2. ECOLOGICAL STUDIES ON *TRYPORYZA INCERTULAS* (WALKER) IN SOUTHERN PART OF WEST PAKISTAN

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Introduction

Rice is one of the most extensively cultivated cereal crops in Pakistan. It occupies an area of about 2 million acres in the province of Sind (southern part of West Pakistan). Several species of insect pest damage the rice crop but the lepidopterous borers take the heaviest toll. These borers have been appearing in Sind in epidemic form at intervals of 10 to 15 years. The relative importance of different species of borers has been varying in different rice growing tracts of this province in different epidemic years. The yellow borer (*Tryporyza incertulas* Walker) has, however, been the most important species both epidemic and normal years. This pest became a serious problem in 1957 and 1958, causing almost total damage in vast tracts of rice area of the districts of Larkana, Sukkur, Jacobalad and Dadu. The damage continued to be high up to 1964, after which the population of the yellow borer has remained low.

Apart from natural factors, the decrease in the population of the borers is ascribed to improved agronomical practices and plant protection measures undertaken with greater efforts since 1958.

With the view to find out the ecology, seasonal history and causes of annual and seasonal fluctuations in the population of *Tryporyza incertulas* Wlk., studies are being made in Larkana district since 1967, with financial assistance of the International Atomic Energy Agency.

These studies include estimation of damage caused by borers, determination of the species involved, their relative abundance, and the seasonal history, population dynamics, parasitization, alternate host plants of the yellow borer and corelation of its seasonal history with the stages of selected local weeds.

Material and Methods

Relative abundance of borers and seasonal history, population dynamics of *Tryporyza incertulas* Walker

The larvae and pupae collected from the rice plants and the moths actually emerging from such collections were counted to determine the species of the borer involved.

Light traps were set to count the moths caught during the crop season, and counts of egg masses, larvae, moths and infested tillers were made in the cropped field.

Light trap: In 1967, the light trap (shown in Fig. 1) consisted of a 'frosted' 100 c.p. bulb fixed at a height of about 6 ft. from the ground over a large metal funnel below which was attached a large glass cylinder painted black from outside and almineum paint applied inside to make the interior bright for maximum flow of the moths inside the cylinder. Cork sheet in DDVP was placed at the bottom of the cylinder to kill the moths quickly before they lose their scales.

From 1968 onwards when the work was shifted away from the source of electricity the electric bulb was replaced by an ordinary Kerosin oil petromax, producing light of

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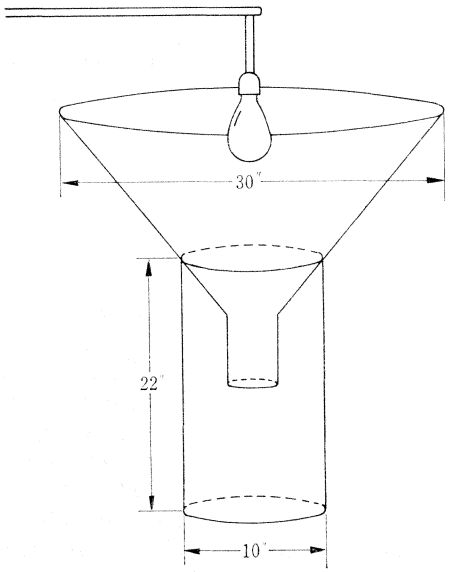

Fig. 1. Light Trap for *Tryporyza incertulas* Walker. (used in Sind, Pakistan)

100 c.p. intensity. The petromax was placed inside the funnel over a wooden cross so that the moths coming to the light would pass through the wide space left between the base of the petromax and sides of the funnel.

The height of the electric bulb and that of the petromax was so adjusted that the upper of the source of light was in the same horizontal plane as the outer rim of the funnel. The light trap was set for the whole night in 1967, but later it was started half an hour after sunset and kept only for 2 hours, as this was found to be the period of maximum catch.

Studies in the crop: Weekly counts on the moths, egg-masses and larval population in the crop were made in the following manner:

Counts of the moth population in crop were made in two ways, namely (1) total number of moths observed on ten 70 feet long pre-fixed rows of the crop, (2) total number of moths observed in 30 minutes in the same plot every week.

Egg-mass counts were made in three ways, namely (1) on ten 70 feet long pre-fixed rows of the plants, (2) in the two straight diagonals of the $70' \times 120'$ observational field and (3) the total number of egg-masses observed in 30 minutes in the same plot.

In order to determine the larval population, counts were made on the number of infested tillers in ten 70 feet long pre-fixed lines of the crop, to calculate the number of infested tillers per acre. Simultaneously 100 attacked tillers uprooted from a non-observational field were dissected to count the number of yellow borer larvae from these figures.

Hibernation and mortality of the hibernating larvae

The observations on the total number of hibernating larvae and their mortality during hibernation, were made in the winters of 1966–67, 1968–69, 1969–70 and 1970–71. No observations were made in the winter of 1967–68.

In 1966–67 the samples were taken from March to June 1967 from different places

in Larkana, Shikarpur and Dadu district taking care that the samples representing the factors of the soil texture and moisture level, as well as various factors of agricultural practices of ploughing versus not ploughing, leaving the land fallow or raising the second crop on the residual moisture and their different possible combination (17 in all) were collected for examination. The sample size from each factor consisted of twenty hills. The total number of tillers were counted and dissected to determine the number of dead and alive larvae. The soil moisture level in 1967 was determined by visual judgment and the fields classified as 'dry' and 'moist'.

In the winter of 1968–69, the observations were started in the month of February and continued upto mid of April at five locations namely, Dokri fed by perennial canal and Kamber, Nasirabad, Larkana and Ratodero fed by seasonal canal. The moisture contents of the soil, from where the samples were taken, were determined in the laboratory after bringing the samples in polyethylene bags.

In the winter of 1960–70, four localities fed by seasonal canal were selected and the fields representing only the following four combinations of factors were selected for taking observations, and 80 hills and twelve samples of soil were taken from each field to make observations on the hibernating larvae and to determine the soil moisture:

(i) Field ploughed after harvest of rice crop and left fallow.
(ii) Field ploughed after the harvest of rice crop and second crop raised on residual moisture.
(iii) Field not ploughed and no crop raised.
(iv) Field not ploughed but second crop raised on residual moisture.

In 1970–71, fifty samples of plant hills were taken for each combination of factors as 1969–70 and 15 samples of soils for determining the moisture content from each field. The number of locations were only three and the observations were recorded only in the end of March to determine the final mortality figures.

Parasitizations

For determining parasitization fortnightly observations were taken to count the parasitized and total number of eggs and larvae. Percentage of parasitization was also recorded in the hibernating larvae after the harvest of the crop.

Alternate host

The weeds growing in different rice tracts were examined particularly after the commencement of emergence of moths from the hibernating generation when the rice plants were not present in the field.

Co-relation with weeds

In an effort to build up any possible co-relation of the period of a significant stage in the seasonal history of the yellow borer with a predominant stage of development of local weeds, regular observations were taken on the growth stages of five selected perennial weeds of the rice growing area.

Results

1. Species of borers

The light trap catches and observations made in the crop from 1967 to 1970 indicated that the following species of borers are present in this area:

1) *Tryporyza incertulas* Walker
2) *Tryporyza nivella* F. (? *innotata*)
3) *Sesamia inferens* Walker
4) *Chilo* sp.

Amongst the above species *T. incertulas* Wlk., was found to be the most dominant species having maximum population in all the rice growing tracts.

Infestation of the crop by *T. nivella* F. could be found only in small numbers in areas situated near the sea coast, away from the main observational area. In Larkana district where studies were made on the ecology of the yellow borer no larvae of *T. nivella* could be collected from the crop, although the moths were frequently seen sitting on the crop.

During 1968 and 1969, the population of the *S. inferens* Wlk. was quite high in the coastal area in the early stages of the crop, and 33% of the rice borer larvae collected belonged to this species. In the observational area of the Larkana district also the proportion of larvae in the crop was 67% *T. incertulas* Wlk. and 33% *S. inferens* Wlk. in 1968, whereas the proportion of tillers infested by the two species was 79.33 and 20.77 percent respectively.

2. Relative abundance of various species of borers

The records of relative abundance of various species of borers made both in the light trap catches and on the crop from 1967 to 1970 are summarized in Table 1 and 2 respectively.

Table 1. Relative aboundance of various species of rice borers caught on light trap.

Species	Years			
	1967	1968	1969	1970
Tryporyza incertulas Wlk.	99.22	89.19	84.56	85.55
T. nivella F.	0.61	3.13	3.39	3.60
Sesamia inferens Wlk.	0.04	0.76	2.98	0.64
Chilo sp.	0.13	6.92	9.06	10.21

Table 2. Relative abundance of various species of rice borers in the crop during the years 1967 to 1970.

Specier	Years			
	1967	1968	1969	1970
Tryporyza incertulas Wlk.	91.63	79.61	99.02	99.00
T. nivella F.	0.00	0.00	0.00	0.00
Sesamia inferens Wlk.	8.37	19.39	0.49	0.50
Chilo sp.	0.00	1.92	0.49	0.50

It would be seen from the table 1 that *T. nivella* was subdominant species in all the years. Although *T. nivella* was found in the observational area, it did not attack the crop. (table 2).

3. Seasonal history of *Tryporyza incertulas* Walker

It was observed that the insect completes one long generation of 22–27 weeks, in which the larvae hibernate for 17–22 weeks, and five generations during the crop season. The active short duration generations occupy 29–34 days. There is increasing overlapping of generations as the crop stage advances.

The first emergence of the moths from hibernating generation occurred as early as the 1st week of March (4th March 1969) or as late as in 2nd week of April (13th April 1971) depending on the prevalent temperature. The first emergence of moth from hibernating generation took place when the maximum temperature rose to above 90°F and minimum to about 60°F. The hibernation of the insect also started as soon as the maximum and minimum temperatures fall below 90°F and 60° respectively.

The emergence of the moths from the over-wintering larvae continues normally for 2 to 2½ moths i.e. starting from the beginning of March or April and lasting upto the 3rd week or end of May. Earlier it was observed that some of the larvae may also continue their hibernation in some of the pockets upto the middle of June, and the emergence from these pockets takes place in the end of June or beginning of July.

The early emerging moths from the over-wintering larvae do not seem to lay eggs because of the non-availability of food plant, as no egg could be observed on weeds or any other object in the absence of rice plant, even when there was heavy emergence. But if the rice plant is available at the time of emergence of moths from the over-wintering larvae the moths lay fertile eggs which do develop further, as it was observed at Moenjodaro (Dokri) in 1967, that the heavy egg laying took place on the available rice plant on 9th April.

Generally however, the rice plant is available in the area from the mid of May. Thus the insect has only the chance to lay eggs on the rice plants in the last week of May, when the population of the emerging moths has very much reduced, and the emergence is about to cease. Therefore, the initial population of the borer in the nurseries or early stage of the crop is very low.

The 1st generation of the insect in the nurseries or crop is completed in the end of June, the 2nd generation is completed in the end of July, the 3rd in the end of August, the 4th in the end of September and 5th generation of the insect is completed in the end of October or beginning of November.

The late larvae of the 5th generation and some of the early larvae of the 6th generation go under hibernation.

The insect thus completes 5–6 generations round the year.

The maximum damage to the crop is caused by the 3rd, 4th and 5th generations from August to the middle of October.

The insect starts hibernation from the beginning of November when the maximum temperature goes below 90°F and the minimum below 60°F.

The data on the seasonal history recorded in different years is presented in Table 3.

It may be observed from Table 3 that although the moth emergence started on 4th

Table 3. Seasonal history of *Tryporyza incertulas* Walker.

Years	Date of first emergence	Date of last emergence from hibernation	First moth in the crop	First egg-laying in the crop	Date of last emergence before hibernation	Date of start of hibernation
1967	2/4	31/5	26/6	*9/4	30/10	31/10
1968	20/3	25/5	12/8	20/8	4/11	5/11
1969	4/3	22/5	27/7	28/7	11/11	12/11
1970	24/3	30/5	9/8	10/8	10/11	11/11
1971	13/4					

* Heavy egg laying observed in rice nurseries specially raised on well irrigation for training of Agricultural Extension workers.

March, 20th March and 24th March 1969, 1968 and 1970, 1st egg layings were observed on 28/7, 20/8 and 10/8 respectively. This was because the earlier emerging moths die without producing the next generation and population of the 1st generation on the crop or nursery was so small that the egg masses could not be deducted early. In 1967, the 1st egg masses were recorded only a week after the 1st emergence of moths in April because specially raised nurseries were available for oviposition. Some moths also probably developed in these nurseries, although most of the plants had died on account of stoppage of water to these nurseries. This seems to be the cause of earlier record of moth on the crop in 1967 than in other years.

The last emerging moth from the hibernating larvae lay eggs in the end of May in the nurseries in which the insect completes its 1st generation in the end of June. The moths emerging in July lay eggs on the crop which give rise to the 2nd generation of the insect and the emergence of moths from this generation takes place in the end of August which lay eggs for the 4th generation. The 4th generation is completed upto the end of September which lays eggs for the commencement of the 5th generation of the insect. The emergence of the moths from the 5th generation starts in the end of October, and continues till the beginning of November.

The late larvae of the 5th generation and some earlier larvae of the 6th generation go under hibernation. It was also observed that the moth emerging in the beginning of November, seldom lays eggs on the mature crop, while they may lay eggs heavily on the new sprouts. The eggs thus laid on the sprouts are destroyed because of the harvest of these sprouts for cattle field. Only very few larvae hatch out which also die because of the fall of the atmospheric temperature.

The maximum population of the moth was observed from the 1st week of September to the 2nd week of October, and maximum oviposition from the 2nd week of September to the 3rd week of October. The significant attack of the insect in the crop started in the 2nd week of September and gradually increased upto the harvest of the corp. Larval population of the insect in the crop is visible from the last week of August and continues till the harvest of the crop. The maximu mpopulation of the larvae in the crop was observed from the 2nd week of September to the 2nd week of October.

The sex ratio of the insect ranged from 1 male : 3 females to 1 male : 5 females.

4. Hibernation and mortality of the hibernating larvae

Studies on the population of the larvae of *T. incertulas* Wlk. in the rice stubbles and their mortality during hibernation were made from 1967 to 1971 in the fields, presenting different soil texture, moisture level and different agricultural practices. The data are presented in Table 4.

It is seen from the Table 4 that the population of the hibernating larvae has been decreasing from year to year. This is because the pest population was decreasing.

Table 4. Population of hibernating larvae of *T. incertulas* and their mortality.

Years	Hibernating population per acre	Average mortality percent during hibernation
1966-67	38519	75.87
1967-68	—	—
1968-69	12982	53.32
1969-70	10682	73.37
1970-71	3277	50.35

Observations were made on the effect of different factors on larval mortality in the fields such as soil texture and moisture, and different agricultural practices viz ploughing and not ploughing, leaving the lands fallow or raising the 2nd crop on the residual moisture. The data are presented in Table 5 to show the effects of ploughing and raising the 2nd crop on the residual moisture.

Table 5. Effect of cultural practices on the mortality of larvae in stubbles.

Factors	Mortality %				
	1966–67	1968–69	1969–70	1970–71	Total
1. Unploughed fallow	72.2	53.13	54.52	13.50	48.34
2. Unploughed cropped	44.9	35.29	62.28	63.69	51.54
3. Ploughed fallow	87.4	69.31	89.96	85.43	83.02
4. Ploughed cropped	87.4	70.72	86.01	75.73	79.97

From the data presented in the Table 5 it is very clear that the maximum protection to the hibernating larvae was provided in unploughed fields, and minimum in the ploughed fields. The difference of mortality in the field with or without the 2nd crop was very narrow, but it can be said that the fields left fallow gave more mortality than the fields under the 2nd crop, though the difference is insignificant.

The observations taken on the moisture content of soil in relation to the mortality of the hibernating larvae were not very significant. It is, however, observed that the fields having higher moisture content had less mortality. The fields having 3 to 5.5 percent moisture at the time of emergence commencement give more protection as compared to the fields having below 3 percent moisture. Still the critical point of moisture is not clear and needs detailed studies and investigations for which the work is in progress.

5. Parasitization

During the course of studies on the *T. incertulas* Wlk. in the years 1967 to 1970, the following species of the parasites have been recorded to parasitize different stages of the insect.

Stage parasitized	Parasits
Egg	*Tricogramma* sp.
Larvae	i) *Tropobracon* (*Shirakia*) sp.
	ii) *Anatrichus* sp.
	iii) One unidentified

Generally very little parasitization was observed during the period of investigation.

In 1966–67 average parasitization of the hibernating larvae was 6.4 percent. In certain fields the extent of parasitization was upto 20 percent during the month of April. No parasitization was recorded in the crop upto September. In the middle of October about 39 percent of the eggs were found parasitized.

In 1968 also only the egg parasitization was recorded and it was found to be below 5 percent. During 1968–69 two species of parasites were observed parasitizing 4.53 percent of hibernating larvae. In the crop of 1969 only 1.57 percent larval parasitiza-

tion was recorded. In the hibernating larvae during 1969–70, the average parasitization was 2.26 percent. In the crop period of 1970 also only 2.72 percent larval parasitization was observed and the egg parasitization was more rare.

6. Alternate host

So far no alternate host plant of *T. incertulas* Wlk. could be recorded.

7. Co-relation of seasonal history of *T. incertulas* Wlk. with the growth stages of selcted weeds

No useful indications were obtained except the fact that *Saccharum spontaneum* starts flowering after completion of the 3rd generation of the insect in the crop.

Discussion

M. D. Pathak: The rice stem borers occur in cycles in West Pakistan. Do you have a long range data of light traps of rice stem borers for West Pakistan?

S. A. Moiz: No research data on light traps are available. However, the data collected by extension workers show that in 1942 heavy attack of pink rice borer *Sesamia inferens* and yellow borer *Tryporyza incertulas* occurred. In 1952 severe damage to the rice crop was caused by *T. nivella*. Again in 1957–58 90% of rice crop was damaged by *T. incertulas*. In 1959, damage of 25% by *Sesamia inferens* was recorded.

M. D. Pathak: How would you interpret data in Table 1 and Table 2 of your paper?

S. A. Moiz: *T. nivella* moths were captured by light trap in all the years. Although *T. nivella* was found in the observational area it did not attack the crop.

Ku-Sheng Kung: On relative abundance data in Table 1 you mentioned *Chilo* spp. What species of *Chilo* you found?

S. A. Moiz: *Chilo zonalus*

Ku-Sheng Kung:
1. Why the relative abundance of Chilo varies year after year in your country?
2. What is the population density of *Tryporyza incertulas* (Wlk) in normal year?

S. A. Moiz:
1. The infestation of Chilo on rice may fluctuate slightly but generally it is very low. The light trap catches come from the maize and sorghum crop grown in the vicinity mainly for fodder. The infestation in these crops is always very high unless control measures are applied. The variation of the volume of light trap cathes depends on the total area of the rice growing tracts.
2. In the month of August and September when the population of the moths is high the number of moths per acre is about 2500 (966–2614 in the rice fields. In the years of low attacks, the attacked tillers vary from 1 to 5%.

M. T. Ouye: Do you have any recommendation to make on cultural control of *T. incertulas?*

S. A. Moiz: Ploughing the field before the end of winter season and sowing the rice crop on proper time give good borer control.