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# Studies on pod infesting insect pest complex of pigeonpea *Cajanus cajan* L. (Millsp.) and their control with insecticides and biopesticides: A review

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**Abstract**
Pigeonpea (*Cajanus cajan* (L) Millsp.) is one of the most important pulse crops grown worldwide because it is endowed with several unique characteristics with diversified uses for human needs and is an important crop in semiarid tropical and subtropical areas. Especially in Asia it is a major source of protein for humans. As many as 250 insect species have been recorded to attack pigeon pea among which the pod-borers and pod fly are the most damaging pests, inflicting considerable damage to the reproductive parts of the plant. The pigeon pea pod fly Melanagromyza obtusa Malloch (Diptera: Agromyzidae) is found throughout south and central Asia. The main country suffering from its pestilence is India because of widespread pigeonpea cultivation (>90% of the world production). Females deposit eggs on the pigeon pea green pods and the developing larva initially feeds just under the epidermis of the seed like a leaf miner. Generally, pod yield losses due to this vary between 5-30 per cent during winter and spring from several countries Hence, attempts were made to evaluate the efficacy of different insecticides and botanicals for the sustainable management of the pigeon pea pod fly.

**Keywords:** pigeon pea (*Cajanus cajan* Millsp.), insecticides and biopesticides

## Introduction
Pigeonpea (*Cajanus cajan* **(**L) Millsp.) is an important multi-use shrub legume of the tropics and subtropics. Pigeonpea is a tropical grain legume mainly grown in India and ranks second in area and production and contribute about 90% of the world's pulse production. In India pigeonpea is cultivated in an area of 4.04 million ha and production of about 2.65 million tonnes, with a productivity of 656 kg /ha. In Madhya Pradesh pigeonpea occupies 13.50% (0.53 million ha) area with 12.60% (0.33 million tonnes) production of India and productivity of 656 kg/ha (DES, 2012) [14].

Pigeonpea has a wide range of products, including the dried seed, pods and immature seeds used as green vegetables, leaves and stems used for fodder and the dry stems as fuel. It also improves soil fertility through nitrogen fixation as well as from the leaf fall and recycling of the nutrients (Mapfumes, 1993; Snapp *et al*., 2002) [31, 62]. It is an important pulse crop that performs well in poor soils and regions where moisture availability is unreliable or inadequate. The crop can withstand low moisture condition and performs well in areas with less than 1000 mm of annual rainfall, depending on the distribution pattern. Pigeonpea can be incorporated with crops such as maize, sorghum or groundnut without significantly reducing the yield of the main crop. Its grain is of high nutritional value with high protein content that ranges from 21% to over 25% making it very valuable for improving food security and nutrition for many poor families who can not afford dairy and meat-based diets (Reddy *et al*., 1993; Kimani, 2001) [22].

A large number of insect pests have been identified to infest pigeonpea. The low yields of pigeonpea crop are due to pod borer complex and physiological shriveling. Among the insect species infesting pigeonpea, the pod borer complex is reported to reduce the yield up to 27.77 per cent (Sahoo and Senapati, 2000) [55]. Pod infesting insect pests recorded at Jabalpur are pod fly (*Melanagromyza obtusa* Malloch*)*, gram pod borer (*Helicoverpa armigera* Hubner*)*, pod bug (*Clavigralla gibbosa* Spinola) and plume moth (*Exelastis atomosa* Walsingham). Out of the four pests, *M. obtusa* has established as the most important pest on the basis of pod and grain damage which range from about 55 to 85 and 29 to 63 per cent, respectively,

*(Landge et al*., 2009) [27]. Pod fly now has become important biotic constraint in increasing the production and productivity under subsistence farming conditions, irrespective of agro ecological zones. The survey of Marathwada region of Maharashtra during 2007–08 revealed that the damage by pod fly ranged from 25.5 to 36% (Anonymous 2008) [4]. The estimates of avoidable losses due to pod borer complex, mainly pod fly and *Helicoverpa armigera* were 43.5 and 30.2%, respectively (NCIPM 2012) [38].

Management of pod borer complex in pigeonpea relies heavily on insecticides, often to the exclusion of other methods of control. Considerable number of insecticides has been tested and few of them found effective against the pod borers in pigeonpea (Yadav and Dahiya, 2004) [72]. Regular and indiscriminate uses of insecticides have induced resistance against several pests besides polluting our much precious environment.

**Review of Literature**

In this chapter an attempt has been made to collect and review the available literature regarding performance of pigeonpea. Keeping in view the objectives of the present investigation, relevant available literature is reviewed and presented in the following headings.

1. To study the succession of insect complex on pigeonpea.
2. To study the population dynamics of major insects on pigeonpea.
3. To study the efficacy of insecticides against pod infesting insect pests.
4. To study the efficacy of biopesticides against pod infesting insect pests.

**1. To study the succession of insect complex on pigeonpea.**

Reddy *et al*., (1998) recorded 37 species of insects at various stages of crop growth in an over lapping manner on pigeonpea variety P-33. Among the various insect species only 7 species of insects attained major pest status. Two species, *Exelastis atomosa* and *Helicoverpa armigera* attained major pest status from the flowering to the pod maturity stage of the crop, while *Melanagromyza obtusa* attained major pest status from the pod filling to the pod maturing stage of the crop. Minja *et al*., (1999) [34] studied the succession of insect pests and natural enemies on pigeonpea in Kenya. They reported three groups of insects which included 5 pests *viz.* pod borers (*Helicoverpa armigera*, *Maruca vitrata* and *Etiella zinckenella*), pod sucking bug (*Clavigralla tomento sicallis*) and pod fly (*M. chaleosoma*). Natural enemies observed included insects from order Coleoptera, Hymenoptera, Diptera and Hemiptera. Singh, (2001) [60] conducted a field trial in Uttar Pradesh, India, during *kharif* 1999 to determine the succession of insect pests in late pigeonpea *cv*. Bahar. Pigeonpea was severely infested *by Mylabris pustulata*, *Helicoverpa armigera*, *Exelastis atomosa* and *Melanagromyza obtusa* during the seedling, vegetative and flowering, pod maturity and pod filling stages, respectively.

Kumar and Nath, (2002) [24] causing damage to the extent of 35.94% and 32.47% and 19.19% in pod, seed and seed weight loss respectively. Subharani and Singh, (2004) [59] recorded 30 insect species on pigeonpea in Manipur agro ecosystem. Yelshetty *et al.,* (2005) [74] studied the influence of predatory birds on the population dynamics of *Helicoverpa armigera* in pigeonpea ecosystem. Analysis indicated black drongo to be the most efficient predator, followed by house sparrow and common myna. Joshi and Shrivastava, (2006) [61] Gram pod borer (*Helicoverpa armigera*); Spotted caterpillar (*Maruca vitrata*), Pod bug (*Clavigralla gibbosa*) and Pod fly (*M.obtusa*) were the major pests of pigeonpea. Balikai and Yelshetty, (2008) [49] observed 30 insect pests feeding on pigeonpea. *Helicoverpa armigera* and *Aceria cajani* were the major pests of this crop, while *Megalurothrips usitatus*, *Empoasca kerri*, *Clavigralla gibbosa*, *Riptortus pedestris*, *Exelastis atomosa*, *Melanagromyza obtusa*, *Cydia ptychora* [*Leguminivora ptychora*], *Maruca testulalis* [*Maruca vitrata*], *Etiella zinckenella*, *Adisura atkinsoni* and *Mylabris pustulata* were moderately damaging pests. Mahalle, (2008) [28] studied the succession of insect pests on pigeonpea and reported that jassid, aphid, cow bug and blister beetle appeared when the crop age was about 63 days old *i.e.* from vegetative stage and remained active upto reproductive stage of the crop.

Rana *et al.,* (2008) [20] among them the status of 4 insects *i.e.* pod borer complex were associated with flowers and pods of the crop. They also observed that *H.armigera*, *E. atomosa*, *C. gibbosa* and *M.obtusa* were noticed from flowering to podding stage of pigeonpea crop *i.e.* from December to February. Landge, (2009) [27] studied the succession of insect pests on pigeonpea and reported that jassid, green stink bug and blue butterfly appeared when the crop age was about 63 days old Yadav *et al.,* (2009) [73] reported 37 different insect species from 9 different orders either harmful or beneficial in eastern Uttar Pradesh. Meena *et al*; (2010) [33], recorded pod fly, *Melanagromyza obtusa* on long duration pigeonpea as the major pest and peak activity was observed during 8th and 10th standard week. Pawar, (2010) [44] recorded at Jabalpur 13 different species of insects (11pests and 2 natural enemies) and an insectivorous bird species on pigeonpea crop representing 6 orders and 13 families, respectively. Rathore, (2011) observed first appearance of gram pod borer, *Helicoverpa armigera*; pod bug, *Clavigralla gibbosa* during 47th standard week and pod fly, *Melanagromyza obtusa* during 52nd standard week. Ambhure, (2012) [2] recorded at Jabalpur 11 different species of insects (9 pests and 2 natural enemies) on pigeonpea crop representing 7 orders and 13 families.

**2. To study the population dynamics of major insects on pigeonpea.**

Varma, (1983) [71] reported that maximum temperature above 25ºC and higher humidity above 90 per cent during pod formation seemed to favour the activity of pod fly resulting in heavy oviposition by female fly in the pods. Akhauri *et al*., (1994) [1] studied the population build up and relative abundance of pod borer spp. *Maruca testulalis* (Geyers), *M. obtusa* (Malloch) and *Helicoverpa armigera* (Hubner) in late maturing pigeonpea variety Bahar. Das and Katiyar, (1998) [11] reported that pod fly was first noticed in the 43rd standard week (SW). Average temperature of about 20ºC coinciding with proper podding stage of the crop was found to be favourable for egg laying during 48th - 50th SW. Patel and Koshiya, (1999) [42] the population dynamics of *Helicoverpa* larva on pigeonpea crop and observed that the pest was active from first week of October to last week of November, while maximum population was recorded during the last week of October. Mishra and Dash, (2001) [35] the seasonal activity of *Clavigralla gibbosa* on pigeonpea. The results revealed that all the stages (eggs, nymphs and adults) appeared simultaneously during the 46th standard week. Reddy *et al*., (2001) [53] studied the effects of temperature, relative humidity, rainfall, wind speed and sunshine on the population of pigeonpea pests, *i.e. Helicoverpa armigera*, *Exelastis atomosa* and *Maruca vitrata* in New Delhi. Dhar *et al.,* (2003)

[15] reported that increase in minimum temperature during 7th - 8th SW with presence of population of the pest during 5th -7th SW and rainfall during 1st - 9th SW favoured the *Helicoverpa armigera* infestation during 10th – 14th SW in pigeonpea.

Kumar and Nath, (2003) [24] reported that among the weather parameters studied, only maximum temperature, evaporation and sunshine of the preceding week had significant negative effect on jassid and thrips population. Kumar *et al.,* (2003) the increase in the population of *A. clavipes* and *M obtusa* was higher compared to that of *H. armigera* and *M. testulalis*. Ram *et al*., (2003) Rainfall and relative humidity showed non-significant positive correlation with larval population. Kumar and Nath, (2004) [25] The activity of pod fly, *Melanagromyza obtusa* and gram pod borer *Helicoverpa armigera* appeared from 4th standard week and lasted upto the 14th standard week. Deshmukh *et al.,* (2005) the correlation of pigeonpea pod borers with weather parameters and reported that none of the weather parameters showed any effect on the population build-up of *H. armigera* eggs. Saxena and Ram, (2007) the number of larvae of *H. armigera* and *Maruca vitrata* was positively correlated with pod damage. Subharani and Singh, (2007) [59] studied the impact of various meteorological factors (temperature, relative humidity, rain, sunshine and wind speed) on the population build up of pigeonpea pod fly maggot, *M. obtusa*. The damage commenced during the pod filling stage *i.e*. in the third week of January. Ambulker, (2008) [3] observed that first appearance of *Helicoverpa armigera* eggs and larvae during 41st and 42nd standard week respectively. Bisane *et al.,* (2008) [8] the other Ichneumonid, *Campoletis chloridae* was observed to be active in December. Kaushik *et al.,* (2008) [20] A negative correlation was evident in case of all the pests with evening relative humidity (except jassid) and wind speed (except blister beetle). Mahalle, (2008) [28] studied the population dynamics of major insect pests during reproductive stage and found that thrips both in buds and flowers showed significant negative correlation with maximum temperature while pod fly eggs and pupae were negatively and positively correlated with morning relative humidity and evaporation respectively Landge, (2009) [27] morning relative humidity evening vapour pressure and minimum temperature had positive impact on immature stages of pod fly population respectively. Kumar *et al.*, (2010) [52] The maximum, minimum and wind velocity of preceding week showed non-significant positive influence on population buildup of flower thrips in pigeonpea. Yadav *et al*., (2011) [73] Correlation between maggot population and rainfall for current, one, two and three weeks before was found significant and negative, indicating adverse effect of rainfall. Pillai and Ruhela (2012) [45] The correlation between PSB population and meteorological parameters was not significant in 2011. Multiple regression analysis indicated that among the abiotic factors, the mean temperature and sunshine hours had the greatest positive effect on PSB population.

**3. To study the efficacy of insecticides against pod infesting insect pests.**

Patil *et al.,* (1990) [43] evaluated the performance of quinalphos, endosulfan, methyl parathion, methamidaphos and fenvalerate against *Heliothis armigera, Exelastis atomosa* and *Melanagromyza obtusa* on pigeonpea. Fenvalerate (0.01%) recorded minimum pod damage and maximum grain yield followed by methamidaphos (0.12%) and endosulfan (0.07%), respectively. Sanap *et al.,* (1994) studied the relative effectiveness of synthetic pyrethroids, organophosphate and chlorinated hydrocarbon insecticides against *Helicoverpa armigera, Exelastis atomosa* and *Melanagromyza obtusa* on pigeonpea. Application of 0.02% fenvalerate at 50% flowering and 15 days later, was found to be most effective in reducing the pod damage and increasing grain yield in comparison to control. Patel *et al.,* (1997) [41] studied the efficacy of synthetic and botanical insecticides against *Helicoverpa armigera, Melanagromyza obtusa* infesting pigeonpea. They reported that endosulfan 35 EC @ 0.035% gave the highest cost benefit ratio (1:14.18) followed by cypermethrin (0.006%) (1:12.95) and chlopyriphos 20EC @ 0.02% (1:11.77) respectively.

Rajshekhar *et al.,* (1998) studied the efficacy of endosulfan, methomyl, chlorpyriphos and cypermethrin against *Helicoverpa armigera* on pigeonpea. All the insecticides were effective in reducing the pod and grain damage in comparison to untreated control. Ram Ujagir, (1999) [5] fenvalerate (0.005 and 0.006%) were also effective in reducing pod borer damage and losses in grain yield. Singh *et al.,* (2001) [60] Methomyl 12.5 L (0.1%) was found to be the most effective insecticide as it recorded minimum pod damage. Baruah *et al.,* (2002) [7] studied the efficacy of four insecticides *viz.*, cypermethrin (0.006%), fenvalerate (0.008%), deltamethrin (0.002%) and endosulfan (0.07%) against pod borer, *H. armigera* infesting pigeonpea. Hussain *et al.,* (2003) reported that endosulphan @ 2ml / litre to be most effective against pigeonpea pod fly. Meena *et al*., (2006) [32] studied the bioefficacy of some newer insecticides against gram pod borer in pigeonpea and reported that flubendiamide 20 WDG @ 50 g *a.i.* / ha was found to be most effective and recorded minimum grain damage. Suganthi *et al.,* (2006) [68] studied the bioefficacy of pyridalyl against gram pod borer, *Helicoverpa armigera* and reported that pyridalyl @ 75 and 100 g *a.i.*/ha and indoxacarb @ 75 g *a.i.*/ha were at par with each other, with regards to pod damage and pod yield and were superior to monocrotophos @ 360 g *a.i.*/ha. Srinivasan and Durairaj, (2007) [65] reported that lowest *Helicoverpa* larval population was recorded in spinosad 45 SC (73 g *a.i.* /ha) treated plots, followed by indoxacarb 14.5 SC and maximum population in the untreated control. Ambulker, (2008) [3] reported that two sprays of emamectin benzoate 5% SG @ 9 g *a.i.* /ha was found to be most effective in reducing *H. armigera* larval population and pod. Singh *et al.,* (2008) [59] studied the relative performance of some newer and commonly used insecticides against insect-pest complex of short duration pigeonpea. The damage to pod and grain by various insect pests was found to be minimum in coragen 20% SC @ 40 g *a.i.* /ha and maximum in the control. Highest grain yield (615.2 kg/ha) was recorded from the plots treated with spinosad 45% SC @ 73 g *a.i. /*ha. Ughade *et al.,* (2008) reported that spinosad 45 SC (Tracer @ 0.005%) and indoxacarb 14.5 SC (Avaunt @ 0.01%) showed lowest pod and grain damage by *H. armigera* and *E. atomosa* on pigeonpea. Chavan *et al*., (2009) [9] among all the treatments flubendiamide 480 SC @ 48 g *a.i. /* ha recorded highest pigeonpea grain yield.

Das *et al.,* (2009) [68] reported that two sprayings, initiating at 50% flowering and repeated at 10 days interval of rynaxypyr (coragen) 20 SC @ 30 - 40 g *a.i.*/ha was quite effective in controlling pigeonpea pod borer complex. Pawar, (2010) [44] Spinosad 45 SC @ 73 g *a.i.*/ha followed by rynaxypyr 20 SC @ 40 g *a.i.*/ ha were the most effective treatments on the basis of the effectiveness against pod borer complex on grain damage and grain yield. Mahendra *et al*., (2011) [29] evaluated seven newer insecticides along with untreated check against *H. armigera* infesting pigeonpea. Among them spinosad

(0.006%) and indoxacarb (0.007%) proved to be effective, which were followed by emamectin benzoate (0.001%), flubendiamide (0.004%) and novaluron (0.0075%) in reducing the larval population as compared to endosulfan (0.07%) and untreated check. Pandey *et al*., (2011) reported that emamectin benzoate 5% SG @ 11g *a.i*./ha recorded minimum pod and grain damage (17.00% and 12.2%) caused by pod fly, followed by spinosad 45% SC @ 37g *a.i*./ha. Joshi and Sharma (2012) Pod damage and larval population was lowest in endosulfan sprayed plot and it was at par with higher dose of HaNPV @ 600ml / ha. Among all the treatments, grain yield was highest (13.25 q/ha) in plots treated with endosulfan and was at par with higher dose of HaNPV @ 600 ml / acre (11.35 q/ha).

**4. To study the efficacy of biopesticides against pod infesting insect pests.**

Puntambekar *et al*., (1997) [48] reported that *Bacillus thuringiensis* subsp. kurstaki at $10^{10}$ and $10^{8}$ spores/ml concentration was effective against the major lepidopteran pests comprising the pod borer complex of pigeonpea (*Cajanus cajan*). Sadawarte and Sarode, (1997) [54] studied the efficacy of neem seed extract, cow dung, cow urine and combinations with and without insecticides to control *H. armigera, E. atomosa* and *M. obtusa* on pigeonpea. Prabhakara and Srinivasa, (1998) [46] reported that the Bt formulations (Biobit, Centari and Dipel) caused 58.72% mortality of third instar larvae of *Helicoverpa armigera* after one day of application. Mandal and Mishra, (2003) [30] to control the pod borers, *Helicoverpa armigera, Maruca testulalis* [*M. vitrata*], and pod fly, *Melanagromyza obtusa* on pigeonpea. The pesticides were applied thrice. Combined application of endosulfan and Dipel (@ 0.5+0.5 litre/ha) recorded lowest pod damage (3.5, 5.6 and 2.8%, respectively, by the above mentioned three pests with a total of 11.9%), highest yield (22.8 q / ha) and profit (Rs. 9420 /- ha) followed by sole application of monocrotophos and endosulfan. Nahar *et al.,* (2004) [37] Endosulfan was found to be most effective in controlling *H. armigera,* while *M. anisopliae* and *B. bassiana* preparations were less effective against *H. armigera*. Kumar *et al*., (2004) [26] studied the efficacy of indigenous botanical insecticides, commercial plant products, animal products, microbial insecticides and synthetic insecticides in controlling pod borer complex (*Melanagromyza obtusa, Maruca testulalis* [*Maruca vitrata*], *A. clavipes* and *Helicoverpa armigera* on pigeonpea *cv*. Sharad during 1998-99 in Samastipur, Bihar, India.

Thilagam and Kennedy, (2007) [69] evaluated biopesticide *Bacillus thuringiensis* var. *kurstaki* based product Spic-BioReg against pigeonpea pod borers. The results revealed that Spic-BioReg @ 2.5 l / ha was the best treatment, and recorded lowest larval population of *Helicoverpa armigera* and *Exelastis atomosa*. Mohapatra and Srivastava, (2008) [36] studied the toxicity of biorational insecticide Biobit (*Bacillus thuringiensis* subsp. *kurstaki*) against the spotted pod borer, *Maruca vitrata*, in short duration pigeonpea *cv*. ICPL 87 and reported that among the biorationals, *B. thuringiensis* subsp. Prashad *et al.,* **(**2010) studied four different concentration of *Beauveria bassiana* (Balsamo) on the 4th instar larvae of *H.armigera.* They reported that mortality starts two days after treatment and a dose dependent mortality was observed that went up to 76.7% with highest dose 0.25 ml x $10^{8}$ spores /ml. Khanpara *et al.,* (2011) [21] studied the dose response of *Bacillus thuringiensis* var. *kurstaki* on feeding and oviposition behaviour of *Helicoverpa armigera* on pigeonpea. They reported that lowest number of eggs and larvae were observed in 2.0 g / litre *B. thuringiensis* var. kurstaki treatment, which exhibited the feeding deterrent effect of *B. thuringiensis* var. *kurstaki.* Sreekanth and Seshamahalakshmi, (2012) [64] The percent inflorescence damage due to legume pod borer was lowest in spinosad 45% SC @ 73 g *a.i.* / ha (4.74%), followed by *Bacillus thuringiensis* -1 @ 1.5 kg / ha (10.52%) and *Beauveria bassiana* SC formulation @ 300 mg / l (14.15%) with 80.9, 57.6 and 42.9 percent reduction over control respectively, as against control (24.7%). The pod damage due to *Maruca* was lowest in spinosad (17.38%).

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