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Biological Study And Its Major Control Of Lophopid Planthopper *Pyrilla perpusilla* Walker (Homoptera : Lophopidae), A Sugarcane Pest in Certain Areas Of Bihar, Rampur -Rudra, District Chapra (Saran), Bihar (INDIA)

Dr. Bibhuti Dutta Singh

Faculty of Science, Zoology, Dayanand Anglo Vedic Postgraduate (DAVPG) College, Siwan,
Jai Prakash University Chapra (Saran) Bihar - 841301 (INDIA)
E-mail: bibhuti.zoology@gmail.com & drbds.email@gmail.com

Abstract: **Sugarcane (*Saccharum officinarum*) is one of the most important commercial crop produced in the state of Bihar. Biology, life history, preliminary behaviour of mating and egg laying and laboratory rearing of *Pyrilla perpusilla* walker (Homoptera: Lophopidae). The bug is one of the serious insect pests of sugarcane in Rampur-Rudra, Bihar. Female *Pyrilla perpusilla* has a pre oviposition period of 8.8 ± 1.077 days and the average fecundity was 133±10.2 eggs. Eggs are laid in clusters on both the lower (abaxial surface) and upper surface (adaxial surface) of sugarcane leaves preferably on lower surface and are covered with white waxy filaments. The eggs are white, oval and have a mean length of 1.04±0.148mm. Incubation period was 6.9±0.87 days in the field conditions and 6.8±0.81 days in cage conditions. There were five nymphal instars and nymphal phase was 40-60 days. Longevity of the adult female was significantly greater than that of males. Analysis of aggregated sampling data for males and females showed that the sex ratio was 1:1.**

Keywords: Pyrilla perpusilla, **Sugarcane planthopper, Incubation, Sugarcane, Nymph etc.**

1. INTRODUCTION

Sugarcane (*Saccharum officinarum*) is commercially cultivated on a large scale in the dry zone of Bihar in the Rampur – Rudra (25º36’ and 26 º 13’ North latitude and 84 º 24’ and 85 º 15’ East longitudes in the southern post).

Sugarcane is subjected to attack by number of insect pests, resulting in loss in yield, poor juice quality and low sugar recovery. The most serious insect of sugarcane recorded in sugarcane growing areas in Saran division during the recent past was the sugarcane Planthopper *Pyrilla perpusilla* walker (Homoptera : Lophopidae) (Kumarasinghe,1988). It is widely distributed in the oriental region. It is one of the most destructive pests of sugarcane (Gupta and Ahamad, 1983).

Both nymphus and adults of this pest suck sap from the leaves of sugarcane but most of the damage is caused by the nymphal stage. The feeding punctures turn pale yellow and coalescence of such spots imparts a yellowish colour to the leaves. (Butani, 1964). Furthermore, due to continuous feeding of sap by thousands of planthoppers, the leaves become wilted and growth of the plant is arrested. In addition to the direct physical injuries, *Pyrilla perpusilla* is also responsible for reduced photosynthesis due to the growth of powdery mildew on its honeydew secretions (Assre et al. , 1983). Rahman (1942) and Rahman and Singh (1943) have assessed that the heavy *Pyrilla perpusilla* infestations reduce the

sucrose content by 3-4% and purity by 3-26%. However, they found that the glucose ratio of the plant increases three fold after *Pyrilla perpusilla* infestations.

A large number of plants including various types of grass species are recorded as alternate hosts of *Pyrilla perpusilla* and some of these are used by this pest for both feeding and reproduction. *Zea mays*, Sorghum sp. (Gupta and Avasthy, 1954) *Pennisetum americanum*, *Hordeum vulgare* (Brar, 1981), *Mormordica charantia*, *Abelmoschus esculentus*, *Luffa aegyptica*, *Citrulus vulgaris*, *Cucurbita pepo* (Rahman and Nath, 1940), *Oryza sativa* (Power,1981), *Avena fatua*(sinha et al., 1974) *Pisum sativum* and *Bambusa arundinacea* (Flether and Ghosh, 1919) serve as alternative host plant for *Pyrilla perpusilla.*

The increasing impact of *Pyrilla perpusilla* has elicited concern among entomologists who require pets management options. The biology and behaviour of *Pyrilla perpusilla* were described by some entomologists in various parts of India (Gupta and Ahamad,

1983; Rahman, 1942; Fletcher, 1914; Quadri ans Aziz, 1950; Patel et al., 1993). However, according to Kumarasinghe and Wratten (1996), many of these studies are incomplete and have limited applicability. The main objectives of the present study were to elucidate the biological, behavioral and morphological aspects of *Pyrilla perpusilla* in the Rampur-Rudra wet zone of Bihar, Fig. (A) Cultivated Sugarcane Plant. Results presented here may be helpful for future planning of large scale cultivation of Sugarcane in the same environmental conditions in the tropics especially for pest management purposes.

Fig. (A) Cultivated Sugarcane Plant

2. MATERIALS AND METHODS

Experimental Plot:

Studies were carried out on a sugarcane plot of 5.03x10.07 meter in selected Rampur Rudra village in Panapur block of Chapra (Saran) District in Bihar. The district of Chapra (Saran) is situated between 25º36’ and 26 º 13’ North latitude and 84 º 24’ and 85 º 15’ East longitude in the southern post of Saran Division of North Bihar during the period of April 2010 to April 2011. The number of plants in the experimental plot was approximately 1100 plants were fertilized with NPK fertilizer once in 3 months and watering was carried out when necessary. No insecticides, herbicides or fungicides were used.

Experimental Insects

Four to five months after planting, naturally occurring *Pyrilla perpusilla* began to attack the plants. Field and laboratory experiments were started after. *Pyrilla perpusilla* became available in the experimental plot. Some biological aspects were studied in rearing cages outside the experimental plot since both nymphs and adults were very active jumpers.

Experimental Steps

Rearing Studies:-

Pyrilla perpusilla was reared in controlled conditions and determine its biological aspects such as oviposition, fecundity, longevity and also for development experiments. Adults of *Pyrilla perpusilla* were collected from the experimental plot and reared outdoors in cages made with wooden frames (150 x 150 x160 cm.) and covered on all sides with organdy cloth. There was an opening of 90 x 60 cm covered with organdy cloth on one side of each cage for introduced sugarcane plants and the insects. Cage was placed on a wooden platform covered with polythene to protect it from termite attack.

Sugarcane plant approximately 60 cm in height and grown in soil polythene container (25 cm. diameter and 35 cm. high) were separately places inside each cage. Unfertilized egg clusters collected from the sugarcane plot together with parts of the sugarcane leaves on which they were found were stapled on to leaves of a potted plant without disturbing the eggs. Egg clusters were examined daily until the egg hatched.

Life Cycle Stages Studies

Upon hatching the first instar nymphs from each egg cluster were transferred to potted plant placed inside another cage. These nymphs were left undisturbed to feed, moult and eventually metamorphose into adults. Adults were carefully observed and sexed using morphological features.

Pre- oviposition, oviposition and post oviposition periods were studied under laboratory conditions. Adult males and females were collected from the rearing cages within 24 h of last moult. Batches of the three males and a female were placed separately in twenty rearing jars (10cm internal diameter X 21 cm high). A 10–12 cm long piece of sugarcane leaf was placed inside each jar; the leaf portions provided nourishment for *Pyrilla perpusilla* as well as surface on which to rest and oviposit. A 2.5 cm thick layer of plaster of pairs was laid at bottom of each jar in order to provide sufficient moisture for sugarcane leaf from wilting. The mouth of each jar was covered with a muslin cloth allowing aeration to the adults. Fresh leaves were supplied daily while removing the old leaves. Insects in the rearing jars were monitored daily until all the insects died. Pre oviposition, oviposition and post oviposition periods were recorded.

Twenty pairs of newly emerged adults collected from the rearing cages were placed inside a new rearing cage containing a potted sugarcane plant. They were allowed to mate and oviposit. The number of egg clusters produced each day by the 20 females was recorded. In another separate experiment, newly emerged adult males (n = 20) and females (n=20) were collected from the rearing cages and placed separately in rearing jars described earlier with 10-12 cm long piece of sugarcane leaf. Fresh leaves were supplied daily while removing the old leaves. Insects in the rearing jars were monitored daily until all the insects died in order to determine the longevity of adults.

Incubation period and viability of eggs were studied both in the laboratory and field. Newly laid egg clusters were randomly selected in rearing cages (n=20) and field (n=20). They were observed daily until hatching. To determine percentage viability of eggs, unfertilized egg clusters along with parts of the sugarcane leaves on which they were found were collected from the experimental plot (n=20) and rearing cages (n=20). The number of eggs in each cluster was recorded after carefully removing the white waxy filament covering with a camel hair brush. Number of unhatched eggs in each cluster was recorded after the incubation period. The incubation period and viability of eggs in inside the cage and under field conditions were compared using t-test.

For the developmental experiment, ten sets of newly hatched first instar nymphs were reared individually on pieces of sugarcane leaves placed in rearing jars described earlier; approximately 10-12 cm long piece of sugarcane leaves were placed obliquely inside the jars with one end resting on the bottom and the touching the sides of the jars with the adaxial surface facing upwards. This disposition of the leaves enabled nymphs to rest and feed on the abaxial surface as they usually do in the field. The pieces of leaves were replaced daily with fresh ones. Nymphs were examined daily and the number of instars was determined by observing moults. Fig.(A)Female *P.purpusilla*, Fig.(B) Male *P. purpusilla*, Fig. (C) Single Nymph of *P. purpusilla*, Fig.(D) Damage Sugarcane leaf by *P . purpusilla*, Fig. (E)Gathering of *P. purpusilla.*

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Fig.(A)Female *P.purpusilla*

Fig.(B) Male *P. purpusilla*

Fig. (C) Single Nymph of *P. purpusilla*

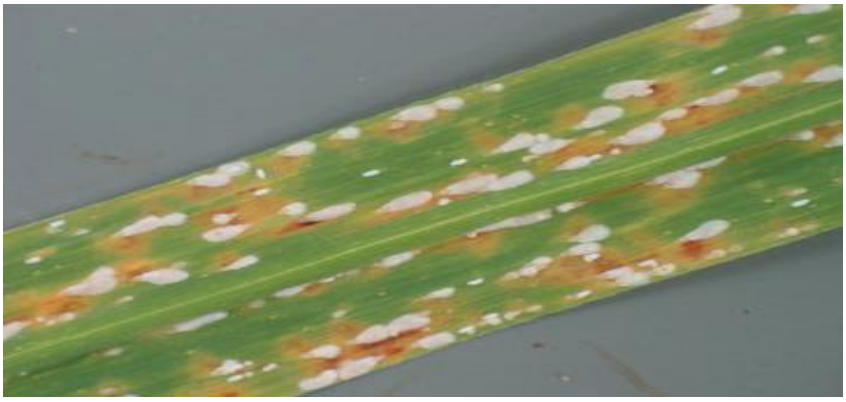

Fig.(D) Damage Sugarcane leaf by *P . purpusilla*

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Fig. (E) Gathering of *P. purpusilla*

Morphological Studies

Twenty egg clusters were collected from the experimental plot and brought into the laboratory with the parts of leaves on which they were attached. Length and breadth of each egg cluster was measured using dividers and a millimeters scale. The waxy filaments covering was gently removed using camel hair brush. The eggs were then individually transferred to a glass slide and length and breadth of each egg was measured under a light microscope fitted with a micrometer eyepiece. A total of 200 randomly selected eggs were measured. The length and breadth of first and second instars were measured using a light microscope fitted with a micrometer eye piece; the later instars and adults were measured using a pair of dividers and a millimeter scale. Morphological features of the eggs, nymphs and adults were examined under a stereomicroscope.

Field Studies

Sex ratio, mating and oviposition behaviour of the *Pyrilla perpusilla* were studied under field condition. To determine the sex ratio, adult *Pyrilla perpusilla* present on every plant under experimental plot were sexed and counted once a week. This was possible on account of low population density. As it was possible to distinguish adult males from females using morphological differences in the abdominal tips; approximately 50% of adults present in the field of each sampling occasion were sexed in situ. Sex ratio of adults was determined using χ 2 test.

Preliminary observations of mating and egg laying behaviour were carried out in the field. Focal animal sampling (Martin and Bateson, 1986) was chosen (observing one individual until the end of the desired behaviour) and duration of time for the behaviour was recorded (n=20). The total numbers of egg clusters found on the adaxial and abaxial surfaces of the leaves of every plant in the experimental plot was counted once a week. At the same time total numbers of egg clusters found on the luxuriant plants and scraggy plants were also recorded. Data were analyzed using paired sample t-test for oviposition site selection.

3. RESULTS AND DISCUSSION

Biology, life history, preliminary behaviour of mating and egg laying and laboratory rearing of *Pyrilla perpusilla* walker (Homoptera : Lophopidae) were studied at the J.P. University Chapra (Saran) Bihar from Rampur-Rudra from April 2010 to April 2011. *Pyrilla perpusilla* was established throughout the study period since there was no use of insecticides, herbicides or fungicides. Subsequently, *Pyrilla perpusilla* found in the experimental plot were identified by comparing their morphological characters.

Adult *Pyrilla perpusilla*, found in Bihar are a straw coloured, medium sized bugs with a prominent cylindrical rostrum. Sexes differ in size, the female has an average length of 1.7±0.2 mm, the male is slightly smaller with an average length of 1.5±0.3 mm. The female also has characteristic circular pads at the tip of the abdomen. Adults were relatively inactive during the early morning, evening and night, typically remaining lower surface of the leaves. During the day (10.00 am to

3.00 pm) adults became more active and were found on both the upper surface and lower surfaces of the leaves and jumping from plant to plant.

Newly emerged adult females were ready to mate two days after emergence from to fifth nymphal instar. Males and females began to copulate about two days after their last moult and mating occurred usually during the day. Males and females mated multiple times, usually with different partners, with each mating episode lasting 1-2 h. females typically mated multiple times during one week period before starting to oviposit. Mating continued throughout the oviposition period.

Females carry an egg cluster for about 60-90 min. at the tip of their abdomen before depositing it on a leaf. Females oviposit mainly during the day. However, in some cases it was observed that females oviposit even at night. Females have a pre-oviposition period which range from 7-11 days, with a mean of 8.8±1.0 days. Maximum, minimum and mean values for the oviposition periods are 22, 10 and 15±1.4 days, respectively while the same values for post oviposition phases are 8, 2 and 5±2.0 days respectively (Table 1)

Eggs are laid in cluster (length ranged from 12 to 18 mm with mean of 13.3±1.9) mainly on the undersides of leaves near the mid rib both during the day and night which are covered with white fibrils of wax. The eggs are oval in shape, small (0.8 to 1.3 mm length with a mean of 1.04±0.148 mm) and white in colour in the early stages turning pale yellow prior to hatching. Although eggs are laid on both the lower (abaxial) and upper (adaxial) surfaces of leaves, the lower surface (abaxial) is preferred (paired t-test: $p<0.001$); furthermore luxuriant plants were preferred to scraggy plants (paired t-test: $p<0.001$): this is probably because they are better protected from direct sunlight and parasitism when laid on the lower surface of the leaf. The brilliant white waxy covering makes the egg cluster conspicuous to predators but the advantage of having a white waxy covering is probably due to the fact that it reflects harmful solar radiation away from the eggs which have a thin and delicate chorion.

Table 01: Duration of various life parameters of *Pyrilla perpusilla*

Life history parameter	Minimum	Maximum	Average (±SE)
Pre oviposition period	**07**	**11**	**8.80±1.00**
Oviposition period	**10**	**22**	**15.00±1.40**
Post oviposition period	**02**	**08**	**5.00±2.00**
Male longevity	**21**	**31**	**25.00±3.10**
Female longevity	**31**	**37**	**33.10±1.80**
Incubation period(in field)	**06**	**09**	**6.90±0.87**
Incubation period (in lab)	**06**	**08**	**6.80±0.81**
First instar nymphs	**08**	**12**	**9.50±1.60**
Second instar nymphs	**07**	**12**	**10.91±1.06**
Third instar nymphs	**06**	**10**	**8.26±1.03**
Fourth instar nymphs	**09**	**14**	**12.26±0.80**
Fifth instar nymphs	**10**	**13**	**11.20±0.95**

A female during her lifespan produces 2-5 egg clusters with an average of 3.3±1.1. The number of eggs in a cluster obtained from rearing cage ranged from 17-56 with mean of 33.0±10.3 while eggs in a cluster obtained from the experimental plot ranged from 18-57 with mean of 32.0±10.8. The difference in means between eggs in a cluster laid in rearing cages and in the experimental plot is not statistically significant (t-test; $p>0.05$). The total number of eggs laid by a female during her lifetime ranged from 47-200 with a mean of 133±10.2.

Gupta, B.D. and Avasthy, P.N. (1954). have stated that the mean number of eggs in an egg cluster of *P. perpusilla* in Bihar. The mean number of eggs in a cluster at Rampur-Rudra (in field) was found to be 33.05±10.39. Despite the differences in climatic conditions between Rampur Rudra the mean number of eggs in a cluster in both places is approximately the same. This indicated that the number of eggs in a cluster is an inherent trait unaffected by climatic differences.

Under laboratory conditions, the incubation period ranged from 6-8days with a mean of 6.8±0.81 days and under field conditions it ranged from 6-9 days with a mean of 6.9±0.87 days (Table 1). The difference between incubation period under laboratory and field conditions is not significantly difference (t-test; $p>0.001$). Egg viability recorded from egg clusters collected from the rearing cages was found to be 89.79% while that of egg cluster collected from experimental plot was 87.22%. There was no significant difference between viability of eggs laid in rearing cages and in the experimental plot (t-test; $p>0.001$).

Longevity of the adult females was significantly greater (t-test; $p<0.01$) than that of the males; females lived for 31-37 days with the means of 33.15±1.81 days whereas the longevity range of the males was 21-31 days with a means of 25±3.13 days (Table 1). The viability of eggs appears to be affected by the ambient relative humidity especially when it shows drastic fluctuations (Mogal et al., 1983). They reported that the viability of eggs was 49% at 7.03% RH and it gradually increased with increasing relative humidity reaching a maximum of 92% at 82.26% RH. Meteorological data recorded during this study showed that the relative humidity at Bihar had a narrow range of fluctuation between 70 and 87% with a mean of 81±3.2% and that the viability of eggs remained high throughout the study period. Since the mean viability of eggs recorded in the study (89.74%) is very close to the maximum percentage viability (92%) recorded by Mogal et al. (1983). It is likely that the range of relative humidity prevailing at Bihar optimal for the hatching of *Pyrilla perpusilla* eggs.

Pyrilla perpusilla has five nymphal instars. The first instar nymphs are white in colour and its two compound eyes are dark red. It has two anal filaments. The mean duration of the first instar nymphs was 9.5±1.6 days. The body of second instar nymphs and their anal filaments is pale brown in colour. The mean duration of the second nymphal period was 10.91±1.06 days. The third instar nymphs are similar to that of the second instar nymphs. The mean duration of the third instar was 8.26±1.03 days. Duration of the fourth instar was 12.26±0.80 days while fifth instar nymphal period was 11.20±0.95 days (Table 1). Nymphs at this stage are dark brown in color and much more active than previous instars.

Recorded of adults males and females counted in the field showed that there is no appreciable departure from the male: female ratio of 1:1 ($\chi 2$ test $p>0.05$). Absolute counting of males and females was carried out for this sex ratio study. Sampling of an animal population is necessary only when the population is large, since counting of individuals is time consuming and costly. However, when a population is small and individuals could be conveniently counted, a census of the population may be carried out; this gives a true value of the absolute population size within limits of human error and wherever possible is preferable to sampling. It was observed that a low population level of *Pyrilla perpusilla* remained through out the study period in the study area.

There was no overlap of adults of different generations of *Pyrilla perpusilla* during the present study since the maximum lifespan of adult females was much shorter than the developmental period from egg to adult and there were no other sugarcane fields in the neighborhood, the study plot was sufficiently isolated and immigration was unlikely. During the period of this study the daily minimum temperature fluctuated between 20.3 to 26.7ºC and the daily maximum temperature 30 to 32.4ºC. The difference between maximum and minimum ranged from 4 to 10.2ºC. Daily value of temperature and relative humidity inside rearing cages used in this study were only marginally higher than those in the experimental plot. However, various biological characteristics such as fecundity of females, mean oviposition period of females and percentage viability of eggs were not significantly different inside cages and field conditions. Therefore these cages can be recommended for use in growth and fecundity studies of *Pyrilla perpusilla.*

DIFFERENT MAJOR CONTROL METHODS OF *Pirilla purpusilla*

(1) Agronomic control

Khan & Khan (1966) and Mohyuddin & Hamid (1987) described the use of agronomic methods to control the pest in Pakistan. Changing sowing and harvesting dates could reduce the effects of the pest by exploiting its phenology, and the burning of trash also had a beneficial effect on pest control. However, Khan & Khan (1966) showed that the practice of

ratooning (continuing with three or four generations of the crop) greatly increased the pest populations, as the crop became a more or less continuous host for the pest. In contrast, however, crop rotation had no observed effect on pest control.

(2) Biological control - Parasitoids

Initial attempts from the 1920s to the 1940s to identify the parasitoids of *P. purpusilla* have been exploited more recently for use in attempts at integrated pest management programmes. *Pyrilla purpusilla* is attacked by sixteen species of natural enemy in India (Butani, 1972). Chaudhary & Sharma (1988) demonstrated that no insecticidal control was carried out in the ten-year period before 1988 in Haryana, India, as about 80% of the *P. purpusilla* nymphal adult parasitoids and predators.

Table 02: Parasitoids, predators and pathogens of *Pyrilla purpusilla*.Parasitoids

Sl.No.	**(A) Egg parasitoids**
01.	Hymenoptera: Encyrtidae
02.	*ManiCheiloneurus pyrilla*
03.	*Ooencyrtus pyrillae* (Mani)
04.	*Proleuroceroides pyrillae* Shafee, Alam & Agarwal
	***Hymenoptera: Eulophidae**
01.	*Parachrysocharis javensis* Girault
02.	Tetrastichus gala Gholap & Chandale
03.	Hymenoptera: Platygasteridae Platygaster sp.
	(B)Nymphal parasitoids
	***Hymenoptera: Dryinidae**
01.	*Agonatopoides pyrillae* (Mani)
02.	*Richardsidryinus pyrillae* (*Kieffer)*
	(C)Nymphal and adult parasitoids
	***Lepidoptera: Epipyropidae**
01.	*Epiricania melanoleuca* (Fletcher)
	***Coleoptera: Stylophidae**
01.	*Pyrilloxenos compadus* Pierce
	(D)Predators
	***Coleoptera: Coccinellidae**
01.	*Anegleis cardoni* (Weise)
02.	*Brumoides suturalis* (Fabricius)
03.	*Cheilomenes sexmaculata* (Fabricius)
04.	Coccinella septempundata Linnaeus
05.	*Coccinella undecimpundata* Linnaeus
06.	*Micraspis allardi* (Mulsant)

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	(E)Pathogens
01.	Aspergillus flavus Link
02.	Fusarium sp.
03.	Hirsutelta sp.
04.	Isaria sp.
05.	*Metarhizium anisopliae* Metschnikoff (Sorokin)
06.	*Mucor hiemalis* Wehmer

(3) Biological control — pathogens day-old larvae were not affected by insecticides due to their waxy covering. Garg & Sethi (1982) confirmed this although the larvae pupated prematurely after insecticide spraying.

Six species of pathogenic fungi have been recorded so far on P. perpusilla but Metarhizium anisopliae (Metschnikoff) Deuteromycetes Sorokin is the only pathogen which has been used for biological control purposes

(4) Ground spraying

The use of organochlorine insecticides such as BHC and DDT attracted the attention of many workers after 1949 (Srivastava, 1954; Patel, 1955; Bagal & Patel, 1956) but even by the early 1950s, those compounds were beginning to be replaced with new insecticides such as phosphamidon, diazinon, endrin, fenthion, parathion, malathion and toxaphene (e.g. Pradhan & Satpathy, 1953; Rajani, I960; Khan & Khan, 1966; Bindra et al, 1970). After 1970, the most frequently used insecticides were organophosphorus compounds, with occasional use of carbamates, such as carbaryl, and pyrethroids such as permethrin (Sinha et al, 1974; Neupane, 1976; Jagtap et al, 1976; Tewari et al, 1990

(5) Aerial spraying

Aerial spraying of insecticides for P. perpusilla control began in the early 1950s with endrin, BHC or malathion (Abbas & Khan, 1955; Agarwal, 1969b). Many of these persistent and broad spectrum compounds have subsequently been superseded, but malathion is still being widely used because of its cheapness (e.g. Ahmad et al, 1970; Bhatia, 1972; Mogal et al, 1983; Rahim, 1989b). The possible environmental consequences of widespread use of the broad-spectrum organophosphorus compound malathion for P. perpusilla control have not been investigated.

(6) Dusting

The use of organochlorine insecticides such as BHC, DDT or toxaphene in dust form controlled the pest effectively from the late 1940s to the early 1970s (e.g. Gupta, 1952; Trehan, 1957). Avasthy (1973) recommended 5-10% BHC dusts for P. perpusilla control at maxima of 27 and 72 kg/ha at early and fully grown stages of the crop, respectively. However, the use of dusts declined subsequently, probably because of practical difficulties in the field.

(7) Fogging

Suspensions of BHC, DDT, toxaphene, endrin and malathion as fogs have been attempted by researchers in India since the late 1950s. Some workers used thermal aerosol or oil carriers such as Diptrex-3 or kerosene to apply the above insecticides as fogs in fields (Gupta & Avasthy, 1959; Khalsa & Kapoor, I960; Teotia & Rajani,

(8) Cultural practices

Removal of sprouts from the stubbles of the ratoons was effective in decreasing pest populations as the eggs and the developing stages of the pest are removed by this process (Avasthy, 1973). However, the studies of Brar et al. (1983) showed that trash burning or mulching do not affect the pest's populations as the development from nymphs to adults takes place on the living plant.

the pest, as they do for aphids in cereals (e.g. Nicol et al., 1992).

(9) Mechanical control

The use of mechanical methods to control P. perpusilla began early this century. Niceville (1903) first reported control of P. perpusilla in this way by collecting sugarcane leaves with egg masses and burning them. Hussain (1925) also

recommended the collecting of egg masses (and adults in bags) for control. This was later confirmed by several other authors, e.g. Desphande (1937); Trehan (1957) and Avasthy, (1973), although Khan & Khan (1966) pointed out the difficulty of the method at an advanced stage of the crop. Stripping of dry leaves bearing eggs of P. perpusilla has been practised by many researchers for a long time (Mathur & Gupta, 1940; Avasthy, 1973). Richards (1938) and Gupta (1948) suggested that stripping had other advantages, such as an increase in sugar content as well as the germination of seed sets as it provided more space for light and air to penetrate to the crop.

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