamethrin, fenvalerate, and endosulfan (three sprays) against pod borers in pigeonpea was previously recorded (Sontakke *et al.*, 1991). According to (Lakshmi *et al.*, 2002), two sprays of chlorpyriphos @ 0.05 percent at ten-day intervals were successful in decreasing the larval population of *M. vitrata* on the black gram (48.86 percent). Cowpea pod damage by the spotted pod borer was considerably decreased (Chand *et al.*, 2006) when treated with chlorpyriphos + DDVP at 2.5 + 1 ml/l. (Malathi *et al.,* 2007) found that at 50 percent flowering stage, on pigeonpea, chlorpyriphos 20 EC @ 2.5 ml/l caused the largest reduction in *M. vitrata* (67.98%), novaluron 10 E.C @ 1.0 ml/lit, and in black gram (Patil *et al.,* 2006), alphamathrin 10 E.C @1.0 ml/lit dramatically reduced pod borer impact. (Rao *et al.,* 2007), Spinosad 45 EC @ 0.4 ml/lit and indoxacarb 14.5 EC @ 0.4 ml/lit were the insecticides that did the least pod damage in pigeon pea. Indoxacarb 14.5 SC and Spinosad 48 SC were highly selective against *M. vitrata* third instar larvae (Sunitha *et al.,* 2008), with mortality rates of 80% and 50% in pigeonpea, respectively. In green gram in Andhra Pradesh, (Samolo *et al.,* 1986) observed that lambda-cyhalothrin in combination with dichlorvos was highly successful with the least pod damage (4.97 percent), followed by Novaluron and Spinosad. (Singh *et al.,* 2008). Against pod borers in pigeonpea, E2Y45 20 percent SC at 30 and Spinosad 45 percent SC at 73 g a.i./ha and 40 g a.i./ha is included. Flubendiamide 480 SC and thiacloprid 48 SC were found to be the most effective Dolichos bean larval reductions (Mallikarjuna *et al.,* 2009), emamectin benzoate 55G, and indoxacarb 14.5SC. Thiodicarb 75 WP @ 562.5g a.i./ha and flubendiamide 480 SC @ 48g a.i./ha are highly efficient in the control of black gramme pod borers, with Indoxacarb 14.5 SC @ 75g a.i./ha leading the way.

CONCLUSION

M. vitrata is becoming a possible danger to dwindling global pigeonpea and other legume supply, based on its recent distribution and emergence of resistance to certain chemical pesticides. As a result, *M. vitrata* became a condition, necessitates a great deal of treatment. More detailed, diverse, and up-to-date data on its biodiversity, diversity, migration patterns and other topics to better understand it and scan for the most effective management methods, pesticide resistance techniques, and off-season occurrence are needed. A more efficient and better management strategy will be the identification of more natural enemies of this pest and their alignment with cultural traditions and other biocontrol techniques, Sex pheromones and traps may also help to reduce the pest's population pressure. To fine-tune the pheromone-based regulation of *M. vitrata* species, further research into the components of this insect pest's sex pheromone in different geographical regions is also required. Crop management projects should concentrate on cultivating tolerant and disease-resistant crops Seeds of pigeonpea and other legumes that have been genetically modified but are nevertheless readily available to local farmers.

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