INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
09–147/AWB/2009/11–6–717–720
http://www.fspublishers.org

Full Length Article

Determination of Economics Threshold Levels for the Stem Borers (*Scirpophaga* sp.) and Leaffolder (*Cnaphalocrosis medinalis*) of Rice (*Oryza sativa*) in the Kallar tract of Punjab, Pakistan

MUHAMMAD ASGHAR[1], ANJUM SUHAIL, MUHAMMAD AFZAL AND MUHAMMAD ASLAM KHAN†
Department of Agricultural Entomology, University of Agriculture, Faisalabad, Pakistan
†*Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan*
[1]Corresponding authors' e-mail: miang786@yahoo.com; dranjumsuhailuaf@yahoo.com

ABSTRACT

Effective and economic suppression of insect pests in rice ecosystem by the judicial use of pesticides on the basis of economics threshold levels (ETL) is very essential. This study was conducted to determine the ETLs for the chemical control of rice stem borers, (*Scirpophaga incertulus* Wlk. & *S. innotata* Wlk.) and rice leaffolder (*Cnaphalocrosis medinalis* Gn.) in the traditional Basmati rice growing area the Kallar tract of the Punjab, Pakistan. On the basis of cost benefit ratio an action threshold of 5% dead-hearts (DH) and 3% folded leaves for stem borers and rice leaffolder, respectively were developed and use of insecticides to control these insects on need basis despite calendar based insecticides application was stressed.

Key Words: ETL; Stem borers; Leaffolders; Basmati rice

INTRODUCTION

Rice crop is attacked and damages by large number of pest insects from nursery to harvest but only a few of them are considered key pest, which cause severe yield losses. In Pakistan about 128 different species of insects have been reported to attack rice crop however 20 of these are of major economic significance (Ahmad, 1981). Among these major pest insects rice stem borers, (*Scirpophaga incertulas* & *S. innotata*) and rice leaffolder (*Cnaphalocrosis medinalis*) considered as dominant pest insects of rice, throughout the rice growing areas. They induce highly discernible damage symptoms (Chaudhary *et al*., 1984; Heong *et al*., 1994; Bhatti, 1995; Alvi *et al*., 2003). Among the various methods used by the farmers to protect the rice crop from these economically important pests the chemical control remains the only mean of economical and rapid method for suppression of insect pests infestation. This is because other methods of pest control are laborious, time consuming and less effective (EJF, 2002). However the indiscriminate use of insecticides has caused many side effects, including, loss of biodiversity, biological imbalance, resulting in changes in community structure the problem of secondary pests, insecticide resistance, residual toxicity, proliferation and resurgence of selected insect pests and environmental pollution (Roger & Kurihara, 1988; Wilson & Tisdell, 2001; Tahir & Butt, 2009).

Determination of economic threshold levels (ETLs) is the main tool, which is helpful in making decisions about whether the insecticides are to be applied or not. But the farmers ignore the ETLs and use insecticides according to calendar-based program to overcome the losses caused by pest insects. Such indiscriminate uses of pesticides not only drain the exchequer but also are a growing threat to the people and environment of the country. It is therefore, important to define the pest population levels, which stresses on immediate intervention mostly by rational insecticide application (Srivastava *et al*., 2004). This practice in turn will help protect the biodiversity and environment from being deteriorated by indulging poisons and lessening the weights of pesticides on country's import along with savings of health and wealth of the farmer 'the mechanic' of agroecosystem.

These studies were planned to determine the ETLs for most commonly known major lepidopterous insect pests of rice, against, which maximum insecticides are being used by rice farmers, so that rational use of insecticides would be employed rather than calendar base use.

MATERIALS AND METHODS

The experiments were conducted at farmer's fields in traditional rice area i.e., Kallar tract during 2004-2006 to determine ETLs of rice stem borers (*Scirpophaga*

To cite this paper: Asghar, M., A. Suhail, M. Afzal and M.A. Khan, 2009. Determination of economics threshold levels for the stem borers (*Scirpophaga* sp.) and leaffolder (*Cnaphalocrosis medinalis*) of rice (*Oryza sativa*) in the kallar tract of Punjab, Pakistan. *Int. J. Agric. Biol.,* 11: 717–720

incertulas, *S. Innotata*) and rice leaf folder (*Cnaphalocrosis medinalis*). The experiments were laid out in randomized complete block design (RCBD) with six treatments for rice stem borers (0, 1, 3, 5, 7 & 9% infestation) and leaffolder (0, 2, 4, 6, 8 & 10% infestation) with three replications. Nursery of rice (*Oryza sativa* L. cv. Super Basmati) was sown and transplanted with row to row and plant to plant distance of 22 cm in well prepared soil according to the traditional land puddling practices of the area as recommended. The plot size was 1 m^2 for each treatment in each replication. All the agronomic practices and input used were same for all the treatments, except different infestation levels. To mimic the damage behavior of rice stem borers and leaffolder the simulative injury technique was used (Anonymous, 2003). The treatments were applied at 55 days after transplanting (DAT).

Due to the attack of stem borers, dead-hearts are formed at early crop stages, so artificial dead-hearts were produced with the help of dissecting needle. The number of tillers injured to produce dead-hearts, was calculated by using the following formula:

No of tillers to be injured = Treatment (%value) x Total tiller count)/100

Whereas in case of rice leaffolder, a 10 cm area of flag leaf, leaving about 4 cm from the tip, was covered with black adhesive tape very carefully to mimic the symptoms of rice leaffolder's attack. The number of leaves, treated artificially, was calculated by using the following formula:

No of leaves to be treated = Treatment (%value) x Total leaves count)/100

After harvesting, data on paddy yield (at 14% moisture) and other yield components i.e., number of panicles per m^2, number of ripened grains per panicle and 1000 grain weight, were recorded and subjected to statistical analysis by using the program MSTAT-C (1989). The means of significant treatments were compared at 5% level of significance through Duncan's multiple range test (DMRT) following the procedure outlined by Steel and Torrie (1984). Economic analysis of yield losses was done to determine the ETLs for chemical control of these major pest insects of rice crop.

RESULTS AND DISCUSSION

The rice yield is predicted by number of panicles per m^2, number of ripened grains per panicle and 1000 grain weight (Srivastava *et al*., 2004). The analysis of variance of variance shows that treatments (% infestation level) had significant effect on number of productive tillers per m^2 ($P < 0.05$) and yield per m^2 ($P < 0.01$), whereas non-significant effect on number of grains per panicle ($P > 0.05$) and 1000 grain weight ($P > 0.05$) in case of rice stem borer (Table I). However, the treatments induced significant variation in number of grains per panicle ($P < 0.05$), 1000 grain weight ($P < 0.05$) and yield per m^2 ($P < 0.05$), whereas no significant variation in number of productive tillers per m^2 ($P > 0.05$) in case of rice leaffolder (Table II).

The number of productive tillers per m^2 in case of rice stem borers decreased significantly with increasing level of infestation, except for 1% infestation level, which indicated the increased number of productive tillers per m^2. Mean number of productive tillers per m^2 was maximum (223) for 1% infestation level, followed by 221, 219, 217, 210 and 208 tillers per m^2 for 0, 3, 5, 7 and 9% infestation levels, respectively (Table I).

The number of ripened grains per panicles and 1000 grain weight were not affected significantly by increasing infestation levels (Table I). This non-significant effect may be attributed to the fact that rice plant compensates for stem borer injury not only by translocation of its photosynthetic assimilates from damaged tillers to healthy tillers and increasing photosynthesis rate of leaves, adjacent to stem borer killed-tiller's leaves (Rubia *et al*., 1996). However their values decreased slightly with increasing the number of damaged tillers per plant (Chen *et al*., 1982).

The grain yield increased with decrease in infestation level (Table I & III). The highest grain yield (4730.35 kg ha^{-1}) was obtained from 1% infestation followed by 0, 3, 5, 7 and 9% infestations with 4727.58, 4675.71, 4638.66, 4446.98 and 4347.20 kg ha^{-1}, respectively. Higher yield at 1% infestation level than 0% infestation level (T0) may be attributed to the fact that rice plant has the ability to compensate the rice stem borer damage by increasing the production of new tillers (Rubia *et al*., 1989 & 1996; Islam & Karim, 1997; Heong & Escalada, 1999). These additional tillers contributed to increase the paddy yield. So, enhancing plant compensating mechanism to stem borer injury may be a better strategy for stem borer management than insecticide application (Rubia *et al*., 1996). Our results also suggested that at low level attack of rice stem borer, control measure should not be adopted at all in any case, because it will be mere wastage of resources. This practice will not only save expenditure incurred in the form of insecticide application, but will also favor the conservation potential of insect biodiversity of rice fields.

The paddy yield data were put for economic analysis by considering the reduction in yields in monetary terms for each treatment and the cost of chemical control involved. The ETL was worked out as 5% damaged tillers for carrying out the necessary control measures against rice stem borers (RSB) (Table III). At this level reduction in yield was 88.92 kg ha^{-1} worth Rs. 2223 (considering paddy@Rs.25 kg^{-1}) and cost of control was Rs. 2100 ha^{-1}, which was nearly equal to benefit drawn, hence it was more economical. The results confirm to the findings of Inayatullah *et al*. (1986), Anonymous (2002 & 2003) and Suhail *et al*. (2008), who also determined 5% damaged tillers as ETL for RSB control. However the results were different from those of Sherawat *et al*. (2007) who recommended 7.5% damaged stem as ETL to control this pest insect.

Table I. Comparison of mean values of different yield components for rice stem borers

Stem borer Infestation level (%)	No. of productive tillers (m^{-2})	No. of grains per panicle	1000-grain weight (g)	Average yield ($g\ m^{-2}$)	Average yield ($kg\ ha^{-1}$)
0	221a	103.22a	20.96a	478.50a	4727.58a
1	223a	103.11a	20.90a	478.78a	4730.35a
3	219ab	103.11a	21.00a	473.25a	4675.71a
5	217abc	102.00a	20.95a	469.50a	4638.66a
7	210bc	101.22a	20.90a	450.10b	4446.98b
9	208c	100.33a	20.71a	440.00c	4347.20c
	LSD = 9.199	LSD = 3.010	LSD = 1.588	LSD = 9.247	LSD = 91.36

Table II. Comparison of mean values of different yield components for rice leaffolder

Infestation level (%)	No. of productive tillers (m^{-2})	No. of grains per panicle	1000 grain weight (g)	Average yield ($g\ m^{-2}$)	Average yield ($kg\ ha^{-1}$)
0	218a	104.0a	20.90a	470.1a	4644.588a
2	218a	103.9a	20.50a	465.5a	4599.140a
4	219a	103.1a	20.20ab	458.0ab	4525.040ab
6	218a	102.9a	20.15ab	454.2ab	4487.496ab
8	218a	101.5a	17.90bc	435.3b	4300.764b
10	216a	96.33b	15.85c	431.7b	4265.196b
	LSD = 5.356	LSD = 4.963	LSD = 2.703	LSD = 24.60	LSD = 243.1

Table III. Economics of chemical control for rice stem borers

Infestation level (%)	Average yield ($kg\ ha^{-1}$)	Reduction in yield ($kg\ ha^{-1}$)	Decrease in yield in monetary terms ($Rs.\ ha^{-1}$)	Cost of control ($Rs.\ ha^{-1}$)	Cost/ benefit ratio
0	4727.58	0	0	0	0
1	4730.35	+2.77	+69.25	2100	Total loss of Rs.2100
3	4675.71	51.87	1296.75	2100	1: 0.62
5	4638.66	88.92	2223.0	2100	1: 1.06
7	4446.98	280.60	7015.0	2100	1: 3.34
9	4347.20	380.38	9509.5	2100	1: 4.53

Table IV. Economics of chemical control for rice leaffolder

Infestation level (%)	Average yield ($kg\ ha^{-1}$)	Reduction in yield ($kg\ ha^{-1}$)	Decrease in yield in monetary terms ($Rs.\ ha^{-1}$)	Cost of control ($Rs.\ ha^{-1}$)	Cost: benefit ratio
0	4644.59	-	-	-	-
2	4599.14	45.45	1136.25	2100	1:0.54
4	4525.04	119.55	2988.75	2100	1:1.42
6	4487.50	157.09	3927.25	2100	1:1.87
8	4300.76	343.83	8595.75	2100	1:4.09
10	4265.20	379.39	9484.75	2100	1:4.51

Note: 1. Means sharing the same letter do not differ significantly
2. As cost of production was the same for all treatment that is why it was not considered during economic analysis and only cost of protection through insecticide and reduction in yield in monetary terms were considered. In case of chemical control measures Padan 4G @ 22.50 kg ha^{-1}, costs Rs. 1750 ha^{-1} (@ Rs.700 bag^{-1} weighing 9 kg), net transportation charges Rs.100 and application charges @250 ha^{-1}. The paddy price was taken @ Rs. 25 kg^{-1}

In case of rice leaffolder the mean values for productive tillers were not affected significantly with increasing infestation by rice leaffolder. However number of grains per panicle and 1000 grain weight decreased gradually with increasing leaffolder damage, which ultimately decreased average yield with a slight significant difference. The highest yield was obtained with full control having 0% infestation followed by 2, 4, 6, 8 and 10% damaged leaves, respectively (Table II).

As evident from the Table II low infestation levels of rice leaffolder produced small decrease in paddy yield as compared to its control, because partial defoliation can cause increased photosynthesis in remaining leaves (Wareing *et al*., 1968). Rice farmers overestimate the losses caused by rice leaffolder and become much frightened due to visible damage symptoms by rice leaffolder and thus often overuse insecticide from fear of losses (Litsinger *et al*., 2005). They mostly spray even at low infestation levels, because of the easy availability of insecticides at low prices in Kallar tract of Punjab. Compared to granular insecticides foliar sprayable insecticides, besides killing rice insects harm to natural enemies to a greater extent, which tend to keep these pests at low densities. This practice, however is not only a cause of environmental pollution but also is harmful to both farmers and ecosystem (Fernando, 1970).

The paddy yields data were put to economic analysis by considering the reduction in yields in monetary terms for each treatment and the cost of chemical treatment involved to control rice leaffolder. From Table IV it is clear that for 2% infested leaves cost of control was more and at 4% infestation loss was more as compared to cost of its control. This implied that ETL for rice leaffolder lied in between these two infestation levels. So, the ETL was worked out as 3% damaged leaves for carrying out the necessary control measures against rice leaffolder by using granular insecticide Padan (cartap 4G). At this infestation level cost of control and benefits were almost equal, hence more economical. The results of the present study are in accordance to those of Tu *et al.* (1985) and Anonymous (2002) but different from those of Bautista *et al*. (1984), who reported 5% damage leaves as action threshold.

CONCLUSION

Chemicals based control measures should be adopted when infestation reaches 5% dead-hearts and 3% damaged leaves for the control of rice stem borers and leaffolder, respectively. For developing ETLs as only economic costs and losses were considered. However, if we also include costs to natural enemies, health, environment and difficulties in performing insecticide application task the higher will be the thresholds.

Acknowledgement. We thank Dr. Muhammad Athar Rafi, National Insect Museum, Islamabad, Pakistan, Mr. Muhammad Mushtaque, Rice Research Institute, Kala Shah Kaku, Mr. Sher Muhammad Sherawat, Adaptive Research Farm, Sheikhupura, Pakistan, Mr. Muhammad Arshad and Mr. Dildar Gogi, Lecturer Department of Agri. Entomology, University of Agriculture, Faisalabad, for providing relevant literature to develop methodology for the experiments and helpful guidance to improve the manuscript. The research was supported by the Higher Education Commission, Islamabad, Pakistan.

REFERENCES

Ahmad, I., 1981. *Studies on the Rice Insects of Pakistan with Reference to Systematics and Pheromone Glands*, pp: 388. Department of Zoology, University of Karachi, Pakistan

Alvi, S.M., M.A. Ali, S. Chaudhary and S. Iqbal, 2003. Population trends and chemical control of rice leaf folder, *cnaphalocrocis medinalis* on rice crop. *Int. J. Agric. Biol.*, 5: 615–617

Anonymous, 2002. *Economics of Rice Stem Borers (Scipophaga & Sesamia spp.) and Leaffolder (Cnaphalocrosis medinalis Gn.) Damage in Transplanted Rice Crop*, pp: 37–40. Annals Reproduction Rice Research Institute, Kala Shah Kaku, Punjab, Pakistan

Anonymous, 2003. *Economics of Rice Stem Borers (Scirophaga & Sesamia spp.) and Leaffolder (Cnaphalocrosis medinalis Gn.) Damage in Transplanted Rice Crop*, pp: 38–40. Annals Reproduction Rice Research Institute, Kala Shah Kaku, Punjab, Pakistan

Bautista, R.C., E.A. Heinrichs and R.S. Rejesus, 1984. Economic injury levels for the rice leaffolder *Cnaphalocrocis medinalis* (Lepidoptera: Pyralidae): insect infestation and artificial leaf removal. *Environ. Entomol.*, 13: 439–443

Bhatti, M.N., 1995. Rice leaffolder (*Cnaphalocrosis medinalis*): A review. *Pakistan Entomol.*, 17: 126–131

Chaudhary, R.C., G.S. Khush and E.A. Heinrichs, 1984. Varietal resistance to rice stem borers in Asia. *Insect Sci. Applic.*, 5: 447–463

Chen, D.Z., R.S. Feng and Z.B. Fu, 1982. A preliminary investigation on hidden damage to rice plants by *Scirpophaga incertulas* (Wlk.). *Fujian Nongye Keji*, 18: 225–227

EJF, 2002. *Death in Small Doses: Cambodia's Pesticides Problems and Solutions*, pp: 1–37. Environmental justice Foundation, London, UK

Fernando, H.E., 1970. Natural enemies of rice stemborers and feasibility of chemical and biological control of these pests in Ceylon. *Mushi*, 44: 43–47

Heong, K.L. and M.M. Escalada, 1999. Quantifying rice farmers' pest management decisions: beliefs and subjective norms in stem borer control. *Crop Prot.*, 18: 315–322

Heong, K.L., M.M. Escalada and V. Mai, 1994. An analysis of insecticide use in rice: case studies in the Philippines and Vietnam. *Int. J. Pest Manag.*, 40: 173–178

Inayatullah, C., 1984. *Determination of Economic Threshold Level for the Control of Rice Stem Borer*, pp: 45–46. Annals Reproduction Rice Research Institute, Kala Shah Kaku, Punjab, Pakistan

Islam, Z. and A.N.M.R. Karim, 1997. Leaf folding behaviour of *Cnaphalocrocis medinalis* (Guenee) and *Marasmia patnalis* Bradley and the influence of rice leaf morphology on damage incidence. *Crop Prot.*, 16: 215–220

Litsinger, J.A., J.P. Bandong, B.L. Canapi, C.G. Dela-Cruz, P.C. Pantua, A.L. Alviola and E.H. Batay-An, 2005. Evaluation of action thresholds for chronic rice insect pests in Philippines. I. Less frequently occurring pests and overall assessment. *Int. J. Pest Manag.*, 51: 45–61

MSTAT-C, 1989. *MSTAT-C a Microcomputer Program for the Design, Management and Analysis of Agronomic Research Experiments*. Michigan State University, East Lansing, MI

Roger, P.A. and Y. Kurihara, 1988. Floodwater biology of tropical wetland ricefields. *In*: '*Proc. First Int. Symp. Paddy Soil Fert.*, pp: 275–300. The Hague, Netherlands: International Soil Science Society, The Netherlands

Rubia, E., B.M. Shepard, E.B. Yambao, K.T. Ingram, G.S. Arida and P. Devries, 1989. Stem borer damage and grain yield of flooded rice. *J. Plant Prot. Trop.*, 6: 205–211

Rubia, E.G., K.L. Heong, M. Zalucki, B. Gonzales and G.A. Norton, 1996. Mechanisms of compensation of rice plants to yellow stem borer, *Scirpophaga incertulas* (Walker) injury. *Crop Prot.*, 15: 335–340

Sherawat, S.M., M. Inayat, T. Ahmad and M.K. Maqsood, 2007. Determination of economic threshold levels (ETL) for the chemical control of rice stem borers. *J. Agric. Res.*, 45: 55–59

Srivastava, S.K., R. Biswas, D.K. Garg, B.K. Gyawali, N.M.M. Haque, P. Ijaj, S. Jaipal, N.Q. Kamal, P. Kumar, M. Pathak, P.K. Pathak, C.S. Prasad, M. Ramzan, A. Rehman, M. Rurmzan, M. Salim, A. Singh, U.S. Singh and S.N. Tiwari, 2004. *Management of Stem Borers of Rice and Wheat in Rice-wheat System of Pakistan, Nepal, India and Bangladesh*, pp: 1–204. Rice-Wheat consortium paper series 17. Rice-Wheat consortium for the Indo-Gangetic Plains, New Delhi, India

Steel, R.G.D. and J.H. Torrie, 1984. *Principals and Procedures of Statistics: A Biomateical Approach*, pp: 232–251. McGraw Hill book Co. Inc. New York

Suhail, A., J. Ahmad, M. Asghar, M. Tayyib and M.M. Majeed, 2008. Determination of economic threshold level for the chemical control of rice stem borers (*Scirpophaga incertulas* wlk. & *Scirpophaga innotata* wlk.). *Pakistan Entomol.*, 30: 175–178

Tahir, H.M. and A. Butt, 2009. Predatory potential of three hunting spiders inhabiting the rice ecosystems. *J. Pest Sci.*, 82: 217–225

Tu, C.W., F.M. Wang, J.Z. Hu, Y.L. Chen, J.A. Zheng and B.C. Cao, 1985. The technical practicality of integrated control of diseases and pests of rice. *Sci. Agric. Sin.*, 2: 85–87

Wareing, P.F., M.M. Khalifa and K.J. Treharne, 1968. Rate limiting processes in photosynthesis at saturating light intensities. *Nature*, 220: 453–457

Wilson, C. and C. Tisdell, 2001. Analysis, why farmers continue to use pesticides despite environmental, health and sustainability costs. *Ecol. Econ.*, 39: 449–462

(Received 04 May 2009; Accepted 27 June 2009)