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Application of sex pheromones in sugarcane pest management

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Abstract. Seven species of moth borers are known to cause heavy losses in sugarcane production in different parts of the country. Because of their concealed habits, the control of these borers becomes complex and hence a number of methods have been tried to suppress their field population. The sex behaviour of four species of these borers *viz.*, internode borer, stalk borer, shoot borer and top borer have been studied in recent years and among these the internode borer and stalk borer have been found to have potent sex attractants.

Mass trapping may be useful in the management of internode borer while disruption technique is likely to be useful in the case of stalk borer. In both the borer species, the synthetic pheromones will be highly useful in monitoring their activity.

Keywords. Sex pheromones; sugarcane; moth borers.

1. Introduction

Moth borers of sugarcane are major pests causing heavy recurring losses in cane yield which has been estimated to be 15·8 to 41·8% due to shoot borer (Parthasarathy *et al* 1953), 40 to 55·4% due to internode borer (David *et al* 1979), 20 to 30% due to stalk borer (Gupta and Avasthy 1954) and 8·8 to 34·8% due to top borer (Kalra and Chaudhary 1964). These borers are concealed within the tissues of cane stalk and are not exposed for parasitisation or predation by natural enemies and for contact with insecticides. Hence the suppression of their population becomes difficult. This warrants different methods of suppression strategies which have to be integrated harmoniously in order to manage them below the economic injuring level. Among the modern technologies for pest suppression, use of sex pheromones offers scope for monitoring the activity of these borers and also in reducing the fertility of wild females thereby bringing down the fertile egg population of the borers. This method can also be conveniently integrated with other methods in the pest management programme. Preliminary investigations on this strategy have been carried out in four species of moth borers and these are summarised in this paper.

2. Sexual activity of the borer moths

These moths are nocturnal in habit. Mating occurs during a specific period in different species. Most of the females mate only once though some of them mate more than once. Mating has been observed to take place between 1000 hr and 0200 hr in stalk borer (Kalra and David 1971), during the early hours of the night in shoot borer (Usman *et al* 1957), during the late hours of the night in internode borer (David and Kalra 1965) and

throughout the night in top borer (Kalra *et al* 1978). Prior to mating the virgin female moths assume a 'calling position' by raising their abdominal tips and during this process the pheromone is released. The male moths downwind take up the scent and fly towards the female. A large number of male moths are attracted simultaneously towards the virgin female and they fly excitedly around it and then mating takes place. This chemical communication between the two sexes in these moths can be taken advantage of for either mass trapping the male moths or for disruption of the communication by suitable contrivances so that mating and fertility of wild females can be reduced.

3. Studies with virgin females

Studies have been conducted on the potency of attraction of male moths by virgin females of stalk borer (Kalra and David 1971), top borer (Kalra *et al* 1978), internode borer (David and Chandra 1972) and shoot borer (David *et al* unpublished). The virgin females collected from pupae which are separated and kept in isolation from the male pupae, when placed in sticky/water traps attracted male moths. The number of male moths attracted ranged from 0 to 107 in stalk borer, 0 to 5 in top borer, 0 to 10 in internode borer and 0 to 33 in shoot borer. In stalk borer, the number of male moths trapped was more during the first 24 hr and it declined subsequently. It was also observed that four-day old virgin females or mated females did not attract male moths. Abdominal extracts of virgin females taken in solvents like ether also attracted males of stalk borer and the number trapped ranged from 0·1 to 4·2 moths/day/trap. These experiments have indicated the presence of potent sex pheromones in the females of stalk borer, internode borer and shoot borer.

4. Identification of sex pheromones

The fresh pupae of stalk borer and internode borer were air freighted to UK and the pheromones were isolated and identified by Dr B F Nesbitt at the Tropical Development and Research Institute. The pheromone of stalk borer consists of the following four components, *viz.*,

(i) (*Z*)-7-dodecynyl acetate,
(ii) (*Z*)-8-tridecenyl acetate,
(iii) (*Z*)-9-tetradecenyl acetate and
(iv) (*Z*)-10-pentadecenyl acetate.

while that of the internode borer consists of two components, *viz.*,

(i) (*Z*)-13-Octodecenyl acetate, and
(ii) (*Z*)-13-Octodecenyl alcohol.

The synthetic products of these pheromones have been prepared in different combinations and were evaluated in the field. The sex pheromones of shoot and top borers are yet to be chemically characterised.

5. Comparative performance of synthetic pheromone with virgin females

The comparative efficacy of the virgin female and synthetic pheromone in water traps was assessed for 42 days in the stalk borer. The number of moths trapped/trap/day was

significantly more in synthetic pheromone traps (7·95) than in virgin female traps (0·39). In the internode borer, the comparative efficacy was evaluated for 17 days. The mean number of moths trapped was significantly high in water traps baited with synthetic pheromone (5·35) compared to virgin females (2·35).

6. Mass trapping

6.1 *Stalk borer*

Two combinations *viz.*, 1:1:1:1 and 4:8:4:1 of the components (*Z*)-7-dodecenyl acetate, (*Z*)-8-tridecenyl acetate, (*Z*)-9-tetradecenyl acetate and (*Z*)-10-pentadecenyl acetate at two different doses, *viz.*, 0·1 and 1 mg were tried at Shamli in 1982 and the results are given in table 1. The combination of 4:8:4:1 at the dose of 1 mg was found to be more potent than the three other treatments. During 1983, eight more combinations (table 2) were tried and it was observed that the moth catch was more in traps baited with vials containing a 2:1 ratio of (*Z*)-8-tridecenyl acetate and (*Z*)-7-dodecenyl acetate and an 8:1 ratio of (*Z*)-8-tridecenyl acetate and (*Z*)-10-pentadecenyl acetate.

Between 25.2.1983 and 8.4.1983, mass trapping was attempted with 20 water traps baited with 1 mg of 4:8:4:1 combination. A total of 2863 moths were trapped with a mean of 7·95 moths/trap/day. The maximum number of moths trapped was 259/trap/day.

6.2 *Internode borer*

The efficacy of different combinations of acetate and alcohol *viz.*, 1:1; 3:1; 5:1; 7:1 and 9:1 was assessed by conducting field experiments at Sakthi Sugars Ltd., Sakthi Nagar and Deccan Sugars Ltd., Pugalur. The experiment had five treatments and each treatment was replicated six times. The distance between the traps was 30 m. Observations on moth catch was recorded at weekly intervals for 11 weeks from the

Table 1. Evaluation of different components in the mass trapping of *C. auricilius*.

Components	Dosage (mg)	Total male moths caught	Mean moths/ trap/day
1:1:1:1 $Z_7:Z_8:Z_9:Z_{10}$ component	1	31	0.70^B
1:1:1:1 $Z_7:Z_8:Z_9:Z_{10}$ component	0·1	25	$0·60^B$
4:8:4:1 $Z_7:Z_8:Z_9:Z_{10}$ component	1	1643	$16·5^A$
4:8:4:1 $Z_7:Z_8:Z_9:Z_{10}$ component	0·1	54	$1·21^B$

Figures followed by the same letters are not statistically different.

start of the experiment. It was found that the average moth catch was more at Pugalur (6·23 moths/trap/day) than at Sakthi Nagar (3·44) and the difference was statistically significant. Among the combinations tested, though the catch was more in 5:1 (acetate:alcohol) combination, the differences between the different combinations were not statistically significant (table 3). The catch was more and on par during fourth to eleventh weeks indicating the persistence of the material under field conditions for longer duration.

Another experiment was conducted to find out the optimum height of the water trap for maximum moth catch. The water traps were set at 60, 90, 120, 150 and 180 cm height and the treatments were replicated five times. The mean moths trapped/trap/day was more in traps set at 60 cm height (12·88) compared to 7·10 to 8·72 moths/trap/day in other treatments.

After fixing up the optimum combination and height of traps, the synthetic pheromone of the borer was used for mass trapping of male moths under field conditions in two centres *viz.*, Coimbatore and Pugalur during 1982. The area trapped was about three hectares at Coimbatore and seven hectares at Pugalur. In both the centres suitable control of about one hectare at a distance of 0·5 km was earmarked for observations. The distance between the traps was 33 m. The traps were set up in about five to six months old crop and two changes of the pheromone vials were given after two

Table 2. Evaluation of different components in the mass trapping of *C. auricilius.*

Components	Total moth caught	Mean moths/ trap/ day
4:8:4:1 mixture CA 83/35		
Z_7:Z_8:Z_9:Z_{10} component	751	$10·80^{BC}$
Z_7 component CA 83/86	21	$0·31^{C}$
Z_8 component CA 83/37	38	$0·55^{C}$
Z_9 component CA 83/38	39	$0·56^{C}$
Z_{10} component CA 83/39	275	$3·94^{C}$
Z_8:Z_7 mixture 2:1) CA 83/40	536	$12·70^{B}$
Z_8:Z_7 mixture 2:1) CA 83/41	1585	$22·75^{A}$
$Z_8 + Z_{10}$ mixture 8:1) CA 83/42	1524	$21·78^{A}$

The dosage used was 1 mg for all the cases.

Table 3. Evaluation of different components on the mass trapping of *C. sacchariphagus indicus* (K).

	Mean moths trapped	
Components	Sakthinagar	Pugalur
1:1 Acetate:alcohol	$3·28^{A}$	$5·87^{AB}$
3:1 Acetate:alcohol	$3·58^{A}$	$5·80^{B}$
5:1 Acetate:alcohol	$3·57^{A}$	$6·57^{A}$
7:1 Acetate:alcohol	$3·39^{A}$	$6·41^{A}$
9:1 Acetate:alcohol	$3·38^{A}$	$6·49^{A}$

months. Observations on the moth catches were made weekly. Observations on the progressive incidence and intensity of infestation of the borer, both cumulative and fresh attack, were made at periodic intervals. Detailed observations were made at harvest on incidence and intensity of the infestation, larval population, yield and quality of canes at Pugalur.

A total of 9822 male moths were collected at Pugalur with a mean catch of 0·83 moths/trap/day. The mean borer incidence was 93·63 and 87·17% in the treated and control plots and the difference was not statistically significant. There was no significant difference in the intensity of borer infestation and larval population, yield of cane and ccs% between the treated and control plots.

At Coimbatore, a total of 1122 male moths were collected with a mean of 0·59 moth/trap/day. The details of observation on incidence and intensity of borer infestation are given in table 4. It was observed that there was significant difference in the incidence of borer at harvest but not with respect to the intensity of borer infestation.

During 1983, mass trapping was attempted in an area of five hectares at Pugalur. Suitable control of one hectare at a distance of 0·5 km with the same variety and age of the crop was earmarked for observations. The distance between the traps was 16·5 m in one set and 24·8 m in another. The traps were set up in about four months old crop and three changes of pheromone vials were done.

A total of 74697 male moths were trapped with an average catch of 3·4 moths/trap /day. The mean moth catch was 2·95/trap/day in the traps set up at 24·8 m distance and it was 3·8 /trap/day in the traps set up at 16·5 m distance and the difference was not significant. The data collected at harvest revealed that there was significant difference in incidence (table 5). The mean incidence in treated plots was 68·36% and in control plots

Table 4. Internode borer incidence and intensity of attack at Coimbatore.

Period	Treated plots		Control plots	
	Per cent incidence	Per cent intensity	Per cent incidence	Per cent intensity
Before setting up of traps	8·73	4·07	13·65	3·39
30 days after setting up of traps	13·44	5·27	19·18	5·08
60 days after setting up of traps	17·16	4·90	31·36	5·57

Table 5. Yield data from the pheromone treated and control plots.

Parameters	Treated	Control
Per cent incidence (plot basis)	$68·36^{B}$	$76·85^{A}$
Per cent intensity—Old	$2·86^{A}$	$3·26^{A}$
Fresh	$1·49^{A}$	$1·29^{A}$
Plot weight (kg)	$564·41^{A}$	$473·26^{B}$
Per cent purity	$84·38^{A}$	$82·73^{B}$
ccs per cent*	$9·63^{A}$	$9·00^{B}$

*Commercial cane sugar per cent

it was 76·85 %. But the differences observed in the intensity of the borer infestation were not significant. The cane yield was significantly more in treated plots and also there was improvement in purity and ccs % due to mass trapping of internode borer male moths.

7. Communication disruption

7.1 *Stalk borer*

The scope of disruption of the pheromone communication system in stalk borer was assessed by saturating the atmosphere near the pheromone trap with the optimum combination of 4:8:4:1 at the dose of 1 mg/vial during 1983. The surround vials used for saturating the atmosphere contained either (*Z*)-7-dodecenyl acetate, (*Z*)-8-tridecenyl acetate, (*Z*)-9-tetradecenyl acetate, (*Z*)-10-pentadecenyl acetate or 4:8:4:1 combination of the above components at the dose of 1 mg. Maximum reduction (85·02 %) in moth catch was recorded when (*Z*)-7-dodecenyl acetate was used in the surround vials. The reduction in other treatments was 1·63, 0·0, 0·0 and 54·07 % respectively.

During 1984, two more experiments were conducted with the most effective component *viz*, (*Z*)-7-dodecenyl acetate. The result obtained confirmed the earlier finding and the per cent reduction observed was 76·18 % in one experiment and 94·96 % in another.

7.2 *Internode borer*

The experiments conducted on the same lines as in stalk borer, did not give much encouraging results. The reduction observed ranged only from 24·87 to 38·58 % when different combinations were used in the surround vials.

8. Discussion

The observations on the sexual attraction in these species of moths showed that there is potent sex pheromone in the females of stalk borer, internode borer and shoot borer while it is apparently feeble in the case of top borer. Intensive studies on the former two species indicate that these two vary with regard to the population density. The population density is low in internode borer and high in stalk borer, especially in the later broods and this is reflected in the number of moths trapped in the water traps with a maximum of 259. Moreover, in the stalk borer, the emergence of moths is apparently not continuous, being restricted to specific broods under subtropical conditions whereas in internode borer, it is continuous throughout the year under tropical conditions. Because of the continuous emergence, male moths of internode borer can be trapped throughout the year using water traps. The traps are to be set up with the commencement of internode formation with only two changes of the synthetic pheromone vials at trimonthly intervals. In the case of stalk borer, the initial two broods have low population and the setting up of the traps will be highly useful for identifying the initial foci of infestation which is otherwise normally difficult to identify in the field.

The results of the communication disruption experiment have shown clearly that it may be highly useful for field application in the case of stalk borer while it may not be much effective for the check of internode borer.

These studies have indicated promise for field application of mass trapping and disruption techniques using synthetic pheromones and hence further detailed information on cheap and durable dispensers, simple traps for field use, optimum number of traps/unit area and scope of combining this method with other methods in the integrated pest management of these highly destructive borers may be obtained.

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