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A review on seasonal incidence and insecticidal management of spotted pod borer [*Maruca vitrata* (Geyer)] with special reference to urdbean (*Vigna mungo* L.) In India

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Abstract
Urdbean or Blackgram (*Vigna mungo* L.) is an important pulse crop in the semi-arid tropics and subtropical farming systems, providing high quality vegetable protein. Among the insect pests attacking on blackgram Spotted pod borer, *Maruca vitrata* (Geyer) is a major constraint for the production of blackgram at critical stages like flowering and pod formation stages. The spotted pod borer is causing serious damage to the crop, leading to huge losses. Because of its extensive host range and destructiveness, it became a persistent pest in pulses, being available throughout the year in different seasons / situations. The efficacy of chemical insecticides belonging to different groups against spotted pod borer was well established on different pulse crops. This review pertains to seasonal incidence at different locations and the most promising conventional and novel insecticidal compounds in the light of their use for the management spotted pod borer in pulses in general and blackgram in particular.

Keywords: Seasonal incidence, insecticidal management, spotted pod borer *Maruca vitrata*, blackgram

1. Introduction
Pulses are recognized as the rich source of proteins and constitute an important human diet after cereals. Undoubtedly, they have been considered as poor man's meat for the underprivileged people who cannot afford animal protein [1]. India is an important pulse growing country contributing 28 per cent to the global pulse basket from an area of about 37 per cent [2]. Blackgram or Urdbean (*Vigna mungo* L.) or mash, mungo bean, mashkalai black mapte etc., belongs to the family leguminosae; sub family Papilionaceae. It is native to Indian subcontinent [2]. It is the fourth most important short-duration pulse crop grown in India and contributes 10% of national pulses production. It contains 24% protein, 3.2% minerals and 59.6% carbohydrate. It also contains 154 mg calcium, 9.1 mg iron and 38 mg β-carotine per 100g of split daul [3]. The important blackgram growing states in India are Andhra Pradesh, Assam, Bihar, Gujarath, Haryana, Maharashtra, Karnataka, Kerala, Tamil Nadu, Madhya Pradesh, Rajasthan, Uttar Pradesh, West Bengal and Tripura [4]. In most parts of the country it is grown traditionally as *kharif* (wet season) crop. The area, production and productivity of urdbean at national level are 32.15 lac ha, 17.66 lac tonnes and 549 kg/ha, respectively [5]. In Andhra Pradesh under different agro climatic conditions, such as kharif (rainy), *Rabi* (winter) and summer crop both in uplands as well as in rice fallows. Though, urdbean is being grown throughout the year in varied agro -climatic conditions [6]. Blackgram is attacked by 40 to 60 insect species at different stages of the crop growth [7, 8, 9, 10]. On an average, 2.5 to 3.0 million tonnes of pulses are lost anually due to pest problems in India [11]. The yild losses on urdbean due to insect pests at vrious stages of the crop growth accounts 30 to 54.3 per cent in India [12, 13, 14, 15, 16, 17]. Among the insect pests spotted pod borer, *Maruca vitrata* (G.) is the devastating pest of pulses [18, 19]. It is widely distributed in Asia, Africa, Australia & America [20]. It feeds on plant species belonging to 20 genera & 6 families, the majority of which belonging to Leguminiaceae and is a major pest of cowpea, pigeonpea, urdbean, mungbean, snap bean, common bean, soya bean, lima bean, faba bean, hyacinth bean & adzukibean [21]. It infests mungbean, urd bean, pigeonpea, cowpea, & field bean in southern zone of A.P [22]. Because of its extensive host range and destructiveness, it became a persistent pest in pulses, being available throughout the year in different seasons / situations.

Spotted pod borer *M. vitrata* larvae feeds on flowers, buds, and pods by webbing with leaves and causing serious damage [23, 24, 25, 26, 27]. So it is difficult to kill them due to this typical feeding habit of the larvae protect from natural enemies and conventional group of insecticides. The repeated use of conventional chemicals results in development of resistance to insecticides. Now days, attempts are being focused on safer insecticides to reduce the resistance development and eco - friendly pesticides. Hence, the present review was done on the bio efficacy of certain new molecule insecticides having unique mode of action, against the spotted pod borer on blackgram.

2. Nature of damage

The spotted pod borer which is also known as legume pod borer, *Maruca vitrata* Geyer. *(M Testulalis)* (Lepidoptera; Pyralidae) is a serious pest of grain legumes in the tropics and subtropics because of its extensive host range, distribution and destructiveness. It was first reported by Dietz (1914) [28] on beans in Indonesia and described by Hubner but the work was published later on by Geyer. Due to its destructiveness at critical stages of crop growth *viz*, flowering and pod development stages especially to the economic plant parts such as flower buds, flowers and pods, it become as a significant constraint to attain the maximum productivity from grain legumes. Normally, larvae feed on anthers, filaments, styles, stigma and ovaries of flowers and larvae move from one flower to another, and each may consume 4-6 flowers before completion of larval development. Third to fifth instar larvae are capable of boring into the pods and occasionally into peduncle and stems [23]. The young larvae nibble into the stems of blackgram from leaf-axils of branches causing wilt [29]. Spotted pod borer (*Maruca vitrata*) is a major constraint for the production of pulses at critical flowering and pod formation stages in the Southern Zone of Andhra Pradesh [30]. The yield losses caused by *M. vitarta* have been estimated to be around 30 million dollars annually in India [31]. The peak bud infestation (50.0%) was noticed during the 2nd week of December *i.e*., 48th standard week on green gram [32]. The grain yield loss due to this pest ranged from 9 to 84 percent on grain legumes [33].

3. Seasonal incidence

Seasonal incidence and development of insect-pests are very much dependent upon prevaling environmental factors such as temperature, relative humidity and precipitation hence, they prefer particular environmental conditions for their survival in a particular host [34].When some insects prefer cool and humid conditions as optimum for their growth and development there are some others which thrive well under dry and high temperature conditions. In this regard, it is essential to study the pattern of seasonal incidence of major pests infesting the crop and their preferable environmental conditions as this will help in their management, if tackled in the right way [34]. The peak activity of *M. testulalis* has been observed during the month of July, August and October [35]. The peak activity of *M. vitrata* was observed from August-September at various locations in India on blackgram [36, 37, 38, 33, 39, 40]. The incidence *M. vitrata* in pigeonpea under normal sowing initially infested during the 1st week of August (27th standard week) and peak incidence during 37th standard week. Under late sowing, moderate infestation was noticed during the first week of September at Maharashtra [41]. The peak incidence of pod borer during the 3rd week of October on blackgram at Kathalagere, Karnataka [19]. Larval incidence of *M. vitrata* in blackgram reached its peak during last week of January coinciding with the maximum flowering and pod ding stage and gradually declined by 1st week of March when pods were matured at Bapatla, Andhra Pradesh [42]. The incidence of *M. vitrata* on cowpea started during 1st standard week *i.e*., at 32 DAS with 0.4 larvae per 10 plants and increased gradually and reached its peak by 7th standard week with 65.4 larvae per 10 plants at pod development stage at 75 DAS[43]. The larval incidence of *M. vitrata* started during the 3rd week of December (early flowering stage of crop @ 4 larvae / 50 plants) and reached the peak level (37 larvae per 50 plants) during the 2nd week of January coinciding with the maximum flowering stage of crop and pest has disappeared at the maturity stage of blackgram in Andhra Pradesh[38]. Population of spotted pod borer started appearing from 5th week after sowing and peak pest density was observed during 7th week after sowing in greengram at Junagadh [44]. Iincidence of *M. testulalis* on blackgram commenced after the 5th week of sowing *i.e.*, the 2nd week of August with 0.80 larvae per plant and gradually increased and attained a peak of 3.84 larvae per plant during the 4th week of August and its incidence gradually declined by the first week of September (3.35 larvae per plant) [39]. Population of *M. vitrata* started from 34th standard week (0.58 larvae per plant) and attained its peak population during 36th standard week (2.40 larvae per plant) [45, 46].

4. Efficacy of chemical insecticides against spotted pod borer *Maruca virata* (Geyer) on Urdbean / blackgram

Several reports were available on the insecticidal management of spotted pod borer on blackgram and other pulses at different locations are reviewed group wise hereunder.

4.1 Organophosphate compounds

Organo phosphorus compounds are broad spectrum insecticides with contact, stomach and non - systemic, good penetrating power also have acaricidal properties.

Endosulfan (0.07%) and dusting with methyl parathion (2%) were significantly superior in minimizing damage due to *M. vitrata*. [47, 48, 49. 50]. Two applications of dimethoate (0.03%) or monocrotophos (0.04%) were effective against lepidopteran pod borers on blackgram[51]. Cumulative pod borer damage caused by *M. Vitrata* in blackgram was the lowest in Quinalphos (0.04 %) followed by Profenophos (0.1%), dimethoate (0.03%) and acephate (0.075%) [52, 53]. Chlorpyriphos (0.04%) in combination with dichlorvos (DDVP) (0.038%) was the most effective treatment in reducing the larval population (62.52 per cent)of *M. vitrata* [54]. Two sprays of chlorpyriphos @ 0.05% at ten days interval was effective in reducing the larval population (48.86%) of *M. vitrata* on blackgram [55]. Chlorpyriphos @ 630 g and endosulfan @ 630 ga.i./ha, each alone consistently and significantly reduced pod borer damage to less than 27.9 per cent with grain yield of more than 880 kg/ha[56]. Profenophos (0.05%) was found to be most effective in reducing the larval population of *M. vitrata* [57]. Triazophos (1ml/l) was effective against legume pod borer and registered highest cost benefit ratio [58, 27].

4.2 Carbamtes

Carbamate compounds are broad spectrum insecticides with contact and stomach action. Effective against various grous of insects. Thiodicarb @ 0.075% was effective in controlling the larvae of *M. vitrata* by recording the larval reduction of (52.11%) blackgram [54, 55, 59, 60]. Indoxacarb 15.8 E C @ 750 ml/ha was found to be very effective against spotted pod borer in blackgram [61, 62, 57, 27, 17, 63].

4.3 Synthetic pyrethroids
Fenvalerate (0.01%) treated plants showed the least damage and greatest grain yield compared to quinalphos (0.12%) and endosulfan (0.07%) in Maharashtra [64]. Novaluron 10 E.C @ 1.0 ml/lt and alphamethrin 10 E.C @ 1.0 ml/lt significantly reduced the pod borer damage in blackgram [65].

4.4 Emamectin benzoate
Emamectin benzoate 5% SG (Proclaim), ananalog of abamectin, belongs to 'Avermectins'. Avermectins are insecticidal compounds derived fromthe soil bacterium *Streptomyces avermitilis* described for the first time in Japan. Avermectin is a natural fermentation product of *bacterium S. avermitilis*. This compound acts as an insecticide by interfering with the nervous system of insect and causes the insect to become paralyzed. Proclaim 5 % SG is both a stomach and contact insecticide effective against legume pod borer [66, 59, 19, 60].

4.5 Spinosad
Spinosad is a macrocyclic lactone developed from an actinomycete (*Saccharopolyspora spinosa*) fermentation culture that was originic acetyl choline receptors and has been reported to be effective on a wide variety of insect pests, especially Lepidopterans and dipterans [67].

Spinosad @ 0.005% was significantly superior by recording 120.12 per cent increase with a pod yield (14.66 q ha^{-1}) over untreated control in blackgram [55]. Spinosad (0.009%) gave significantly higher mortality (90.43 %) of *M. vitrata*, minimum pod damage (7.53) and maximum per cent increase in seed yield (79.37 per cent) over control in blackgram [57]. Spinosad 45 SC @ 0.015% was highly effective treatment as it recorded 85.20 per cent reduction in mean larval population of *M. vitrata* in rice fallow blackgram in Andhra Pradesh [68]. Spinosad @75 g ha^{-1} was found to be highly effective against spotted pod borer by recording highest larval mortality 99.97 % in blackgram [69].

4.6 Flubendiamide
Flubendiamide is a new benzene dicarboxamide insecticide developed for lepidopteran pest control. It shows high selective activity against lepidopteran insect pests, which leads to excellent efficacy in the field and excellent safety against non-target organisms, including various beneficial arthropods and natural enemies. These properties suggested the suitability of flubendiamide for integrated pest management (IPM) programes [70]. Flubendiamide 480 SC @ 48 g a.i. ha^{-1} recorded minimum survival of pod borer population (1.13 and 0.5 larvae/5 plants) in blackgram [71, 62]. Flubendamide 39.35 SC @ 0.2 ml/l against legume pod borer recorded lowest mean flower or pod damage 6.95% per plant and recorded highest pod yield 312.50 kg $acre^{-1}$ in blackgram [59, 72]. Flubendiamide 24% + thiacloprid 24-48% SC @ 2ml l^{-1} recorded highest larval reduction (84.45%) against *Maruca* in blackgram at Karnataka and Andhra Pradesh [19, 73]. Flubendiamide 24% + thiacloprid 24% combination @ 175 ml ha $^{-1}$ was most effective in reducing the larva of *M. testulalis* by (60.35 %) over untreated control in cowpea [74].

4.7 Chlorantraniliprole
Chlorantraniliprole is an anthranilic diamide that activates the insect ryanodine receptors and stimulates the release and depletion of intracellular calcium stores from the sarcoplasmic reticulum of muscle cells, causing impaired muscle regulation, paralysis and ultimately death of sensitive species and also long lasting and highly effective against lepidopteran pests[75]. Lowest mean pod damage of 14.5 per cent and also highest mean larval population (0.67 larvae per plant) was recorded with chlorantraniliprole 20 SC @ 20 g a.i. ha^{-1} on blackgram [10, 73]. Chlorantraniliprole + lambda-cyhalothrin 150 ZC @ 250 ml l^{-1} was effective in management of *Helicoverpa armigera* (Hub) resulting in lowest fruit damage (3.17%) with 90.21 per cent larval reduction over control [76]. Chlorantraniliprole + lambda-cyhalothrin @ 215 g a.i. ha $^{-1}$ was found to be very effective against the larval population of *M.vitrata* on soybean by recording 93.33 per cent mean larval reduction over control [77]. Chlorantraniliprole 9.3% + λ cyhalothrin 4.6% @ 0.5 ml l^{-1} was found highly effective against spotted pod borer with least per cent pod damage. And highest yield of 8.31 q ha^{-1} was recorded from chlorantraniliprole 9.3 % + λ cyhalothrin 4% @ 0.5ml/l in rice fallow blackgram at Andhra Pradesh [73].

5. Conclusion
A critical review on the seasonal occurrence of the pest in the above references cited clearly depicted the possible occurrence of the pest which will be helpful to take the fore warning measures in curtailing the pest. Critical review on various groups of chemical insecticides indicates that for the last five decades conventional insecticides, all neuro active chemicals have played major role in management of insect pests in pulses, their indiscriminate uses led to several problems like resistance, residue, resurgence and safety to environment. The focus on insecticide research shifted to search for and development of new green chemistries having novel biochemical targets in the context of pest control and resistance management. Now it is in a renaissance of integrating chemicals for sustainable pest control with human safety. The novel groups of insecticides are very effective at lower doses and low risk to non-target organisms and environment, and their versatility in application methods, these important classes of new insecticides will certainly play a greater role in the present context of environmental safety and their consequent uses in integrated pest management and insect resistance management programmes.

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