Integrated Pest Management in Redgram

Chitta Ranjan Satpathi

Redgram *Cajanus cajan* (L.) Millsp. an important leguminous crop harboring about 77 insect pests but only the appearance of forget-me-not butterfly *Catochrysops strabo* (Fab.), plume moth *Exelastes atomosa* W., Bengal borer *Cletthara floccifera* Hamp., maruca pod borer *Maruca testulalis* (Geyer), gram pod borer (*Helicoverpa armigera* Hub.), pod boring weevil *Apion clavipes* Gerst. and pod fly *Melanagromyza obtusa* Mall. caused considerable damage to the crop, all these insects are serious pest of red gram and it is very common that five lepidopteran larvae per plant and 4.50 percent pod damage or 2.04 percent grain damage either by pod boring weevil *Apion clavipes* Gerst. or pod fly *Melanagromyza obtusa* Mall. caused economic threshold level of damage in red gram. Although the body size of these insects are small but hand picking and destruction of mature larva and egg masses could suppress to build up the initial population of this pest. Among the different bioagents the application of Ha NPV 3 $x10^{12}$ POB/ha in 0.1% teepol or *Bacillus thuringiensis* serovar kurstaki 5%WP1000-1250 g/ha might be considered as an alternate to chemical insecticides. If the insect population reached too high application of chemicals like emamectin benzoate 5% SG @ 220 g/ha, chlorantraniliprole 18.5% SC @ 150ml/ha, spinosad 45% SC @ 125-162 ml/ha are useful to keep pest population within threshold limits.

Keywords: *Pod borer, Plume moth, Bengal borer, Pod fly, Pod boring weevil, Parasitoids, Natural enemies, Bio agents, Augmentation, Insecticides*

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Introduction

Redgram *Cajanus cajan* (L.) Millsp., an important leguminous crop widely distributed in the tropics and cultivated extensively for its edible seeds. At present it is grown almost all the tropical regions of the world (43.87 lakh hectare) including Uganda, America, Italy, Australia, Pakistan, West Indies, India and South east

Asia (FAO STAT 2023-24). In India it is (40.42 lakh hector) mainly grown in Uttar Pradesh, Bihar, Maharashtra, Madras, West Bengal and Assam(https://www.agmarknet.gov.in). A total of 77 insect species feeding on redgram could be found in Eastern India of which *Amrasca kerri* Pruthi (Cicadellidae: Homoptera), *Megalurothrips usitatus* Bag., *Megalurothrips distalis* (Karny.) (Thripidae: Thysanoptera), *Catochrysops stabo* (Fab.) (Lycaenidae: Lepidoptera), *Cletthara floccifera* Hamp. (Noctuidae: Lepidoptera), *Cydia critica* Meyr (Eucosmidae: Lepidoptera), *Exelastes atomosa* W. (Pterophoridae: Lepidoptera), *Maruca testulalis* Geyr. (Pyralidae: Lepidoptera), *Trigonocolus* sp. (Curculionidae: Coleoptera), *Apion clavipes* Gerst. (Apionidae: Coleoptera) and *Melanagromyza obtusa* Mall., (Agromyzidae: Diptera) were of persistent occurrence and often caused noticeable damage to crop in West Bengal, India. Five other insect species such as *Aphis craccivora* Koch., *Aphis gossypii* Glove. (Aphididae, Hemiptera), *Clavigralla gibbosa* Spin., *Riptortus pedestris* (Fabricius) (Alydidae: Hemiptera), and *Heliothis armigera* Hubn. (Noctuidae: Lepidoptera) were of sporadic occurrence and sometimes cause appreciable damage during their period of incident. Few more species of insects were conspicuous by their presence on red gram but rarely caused noticeable damage to crop and it involves: *Megacopta cribraria* Fab., *Megacopta siamicum* (Plataspidae: Hemiptera), *Gargara mixta* Buckton, *Oxyrachis tarandus* F. (Membricidae: Hemiptera), *Stauropus alternus* Wlk. (Notodontidae: Lepidoptera), *Mylabris pustulata* Thunb. (Meloidae: Coleoptera), and *Myllocerus* sp (Curculionidae: Coleoptera) (Satpathi 1992, Satpathi et al.1992).

Presently the crop is attacked by more than 250 insect pests but *Helicoverpa armigera*, *Melanagromyza obtusa*, *Maruca vitrata* and *Clavigralla gibbosa* caused major reduction to grain yield in north India (Srivastava & Joshi 2011). It is very common that all the insect pests have importance with respect to damage and its appearance on red gram crop but pod borer complex caused about 19.11% pod damage of which *Maruca vitrata* 9.7%, pod fly 5.3%, gram pod borer 2.6% and the leaf webber 2.3% in India (Sujithra & Chander 2014).

Diversity of insect pest of red gram

To examine the change in diversity and dominance of 52 insect pests during different growth phase of crop/year the Simpson's dominance index formula was employed on pest species and their population (Shannon1949). Here the cumulative number of species of insect increased with the cumulative population of all insects recorded. But in each case the number of insect species reached asymptote as the crop approach maturity but cumulative population kept increasing the maximum number of species which fed on the crop. The value of Simpson's dominance index was obtained during the month of August (90.71) and November (0.88) when *Cydia critica* Meyr. and *Aphis craccivora* Koch. numerically surpassed all other insect species found during the respective months. Least values of this index (0.18) were obtained during October and January denoting the species occurring during these two months had importance values not differing much among themselves. The lowest value of this index during October inspite of having highest number of species occurring was due to phenological changes occurring in the plant. The insect population feeding predominantly on the vegetative parts of plant showed waning population and the insect feeding on the reproductive parts of the plant were just initiating their occurrence with low population (Satpathi 1992). From very recent data it also exhibited that more than 250 insect species attack on redgram in various growth stage in India (Gopali et al., 2010) but loss may vary 27 to even 100% (Srilaxmi & Pal 2010). In another study only 26 were found of which only *Empoasca kerri* Pruthi, *Grapholita critica* (Meyr), *Maruca testulalis* (Geyer), *Clavigralla gibbosa* Spinola and *Melanagromyza obtusa* (Malloch) were considered as major pest of this crop (Chakraborty et al., 2016).

Borer complexes of red gram

The spotted pod borer *Maruca testulalis* (Geyer), gram pod borer (*Helicoverpa armigera* Hub.), plume moth (*Exelastis atomosa* W.), red gram pod fly *Melanagromyza obtusa* (Mall.) are collectively referred to as "pod borer complexes" (Wadaskar et al, 2013) which caused 30 to100 % yield loss in India (Sharma et al. 2010). A separate study showed that seven different borers usually found in West Bengal and it was noted that initiation of these insects occurred during second week of November with the appearance of forget-me-not butterfly *Catochrysops strabo* (Fab.) then successively of plume moth *Exelastes atomosa* W., Bengal borer *Cletthara floccifera* Hamp., maruca pod borer *Maruca testulalis* (Geyer), gram pod borer (*Helicoverpa armigera* Hub.), pod boring weevil *Apion clavipes* Gerst. and pod fly *Melanagromyza obtusa* Mall. (Satpathi 1992). Here both *Cletthara floccifera* Hamp., and *Apion clavipes* Gerst. were recorded first time as major pest of red gram. The larva of *Cletthara floccifera* Hamp. is cylindrical, stout, brown colored with dark brown head, dorsum of body with characteristic 5 to 6 yellowish brown V- shaped with open end directed anteriorly measuring up to 25 mm in length (Figure 1).

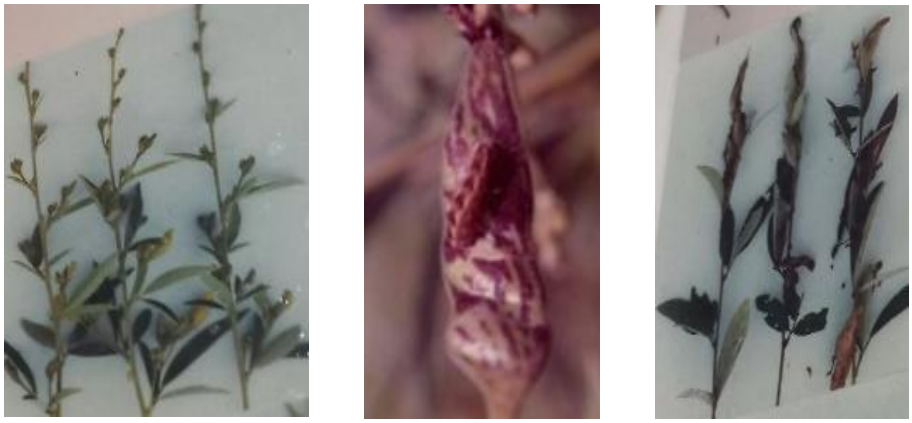

Figure 1. Bengal borer *Cletthara floccifera* Hamp., and its damage on pod and inflorescence (Image credit: Dr. C.R. Satpathi)

The damage caused by the insect is very prominent as the webbed rachis look dried up and black, larvae are very agile and take shelter within dried leaves at basal part of the web nest (Satpathi et al. 1992, Ghosh et al. 1992). Similarly, the adult of *Apion clavipes* Gerst. a new pest is identical and larger than Jute stem weevil *Apion corchori* Gerst. Grubs are cream colored, black headed, somewhat bent larvae measuring up to 5mm in length (Figure 2).

Figure 2. Different stages of pod boring weevil *Apion clavipes* Gerst. (Image credit: Dr. C.R. Satpathi)

Discolored pods when split reveal de-shaped a shriveled seed, such seed often contain a larva (Satpathi et al., 1992). From the pattern of incidence of different borer pest of red gram in West Bengal might be seen as at least two broods of *Melanagromyza obtusa* (Mall.), three of *Catochrysops strabo* (Fab.) and two to three of *Apion clavipes* Gerst., two of *Melanagromyza obtusa* (M.) and only one *Cletthara floccifera* Hamp. (Satpathi 1992).

General approaches to insect pests management of red gram

Among the different approaches for insect pest management of redgram cultural practices, varietal resistance, bio intensive management, use of semiochemical and chemical control are predominant.

Cultural methods

The adult stages of most of the insect pests of red gram are exogenous which directly influence to build up the development of the next generation. Therefore, the reducing initial population in number of either overwintering or immigration generation are the basic strategy of pest management of red gram crop. Different methods implied to achieve this programme are as follows**:**

- Stubble burning, killing the dormant stage of insect by tillage, flooding before field preparation.
- Avoid monocropping.
- Synchronization of sowing time.

Stubble burning and ploughing: Deep ploughing of red gram field is to be done on bright sunny days during the months of April and May and the field should be kept exposed to sun light at least for 2-3 weeks. Most of the borers spends their dormant stage in soil which are either killed by desiccation or consumed by different predators in the field.

Avoid monocropping: Crop rotation is the planned succession growth of various crops on a given plot of land which might be used to reduce the pest load of red gram. Non leguminous crops especially the cultivation of jute, mustard after every 5 years reduce the borer complexes in succeeding years.

Synchronization of sowing time: Level of infestation of some pests as influenced by dates of sowing of red gram in the plains of West Bengal. Here plant sown during early June (one month early than normal sowing) had the least damage of pod fly *(Melanagromyza obtusa*) and pod weevil (*Apion clavipes*) than whereas it was last week of July for *Catochrysop strabo* and *Maruca testulalis*. (Satpathi 1992).

Varietal effect on incidence of borer pest: The red gram varieties could be differentiated in three groups depending on maturity of crops somewhere early variety took 90 to 120 days (TAT -10, UPAS 120) and others were medium duration which matured within 150 to 180 days (20/105, B-517, and B7) and rest were late matured took 180 to 270 days (S-220). The varieties according to maturity were TAT-10, UPAS-120, B-517, B7, 20/105, and S-220, where late maturing varieties were more susceptible to damage by borer pests (Satpathi 1992). As 'UPAS 120'. is moderately early maturing, it evaded infestation of *Melanagromyza obtusa* and *Apion ciavipes* (Satpathi & Ghosh 1994). Very recently JKM 189 and CRG 2015-007 were found to be most tolerant genotypes against pod fly *Melanagromyza obtusa* (Mall.) damage and also recorded better yield (Kumar et al., 2020). LAM-41 is tolerant to *Helicoverpa armigera*, TJT 501 tolerant to Pod Borer &

pod Fly (Project Coordinator's Report, Annual Group Meet on Pigeonpea, 2016-17, AICRP, ICAR, IIPR, Kanpur.)

Biological control agents

Biological control has now been recognized as an important component of bio intensive integrated pest Management (BIPM) where artificial release of the natural enemies of crop pests are done. Biocontrol is an important component for organic agriculture and considered as a alternative to conventional pesticide based control (Ehlers2011). Additionally some agro-ecologists have established that under certain conditions bio-control is better than chemical control with respect to long term productivity (Altieri 1981, Gurr & Wratten 2000).

Augmentation of natural enemies

It is a common practice to increase the effectiveness of natural enemy populations either by their propagation and release or by manipulating environmental conditions that result in temporary suppression of pests below the threshold level.It is a common practice to increase the effectiveness of natural enemy populations either by their propagation and release or by manipulating environmental conditions that result in temporary suppression of pests below the threshold level. It is a common practice to increase the effectiveness of natural enemy populations either by their propagation and release or by manipulating environmental conditions that result in temporary suppression of pests below the threshold level. Augmentation is a common practice to increase the effectiveness of natural enemies either by release or by manipulation of environmental conditions which resulted to keep the insectpest population below the economic threshold level.

Parasitoids: Out of 14 insects that have been considered important, parasitoid could be recorded eleven of them (Table 1). Among these parasitic insects only three species of parasitoids are very much common and occurred almost throughout the period of occurrence of host insects. These were *Apanteles machaeralis* Wlk., *Eurytoma* sp and *Gryon* sp

Table 1. Hymenopteran parasitoid associated with insect pests of red gram in India (Satpathi 1992, Ketipearachchi, 2002, Makinson et al., 2005, Narendran et al., 2005, Sharma et al., 2010, Chakravarty et al., 2016)

Family	Parasitoids	Hosts
Elasmidae	*Elasmus* sp.	*Cydia critica* Meyor (Larva)
Perilampidae	*Perilampus* sp.	*Cydia critica* Meyor (Larva)
Braconidae	*Apanteles machaeralis* Wlk.	*Cydia critica* Meyor (Larva)
	Apanteles africanus Wlk.	*Porthesia scintilans* W. (Larva)
	Phanerotoma sp.	*Porthesia scintilans* W. (Larva)
Chalcididae	*Tropimeris mondon* Boucek	*Maruca testulais* Greyon (Larva)
		Exelastes atomosa W. (larva)
Ormyridae	*Ormyrus orientalis* (Walk.)	*Exelastes atomosa* W. (larva)
	Ormyrus orientalis (Walk.) *Ormyrus* sp.	*Melanagromyza obtusa* Mall. (Pupa)
Scetionidae	*Gryon* sp.	*Melanagromyza obtusa* Mall. (Maggot)

	G. clavigrallae Mineno	*Clavigralla gibbosa* Spin.
	Paratelenomus sp.	*Megacopta cribraria* Fabr. (Egg)
Eurytomidae	*Eurytoma* sp.	*Apion clavipes* Gerst. (Grub) *Melanagromyza obtusa* Mall. (Maggot)
Pteromolidae	*Pteromalus* sp.	*Apion clavipes* Gerst. (Grub)
	Callitula sp.	*Melanagromyza obtusa* Mall. (Maggot)
Eupelmidae	*Eupelmus* sp.	*Apion clavipes* Gerst. (Grub)
Ichneumonidae	*Diadegma* sp.	*Exelastes atomosa* W. (larva)
Trichogrammatidae	*Merufens* sp.	*Nephopteryx* sp. (Larva)
Bathylidae	*Goniozus indicus*	*Remigia archesia* (Cram.)
	Megaselia sp.	*Heliothis armigera* Hub.
Eulophidae	*Aprostocetus* sp. *Euderus* spp. *Diglyphus funicularis* Khan	*Melanagromyza obtusa* Mall. (Maggot)

The % of parasitization of these three species ranged between 14-40%, 42 to 78%, and 16 to 24% respectively. *Apanteles machaeralis* Wlk. was first appeared on redgram in West Bengal during first week of September and showed 3 other peaks during last week of September, third week of October and third week of November respectively. But appearance of peak incidence of other two parasitoids were found a week later than the peak population of their hosts (Satpathi 1992, Chakravorty et al., 2016).

Common predators: Spider, preying mantid (*Mantis* sp.), dragonfly, coccinellid beetle (*Menochilus sexmaculata* (F.) and *Coccinella septempunctata* L., Canthecona bug, *Eucanthecona furcellata* (Wolff.), Reduvid bug *Rhynocoris fuscipes* (F.) (Satpathi 1992, Chakravorty et al., 2016)

Use of plant extracts to attract natural enemies: According to Altieri et al., (1981) artificially prepared extracts from plants *Amaranthus* sp. and corn increased parasitization of *H.zea* egg parasitization by *Trichogramma* sp. and *T. pretiosurn* and compared to natural condition in crop fields.

Biopesticides

Biopesticides are certain types of pesticides derived from animals, plant, bacteria, fungi, virus, protozoa, nematode and some minerals. Among the different insect pests, maximum control was done on homopterous insects (46.7%) causing considerable damage to crop (Singh 2003).

Entomopathogenic Bacteria: This bio agent is parasitic in nature and it grows either inside or outside of insect body. Among the different entomopathogenic bacteria both *Bacillus thuringiensis*, and *B. sphaericus* are extensively used for controlling the insect pests of red gram. All lepidopteran borer pest complex of red gram is susceptible to this biopesticide and keep the population below the threshold level.

Entomopathogenic fungi: Entomopathogenic fungi (EPF) are common in terrestrial environments and can penetrate the outer protective covering/ layer of insect and arachnid populations. The cause of the insect's death is extensive growth of *Metarrhizum anisoplae* and poisoning by its toxin. This fungus could be used for controlling both homopteran and heteropteran insect pests infesting red gram.

Virus replication: Insect baculoviruses have a potential as viable alternatives to chemicals in the control of red gram borer pests. The infected larvae of *Helicoverpa armigera* (Hub.) and *Spodoptera litura* (Fab.) stop feeding and gradually it changed into pinkish white color on the ventral side. For practical use the dead larvae are harvested mechanically and homogenized (at 5 to 10°C temperature) followed by filtered through a 100-mesh screen. The filtrate is then concentrated using a vertical centrifuge to prepare a NPV cream eg. Ha NPV against *Helicoverpa armigera*, SL NPV against *Spodoptera litura* **(**Fab.).

Entomopathogenic nematodes against insect pests of red gram: Entomopathogenic nematodes (EPNs) cause disease within an insect which may vary from a phoretic relationship to obligate entomoparasitism leading to sterility, reduced fecundity, delayed development or death of the host. Among the different formulations the dust, sprays, capsules, and granules form of Entomopathogenic Nematodes (EPNs) are applied through spraying suspension or through irrigation system.

Semiochemical

Semiochemicals are marker or signal chemicals which transmitted information between individuals of the same species (pheromones) or different species (allelochemicals) but in some cases it is used for disrupting their mating process. The use of pheromone for insect monitoring was initiated in 1940' when crude extract of abdominal tips of female Gypsy moths were used in traps in USA but later this pheromone applied as tools for insect pest management (Stern et al. 1959). For monitoring *Helicoverpa armigera* Hub. two components of female sex pheromones (Z- 11- 17 Ald: Z-9-16 Ald at the ratio of 97: 3 are used for preparing lure (Wu et al., 2013).

Use of herbivore induced plant volatile (HIPV)

Whenever plants are attacked by insect herbivores the injury induces release of certain volatile chemicals which invites natural enemies for the insect pests thus indirectly invites plant body guards or saviors, such chemicals are called Herbivory induced plant volatiles (HIPV) (Dicke and Sabelis, 1988). Methyl salicylate (MeSA) and (Z) -3-hexenyl acetate (HA) can invite a considerable number of predatory insects to reduce aphids and spider mite and aphid population (Khan et al., 2008).

Habitat manipulation in insect pest management

Black aphid *Aphis craccivora* (Koch) (Aphididae; Homoptera) is the most serious pests of red gram (Satpathi et al., 1992). The golden rod plant provides food for the ladybird beetle, the potent predator of aphids (Altieri &Whitcomb 1979). The tall vegetative growth of flowering plants around the crop field can invite spiders (Satpathi 1995).

Integrated Pest Management of borer complexes of red gram

The Integrated Pest Management (IPM) has been developed over the decades to express the deleterious impacts of synthetic chemical pesticides on environment. The economic threshold level (ETL) was the prime criteria for several decades but in modern IPM emphasis is given to researcher where farmers take decisions based on larger range of field observations on biotic (i.e. insect pests, diseases and weeds) and abiotic factors include soil, rain, sunshine hours and wind. All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. The IPM module for some key pests of red grams were

developed by TNAU as given below (http://www.agritech tnau.ac.in/ crop_ protection/ crop_ prot_crop _ insect_pul_red%20gram.html)

Gram pod borer (*Helicoverpa armigera* Hub.): Growing of one row of sunflower after every nine rows of pigeon pea where maize crop was grown as border crop can suppress initial population buildup of *Helicoverpa armigera* in red gram**.** For monitoring the movement of this borer pest 10 to 12 pheromone traps might be used per hectare of red gram field. In addition to this collection and destruction of matured larvae and installation of about fifty bird perches /ha plays an important role for controlling initial population of this pest. Considering toxicity of pesticide Ha NPV $3x10^{12}$ POB/ha in 0.1% teepol or *Bacillus thuringiensis* serovar kurstaki 5%WP @ 1000-1250 g/ha might be used as viable alternatives to chemicals in the control. Recently azadirachtin 0.03% WSP @ 2500-5000 g/ha or Neem oil 2% are used when the population remain low but when the larval population reached high the chemicals like emamectin benzoate 5% SG @ 220 g/ha or indoxacarb 15.8% SC @ 333 ml/ha or chlorantraniliprole 18.5 SC @ 150ml/ha or spinosad 45%SC @ 125-162 ml/ha could be used as last resort when all other methods fail to keep the pest population below economic loss.

Plume moth (*Exelastis atomosa* W.), Spotted pod borer: *Maruca testulalis* (Geyer), forget-me-not butterfly *Catochrysops stabo*(Fab), Bengal borer *Cletthara floccifera* Hamp.: All the larvae are serious pest of red gram which damage flowers as well as pods and feeds on developing grains. The life cycle of this insect is moderate and multiply so rapidly that initial five larvae per plant could reach economic threshold level. Although the body size is small but hand picking and destruction of mature larva could suppress to build up the initial population of this pest. Among the different bioagents the application of Ha NPV 3 $x10^{12}$ POB/ha in 0.1% teepol or *Bacillus thuringiensis* serovar kurstaki 5% WP @1000-1250 g/ha might be considered as alternate of chemical insecticides. If the population level is relatively high azadirachtin 0.03 % WSP @ 2500-5000 g/ha or neem oil 2% might be considered to suppress this pest. If the insect population reached too high apply chemicals like emamectin benzoate 5% SG @ 220 g/ha, chlorantraniliprole 18.5 SC @ 150ml/ha, spinosad 45%SC @ 125-162 ml/ha were used to keep pest populations within threshold limits.

Red gram pod fly *Melanagromyza obtusa* (Mall.) and pod boring weevil *Apion clavipes* Gerst.: Both the pests cause direct effect on yield of redgram and its ETL varies 4.50 percent pod damage and 2.04 percent grain damage in West Bengal (Satpathi 1992). The initial population can be controlled by bird perches @ 50no/ hectare. The adult *Apion clavipes* could easily be controlled by collection and destruction. Like other borer pest the green level pesticide like Azadirachtin 0.03 % WSP 2500-5000 g/ha or *Bacillus thuringiensis* serovar kurstaki 5%WP@1000-1250 g/ha might be used at weekly interval as soon as pod formation started and continued untill the crop matures. In addition to these pesticides spinosad 45% SC @ 125-162 ml/ha or NSKE 5% twice followed by triazophos 0.05% might be used. If the population goes above economic threshold level use emamectin benzoate 5% SG @ 220 g/ha or indoxacarb 15.8% SC @ 333 ml/ha or chlorantraniliprole 18.5 SC @ 150ml/ha or spinosad 45%SC @ 125-162 ml/ha at 15 days interval till the crop is matured.

Pod bugs: *Clavigralla gibbosa* Spin. and *Riptortus pedestris* (Fab.): Mode of damage and biology of both the bugs are mostly identical as it damage the red gram crop by direct sucking the sap from the pod. Here one nymph per plant is considered as economic threshold level but the initial population could be controlled either by bird perches @ 50/ ha or by mechanical collection and destruction of egg masses. The body of the nymphs are soft which could easily be controlled either by Ha NPV 3 $x10^{12}$ POB/ha in 0.1% teepol or azadirachtin 0.03 % WSP @ 2500-5000 g/ha. Initially the nymphs are congregated in particular plant but

with the maturity it spread throughout the field and reaches above the economic threshold level. When it reaches high used either emamectin benzoate 5% SG @ 220 g/ha or spinosad 45%SC @ 125-162 ml/ha. If the population reaches above Economic Threshold Level use either indoxacarb 15.8% SC @ 333 ml/ha or chlorantraniliprole 18.5% SC @ 150ml/ha.

Conclusion

Red gram being a relatively long duration annual crop having typical growth characteristics harbor a multitude of insect species that utilize this crop as their food and shelter. Insect species feeding on the reproductive parts of plant inflict irreparable damage. To encounter the problem of insect pests, farmers are leaning more toward the use of chemical insecticides as these provide a quick remedy to the problem. Consequently, the rapidly increasing awareness of the human and animal health issues as well as environmental impacts the host plant resistance, bio intensive management, use of semiochemical and chemical are different methods to formulate an Integrated Pest Management (IPM) programme of red gram.

Competing interest

The author has declared that he has no conflict of interest.

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