CROP PROTECTION PROGRAMME

COMMERCIAL ADOPTION OF PHEROMONES AS A COMPONENT IN THE INTEGRATED CROP MANAGEMENT OF RICE IN BANGLADESH

R8026 (ZA0480)

FINAL TECHNICAL REPORT

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1 - SUMMARY SHEET

Title of project:	**COMMERCIAL ADOPTION OF PHEROMONES AS A COMPONENT IN THE INTEGRATED CROP MANAGEMENT OF RICE IN BANGLADESH**
R Number:	R8026
Project leader:	Dr Alan Cork
Institution:	Natural Resources Institute
CPP Production System:	Land-Water Production System
CPP Purpose:	Purpose 2: To increase yields in rice-based systems in floodplain areas by environmentally-benign pest control methods. Output: Promotion of environmentally benign ICM strategies for major insect pests of rice appropriate for use by poor farmers.
Commodity base:	Rice
Beneficiaries:	Rice producers in Bangladesh with potential for other growers in the region to benefit.
Target Institutions:	Syngenta Bangladesh Limited, Bangladesh Rice Research Institute
Geographic focus:	Bangladesh.

	Planned	***Actual***
Start date:	1 June 2001	1 June 2001
Finish date:	31 August 2003	31 August 2003
Total cost:	£149,715	£149,715

2 - Contents

3 - ABBREVIATIONS

ANOVA	Analysis of variance
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BCRL	BioControl Research Laboratories Limited, Bangalore, India
BRAC	Bangladesh Rural Agriculture Committee
BRRI	Bangladesh Rice Research Institute
BSRI	Bangladesh Sugar Research Institute
CP	Dark headed borer, *Chilo polychrysus*
CPP	Crop Protection Programme of DFID
DAE	Department of Agricultural Extension
DAT	Days after transplanting
DFID	Department for International Development
DH	Dead Heart
DOT	Day of transplanting
IPM	Integrated Pest Management
IPM CRSP	IPM Collaborative Research Support Program
NGO	Non-Governmental Organisation
NRI	Natural Resources Institute
PTAC	Pesticide Technical Advisory Committee
SE	Standard Error
SI	Pink borer, *Sesamia inferens*
SME	Small and Medium Enterprise
SVDS	Sarada Valley Development Samithi
SVT	Sri Vidya Trust
WH	White Head
YSB	Yellow stem borer, *Scirpophaga incertulas*

4 - EXECUTIVE SUMMARY

A robust, cost-effective and efficient trapping system for male yellow rice stem borer, *Scirpophaga incertulas*, was developed utilising an optimised female sex pheromone lure and trap design.

On-farm large-scale mass trapping trials demonstrated that 20 traps per ha were sufficient to significantly reduce male *S. incertulas* populations. The trials provided good evidence to support the view that mass trapping could significantly reduce the level of mating with consequent reductions in larval progeny. Nevertheless, the level of control achieved by mass trapping in these trials did not have a measurable impact on yield. This was due to the low level of stem borer damage observed in both treated and untreated plots and because of the presence of other stem borer species.

Despite the high intensity of rice cultivation *S. incertulas* was only found to be of economic importance in the Aman season and, based on project results, stem borer control is not recommended in Aus and Boro season crops.

Syngenta intend to register the pheromone of *S. incertulas* in the near future and market it as a monitoring tool in the first instance. A visit was made to their production facility and training provided on the methodology used for producing lures. Technical assistance will be provided by BCRL to enable Syngenta to acquire an extrusion mould for manufacturing the trap and negotiations are underway with project partners Agrisense and BCRL for supply of pheromone concentrate.

The research confirmed that despite low levels of *S. incertulas* infestation being recorded in all seasons other species did not increase to fill the niche. The reasons for the low infestation levels are not known but broadly reflect those found in a previous study funded by DFID (R7296, NRI 2002) in which, over the course of four seasons, rice stem borer infestations did not exceed the economic threshold at any site.

Extensive sampling between and within seasons demonstrated that rice stem borers in Bangladesh constituted a species complex of *S. incertulas*, *Sesamia inferens* and *Chilo polychrysus*. The relative abundance of each species varied markedly within and between seasons with *S. incertulas* appearing early in the season often to be replaced by *S. inferens*.

The project contributed significantly to the understanding of how mass trapping can be developed and implemented as a method of controlling field crop pests. The new knowledge has already been utilised in a related DFID-funded project for control of brinjal fruit and shoot borer, *Leucinodes orbonalis*, in India and Bangladesh (R7465(C), AVRDC 2002) and will have significant value for other target pest species.

In surveys over 90% of farmers identified rice stem borer as the major pest of rice with 58% of respondents citing damage levels in excess of 10%. Farmers had a good knowledge of the effect of stem borer larvae on rice but did not distinguish between species. Pesticide dealers were considered by farmers to be a main source of knowledge on pest control although 65% indicated they chose an insecticide based on brand name. Despite the apparent importance of stem borers farmers only spent between 2 and 5% of their crop production costs on insecticides, although this was significantly higher than for other pests, apart from weeds. Over 60% of farmers interviewed had received IPM training and over 80% believed it was effective but few practised it. Pesticides were generally considered to be effective and although most farmers were aware of side effects over 80% of farmers surveyed used them for control of stem borers.

Farmers involved in the trials were unclear about the effectiveness of pheromone traps, in part because of low infestation levels. To test their interest in the technology farmers were offered a chance to purchase traps. Seven farmers bought 27 traps between them and on seeing the moths they caught and low infestation levels in their fields were generally pleased with the technology. They suggested they would purchase them again and motivate neighbours to use them, but price was an important criterion in their choice of stem borer control technology.

Prior to the project the Government of Bangladesh had no legislation governing the registration and use of biopesticides and related biorational pest control technologies even though IPM is widely promoted as the method of choice for agricultural pest control. NRI provided considerable technical assistance to Syngenta Bangladesh Limited (hereafter referred to as Syngenta) and BRRI in their efforts to clarify the position with the Pesticide Technical Advisory Committee (PTAC). Following intensive lobbying by Syngenta, BRRI and BARI the PTAC accepted that pheromones were a special case and have allowed Syngenta to submit documentation for registration of pheromone products, Giant and Gem, for control of brinjal fruit and shoot borer, *L. orbonalis,* and the fruit fly *Bactrocera cucurbitae* respectively. This activity has resulted in policy change and increased the profile of biopesticides within Bangladesh to the extent that other biopesticides are now actively being considered for pest control notably nuclear nuclear polyhedrosis virus and neem products.

Promotional material in the form of a flyer (printed in English and Bengali) and a multi-media presentation that describes problems associated with insecticide use, function of pheromone traps and how they can be incorporated into IPM strategies for rice cultivation were developed and disseminated.

5 - BACKGROUND

Rice in Bangladesh is produced from an essentially fixed land area (table 1). Nevertheless, recent data (Bangladesh Bureau of Statistics, 2001) suggest that rice production has increased from 17.7 million tonnes in 1995-96 to 25 million tonnes in 2000-01, an increase of almost 42%. Over the same period, 1995-96 to 2000-01 the population increased by 9.2% to 131 million (World Bank Atlas, 2002). Yet despite this increase in rice production Bangladesh is still thought to import about 1 million tonnes of rice per annum. Given that the average yield of rice was 2.35 tonnes/ha in 2000-01 there is still considerable scope for improvement in productivity to assure self-sufficiency in production for the foreseeable future. However, this simplistic view assumes that all rice-producing areas are equally capable of achieving high levels of productivity. Despite recent successes in introducing high yielding varieties (HYV) in the Boro season much of the rice produced in the Aman is still dependent on low yielding local deep-water varieties.

Table 1. Rice production in Bangladesh compared to population growth

Year	Area of rice production (million ha)	Rice production (million tonnes)	Population (million)
1995 - 1996	9.83	17.69	120
1996 - 1997	10.06	18.88	122
1997 - 1998	10.14	18.86	124
1998 - 1999	10.00	19.91	126
1999 - 2000	10.58	23.07	127
2000 - 2001	10.67	25.09	131

From the farmers perspective rice represents an increasingly poor investment. The retail price index increased by 14% from 1996-97 to 2000-01 while the value of rice only increased by 2.34% over the same period. This difference was to some extent negated for some farmers by increased productivity of over the same period. Notably the value of rice produced in the T. Aman crop increased from 1998-99 to 2000-01 by 13.7% while production costs increased other same period by only 8.1%.

In 2000-01 72% of the land available for agriculture was used for rice cultivation, but rice only accounted for 51% of the total agricultural production. In order to protect their investment 79.9% of the insecticide applied to crops in Bangladesh in 1999 was used on rice and of those pesticides used 92% were insecticides (Pesticide Association of Bangladesh).

The level of insecticide use in Bangladesh has increased dramatically from the mid-1980's to the current 16,000 tonnes per year (table 2, Pesticide Association of Bangladesh) although the consumption of insecticides on rice is still relatively low compared to other countries at 0.2 kg/ha in 1999.

Table 2. Pesticide consumption in Bangladesh

Year	Pesticide consumption in Bangladesh (tonnes)	Percent increase over 1996 levels
1956 - 1957	3,000	
1986 - 1987	3,670	
1987 -1988	3,991	
1996 – 1997	6,976	100
1997 – 1998	10,514	151
1998 – 1999	14,240	204
1999 – 2000	16,400	235

It is important that in order to ensure pesticide, and in particular insecticide, use in rice production does not increase beyond current levels, as it has with other crops such as vegetables (Rashid *et al.*, 2003), new ways to protect the farmers' investment from pests and diseases are identified and adopted.

The Government of Bangladesh has adopted integrated pest management (IPM) as the preferred means of controlling pests and diseases. Unfortunately there are as many definitions of IPM as there are practitioners and promoters of the ‘concept’. Much of the ‘technology’ promoted remains untested and is at best benign. The assumption was that, if it stops farmers using pesticides then it is useful to promote. Given Bangladesh’s need to intensify production to meet ever increasing demands from its population farmers and policymakers can not afford to be complacent but need to embrace control strategies that enable sustainable production while assuring the farmers' livelihood.

Recognising this need Syngenta Bangladesh Limited approached the Bangladesh Rice Research Institute (BBRI) with a request for assistance in the development of an IPM strategy for farmers that they could promote through a self-funded farmer field school scheme. BRRI responded by providing Syngenta with information on key pests and diseases and I particular a methodology for farmers to assess the likely impact of these biotic constraints on their crop and guidelines on the need for and timing of interventions. Despite early setbacks Syngenta developed a series of six ‘sessions’ per season for farmers in which they learned about the insect, plant, disease and nutrient problems that could affect their crops and how to deal with them. Nevertheless, Syngenta were still dependent on insecticides for control of yellow stem borer, *Scirpophaga incertulas* and were aware that class I insecticides were to be phased out by the Government in the near future.

6 - INTRODUCTION

Previous work conducted by the Natural Resource Institute in collaboration with the ICAR, Directorate of Rice Research, Hyderabad, India, over a six-year period established that the female sex pheromone of yellow stem borer, *Scirpophaga incertulas*, could be utilised for population control by mating disruption (R5747CB, Cork and Basu, 1996). The technique involved the placement of a network of PVC-based controlled release dispensers into the rice field that released pheromone in such a way as to create a fog that effectively prevented male moths from orienting to receptive females. Pheromone dispensers were optimised to ensure that a single application would be sufficient to provide season-long control and research established that the timing of application was not critical (Cork *et al*., 1996, 1998). Thus providing farmers with a simple, low maintenance technology that could be applied at their convenience.

The use of pheromones for rice pest control has a number of features that make them particularly attractive for use in rice cultivation. They are applied at low dose (40 g a.i. per ha per season) and being non-toxic avoid the environmental and health problems associated with the use of granular insecticides presently used for control of rice stem borers.

In a second phase of the project NRI researchers worked with two NGOs, Sarada Valley Development Samithi (SVDS) and Sri Vidya Trust (SVT) to assess the likelihood of uptake of the technology at the farmer level. Socio-economic data showed a direct correlation between insecticide use and intensity of cultivation. Pesticide inputs accounted for 6.1% and 3.1% of production costs in Dibba Palem and Yerravaram in the Kharif but this rose to 5.6% in Yerravaram in the Rabi. However, in Nadurubada and Narasapurapupeta pesticide inputs accounted for 13.5 and 13.0% in the Kharif and 25.1 and 21.0% respectively of production costs in the Rabi. Despite the increased proportion of production costs expended on pesticides in villages in East Godavari District (Nadurubada and Narasapurapupeta) compared to the farmers in villages near Anakapalle (Dibba Palem and Yerravaram) the ratio of investment to profit was relatively constant for all seasons, at 1 : 2.1 to 1 : 2.6, which was significantly higher than that recorded from Dibba Palem and Yerravaram which averaged 1 : 1.8. This would suggest that the increased costs of pesticide inputs used in East Godavari District could be justified on the basis of the extra crop harvested. However, it should be remembered that not only was the proportion of production costs spent on pesticides increased in the Rabi compared to the Kharif but that the overall cost of production increased in the Rabi suggesting that the actual amount of money spent on pesticides in the Rabi was more than double that of the 1998 Kharif. Data from Nadurubada suggested that almost all farmers surveyed applied four rounds of pesticide in the 1999 Rabi on the main crop compared to one to two in the previous Kharif. From discussions with farmers it was known that some in Nadurubada applied up to 12 sprays in the 1998 Rabi and that may well have accounted for up to 50% of their crop production costs, a level that would not be sustainable, but provides a measure of the farmers' determination to secure a good crop (Cork, 1998). Apart from *S. incertulas* farmers were concerned about brown planthopper (*Nilaparvata lugens*) and white backed planthopper (*Sogatella furcifera),* although infestation by the latter is known to be induced by insecticide application.

Farmers in Andhra Pradesh typically applied between one and seven applications of pesticide per season depending on the season and village sampled. The average cost of one pesticide application (£4.30 – £7.10/acre) was comparable to the cost of applying mass trapping to control YSB for the whole season.

Nevertheless, farmers expressed their reticence to adopt the technology because they would still be obliged to use insecticides for other crop pests. The argument was put forward to farmers that by applying insecticides for control of stem borers they would enhance the survival of natural enemies who would be able to control other secondary pests and that the early season attack by leaffolders did not present an economic threat to the crop. However, farmers did not appear to accept the arguments.

NGO's engaged in the project were experienced in social development and while sympathetic to project objectives they were unable to articulate the concept of integrated crop management (ICM) to farmers in project areas. In addition despite numerous efforts to engage the interest of companies involved in pheromone production they did not accept the technology as a commercially viable product.

In an effort to reduce the cost of the pheromone technology to farmers, researchers at the DRR engaged in a programme of research to develop mass trapping as an alternative to mating disruption. The advantage being that it only required the use of 600 mg of pheromone per ha per season compared to the 40 g a.i. used in mating disruption. Mass trapping also has the intrinsic advantage that farmers can see insects killed in traps, whereas mating disruption has no visual affect.

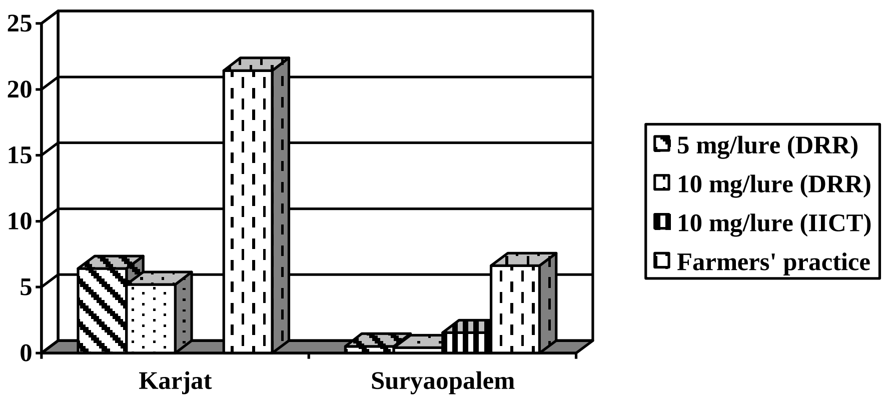

Figure 1. Percentage white head damage in 12 ha replicated mass trapping trials

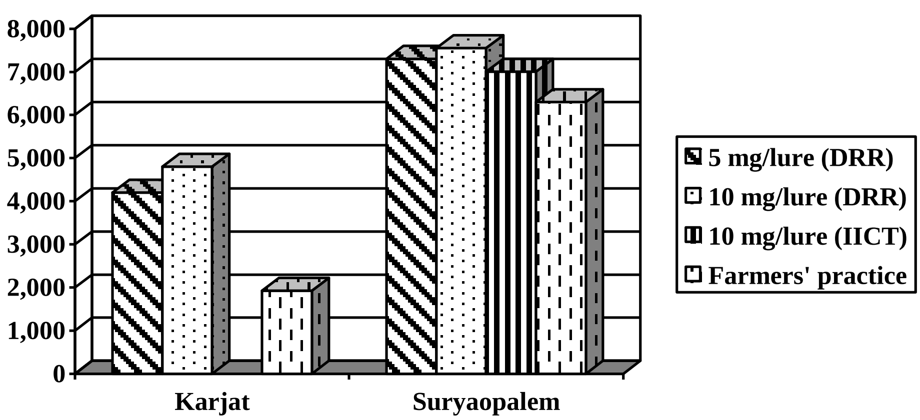

Figure 2. Yield (kg/ha) in 12 ha replicated mass trapping trials

Data generated by the DRR (figures 1 & 2) confirmed that mass trapping could control *S. incertulas* at a level that produced similar yields to crops protected with insecticides (Suryaopalem) and significantly increased yield compared to plots where no insecticides were applied (Karjat). The DRR went further and promoted mass trapping to rice farmers with some success selling over 10,000 trap systems. However, in the absence of a commercial company to promote and market the technology the venture was not sustainable.

7 - Project Purpose

The purpose of the project is to promote uptake and adoption of sustainable methods of YSB control in Bangladesh developed with CPP funding. This will be achieved by working in partnership with commercial companies, Syngenta Bangladesh Ltd. Agrisense-BCS Ltd. and Bio-control Research Laboratories (BCRL) to adapt existing pheromone-based control technologies to local conditions and incorporate them into the ICM programme promoted by Syngenta Bangladesh Ltd. through their FFS programme.

8 - Research Outputs

Output 1 – Cost-effective, trapping system suitable for use in mass trapping by smallholder rice cultivators in Bangladesh developed.

The pheromone trapping system has two elements that required optimisation for use in Bangladesh, trap and pheromone lure. However, within these two elements there was a wide range of parameters that required optimisation. A summary of the results of field trials to optimise the pheromone trapping system is given below with a detailed description of the work presented in Annex 1.

Trap design

Pheromone traps come is a wide range of shapes and sizes. Their utility depends on the behaviour of the target insect and on likely population density. Some traps are highly efficient at low density but become saturated at higher densities, other traps are less efficient at low density but have larger capacities and are more effective at high population densities. Given the economic constraints of rice farmers it was important that the traps should be inexpensive, readily available, low maintenance and sufficiently robust to last for at least one and ideally more seasons.

A wide range of trap types was tested over the project cycle. Initial efforts were directed at locally-produced sticky plate traps because they had been found to be highly efficient in trials with the brinjal fruit and shoot borer, *Leucinodes orbonalis,* in Bangladesh. It was assumed that like *L. orbonalis* the populations would be relatively low and a saturating trap design such as the sticky plate would be acceptable. Indeed early trials suggested that the sticky plate was at least as effective as commercially available delta traps and better than high capacity traps such as the commercially produced sleeve trap. Accordingly a refined version of the trap was incorporated into the first large scale mass trapping trial (Boro 2002). However, as the lure was improved it became increasingly apparent that the glue used for the sticky plate was impractical for farmers and researchers alike and that in dry weather it became contaminated with dust reducing its effectiveness. The decision was made to change to a plastic sleeve trap which was more effective at higher levels of catch and was unaffected by weather.

Attempts to develop an effective water trap from local materials, as had been achieved for *L. orbonalis*, were largely ineffective. Water traps did catch moths but in low numbers and maintenance costs were high. Sleeve traps were imported from BCRL in India and although inexpensive in India (£0.15 per trap) freight charges more than doubled the cost in Bangladesh. To reduce the cost of transport the manufacturer redesigned the plastic funnel so that they could be more densely packed. They also took the opportunity to strengthen the arm between the funnel and the support to take the weight of birds (such as drongos) that were found to perch on them.

Pheromone dispenser

A number of controlled release formulations (white and black natural rubber septa, polyethylene vials and monolithic PVC resin blocks) were tested. Results suggested that catch was not affected by the choice of dispenser and so the cheapest (polyethylene vial) was chosen for further work.

The Syngenta manufacturing plant, Chittagong was visited in the final phase of the project where they have two plastic extrusion machines that are capable of producing polyethylene vials and pheromone traps at low cost. Dr Jayanth, General Manager BCRL, offered to assist Syngenta to obtain a mould for the production of the plastic sleeve trap using the design developed by BCRL. Syngenta indicated that they are committed to commercialising pheromones in Bangladesh and were prepared to pay for the mould at an estimated cost of 2 - 300,000 taka (2 - 3,000 pounds sterling).

Pheromone blend

In preliminary discussions with BRRI, Dr Hamid Maih (ex DG) expressed concern that the pheromone of *S. incertulas* in Bangladesh might be different from that found in India. Subsequent to that discussion the DRR published data (DRR 1999 Annual report) to support their claim that the pheromone of *S. incertulas* varied in different parts of India. The data was based on relative trap catch using different blends of pheromone, but was by no means conclusive.

In order to ensure that the optimal blend of pheromone components was used in lures a number of different blends of the two principle components, (*Z*)-9- and (*Z*)-11-hexadecenal were tested in a wide range of ratio's over a number of seasons and locations. Initial results suggested that as the proportion of Z9-16:Ald increased with respect to Z11-16:Ald, up to and including a 1 : 1 ratio, the relative catch of male *S. incertulas* increased. Indeed the unnatural 1 : 1 blend caught two times more moths than the natural 1 : 3 blend, the difference was highly significant (Annex 1, table 3, ANOVA $F = 7.64$, $P = 0.001$) even though trap catches were low. This unexpected result provided an opportunity to investigate the possibility of obtaining a 'use' patent for a novel attractant of *S. incertulas*. Such a patent would provide Syngenta with market lead over potential rivals, because they would be in a position to produce lures that out-competed other products, or produce lures with the same level of attraction as the natural ratio of compounds but incorporating less active ingredient. The apparent increase in attractiveness of the new lure also opened up the possibility of conducting mass trapping on a smaller scale (equivalent to a single farmer's holding) or using fewer traps to achieve control.

Extensive efforts were made to determine whether the new lure could be patented through Syngenta's Headquarters, Basle, Switzerland and establish ownership of the idea. Syngenta indicated that the idea was indeed patentable and that they were interested to pursue a claim given that *S. incertulas* is of economic importance in a number of countries in South and South East Asia providing a significant market for the product. A ruling was eventually obtained from DFID through the efforts of Dr G Rothschild to suggest that providing the livelihoods of the poor were not disadvantaged by the marketing the new lure Syngenta would be allowed to pursue a patent claim. Question marks remained about whether the University of Greenwich, Agrisense and BCRL as partners in the project would have any clam on the invention. However, before these questions could be resolved a second season of field results appeared to contradict initial findings (Annex 1, table 9). Further work conducted in the 2003

Boro season re-confirmed the latter data and showed that the natural ratio was indeed more attractive than the unnatural 1 : 1 blend and that the basis for the invention was lost.

Discussions with DFID had to some extent clarified their position on patenting ideas and technologies that arise from work that they have funded. Nevertheless, it was evident that each claim would have to be vetted by DFID on an individual case by case basis and that the initial ruling by DFID in this instance may not have provided Syngenta with sufficient confidence to begin the patent application process.

If commercial companies are to act as intermediaries for promoting pro-poor technologies they need to be assured that their investments are secure. The possibilities for successfully obtaining patent rights from research outputs are fraught with problems. Open reporting of project results to RNR Programme managers, contracts without clear statements on IPR and multiple partner projects all act to jeopardise the chances of commercial companies attempting to exploit technology developed through DFID funding.

Given the scale of DFIDs investment in RNR research it would have been prudent to develop a pathway where DFID could patent products with the intention of licensing them to appropriate companies for commercialisation. This would ensure that only companies that agreed to promote the technologies to improve the livelihoods of resource poor communities in developing countries were licensed to commercially exploit it.

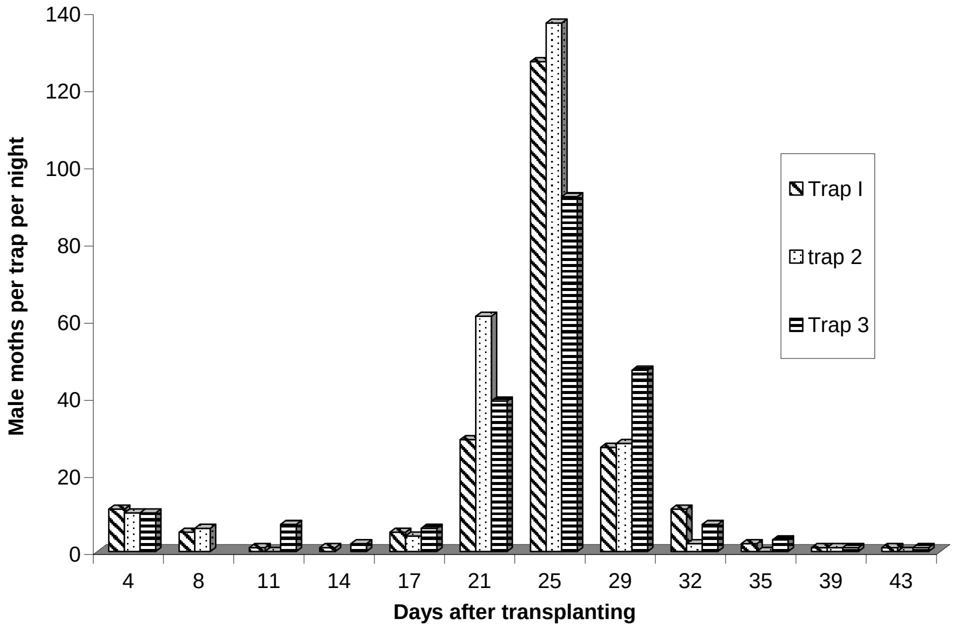

Figure 3. Trap catch from three optimised pheromone traps, T. Aman 2002

Despite the low *S. incertulas* population levels experienced throughout the project cycle all farmer meetings were very well attended. It was quite evident that farmers were impressed by the ability of the traps to catch insects and in particular that they only trapped rice stem borers. In a single field trial conducted during the 2002 Aman season in Comilla District three fully optimised traps caught 587 moths over a 12 night period, 300 of the moths were caught in a three-day period (figure 3). This result was well received by farmers and clearly news of the high catches had spread because in a subsequent farmers' meeting over one hundred farmers attended and there was a general call for pheromones for use in control of other crop pests in addition to rice.

OUTPUT 2 – SOCIAL ECONOMICS OF RICE CULTIVATION IN BANGLADESH AND EFFECT OF ICM STRATEGY ON RICE CULTIVATION ON FARMER ATTITUDES UNDERSTOOD.

Background and objectives

There are a number of key socio-economic factors that can affect farmers' willingness to adopt alternatives to pesticides. These centre around each farmer's situation; available resources, perceptions of the pest concerned and attitudes towards pest management practices. Farmers are also subject to numerous external constraints on their farming systems. Unless these circumstances are adequately understood and the ensuing product appropriately developed, farmers are unlikely to adopt it.

The aims of the Project were to adapt the pheromone for farmer adoption for integrated pest management (IPM) of the YSB in Bangladesh rice. There were two inter-related components in the project: a technical one, which tested options for field-release (Output 1) and a socio-economic one, designed to understand the farmer's context, so that the product – mass trapping (MT) would be appropriate for adoption and use by farmers. Output 2 presents the results of the socio-economic investigation into farmers' situations and how this can be used in the development of a farmer-appropriate technology, and is presented in detail in Annex 4.

Methodology

The locations chosen for data collection were conditioned by those chosen for the technology farmer trials focused on two important rice-growing areas: Comilla, which is south-central and adjoins the Delta, and Sakholla, which is north-central Bangladesh. The field work was carried out through four stages and employed a number of approaches:

- The first stage was carried out in Sakholla during the *boro*[1] season and involved the gathering of socio-economic data from: secondary sources; key informants and farmers in the technology trials through a **baseline survey** using a purposive sample (December 2001). The questionnaire covered: household biodata; resources; cultivation; knowledge of insect pests; costs of production; constraints on rice production and knowledge of IPM.
- The second stage was an **in-depth** socio-cultural study of a sub-sample of these farmers selected purposively by occupational and land-holding status and willingness to participate, through interview and observation (May – June 2002). This focused on farmers' views on the technology and factors which could influence adoption, including; efficacy, modifications, pricing, collective action and willingness to adopt.
- The third stage was a **baseline survey** in Comilla, using the same approach to allow comparative analysis with Sakholla. Data was gathered during the transplanted *aman* season (September 2002). The parallel technology trials were mass trapping of YSB based on the most effective trial results.
- The final stage was to discuss their perceptions of the MT with farmers involved in the scattered technology trials (10 traps per acre) and observe their responses.

Outcomes

[1] The three major rice growing seasons in Bangladesh are: *boro*, (summer); *aus* (autumn) *aman* or transplanted *aman* (winter).

Farmer situation

The study provides insights into two Bangladesh rice farming communities, thought to be reasonably representative before the attempted introduction of a new technology. Farmers perceived that they were incurring significant rice losses every year from YSB infestation. Most farmers apply insecticides and are unaware of their environmental side effects. Although others are aware, and also of less detrimental alternative approaches such as IPM, they continue to use pesticides. They would like to reduce pest management costs. For pest management advice there is heavy reliance on pesticide retailers, whom most farmers consult when faced with pest problems.

Alternative approaches to YSB management have generated considerable interest within the Project area. However, losses appear to vary seasonally and year to year, blurring the advantages to farmers of using pheromones pest management. Farmers want quick and visible results, having long been conditioned to management approaches which result in dead pests.

Farmers differ in their responses to pest attack. Those that are smaller scale and with higher dependence on rented land being more risk averse and less likely to invest in management.

Farmers' Interest in Using a New Technology Instead of Insecticides

In the trial areas project pheromones created strong interest amongst farmers who were keen to see whether MT are effective in stem borer management. Farmer's opinions differ regarding the effectiveness and interest in using MT because the *boro* season pest infestation was very low. They are not concerned about the infestation of SB or YSB alone but in total. They are also unsure if infestation occurred naturally[3] or resulted from setting MT in their rice fields if they only see flies and mosquitoes in their traps. Some think they are effective and say they will use them, some take the opposing view, and others are aware of low pest infestation during the *boro* season and so will **wait and observe** trap effectiveness if they are used by neighbouring farmers. Most farmers would use a technology if it was cost effective, to avoid the use of pesticides and safeguard human and animal health.

The effect of the project may also be a factor conditioning farmers' responses; their apparent interest in pheromones may be driven by a desire for free material from the Project.

Understanding farmers' views

Although after the 2002 T. Aman season farmers in Adompur felt that MT was effective and they had expressed great interest in using the technology it was observed later that most did not use MT in their fields. To understand farmers' views, pheromone traps (PT) were sold through local retailers at a nominal price based on farmers' price assumptions. Some preliminary promotional groundwork was undertaken with farmers and a retailer, with the latter assisting farmers to use MT. Although initially farmers agreed to purchase PT's for cash, some of them later asked the retailer for credit. They wanted to observe what happened to other farmers and not to invest with uncertainty. This uncertainty suggests that sound technical back-up information to the farmers was inadequate for PT implementation. Because of their significant role in local pesticide application practices, training for local pesticides retailers would be very useful to motivate farmers. The dichotomy in farmers views is demonstrated in Table 1 in those receiving training, with efficacy completely juxtaposed with practitioning.

Table 1: Farmers IPM Status

	Farmers response	**No. of farmers sampled**	***All farmers %***	***Trained farmers %***
Received Training	Yes	34	38	
	No	55	62	
Opinion about the training	Effective	29		85
	Not sure	5		15
Current IPM Status	Practitioner	5		15
	Non-practitioner	29		85
Interest in using new technology/MT	Interested	78	88	
	Uninterested	3	3	
	Not sure	8	9	

Comparison between the farmer's views about herbicides and pheromones

Past experience with fertilizers, shallow tube wells and power tillers, suggest farmers will adopt a technology if they think it is effective/useful and cost-effective. The experience with herbicides suggests they are ready to adopt new technology. A number of farmers think that an alternative method is required to management of SB instead of insecticides and must be cost effective. Considerable importance was attached to other factors reducing rice yield potential, particularly weeds, where a favoured management option is herbicides. Managing weeds is one of the most expensive activities in rice cultivation. Herbicides were used alongside pheromones in the trials. Very few farmers had used herbicides and were impressed with the trials, which demonstrated weed removal without high labour cost, intending to use herbicides from the next season, whereas they are not sure of using MT. Key issues for farmers are that they are not sure about the effectiveness of PT when they use it individually and because it benefits from collective use, which does not apply to agro-chemicals. There is a reluctance both to take responsibility for a collective decision and incur the risks associated with individual use.

Factors influencing the adoption of Mass Trapping in Bangladesh

Pheromones represent a departure and so adoption needs to be promoted through training programmes. Implementation and adoption of a new technology is very dependent variously on the potential users' socio-cultural practices, resources, constraints and perceptions. Implementing a new technology such as MT requires well informed pre-knowledge about the methods of use. It is necessary to create awareness about the side effects of insecticides and the benefits of using MT.

A key factor in farmers' choice of management option is the influence of pesticide dealers, whose livelihoods are potentially threatened by the uptake of alternatives. Their involvement during implementation of IPM programmes based on pheromones (and other alternatives to pesticides) is crucial to successful adoption and should be based on training, to broaden the advice they are able to provide, and exploit opportunities for marketing alternatives, to compensate for income foregone.

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[3] The technical report confirmed that the 2002 *boro* season was not favourable for stem borers' infestation.

As using MT would benefit from collective action if farmers use them **collectively**, there are potential spin-offs for cost effective dissemination through these emerging farmer groups which also benefit the uptake.

Pesticides also provide the reference point for pricing, with farmers expecting pheromones to cost less. Pricing is a key factor as **farmers seek a technology that is cost effective**.

Implications for the future

For private sector companies in the pest management sector producing technology (usually pesticides) is their *raison d'etre* and they must sell to survive. If they are to sell alternatives, the approach needs to evolve and demonstrate greater sensitivity to farmers' situation. The socio-economic component has emphasised since its inception that the farmers situation; their resources, constraints and perceptions, is central to the success of any technology adoption programme, and particularly one involving alternative approaches which requires farmers to change their practices in a fundamental way. The research has arrived at a point where the technology has largely been shown to work under Bangladesh conditions, but adoption by farmers on a commercially viable scale is not yet a reality because of socio-economic constraints.

Pheromone technology could be introduced through Syngenta Farmers Field School (FFS), but it would be better if it were also possible to work with various enabling organisations, in order to realise the benefits of collective adoption through farmer community action. One of the keys to implementation of alternative pest management programmes is partnerships between different types of institutions which individually have strengths and weaknesses. In no particular order:

- NGOs that operate locally tend to be strong on community development, farmer involvement and social aspects, perhaps weaker on the technical dimension;
- The strengths of government institutions lies in their technical and research capacity, the structure of the agricultural extension programme and the ability to shape policy, perhaps less well placed to deliver research output to farmers;
- private sector institutions such as Syngenta also have strong technical capacity and through product supply are well-placed to implement retailer training programmes, perhaps less strong on the social dimension, and
- universities have good technical and research capacity, but are less well placed to support farmers.

Recommendations

Firstly: Farmers have **to understand how a new technology works**. The different modes of action between pheromones and conventional insecticides must be explained to farmers. The message that has to be passed to farmers is that the technology **manages the infestation by inhibiting reproduction of the stem borer**. The side effects of traditional insecticides and benefits of MT, should also be stressed for positive impact on **farmers' attitudes** towards IPM and MT. Farmers' views conflict about rice pest management. The better informed farmers are about pheromones, the more interested they will be to adopt the technology.

Secondly: It has been observed that there are some **enthusiastic farmers** who want to adopt a new technology. These farmers should be selected for **training** in order to **influence** other farmers to use the new technology. Wherever possible, learning by seeing is more effective than by hearing from others. So, **demonstrations** are recommended, involving enthusiastic and potentially interested farmers to allow the latter to observe results directly.

Thirdly, active involvement of farmers with projects and trials. The more participatory the research and the more the farmers are involved, the more they will be prepared to provide accurate feedback on acceptance, rejection, effectiveness, limitations and pricing of PT's.

Fourthly, as local retailers play an important '*doctor of pest/rice field'* role, **they should be trained** in order to be well-informed about how pheromones work.

Further work

The dilemma between farmers' thoughts and actions:

- what can research do to understand this
- can training material be developed that will improve adoption?

The report makes recommendations on future action to facilitate adoption. For implementers and policy makers, the private sector, NGOs and government, an understanding of the farmer's situation is central to the shaping of alternative technology if farmers are to adopt. The case can be made for understanding the farmers' context in respect of a pest problem/ complex before work starts on shaping technical solutions.

As early as possible in the research – implementation continuum, the focus should be on farmer training programmes which: build on understanding of the farmers' situation; emphasise the holistic nature of pest management, and anticipate the implications for incorporating alternatives to pesticides within farming systems. For researchers, there are unanswered questions around farmers' dilemma – the difference between their declared intentions to use pheromones and their actions. Further comparative research is proposed in Bangladesh and other Asian rice-growing countries to resolve this dilemma.

OUTPUT 3 – IMPACT ON RICE CROP OF INCORPORATING MASS TRAPPING, FOR CONTROL OF YSB, AS A COMPONENT OF THE SYNGENTA ICM PROGRAMME IN BANGLADESH ASSESSED.

At the commencement of the project it was assumed that mass trapping to control *S. incertulas* could only be conducted effectively over relatively large areas (1-10 ha) suggesting that farmers would need to work in groups in order to implement the technology. In contrast the IPM techniques promoted by Syngenta through their farmer FFS was implemented by farmers acting as singletons. In order to incorporate mass trapping into the IPM programme it was decided to mass trap 10 ha plots and designate fields (sub-plots) within each block as IPM, farmers' practice and check plots. Farmers cultivating fields designated for IPM would follow the Syngenta IPM recommendations, farmers in farmers' practice fields would follow their traditional methods of crop production and in particular pest control while those in 'check' fields would not practice any means of insect pest control.

The experimental protocol was replicated in similar areas or plots in which mass trapping was not applied. This protocol, it was felt, would provide a means of assessing the effectiveness of mass trapping for control of *S. incertulas* in the presence of IPM or conventional pest control methodologies. The weakness of the protocol was that because of the physical grouping of replicates they could not be viewed as independent and therefore constituted pseudo-replicates. However, the logistics of conducting a replicated series of large-scale trials incorporating each variable separately was not practicable.

It was originally envisaged that farmers would be positively engaged in field trials and conduct much of the work. This would have enabled them to provide informed feed back on the value of the technology. However, in the event most of the trials were laid out in farmers' fields and data collected by Syngenta researchers. This was desirable in the early stages of the project when Syngenta personnel were themselves learning how to undertake the trials. However, it would have been useful to for researchers to have engaged more directly with farmers in subsequent trials. The reason why this was not undertaken was because trial results were somewhat ambiguous, due to low infestation levels, and researchers were reticent to relinquish control in case they lost an opportunity to get statistically meaningful data.

A summary of the results of the large-scale field trials is given below with detailed results presented in Annex 2.

Boro 2002 mass trapping trials

A comparison of yield data from the Boro 2002 mass trapping trials showed that in both mass trapped and non-mass trapped plots the Syngenta IPM treatment sub-plots gave the highest average yields (8,120 and 7,790 kg per ha) although they were not significantly different from check sub-plots (7,970 and 7,700 kg per ha). This may in part reflect the fact that stem borer damage levels did not exceed the action threshold and no insecticide was applied in either the Syngenta IPM sub-plots or the farmers' practice plots. Nevertheless, in both plots farmers' practice sub-plots produced significantly lower yields than other treatments (6,240 and 6,190 kg per ha) although the reasons for the reduced yields are uncertain but may be due to poor farmer practice.

There was no significant difference between the yields obtained in mass trapped sub-plots and the non-mass trapped sub-plots although in each case they were about 5% higher). These results probably reflected low stem borer populations observed in all treatment sub-plots based on pheromone trap catch and damage data. For this reason the trials did not provide definitive information on the relative value of mass trapping for controlling *S. incertulas.*

Larval sampling data demonstrated that there were three species of stem borer present in the rice crop and that in the latter stages of development it was *S. inferens* and *C. polychrysus* that were the most abundant species. This data suggested that mass trapping for *S. incertulas* alone would not have had a significant impact on stem borer damage levels. It was unclear from the data whether the relatively high proportions of *S. inferens* and *C. polychrysus* resulted from an unusually low incidence of *S. incertulas* or whether this was a normal distribution for the Boro season. Dr. N. Q. Kamal (in press) reported similar findings during last Boro season.

T. Aman 2002 mass trapping trials

Stem borer incidence is traditionally higher in the Aman than the Boro season in Bangladesh and it was hoped that the transplanted 2002 Aman crop (subsequently referred to as T. Aman) would provide the best opportunity to demonstrate a significant difference between mass trapped and non-mass trapped plots.

Because of the logistical problems encountered trying to conduct trials in more than one District the work in the 2002 T. Aman crop was located entirely at Laksam, Comilla District.

Pheromone trap catches and larval damage estimates enabled the progress of each generation of *S. incertulas* through the cropping season to be closely monitored. Pheromone trap catch in particular provided a useful means for anticipating oviposition and could be used by farmers or extension personnel alike as an early warning system. Farmers could then decide on whether to apply conventional insecticides or mass trapping for control.

By comparing relative pheromone trap catches inside the mass trapped plots with those on the edge of the plot it was possible to demonstrate that mass trapping was indeed suppressing male moth populations (Annex 2, Table 8).

The effect of reducing male moth populations on progeny was apparent from larval damage data. In Trial I the second generation of larvae was observed at 81 DAT in the non-mass trapped trial (figure 4a) but no corresponding increase in larval numbers was observed in the mass trapped area (figure 4b) suggesting that mass trapping had successfully reduced larval damage levels.

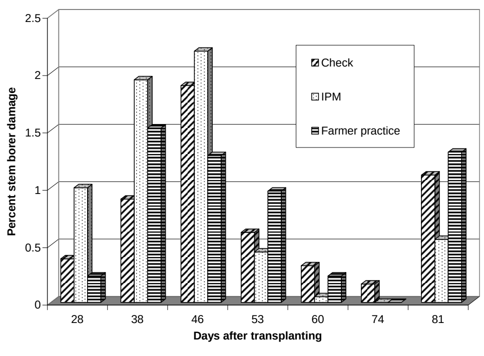

Figure 4a Stem borer larval damage (no mass trapping)

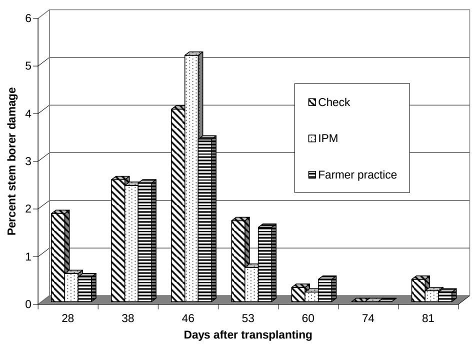

Figure 4b. Stem borer larval damage (mass trapped plot)

Despite clear evidence to support the supposition that mass trapping was having an impact on larval damage this was not translated into increased yields (Annex 2, table 9) in the mass trapped sub-plots. The reason for this was the low larval population levels and the confounding effect of other stem borer species.

Boro 2003 mass trapping trials

A mass trapping trial was set up in the 2003 Boro season in Comilla District but stem borer damage to the crop remained less than 1% throughout the season (Annex 2, table 10). No significant differences were observed between the yields obtained in the different treatment plots (Annex 2, table 11).

Conclusion

Large-scale trials clearly demonstrated that 20 pheromone traps per ha could reduce male moth populations and there was good evidence to support the view that mass trapping had indeed reduced the level of mating in the plots with consequent reductions in larval populations. Nevertheless, the level of control achieved by mass trapping did not have an impact on yield because of the low levels of stem borer damage in both treated and untreated plots and because of the presence of other stem borer species that were not thought to be affected by the *S. incertulas* pheromone.

Stem borer complex

Yellow stem borer, *S. incertulas* has long been considered the predominant rice stem borer in Bangladesh (Catling & Alam, 1977). Nevertheless, Islam (1996) found that *S. incertulas* and *C. polychrysus* were widely distributed and *S. inferens* was more common during the winter months when it has been shown to infest wheat during the latter stages of crop development causing significant levels of white head damage (Ahad *et al*., 1994). However, the data presented in this report (Annex 3) demonstrated that the rice stem borer species complex varied not only between seasons but also between locations and most importantly throughout crop development at a single location. These data suggest that predicting the status of a particular species at a particular time and at a particular location in Bangladesh is far from simple and probably beyond the scope of rice farmers even with appropriate training. Such a scenario could have a profound effect on the development of control strategies for rice stem borer that are dependent on the assumption that a particular species is predominant, such as mass trapping with pheromones.

It was unclear from the data whether the low level of stem borer incidence observed during the sampling period were typical of those found under current crop production practices, because they were much lower than had previously been reported (Islam and Karim, 1997), or that anticipated by the rice farmers (P. Kamruzzaman and M. J. Iles, personal communication). Similarly, it was unclear whether the apparent increase in relative importance of *S. inferens* and *C. polychysus* in the samples collected reflected exceptionally low abundance of *S. incertulas* or whether they had increased in number to occupy the niche vacated by *S. incertulas*.

Data subsequently collected by Dr Kamal from the 2003 T. Aman crop indicated that DH levels exceeded 10% throughout Bangladesh and that *S. incertulas* was the predominant species. Because the weather during the late summer months of 2003 was unusually dry compared to 2001 and 2002 it could be implied that the data described in the current publication reflected the normal level of stem borer incidence in areas of Bangladesh where high yielding varieties are grown. The status of the rice stem borer complex in deep water rice may well be different (Islam, 1994, Catling & Islam, 1995). The ability of the *S. incertulas* population to increase in response to changes in weather quicker than *S. inferens* or *C. polychrysus* suggests that in seasons when stem borer incidence exceeds the economic threshold *S. incertulas* is most likely to be the pre-dominant species but when damage levels are low the situation is more complex.

OUTPUT 4 - DISSEMINATION

4.1 STAKEHOLDER WORKSHOP TO ASSESS IMPACT OF ICM AND PHEROMONES ON PEST CONTROL, COMMERCIAL RELEVANCE AND VIABILITY OF TECHNOLOGY

Final Project Workshop

The final project workshop provided a venue for stakeholders to discuss project outputs from both technical and social science inputs. The project approach and outcomes were presented in formal sessions (Annex 5) and well received by the delegates. The implications of the work and in particular how farmers might gain from the technology developed were discussed in detail. General areas covered in the open discussions included:

- Importance of rice stem borers in Bangladesh.
- The relationship between pheromone application and yield.
- Possibility of using pheromone traps to monitor pest incidence.
- The involvement of women farmers in the project.
- Registration of pheromones.
- The expected cost of pheromones by the farmers.
- The availability of the pheromone traps in Bangladesh.
- Compatibility of pheromone traps with IPM technology promoted by DAE.
- Effectiveness of Syngenta, BRRI and NRI partnership.

Despite problems associated with low stem borer incidence and the changing stem borer species complex the workshop were able to come to a series of recommendations as to how pheromones and mass trapping might be utilised for more environmentally friendly means of controlling rice stem borers in Bangladesh.

WORKSHOP RECOMMENDATIONS

- Mass trapping is recommended for use in the Aman crop when rice stem borer populations are high and insecticide is problematic to apply because of rain.
- Stem borer control is not recommended in the Boro and Aus seasons because of low infestation levels.
- Pheromone traps should be adopted into IPM practice to provide farmers with early warning of *S. incertulas* infestations.
- *S. incertulas* pheromone should be made available to rice farmers in Bangladesh and promoted through the efforts of Syngenta's marketing system and the DAE.
- Pesticide use in rice cultivation is relatively low in Bangladesh, adoption of pheromone traps would help to educate and reassure farmers that they do not need to apply insecticides.
- Further work is needed to understand the impact of the rice stem borer complex on yield and develop the potential of pheromone traps for monitoring populations.
- Technical and social science support should be provided to Syngenta to assist them market the pheromone product and in particular assess the impact of marketing and pesticide dealer training on the attitude of risk adverse farmers.

OUTPUT 4.2 – DISSEMINATION OF PROJECT RESULTS

The project envisaged disseminating project results through project reports to collaborators, a stakeholder workshop and a presentation at a regional ICM symposium. It was anticipated that if field data were of sufficient quality it would be disseminated through a peer-reviewed publication. Further dissemination and promotion was expected to be the responsibility of the commercial partners in the project.

It was important for the project to develop an awareness in Syngenta of the intrinsic economic value of pheromones for agricultural crop pest management, not only in rice but to encourage them to consider other cropping systems as well. This approach was amply rewarded by Syngenta championing the case for clarification on the registration requirements for pheromones and related biorational control products. This was achieved through persistent lobbying of members of the Pesticide Technical Advisory Committee (PTAC) and active encouragement of scientists in BRRI and BARI to lobby members at the sub-Committee level.

Following successful demonstration of pheromones for control of related plant pests, brinjal fruit and shoot borer, *L. orbonalis* and cucurbit fly, *B. cucurbitae,* by BARI in collaboration with a range of partners, Syngenta submitted documents to register their pheromone products, Gaint and Gem respectively with the Plant Protection Wing of the Directorate of Agricultural Extension in May 2003. Syngenta delayed registration of the *S. incertulas* pheromone because at the time of submission there appeared to be good evidence to support the prospect of obtaining a use patent on a novel blend of the pheromone. As a direct result of the activities of the project Syngenta are now firmly committed to commercialising pheromones for use in Bangladesh.

In order to raise the profile of the technology in Bangladesh in general two publications were developed. A flyer entitled 'Mass trapping: An alternative to insecticides for control of rice stem borers in Bangladesh' (Annex 7). This publication has particular value for scientists, extension officers, NGO personnel and has been translated into Bengali (500 copies printed) for distribution to farmers. The flyer contains both visual and textual messages and builds links between the Government approved IPM approach to pest control and the use of pheromones in rice. Because the flyer is co-authored by researchers from NRI, BRRI and Syngenta it not only indicates endorsement by Syngenta but also demonstrates an active desire to promote the technology and acknowledge its benefits.

The second publication is a review article entitled 'Pheromones and their applications to insect pest control: A Review'. The article is co-authored by researchers from NRI, BRRI, BARI, AVRDC and Syngenta and has been accepted by the *Bangladesh Journal of Entomology* for publication. The Review paper will help to raise awareness of the technology in the scientific community in Bangladesh.

Plans to present project results at the 2003 International Society of Chemical Ecology meeting in Korea were disrupted because the conference was cancelled due to a SARS scare. Dr Kamal, Head of Entomology, BRRI, utilised the funding instead to visit NRI and NRIL to learn more about chemical ecology and meet colleagues involved with related DFID-funded research projects. In the event the visit was highly productive and Dr Kamal benefited greatly from the exposure.

A peer-reviewed publication concerned with the distribution of rice stem borer species in Bangladesh based on a survey conducted by BRRI is in preparation. In addition the Associate Editor of Outlook in Agriculture, Dr Roger Atkin, has invited us to submit an article on the project.

Interviews were conducted by AgFax, the radio and press service from WRENmedia, with researchers from NRI, BRRI and Syngenta on the project and this was followed up by an article in New Agriculturalist (2003 Issue 4, Annex 6).

The stakeholders workshop conducted in the second project year involved sessions with researchers in Dhaka and a farmers' field meeting in which over 100 people participated. The proceedings of the workshop (Annex 5) will be disseminated to interested people in Bangladesh and India to ensure an impact beyond the audience of those who participated. The highlight of the workshop was a multi-media presentation developed for Syngenta that provides a valuable tool for teaching non-specialists the economic and environmental importance of adopting IPM and related technologies for crop pest management.

9 - CONTRIBUTION OF OUTPUTS TO DEVELOPMENTAL IMPACT - DISCUSSION

Introduction

Bangladesh has been enormously successful in increasing its rice production in an effort to attain self-sufficiency. This has been largely achieved through the increase in the acreage of the Boro crop concomitant with BRRI introducing a range of appropriate high yielding varieties to replace the more traditional deep-water varieties.

Under the present cropping regime pesticides and insecticides in particular are not intensively used in rice cultivation in Bangladesh, although the total amount of insecticide applied to rice exceeds that in any other crop. There has been a growing awareness of the social and environmental costs of using pesticides in Bangladesh and Syngenta in particular is keen to encourage and promote sustainable production through the development of new, environmentally- and socially-acceptable crop production technologies.

The project was not only designed to develop mass trapping as an alternative control technology to insecticides but to develop the technology in partnership with both end-users and Syngenta. It was important that the technology both fitted in with the FFS programme promoted by Syngenta and their product portfolio. Provided the new technology was 'farmer friendly' and the costs of that technology were acceptable to the farmer then both Syngenta and farmers would be more likely to buy into the technology.

The project therefore set about developing an awareness in Syngenta of the value of pheromones and by association other biorational pest control technologies and working with Syngenta optimise the technology for use under rice cultivation conditions that pertained to Bangladesh.

Thus, control of *S. incertulas* by mass trapping had the potential to contribute to achieving the RNRKS goal by providing an environmentally benign, species-specific and sustainable pest control technology that was compatible with smallholder needs and methods of rice cultivation.

Cost effectiveness of technology

Efforts were made in the project to ascertain the costs borne by smallholder farmers in rice production and to determine whether mass trapping would be cost-competitive with current insecticide-based control practises.

Project data suggests that the cost of cultivation of rice in Sakolla and Comilla were typically £147 and £166 per ha per season. Insecticide use accounted for between 2 and 5% of these costs (between £4 and £7.4 per ha per season). The mass trapping technology developed in the project requires 20 traps per ha with two lures per trap to cover the period when the crop is at risk from *S. incertulas*. The sleeve trap adopted for use in mass trapping is sold for £0.25 in India and lures cost typically £0.1 to £0.2 each. Assuming the costs are roughly equivalent in both countries mass trapping should cost a maximum of £12 per ha per season or 7-8% of crop production costs. This suggests that mass trapping is more expensive than currently used levels of insecticide. However, the averaged insecticide cost disguises the fact that some farmers do not apply insecticide at all (approx. 20% of those surveyed) and so those that do will actually spend more than the averaged value. In addition pheromone traps can be used for a number of seasons and farmers are unlikely to adopt the density used in trials.

Pheromone trap catch data appears to suggest that they can be used to predict the emergence of adult moths and hence the likely timing of mass trapping or other remedial actions to control progeny. Syngenta will promote pheromone traps in the first instance for monitoring and, depending on farmer interest, introduce mass trapping in selected areas as part of their IPM FFS programme.

New Knowledge

The project has contributed significantly to understanding of how mass trapping can be developed and implemented as a method of controlling field crop pests. The new knowledge has been utilised in a related DFID-funded project for control of brinjal fruit and shoot borer, *Leucinodes orbonalis*, in India and Bangladesh (7465(C)) and will have significant value for other target pest species.

The project has provided new insight into the dynamic changes in stem borer species both within and between seasons. The research has also confirmed that despite the low levels of *S. incertulas* infestation recorded in all seasons other species do not appear to be increasing to fill the niche. The reasons for the low infestation levels are not known but broadly reflect those found in a previous study funded by DFID (NRI, 2002) in which, over the course of four seasons, rice stem borer infestations did not exceed the economic threshold at any site.

The project has confirmed that despite farmers concerns there is no need to apply insecticides in either Aus or Boro season crops to control stem borers.

The project has contributed to significant policy changes at government level to enable commercialisation of biopesticides for use in pest and disease control in Bangladesh. As part of that process it has raised the awareness of biopesticides in all major Government research Institutes in Bangladesh and the DAE in particular.

The project has confirmed that although farmers apply more insecticide on rice than any other crop their use is still very low by international standards. However, given that farmers perceive stem borers as a considerable constraint to production it is important to ensure that alternative pest control measures are made available. Indeed it could be argued that it is only because of the poor financial returns on rice cultivation that farmers are discouraged from investing more heavily in insecticides.

10 - Promotion pathways

The increased awareness in Syngenta, BRRI and latterly the DAE of the potential value for pheromones for both monitoring and control of rice pests and stem borers in particular has produced a strong desire by them to see this technology adopted at the farmer level. The technology developed is not the exclusive preserve of any one organisation and while it may appear to be anti-competitive to provide assistance exclusively to Syngenta to develop pheromone products the very fact that Syngenta have taken the lead to commercialise them will inevitably encourage others to follow. The success or otherwise of any such venture will depend critically on price, farmer acceptance and promotion by Syngenta and, most importantly, other agencies such as the DAE and NGOs.

Syngenta have benefited enormously from the participation of a strong social science team in the project and their work has confirmed farmer interest in the technology and price sensitivity. Nevertheless, unless farmers can see a financial benefit to using pheromone traps they will not accept the technology and they will not be provided with an opportunity to purchase them if the dealers can not see a profit in selling them. Thus any promotion pathway has to accommodate the needs of both end-user and manufacturer.

Syngenta have considerable experience in commercialising new products in Bangladesh and have already commissioned a report by Mr Shikdar Akhtar-Uz-Zaman (2003) on a proposed marketing strategy entitled, 'Marketing mix of pheromone to control yellow stem borer'. In his conclusions Mr Akhtar-Uz-Zaman suggests that 'Syngenta will have to build an awareness among the farmers and that they should 'also go for collaboration with the GO and NGOs'. He suggests that promotional activities should be undertaken to 'create an awareness, stimulate demand, encourage product trials, identify, prospect and facilitate reseller support'. Syngenta are clearly well placed to undertake such promotional activities. Such promotional activity could also be used as a vehicle for other messages such as the environmental advantages of using pheromones compared to insecticides, their compatibility with IPM, the role of natural enemies and other biotic factors in crop management and the need for balanced inputs to obtain sustainable yields. By involving current project partners in the Syngenta marketing and promotion activities DFID would have an ideal opportunity to promote the concept of sustainable agriculture both to end-users, intermediaries and the agrochemical industry.

11 - FOLLOW -UP INDICATED/PLANNED

The project has gone a long way to developing mass trapping as a viable means of controlling *S. incertulas* in Bangladesh. Project results suggest that the Boro and Aus season crops are not at risk from *S. incertulas* but that mass trapping may be economically viable in the Aman season. There is significant evidence to show that insecticide use in Bangladesh is increasing dramatically, 16.8% increase between 1999 and 2000 (table 2), and that while application on rice is still significantly less than in other countries in the region farmers perceive stem borers as a significant threat to their crop and alternative means of control are needed.

Given the technical advances made as a result of the project and the greater understanding of farmers' perceptions the priority for project partners should now change to one of actively assisting Syngenta to market pheromones. This goal would come under two headings: incorporating mass trapping into the FFS programme and developing & implementing technical training packages in IPM for pesticide dealers, NGOs and extension workers (for both rice and vegetables).

Incorporating mass trapping into FFS

- No technical assessments but assess farmer reaction to technology in their terms
    - Price (compared to alternatives - insecticides, IPM)
    - Effectiveness (their views on performance & how do they assess it)
    - Ease of use (compared to insecticides and other IPM options)

Develop & implement technical training package in IPM for pesticide dealers, NGOs and extension workers (both rice and vegetables)

- Introduce pesticide dealers, DAE, NGOs to IPM concepts in relation to biorationals
    - Importance of ecological balance,

Concept of healthy plants making healthy environment and producing healthy crop

- Develop an awareness of potential market for biorational products to replace earnings from sales of insecticides
    - pheromones, natural enemies, BT, NKSE, Trichoderma, NPV.
    - high seed quality
    - balanced fertiliser inputs

Note - The approach could be adopted for use in India. However, there is no single agrochemical company in India with the interest or market penetration of Syngenta to promote the message {although could work through SME's as had been envisaged in DFID promotion project for brinjal borer}.

As with any new technology there are a number of additional technical issues that remain to be resolved;

Syngenta - Technical

Fine tuning of mass trapping technology for <u>S. incertulas</u>
- Large scale mass trapping in Aman 2004 and 2005
- Trials on individual plot basis to determine the minimum area required to achieve efficacious use of mass trapping.

Better understanding of factors that affect farmer decision making
- Uptake of new technologies,
- Farmers are risk averse but what key issues would provide sufficient motivation for change
- Why are farmers reticent to take up new challenges e.g. pheromones, even at nominal cost
    - Investigate issues further with farmers invited to take up option of pheromones in phase I
    - Revisit farmers and NGOs involved in previous rice pheromone work in India
    - Revisit DRR, India to study reasons for lack of uptake
    - Revisit pheromone producers in India (SPIC Science Foundation, BCRL) to establish why they did not take technology forward

Note - some of this work has already been done [and the issues understood] in previous studies associated with development of pheromones for use in rice pest control [R6739, R7576]. Nevertheless, Syngenta are close to entering the market with pheromone product(s) and it would be valuable for CPP to learn more about the issues involved in achieving market impact with a novel biorational product both from the social as well as the technical side. In particular how does agri-business achieve farmer impact where extension officers and even NGOs fail?

BRRI - Technical

Pheromone and light trap network
- To correlate light and pheromone trap catches - develop national network for early warning to farmers (radio) (self sustainable as pheromone traps will be locally available from Syngenta at nominal cost).
- Determine whether timing and size of pheromone trap catches can act as a predictor of WH damage. - Useful if Syngenta wish to promote pheromones as a monitoring (early warning) tool.

Impact of stem borers on crop
- Undertake studies to assess relative impact of *S. incertulas* and *S. inferens* on crops given that they attack the crop at different times in the season, particularly for *S. inferens* which increases in prevalence late season and could have a disproportionate impact on yield loss compared to *S. incertulas*.

Outputs

1) Promotion of mass trapping of *S. incertulas* to replace insecticides currently applied.

2) Promotion of pheromones as integral part of rice IPM promoted by DAE & NGOs.

3) Training of pesticide dealers in ecological crop management strategies promoted.

4a) Better understanding of relative of importance of different stem borer species on Boro and Aman crops.

4b) Identify whether pheromone traps can be used as a means of determining likely impact of *S. incertulas* on the crop and its use promoted in early warning. This will act to establish the product with farmers and improve the prospects of their adoption of mass trapping in place of insecticides.

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Project Title: Commercial adoption of pheromones as a component in the Integrated Crop Management of rice in Bangladesh	**Estimated Project Start Date:** 1 April 2001 **Estimated Completion Date:** 30 June 2003 **Date of this Framework:** March 2001

Narrative Summary	**Objectively Verifiable Indicators**	**Means of Verification**	**Important Assumptions**
Goal			
To increase yields in rice-based systems in floodplain areas by environmentally benign pest control methods.	To be completed by Programme Manager	To be completed by Programme Manager	To be completed by Programme Manager
Purpose			
New knowledge developed, validated and promoted that reduce poverty through sustainable management of major insect pests of rice.	To be completed by Programme Manager	To be completed by Programme Manager	To be completed by Programme Manager
Outputs			
1 Cost-effective, trapping system suitable for use in mass trapping by smallholder rice cultivators in Bangladesh developed.	Data on relative efficiency of four commercially-available trap designs established. Data on effect of loading, age, composition and dispenser type on attractiveness of the pheromone bait established.	Quarterly and annual project reports	Insect populations are of sufficient magnitude to allow comparison of traps and lures.
2 Social economics of rice cultivation in Bangladesh and effect of ICM strategy on rice cultivation on farmer attitudes understood.	Data on farming practises, farmer resources, constraints to production, and agrochemical use available. Data on farmers views of ICM and use of pheromones for control of YSB available.	Quarterly and annual project reports	
3 Impact on rice crop of incorporating mass trapping, for control of YSB, as a component of the Syngenta ICM programme in Bangladesh assessed.	Data on larval damage caused by YSB in untreated, farmers' practice, ICM areas, with and without pheromone treatment available.	Quarterly and annual project reports	
4 Dissemination of project results.	Stakeholder workshop, presentation at regional scientific meeting and publication of project results.	Workshop proceedings Conference proceedings. At least one scientific publication.	Field data of sufficient quality to enable results to be published.

Activities	Inputs	Means of Verification	Important Assumptions
1.1 Field trials to optimise novel lures and traps for mass trapping system (yr. 1).	Project Inputs over 2 years (£)	Quarterly and annual project reports	Insect populations are big enough for meaningful field trials.
2.1 Socio-economic studies in trial and non-trial areas to understand farming practises, resources, constraints, agrochemical use, and relevance of ICM and pheromones to rice farmers (yr. 1 & 2).		Quarterly and annual project reports	Syngenta farmers' groups representative of rice cultivators in the country.
3.1 Project meeting to familiarise project partners with project objectives, assign responsibilities and timetable of workplan (yr. 1).		Quarterly and annual project reports	YSB damage levels are sufficient to enable meaningful assessment of efficacy of technology.
3.2 Farmers' meetings at beginning and end of field seasons to discuss trials and assess results (yr. 1 & 2).		Quarterly and annual project reports	
3.3 Farmer participatory ICM trials conducted by Syngenta Ltd. incorporating pheromones for YSB control (yr. 1 and 2).		Quarterly and annual project reports	
4.1 Stakeholder workshop to assess impact of ICM and pheromones on pest control, commercial relevance and viability of technology (yr. 2).		Workshop proceedings	
4.2 Dissemination of project results through a conference and publication (yr 2).		Conference proceedings. At least one scientific publication.	

Note: Outputs should be numbered 1, 2, 3, *etc.* Activities should relate to these outputs and be numbered 1.1, 1.2, ...2.1, 2.2, ...*etc*

ANNEX 1 – FIELD TRIALS TO OPTIMISE NOVEL LURES AND TRAPS FOR MASS TRAPPING SYSTEM

Materials and methods

Field trials were conducted in two forms. Small-scale replicated field trials were conducted throughout the project in order to optimise lure and trap designs. In addition large-scale farmer participatory mass trapping trials were conducted in order to ascertain the efficacy of the technique overlaid on check, farmers' practice and Syngenta IPM treatments.

Trial Protocol

Trials were conducted using a common protocol. Each treatment was replicated at least three times and more usually four times with traps in a replicate placed out in circles with at least 20 m between nearest neighbours. Treatments were randomised in replicates but the position of traps in a replicate was not moved during the trial. Pheromone trap catch was recorded either once or twice a week at which time insects were discarded and traps were repaired as required. Lures were loaded with 1 mg of pheromone, unless otherwise stated, and renewed every four to six weeks.

Controlled release dispensers

Pheromone dispensers were produced from a number of polymer materials by impregnating 0.1 ml of a hexane solution containing the synthetic pheromone blend and an equivalent weight of the antioxidant BHT (2,6-di-*tert*-butyl-4-methylphenol). Polymer materials included white natural rubber septa (Aldrich Chemicals Ltd., catalogue No. Z10,072-2), polyethylene vials (25 mm length, 8 mm diameter and 1.5 mm wall thickness, Transatlantic Plastics Ltd., UK) or black rubber septa (Bio-Control Research Laboratories Ltd., Bangalore, India). After the solvent had evaporated the lids on the polyethylene vials were closed to prevent loss of active compound. White and black rubber septa were used without sealing.

Statistical analysis

Where trap catches were low no attempt was made to analyse the data by statistics. However, where data merited statistical analysis the data were analysed by analysis of variance (ANOVA) after converting the catches for each treatment to mean catch per trap per night and, if required, transforming them to log (x + 1). If differences in treatment means were significant at the 5% level or less, then they will be ranked by Newman Keuls or LSD range tests.

Additional data

In addition to moth catches a record was kept of date of collection, days after transplanting, stage of crop (crop height, flowering stage, heading, etc.), maximum and minimum temperatures, humidity and wind speed but the data is not presented in the report.

Summary of small scale field trials

2001 T. Aman season, Comilla District

Trial 1: Optimisation of pheromone dispenser

The effect of pheromone dispenser was tested on attraction of male *S. incertulas* to a 1 : 3 blend of Z9-16:Ald and Z11-16:Ald at a 1,000 μg loading. Traps were placed in farmers' field in Doulatpur Laksam, Comilla District.

Trial 2: Optimisation of pheromone trap design I

The effect of pheromone trap design on catch of male *S. incertulas* using a 1 : 3 blend of Z9-16:Ald and Z11-16:Ald at a 1,000 μg loading in polyethylene vials was assessed in farmers' fields Doulatpur, Laksam, Comilla District.

Trial 3: Optimisation of S. incertulas pheromone blend

The effect of changing the ratio of Z9-16:Ald and Z11-16:Ald released from polyethylene vials at a 1,000 μg loading on catch of male *S. incertulas* was assessed using sticky plate traps placed in farmers' fields in Doulatpur Laksam, Comilla District.

2002 Boro season, Mymensingh District

Trial 4:Optimization of size of sticky plate trap design
Four sticky plate trap designs were compared with a commercial sleeve trap. Each trap was baited with a standard lure composed of a 1 : 3 blend of Z9-16:Ald and Z11-16:Ald at 1,000 μg loading in polyethylene vials. Traps were placed in farmers' fields in Teghori, Nokla, Sherpur.

Trial 5: Optimisation of trap design II
Three plastic cylinder trap designs were compared with a commercial sleeve trap. Each trap was baited with a standard lure composed of a 1 : 3 blend of Z9-16:Ald and Z11-16:Ald at 1,000 μg loading in polyethylene vials. Traps were placed in farmers' fields in Shingheshwar, Phulpur.

Trial 6: Optimisation of pheromone dose in polyethylene vials
The effect of dose (0 to 3,000 μg) on attractiveness of the 1 : 3 blend of Z9-16:Ald and Z11-16:Ald to male *S. incertulas* was assessed using sleeve traps with the pheromone formulated in polyethylene vials. Sticky plate traps were used (15 x 20 cm) with metal shades for the lures. Traps were placed in farmers' fields in Meradewra, Phulpur, Mymensingh District.

2002 Aus season, Comilla District

Trial 7: Optimisation of trap designs III
A new sleeve trap design was compared with the standard model and sticky plate and plastic cylinder trap designs. The new sleeve trap was modified so that the funnels could be close packed but the overall dimensions of the trap were essentially the same as the original. Traps were placed in farmers' fields in Aus 2002 season, Laksham, Comilla District.

2002 T. Aman season, Comilla District

Trial 8: Effect of combining pheromone lures in traps
Because *S. incertulas* was not found to be the only species of stem borer in the rice growing areas studied it was essential to assess whether more than one pheromone could be deployed in a mass trapping trial and how best to deploy them. Accordingly the effect of placing pheromone lures *S. incertulas* and *S. inferens* pheromone lures singularly or in pairs in traps and with lures that contained both pheromones on catch of male moths was assessed. The trial was conducted with sleeve traps placed out in farmers' fields in Doulatpur, Laksam, Comilla District.

Trial 9: Effect of changing ratio of pheromone components on catch

Sleeve traps were baited with 1 mg doses of lures containing different ratios of the pheromone components of the *S. incertulas* pheromone to ascertain if the natural ratio was the most attractive to male moths. In this trial the relative quantity of Z9-16:Ald was increased from 0% to an equal quantity with Z11-16:Ald. The trial was conducted with sleeve traps placed out in farmers' fields in Bagmara, Laksam, Comilla District.

2003 Boro season, Comilla District

Trial 10: Optimisation of pheromone dose in polyethylene vials dispensers

The effect of changing the dose of a 1 : 1 ratio of Z9-16:Ald and Z11-16:Ald on catch of male *S. incertulas* was tested in farmers' fields in Adampur, Laksam, Comilla district. Polyethylene vials were used as pheromone dispensers and moths were caught in sleeve traps.

Trial 11: Optimisation of S. incertulas pheromone blend

A wide range of pheromone blends from 0 : 100 to 100 : 0 of Z9-16:Ald and Z11-16:Ald were tested at 1000 μg loading in polyethylene vials on the attraction of male *S. incertulas*. The trial was conducted with sleeve traps placed out in farmers' fields in Batora, Laksam, Comilla District.

Trial 12: Effect of combining pheromone lures together on trap catch

The trial was a repeat of Trial 8 in which the effect of placing *S. incertulas* and *S. inferens* lures separately and together in a single trap on catch of male moths was assessed. The trial was conducted with sleeve traps placed out in farmers' fields in Aratuli, Laksam, Comilla District.

Trial 13: Comparison between 1 : 1 and 1 : 3 blends of S. incertulas pheromone blends

The relative attractiveness of 1 : 1 and 1 : 3 blends of Z9-16:Ald and Z11-16:Ald in a range of doses in polyethylene vials was tested on the attraction of male *S. incertulas*. The trial was conducted with sleeve traps placed out in farmers' fields in Chaidana, Laksam, Comilla District.

Results

T. Aman 2001 Season, Comilla District

Comilla was chosen for the first seasons trials because the area was considered to be advanced and the farmers more receptive to new ideas. Late planting that season also allowed the trials to be conducted at a stage in the growth cycle that would provide the best chance of getting statistically meaningful data. Three small-scale trials were conducted to investigate the effort of a number of parameters on trap catch and retention, pheromone dispenser, trap design and pheromone blend. .

In Trial 1 sticky delta traps were baited with a single dose (1000 μg) of the standard 1 : 3 blend of Z9-16:Ald and Z11-16:Ald in a range of pheromone dispensers. Previous trials in Bangladesh with the eggplant shoot and fruit borer, *Leucinodes orbonalis* had shown that the pheromone dispenser could have a profound effect on catch. However, in this case catches (table 1) were not significantly affected by changes in the dispenser (ANOVA, $F = 0.328$, $P = 0.8582$). Indeed even the higher dose of 3000 μg of pheromone formulated in white septa did not increase catch over the 1000 μg dose. This result was unexpected and may, in part, reflect the fact that the catches were very low overall.

Table 1. Optimisation of pheromone dispenser [1]

Pheromone dispenser	Pheromone dose (μg)	Mean catch per trap per night[2]	S.E.
White natural rubber septa	3,000	0.22	± 0.01
White natural rubber septa	1,000	0.25	± 0.01
Black neoprene rubber septa	1,000	0.29	± 0.01
Polyethylene vial	1,000	0.24	± 0.01
PVC Resin	1,000	0.16	± 0.01

[1] Doulatpur, Laksam, Comilla District, T. Aman 2001, 5 Replicates, 42 nights.
[2] Means were not significantly different $P < 0.05$ by ANOVA on log(x + 1) transformed data.

In trial 2 the effect of trap design on trap catch was investigated. Two commercially available trap designs, delta (Agrisense BCS Ltd., U.K.) and sleeve (Bio-Control Research Laboratories Ltd., India) were compared with a modified delta trap and three traps of local construction, sticky plate (constructed out of a flat metal plate coated with tangle-foot, Agrisense, UK) plastic cylinder trap and a modified plastic pot (figures 1a-g). The latter two trap designs utilised water with detergent as the killing agent.


Figure 1a Delta trap


Figure 1b Open delta trap


Figure 1c Sticky plate trap

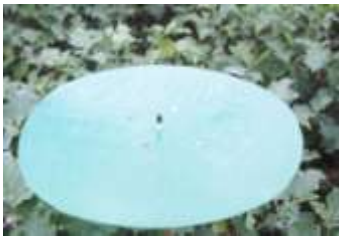
Figure 1d Plastic disc trap


Figure 1e Plastic cylinder trap


Figure 1f Plastic pot trap


Figure 1g Water trap

Figures 1a-g. Trap designs tested for their efficacy in catching and retaining adult stem borers

Trap design was found to have a significant effect on trap catch. The results of Trial 2 (table 2) showed that the open delta trap caught significantly more male moths than the plastic pot trap (ANOVA, $F = 3.096$, $P = 0.0143$). There was no significant difference between the catch recorded with open delta traps and sleeve, sticky plate and cylinder traps.

Table 2. Optimisation of pheromone trap design [1]

Trap design	Pheromone dose (μg)	Mean catch per trap per night[2]	S.E.
Delta	1,000	0.41	± 0.16 ab
Sleeve	1,000	0.72	± 0.17 ab
Sticky plate	1,000	0.85	± 0.28 ab
Open-delta	1,000	1.15	± 0.29 b
Plastic cylinder	1,000	0.47	± 0.11 ab
Plastic pot	1,000	0.22	± 0.07 a

[1] Doulatpur, Laksam, Comilla District, T. Aman 2001, 4 Replicates, 42 nights.
[2] Means followed by the same letter in a group are not significantly different $P < 0.05$ by Newman-Keuls multiple range test on log(x + 1) transformed data.

The sticky plate trap did not have any shading for the pheromone dispenser which may well have resulted in a premature release and/or degradation of active ingredients. Apart from the glue, tanglefoot, all the components of the sticky plate trap were locally available. On the basis of cost and local availability the sticky plate trap was selected for use in next season's large-scale trials.

The Indian Council of Agricultural Research, Directorate of Rice Research reported (Annual Report 1998) there an apparent difference in the pheromone blend of *S. incertulas* in West and East India, with a 1 : 10 ratio of Z9-16:Ald : Z11-16:Ald catching higher numbers of male moths in Maharashtra than the 1 : 3 blend. As the composition of the pheromone of *S. incertulas* in Bangladesh has not been analysed it was conceivable that the pheromone blend might be different from that found in other areas of South Asia.

Trial 3 was designed to optimise the blends of the two pheromone components by changing the relative amount of one, Z9-16:Ald, while keeping the quantity of the other, Z11-16:Ald, constant. The results (table 3) showed that as the proportion of Z9-16:Ald increased so the catch increased and this increase was statistically significant (ANOVA, $F = 7.636$, $P = 0.001$). One unexpected consequence of the trial was the fact that the unnatural 1 : 1 blend of pheromone components was found to catch significantly more male moths than the natural blend of components.

Table 3. Optimisation of *S. incertulas* pheromone blend[1]

Ratio of Z9-16:Ald to Z11-16:Ald	Pheromone dose (μg)	Mean catch per trap per night[2]	S.E.
0 : 100	1,000	0.09	± 0.03 a
3 : 100	1,000	0.09	± 0.03 a
10 : 100	1,000	0.12	± 0.08 a
30 : 100	1,000	0.39	± 0.11 a
100 : 100	1,000	0.74	± 0.21 b

[1] Laksam, Comilla District, T. Aman 2001, 5 Replicates, 42 nights.
[2] Means followed by the same letter in a group are not significantly different $P < 0.01$ by Newman-Keuls multiple range test on log(x + 1) transformed data.

Boro 2002 season, Mymensingh District

To further optimise the sticky plate trap the effect on trap catch of changing the size of the sticky plate or providing a shade for the pheromone lure was tested in trial 4. The trial included a commercially produced sleeve trap as a standard. Catches were too low to provide statistically meaningful data despite maintaining the traps in the field for 34 nights. Trap data is shown in Table 4 as the total trap catch per treatment. The highest catch was recorded from the largest sticky plate trap with a shade for the lures although the catch was comparable with that obtained with the commercial sleeve trap imported from India.

Table 4 Optimisation of sticky plate trap design[1]

Trap (Sticky plate)	Pheromone dose (μg)	Ratio of Hexadecenals Z9 : Z11	Total trap catch per treatment
Plate 15 x 20 cm, no shade	1,000	1 : 3	1.75
Plate 15 x 20 cm, shade	1,000	1 : 3	1.00
Plate 25 x 30 cm, shade	1,000	1 : 3	6.75
Plate 15 x 20 cm, BSPS	1,000	1 : 3	1.00
Sleeve trap	1,000	1 : 3	5.50

[1] Teghori, Nokla, Sherpur, Boro 2002, 4 replicates, 34 nights

Ideally the trial should be repeated but logistical problems in placing the sticky plate traps and maintaining them for long periods suggested that they would probably not be acceptable to the rice farmers.

The locally produced plastic cylinder trap was not found to be particularly effective in Trial 2. Nevertheless, it had the advantage that it was not reliant on importation of any components and would be more acceptable to farmers because water was used as the killing agent.

Trials of the cylinder trap with *L. orbonalis* had shown that the choice of surfactant used to kill the insects and the size and number of entry holes were important for trap efficacy. Trial 5 was undertaken to investigate the effect of these parameters on trap catch of *S. incertulas* in more detail.

Overall trap catches were too low to provide statistically meaningful data, reflecting the low stem borer population as measured by percentage damage in the crop. Nevertheless, none of the variations in the plastic cylinder trap design caught more than the commercially available sleeve trap although the data did suggest that the detergent in water was more effective than engine oil at retaining the insects attracted (table 5).

Table 5. Optimisation of trap design[1]

Trap design	Pheromone dose (μg)	Ratio of Hexadecenals Z9 : Z11	Total trap catch per treatment
Plastic cylinder, 2 holes, detergent	1,000	1 : 3	3.25
Plastic cylinder, 4 holes, detergent	1,000	1 : 3	4.00
Plastic cylinder, 4 holes, oil	1,000	1 : 3	3.00
Sleeve trap	1,000	1 : 3	7.50

[1] Shingheshwar, Phulpur, Mymensingh District, Boro 2002, 4 replicates, 34 nights

Trial 6 investigated the effect of increasing the dose of the 1 : 3 blend of Z9-16:Ald and Z11-16:Ald on trap catch. Trap catches remained low throughout the period of study (table 6), not exceeding one moth per trap per night throughout the 29 nights of the trial, and so the data was not subjected to statistical analysis. Nevertheless, there was a trend of increasing catch with dose as would be expected from related work.

Table 6 Optimisation of pheromone dose in polyethylene vials[1]

Trap design	Pheromone dose (μg)	Ratio of Hexadecenals Z9 : Z11	Total trap catch per treatment
Plate 15 x 20 cm, shade	0	1 : 3	0.00
Plate 15 x 20 cm, shade	100	1 : 3	0.25
Plate 15 x 20 cm, shade	300	1 : 3	0.75
Plate 15 x 20 cm, shade	1,000	1 : 3	0.50
Plate 15 x 20 cm, shade	3,000	1 : 3	1.25

[1] Meradewra, Phulpur, Mymensingh District, Boro 2002, 4 replicates, 29 nights

Aus 2002 Season, Comilla District

As a result of previous trial experience BCRL redesigned their sleeve trap. Two issues were addressed, the connecting arm to the wooden stack was strengthened because of problems encountered by birds perching on the traps and the couplings for the lid were redesigned to allow the trap bases to fit into one another thereby reducing the volume and hence cost of transport.

To ensure that the changes in trap design had not adversely affected performance the two designs were field tested (Trial 7) along with sticky plate and plastic cylinder traps during the 2002 Aus season in Comilla District baited with the *S. incertulas* pheromone.

Unlike previous trials the sticky plate and plastic cylinder traps caught almost double the number of moths of either sleeve trap design although there was no significant difference in catch between the treatments (ANOVA, $F = 1.76$, $P = 0.174$) (table 7).

Table 7. Optimisation of trap designs for *S. incertulas* [1]

Trap design	Pheromone dose (μg)	Ratio of Hexadecenals Z9 : Z11	Mean catch per trap per night ±SE[2]
Sleeve trap (old)	1,000	1 : 3	0.59 ± 0.11
Sleeve trap (new)	1,000	1 : 3	0.47 ± 0.12
Sticky plate (15 x 20 cm), shade	1,000	1 : 3	1.49 ± 0.60
Plastic cylinder, 2 holes, detergent	1,000	1 : 3	1.24 ± 0.40

[1] Voschi, Laksam, Comilla District, Aus 2002, 4 replicates, 34 nights.
[2] Means were not significantly different by ANOVA $P < 0.05$.

Considerable logistical problems were encountered with the plate traps. They were difficult to assemble in the field and the detritus accumulated on the plates made maintenance problematic. So despite the higher efficiency of the sticky plate traps under low population conditions the sleeve trap was chosen for future mass trapping trials because of its ease of use and low cost. The plastic cylinder trap was not selected because of fears about the need for maintaining adequate amounts of water in the trap, although it had been found to be effective in mass trapping trials conducted in Jessore with the eggplant fruit and shoot borer (Cork *et al*., 2003).

2002 T. Aman season, Comilla District

The 2002 Boro season trials confirmed that *S. inferens* and *C. polychrysus* constituted an important proportion of the rice stem borer complex in Phulpur. The sex pheromone of *S. inferens* had been identified but not that of *C. polychrysus*. In order to address the problem of a late season infestation by *S inferens* and to minimise the complexity of the mass trapping technology for farmers the decision was taken to test the effect of combining the pheromones of *S. incertulas* and *S. inferens* in a single trap (Trial 8). Two methods were used to combine the pheromones of both species in one trap, separate lures for each species were placed in one trap and the components of the two pheromones were combined in a single lure.

Despite low catches of both species it was apparent that male *S. incertulas* and *S. inferens* were caught predominately, but not exclusively, in traps baited with con-specific pheromone lures (table 8). The *S. inferens* lure caught far fewer con-specific male moths than the corresponding *S. incertulas* lure although in the absence of any independent data it was unclear whether the difference in catch reflected relative adult population levels or a lower efficacy of the *S. inferens* lure. Nevertheless, combining the pheromones of *S. incertulas* and *S. inferens* into a single lure or placing lures for both species in the same trap reduced the catch by at least a factor of ten compared to catches obtained with the lures placed in individual traps.

Table 8. Effect of combining pheromone lures together on trap catch[1]

Pheromone baits	Total catch per treatment		
	S. incertulas	*S. inferens*	*C. polychrysus*
S. incertulas	134	1	0
S. inferens	1	6	0
S. incertulas, S. inferens (combined)	4	0	0
S. incertulas, S. inferens (separate)	15	1	0
Unbaited trap	2	1	0

[1] Doulatpur, Laksam, Comilla District, T. Aman 2002, 4 Replicates, 25 nights.

Data from Trial 3 suggested that lures containing the unnatural 1 : 1 blend of Z9-16:Ald and Z11-16:Ald of the sex pheromone of *S. incertulas* were more attractive than the natural 1 : 3 blend of compounds. The trial was repeated in the 2002 T. Aman crop to determine the optimum ratio (Trial 9).

The results (table 9) confirmed that the natural 30 : 100 ratio of components was significantly more attractive than the other blends tested (ANOVA, $F = 6.824$, $P < 0.001$) using log transformed data, including the 1 : 1 blend of compounds. The maximum trap catch was recorded on 31 October when three of the four traps baited with the 30 : 100 ratio of compounds had catches of between 92 and 137 male moths after three nights. The trial not only confirmed the attractiveness of the natural ratio of compounds but also demonstrated that the sleeve trap could catch and retain high numbers of male moths. Other trap designs tested previously, such as the sticky plate, do not have such a high capacity and would have been saturated under such high population pressure after one night.

Table 9. Optimisation of *S. incertulas* pheromone blend[1]

Ratio of Z9-16:Ald to Z11-16:Ald	Pheromone dose (μg)	Mean catch per trap per night[2]	S.E.
0 : 100	1,000	0.02	± 0.16 a
3 : 100	1,000	0.02	± 0.11 a
10 : 100	1,000	0.14	± 0.01 a
30 : 100	1,000	5.15	± 2.74 b
100 : 100	1,000	1.75	± 0.88 ab

[1] Bagmara, Laksam, Comilla District, T. Aman 2002, 4 Replicates, 18 nights.
[2] Means followed by the same letter in a group are not significantly different *P* < 0.05 by Newman-Keuls multiple range test on log(x + 1) transformed data.

Boro 2003, Comilla District

In order to confirm that the 1 : 3 blend of Z9-16:Ald to Z11-16:Ald was more attractive than the 1 : 1 blend a series of small-scale trials was conducted in the 2003 Boro season crop.

In Trial 10 the effect of dose on the catch of *S. incertulas* with the 1 : 1 blend of compounds using a 1 : 3 blend of compounds at 1000 μg loading as the standard was tested. The results (table 10) showed that the 1,000 μg loading of the 1 : 1 ratio of components was the most attractive. Increasing the dose did not significantly increase catch. The catch of the 1000 μg loading of the 1 : 1 blend of components was not significantly different from that of the same dose of the 1 : 3 blend (ANOVA, $F = 2.61$, $P = 0.046$).

Table 10. Optimisation of pheromone dose in polyethylene vials[1]

Ratio of Z9-16:Ald to Z11-16:Ald	Pheromone dose (μg)	Mean catch per trap per night[2]	S.E.
1 : 3	1,000	0.75	0.03 ± b
1 : 1	100	0	0 a
1 : 1	300	0.75	0.03 ± b
1 : 1	1,000	0.25	0.14 ± ab
1 : 1	3,000	0.039	0.02 ± ab

[1] Adampur, Laksam, Comilla District, Boro 2003, 4 Replicates, 39 nights.
[2] Means followed by the same letter in a group are not significantly different *P* < 0.05 by LSD multiple range test on log(x + 1) transformed data.

In Trial 11 the effect of changing the ratio of the two components of the *S. incertulas* pheromone blend was tested at a single dose of 1000 μg. In common with other trials the highest catches were obtained with the 3 : 7 and 1 : 1 blends of pheromone components, although only the catch from the 3 : 7 blend of pheromone components was significantly higher than the other blends (ANOVA, $F = 2.641$, $P = 0.043$).

Table 11. Optimisation of *S. incertulas* pheromone blend[1]

Ratio of Z9-16:Ald to Z11-16:Ald	Pheromone dose (μg)	Mean catch per trap per night[2]	S.E.
0 : 100	1,000	0.02	0.02 ± b
10 : 90	1,000	0.04	0.02 ± b
30 : 70	1,000	0.26	0.12 ± a
50 : 50	1,000	0.11	0.04 ± ab
70 : 30	1,000	0.10	0.02 ± b
100 : 0	1,000	0.02	0.01 ± b

[1] Batora, Laksam, Comilla District, Boro 2003, 4 Replicates, 21 nights.
[2] Means followed by the same letter in a group are not significantly different $P < 0.05$ by LSD multiple range test on log(x + 1) transformed data.

In Trial 12 the 1 : 1 and 1 : 3 blends of Z9-16:Ald to Z11-16:Ald of the *S. incertulas* pheromone were compared separately and in combination with the *S. inferens* pheromone.

The results (table 12) showed that as with previous trials, adding the *S. inferens* pheromone either separately or in combination with the *S. incertulas* pheromone in the same trap reduced the catch of *S. incertulas*, although in this instance the mean catch per trap per night were significantly different at the 6% level of significance (ANOVA, $F = 2.33$, $P = 0.06$) using log transformed data.

Table 12. Effect of combining pheromone lures together on trap catch[1]

Pheromone baits	Ratio of Hexadecenals Z9 : Z11	Mean catch per trap per night *S. incertulas*	*S. inferens & C. polychrysus*
S. incertulas	1 : 1	0.13 ± 0.06ab	0
S. incertulas	1 : 3	0.18 ± 0.10b	0
S. incertulas, S. inferens (separate)	1 : 1	0.02 ± 0.01a	0
S. incertulas, S. inferens (separate)	1 : 3	0.01 ± 0.01a	0
S. incertulas, S. inferens (combined)	1 : 1	0.02 ± 0.01a	0
S. incertulas, S. inferens (combined)	1 : 3	0.01 ± 0.01a	0

[1] Aratuli, Laksam, Comilla District, Boro 2003, 4 Replicates, 20 nights.
[2] Means followed by the same letter in a group are not significantly different $P < 0.06$ by LSD multiple range test on log(x + 1) transformed data.

In Trial 13 a comparison was made between the 1 : 1 and 1 : 3 blends of Z9-16:Ald and Z11-16:Ald over a range of doses to confirm that the natural 1 : 3 blend was the most attractive. As in previous trials there were no significant differences between treatment means (ANOVA, $F = 0.745$, $P = 0.595$) although the 300 and 1000 μg doses of the 1 : 3 blend of compounds caught higher numbers of moths.

Table 13. Comparison between 1 : 1 and 1 : 3 blends of *S. incertulas* pheromone components

Ratio of Z9-16:Ald to Z11-16:Ald	Pheromone dose (μg)	Mean catch per trap per night[2]	S.E.
1 : 3	300	0.12	± 0.06 a
1 : 3	1,000	0.14	± 0.06 a
1 : 3	3,000	0.09	± 0.05 a
1 : 1	300	0.08	± 0.04 a
1 : 1	1,000	0.05	± 0.02 a
1 : 1	3,000	0.05	± 0.03 a

[1] Chaiadana, Laksam, Comilla District, Boro 2003, 4 Replicates, 20 nights.
[2] Means followed by the same letter in a group are not significantly different $P < 0.05$ by LSD multiple range test on log(x + 1) transformed data.

ANNEX 2: FARMER PARTICIPATORY ICM TRIALS CONDUCTED BY SYNGENTA LTD. INCORPORATING PHEROMONES FOR *S. INCERTULAS* CONTROL

Materials and Methods

Boro 2002 Season, Mymensingh District

Location
Field trials were conducted in farmers' fields in Phulpur, Mymensingh District, 150 km north of Dhaka. Daily average temperatures and relative humidity during the period of the trials were between 15 and 20°C and 60 and 65%, respectively. The crop was transplanted between 24 and 28 January 2002, with the date of transplant estimated at 26 January 2002.

Field trials
Two 10 ha field sites, hereafter referred to as 'plots' were selected with a minimum distance of 1km between the sites, involving 30 farmers at each site with land holdings of between 0.1 to 1 ha. At each plot 12 farmers' fields, hereafter referred to as 'sub-plots' of approximately 0.2 ha were randomly selected and designated as, check (no insecticide), Syngenta IPM or farmers' practice. In the check sub-plots, farmers did not apply insecticide and were compensated for any loss of yield. In the farmers practice sub-plots, farmers were asked to apply pesticides for control of insects and diseases according to their normal routine but to inform project members of the actions they had taken. In the Syngenta IPM sub-plots farmers applied pesticides based on damage thresholds established through the Syngenta IPM programme developed in conjunction with BRRI. At one field site pheromone traps were placed out over the entire 10 ha plot on 21 DAT at the rate of 25 traps per ha. Farmers were actively encouraged to set out traps on their own land under the guidance of project staff.

To ensure that there was no bias in the data seed and fertiliser inputs in each of the 15 sub-plots selected at each plot were standardised. A Syngenta farmer field school (FFS) was set up in Phulpur and the farmers provided with training in IPM throughout the season in a series of six sessions. Each session was timed to provide information relevant to the stage of development of the crop.

Pheromone traps and lures
Sticky plate traps were used for the 2002 Boro season mass trapping trials. The plates were prepared from 15 x 20 cm galvanised metal sheet. The plates were nailed onto wooden stakes placed 0.5 m above the field level. Traps were coated with 'trappit' glue and pheromone lures were placed on the surface of the plate and protected from sunlight under a metal roof as show in Annex 1, figure 1c. Trap inspections were made twice weekly when missing lures or damaged traps were replaced and insect catches removed.

In the 2002 Aman and subsequent mass trapping trials sleeve traps (Bio-Control Research Laboratories Ltd., India) were used exclusively.

Pheromone lures consisted on polyethylene vials treated with 3 mg of a 90 : 10 mixture of (*Z*)-11-hexadecenal and (*Z*)-9-hexadecenal. Lures were changed at 30 day intervals after the first application on 18 February (23 DAT). White rubber septa loaded with 3 mg of the 1 : 3 blend of compounds was used in the 2002 Aman field trials.

Traps were placed out 18 DAT in the 2002 Aman field trial and changed once after 32 days (52 DAT).

Data Collection:
The following data were collected from each plot:

i) Rice stem damage data: 20 hills from each plot were randomly selected and checked for visual signs of stem borer damage at 15 day intervals starting 15 days after laying out the trials. In the 2002 Aman season trials damage data was assessed from 40 tillers collected per sub-plot. Data are presented as the percentage damaged tillers, dead heart (DH), or damaged panicles, white heads (WH).

ii) Distribution of rice stem borer larvae: 20 infested tillers from each of the five check sub-plots from each plot were collected at random at 15 day intervals and longitudinally dissected using a sharp knife for the presence of stem borer larvae. The species and number of larvae present were recorded.

iii) Pheromone trap catch: Pheromone trap catch data were recorded from each of the 24 sub-plots. In the pheromone-treated plot, two pheromone traps in each of the sub-plots were randomly selected and in the non-pheromone treated plots two traps were placed in each sub-plot. The number of male *S. incertulas* caught in each trap was recorded twice a week.

iv) Grain yield: Grain yield estimates were obtained from 24th April (88 DAT) to 5th May (99 DAT) by sampling three 1 m^2 quadrats, selected randomly, per sub-plot. Yield data were averaged for each treatment and converted to kg per ha per sub-plot.

2002 T. Aman season, Comilla District

Location

Mass trapping trials were set up in farmers' fields at two location in Comilla District, Daulatpur and Adampur, both in Laksam Thana about 150 km SE of Dhaka. Daily average temperatures and relative humidity that prevailed during the study period were between 28 and 32^0 C and between 75 and 85% respectively.

Field trials

Each of the two trials consisted of two 10 ha plots. Within each plot three treatments (check, Syngenta IPM, farmers' practice) were replicated in four sub-plots. Each treatment was distributed in randomized complete block designs (RCBD) in each plot. In the check sub-plots farmers were prohibited from using any kind of insecticide and compensated for loss. In the Syngenta IPM sub-plots farmers were advised to apply insecticides to control stem borers only if damage levels exceeded 5% DH or WH while in the farmers' practice they had complete flexibility to control pests and diseases as they saw fit. In one plot the fields were mass trapped with pheromone traps placed out at 25 per ha and the other plot untreated.

Rice seedlings were transplanted by the farmers from 1 to 3 September 2002 and traps (sleeve trap, Bio-Control Research Laboratories Ltd., India) set in the farmer's fields at the mid tillering stage in the mass trapped plots.

Data collection

The data were collected according to following headings.

(i) Damage data (%DH / WH):

One hundred and twenty hills (40 tillers per plot x 3) from each sub-plot were selected by systematic sampling and checked for stem borer damage every 15 days interval. Sampling started seven days after laying out the trials. Data are presented as the percentage damaged tillers, dead heart (DH), or damaged panicles, white heads (WH).

(ii) Distribution of rice stem borer species: Ten infested tillers from each replication were collected at randomly. Altogether 40 (10 infested tillers / plot x 4 replication) infested tillers were collected and dissected with a view to identifying the larvae. Data were collected and recorded every 15 days.

(iii) Pheromone trap catch: Trap catch data was recorded from each of trap in the sub-plots twice in a week. Traps were placed out 18 DAT on 19 September 2002 and lures replaced once on 23 October 2002 (52 DAT), although damaged traps or lures were replaced as and

when required. Lures were composed of white rubber septa loaded with 3 mg of the 1 : 3 blend of compounds.

iv) *Grain yield:* Grain yield was calculated from the average of 5 quadrats (2 x 2m^2) taken from each sub-plot.

2003 Boro season, Comilla District

The trial was laid out in two 10 ha plots essentially as conducted in the 2002 T. Aman crop. Average temperature and relative humidity during the study period were 33-34^{o}C and 75-85% respectively. Seedlings were transplanted from 6 to 7 February 2003 and traps were placed out on 24 February (17 DAT). Lures were replenished on 24 April (77 DAT).

Results

Boro 2002 Season, Mymensingh District

The level of stem borer damage observed in the sub-plots remained low throughout the season (table 1). Dead heart (DH) was very low in both mass trapped and non-mass trapped trial plots, ranging between 0.43 to 0.74 and 034 to 0.77% respectively. However, just prior to harvest the WH damage level increased to the economic threshold of 5% in mass trapped and non-mass trapped plots.

Larval sampling confirmed that *S. incertulas* was the pre-dominant species early in the season, accounting for 43% and 80% of the larvae in the mass trapped and non-mass trapped plots at 38 DAT respectively (table 1). However, as the season progressed the proportion of *S. incertulas* larvae in the crop decreased and near harvest *S. incertulas* only accounted for 13.6% and 12.8 of the larvae in the mass trapped and non-mass trapped plots respectively. In contrast the proportion of *S. inferens* in particular increased dramatically to account for 58 and 56% of the larvae present near harvest.

Table 1. Population distribution of rice stem borers in trial plots, Boro 2002

Date	DAT	Percent DH/WH	Percentage stem infestation by species		
			S. incertulas	*S. inferens*	*C. polychrysus*
Mass trapped					
05-Mar	38	0.43	42.9	0.00	57.1
20-Mar	53	0.56	64.3	21.4	14.3
05-Apr	69	0.74	50.0	36.4	13.6
18-Apr	82	1.06	23.7	44.7	31.6
03-May	97	5.15	13.6	57.6	28.8
Not mass trapped					
5-Mar	38	0.34	80.0	0.0	20.0
20-Mar	53	0.57	42.9	33.3	23.8
5-Apr	69	0.77	48.0	28.0	24.0
18-Apr	82	1.01	25.0	45.8	29.2
3-May	97	5.13	12.8	56.4	30.8

DAT = Days after transplanting

Pheromone trap catch
Pheromone trap catches of *S. incertulas* remained low in all sub-plots (table 2) throughout the season. There were no apparent differences between catches recorded in any of the treatment plots although the trap catches were too low to warrant statistical analysis.

Table 2. Mean trap catch in sub-plots without mass trapping, Boro 2002

Treatment	Mean Trap Catch per Treatment					
	64 DAT	68 DAT	72 DAT	77 DAT	81 DAT	Total catch
Check	0.10	0.00	0.40	0.40	0.10	1.00
Syngenta IPM	0.10	0.10	0.20	0.00	0.00	0.40
Farmers practice	0.00	0.40	0.00	0.00	0.10	0.50

Grain yield

Grain yield in the Syngenta IPM plots was not significantly different from the check plots although both were significantly higher than the farmers' practice plots in both mass trapped (ANOVA, $F = 194$, $P < 0.0001$) and non-mass trapped plots (ANOVA, $F = 108$, $P < 0.0001$). In addition, yields were on average 4% higher in the check and Syngenta IPM sub-plots of the mass trapped plot compared to the non-mass trapped plots (table 3) although this difference was not significant.

Table 3. Rice grain yield in pheromone and non-pheromone treated plots, Boro 2002

Treatment	Mass trapped plots		Non-mass trapped plots	
	Average Yield (kg/ha)	SE	Average Yield (kg/ha)	SE
Check plots	7,973	101.4 b	7,700	47.1 b
Syngenta IPM	8,120	46.7 b	7,786	45.4 b
Farmers' practice	6,226	68.5 a	6,187	134.7 a

[1] Laksham, Comilla District, Boro 2002 season, 5 replicates.
[2] Means followed by the same letter are not significantly different $P < 0.05$ by Newman-Keuls multiple range test.

T. Aman 2002 Season, Comilla District

In the 2002 T. Aman season two mass trapping trials (Trials I and II) were undertaken in Comilla District using 10 ha plots.

Changes in the relative proportions of the species of stem borer larvae in treated and untreated plots can provide a useful measure of the effectiveness of mass trapping for the control of one species such as *S. incertulas*. In the 2002 Aman season two mass trapping trials were conducted in Comilla District. At both trial locations *S. incertulas* larvae were the predominant species during the vegetative stage of the crops (tables 4 & 5) but in the reproductive stage of the crop, when WH damage became apparent, the proportion of *S. incertulas* decreased dramatically in all trial plots with an apparent increase in the number of *S. inferens.* In addition, at both trial locations the proportions of *S. incertulas* to *S inferens* decreased more in the mass trapped plots than in the non-mass trapped trial plots suggesting that mass trapping had had an impact on the number of progeny produced by the first generation attacking the rice crop.

Table 4 Population distribution of rice stem borers in trial I plots, 2002 T. Aman

Date	DAT	DH/WH	Percentage stem infestation by species		
			S. incertulas	*S. inferens*	*C. polychrysus*
Mass trapped					
26.09.02	28	DH	100.00	0.00	0.00
06.10.02	38	DH	100.00	0.00	0.00
14.10.02	46	DH	100.00	0.00	0.00
21.10.02	53	DH	92.50	7.50	0.00
28.10.02	60	DH	100.00	0.00	0.00
18.11.02	81	WH	33.33	56.41	10.26
Non-mass trapped					
26.09.02	28	DH	66.67	0.00	33.33
06.10.02	38	DH	97.14	2.86	0.00
14.10.02	46	DH	97.50	0.00	2.50
21.10.02	53	DH			
28.10.02	60	DH	89.66	3.45	6.90
18.11.02	81	WH	57.50	37.50	5.00

Table 5 Population distribution of rice stem borers in trial II plots, 2002 T. Aman

Date	DAT	DH/WH	Percentage stem infestation by species		
			S. incertulas	*S. inferens*	*C. polychrysus*
Mass trapped					
26.09.02	25	DH	83.33	16.67	0.00
06.10.02	35	DH	96.67	3.33	0.00
14.10.02	43	DH	97.30	2.70	0.00
21.10.02	50	DH	92.86	4.76	2.38
27.10.02	56	DH	100.00	0.00	0.00
11.11.02	71	WH	45.00	52.50	2.50
17.11.02	77	WH	33.33	62.96	3.70
Non- mass trapped					
26.09.02	26	DH	100.00	0.00	0.00
06.10.02	35	DH	100.00	0.00	0.00
14.10.02	43	DH	97.14	2.86	0.00
21.10.02	50	DH	97.50	2.50	0.00
27.10.02	56	DH	95.00	0.00	5.00
11.11.02	71	WH	62.50	35.00	2.50
17.11.02	77	WH	68.29	26.83	4.88

DAT = Days after transplanting

If the mass trapping had indeed reduced the number of *S. incertulas* larvae in the crop then this should have been reflected in the damage assessment data. In trial I the level of DH in the pheromone treated sub-plots increased to a maximum of twice that observed in the non-pheromone treated plots, 5.2% and 2.2% respectively, by 46 DAT (table 6). Because the traps were placed out on 18 DAT (19 September 2002) they could not have had an impact on the generation that caused DH. Nevertheless, by 81 DAT the level of larval damage, as expressed by the percentage of WH, in the pheromone-treated sub-plots, was significantly less than in the non-pheromone treated sub-plots (ANOVA, $F = 10.831$, $P = 0.003$). This suggested that mass trapping had reduced the overall level of stem borer damage in the second generation and that the apparent increase in the number of *S. inferens* larvae was largely due to a decrease in the numbers of *S. incertulas* larvae.

In trial II the results were not so clear cut. Overall there was no significant difference in the level of WH in the pheromone and non-pheromone treated plots (ANOVA, $F = 1.14$, $P = 0.29$) and no consistent difference between check, IPM and farmers' practice plots in either pheromone or non-pheromone treated plots. Stem borer damage levels remained low in all sub-plots not exceeding 3% DH or 2% WH (table 6).

Table 6 Population distribution of rice stem borers in trial I plots, 2002 T. Aman

Date	DAT	DH/WH	Percentage stem damage		
			Check	IPM	Farmer practice
Mass trapped					
26.09.02	28	DH	1.85	0.59	0.52
06.10.02	38	DH	2.56	2.44	2.49
14.10.02	46	DH	4.04	5.17	3.41
21.10.02	53	DH	1.70	0.72	1.56
28.10.02	60	DH	0.30	0.20	0.47
11.11.02	74	WH	0.00	0.00	0.00
18.11.02	81	WH	0.47	0.23	0.20
Non- mass trapped					
26.09.02	28	DH	0.38	1.00	0.23
06.10.02	38	DH	0.90	1.94	1.52
14.10.02	46	DH	1.89	2.19	1.28
21.10.02	53	DH	0.61	0.44	0.97
28.10.02	60	DH	0.32	0.05	0.23
11.11.02	74	WH	0.16	0.00	0.00
18.11.02	81	WH	1.11	0.55	1.31

Table 7 Population distribution of rice stem borers in trial II plots, 2002 T. Aman

Date	DAT	DH/WH	Percentage stem damage		
			Check	IPM	Farmer practice
Mass trapped					
26.09.02	25	DH	0.77	0.62	0.71
06.10.02	35	DH	0.66	0.68	2.96
14.10.02	43	DH	0.55	0.38	0.45
21.10.02	50	DH	0.53	0.87	0.66
27.10.02	56	DH	0.02	0.19	0.14
11.11.02	71	WH	0.58	0.95	0.77
17.11.02	77	WH	0.52	1.98	0.68
Non-mass trapped					
26.09.02	25	DH	0.07	0.19	0.45
06.10.02	35	DH	2.18	1.97	2.82
14.10.02	43	DH	1.79	1.69	1.93
21.10.02	50	DH	0.89	0.85	0.53
27.10.02	56	DH	1.14	0.40	0.53
11.11.02	71	WH	0.52	0.33	1.06
17.11.02	77	WH	1.20	0.41	0.76

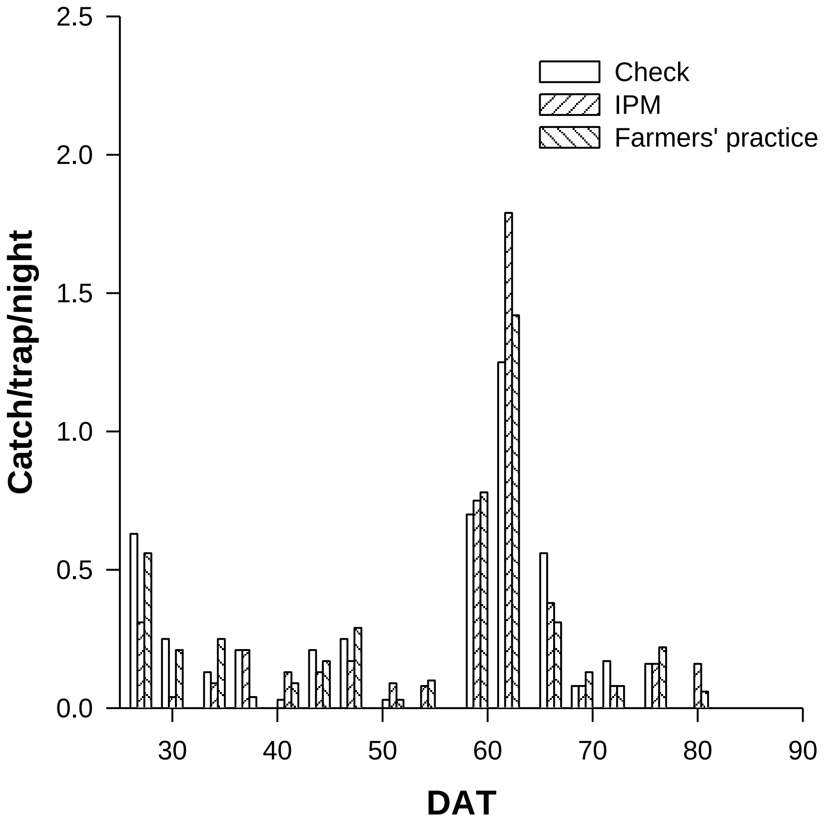

Figure 1a Trial 1 Pheromone trap catch in mass trapped plots

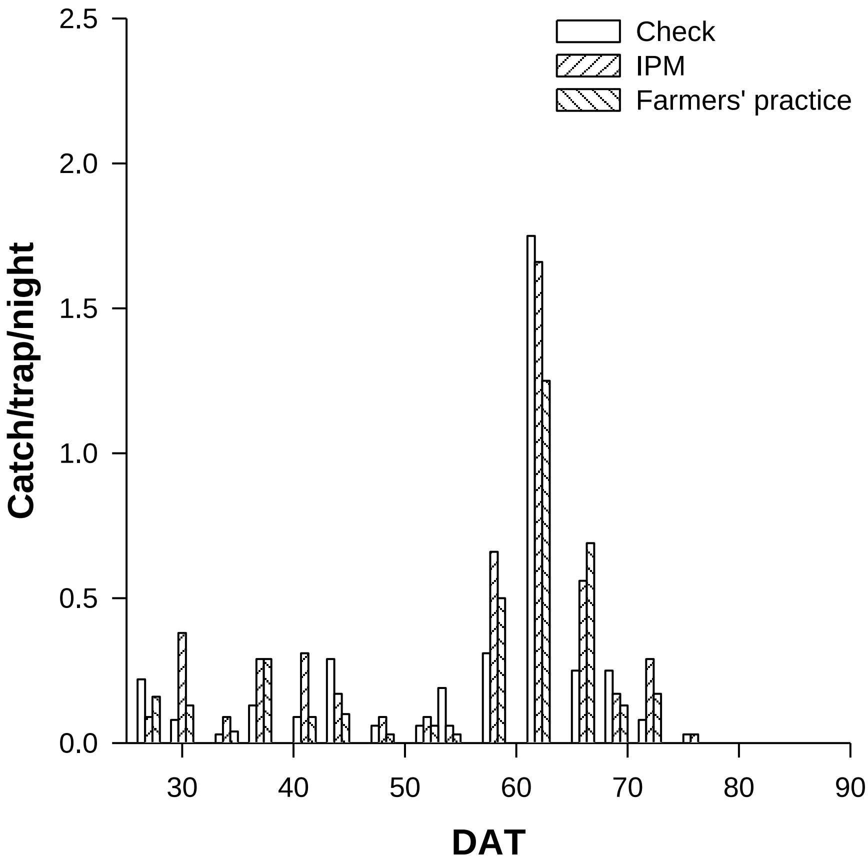

Figure 1b Trial II Pheromone trap catch in mass trapped plots

Figure 1a shows a small peak in male moth population at 25 DAT arising from the emergence of progeny from the first generation in Trial I. This was followed by a peak in larval damage by 46 DAT (table 6). A similar peak in adult male catches from Trial II was not observed. However, the peak in larval damage occurred at 35 DAT (table 7) suggesting that the peak in adult population must have occurred before the pheromone traps were placed in the field.

Pheromone trap catch data from both mass trapped plots in Trials I and II (Figures 1a & 1b) clearly showed a second peak in adult population between 58 and 65 DAT. This peak corresponded with the minimum in larval damage estimates (tables 6 and 7). However, the level of rice tiller damage subsequently began to increase from 71 DAT onwards presumably due to the feeding activity of the progeny of those moths that had successfully mated and oviposited on the crop at the same time as the pheromone trap catch peaked.

Pheromone traps could therefore be used to predict the timing of oviposition of those insects that would cause WH damage in the crop.

If mass trapping had an impact on the availability of male moths trap catches from traps inside the mass trapped areas would be expected to have lower catches than those at the periphery. In Table 8 the relative trap catches of 20 traps each from the edge and centre of the two mass trapped plots are compared.

In each case there is a significant reduction (ANOVA, $P < 0.01$) in pheromone trap catches recorded from traps inside the mass trapped plots compared to those on the edge. This clearly indicated that the traps were indeed reducing the number of available male moths inside the mass trapped plots.

Table 8. Comparison between pheromone trap catches from traps at the edge and centre of mass trapped plots, 2002 T. Aman

	Edge of Mass Trapped plot		Centre of Mass Trapped plot	
	Total Catch	SE	Total Catch	SE
Trial I (Doulatpur)				
28 - 55 DAT	10.90	1.30 a	4.35	0.66 b
56 - 77 DAT	31.30	5.40 a	16.6	1.33 b
Trial II (Adampur)				
28 - 55 DAT	17.60	2.33 a	6.65	0.76 b
56 - 77 DAT	30.65	7.77 a	10.90	1.11 b

[1] Laksham, Comilla District, T. Aman 2002 season, 20 replicates.
[2] Catches followed by the same letter are not significantly different *P* < 0.01 by Newman-Keuls multiple range test.

In Trial I the yields from farmers' practice sub-plots were significantly less than check and Syngenta IPM sub-plots (ANOVA, $F = 118$, $P = 0,.001$) in both pheromone and non-pheromone treated plots (table 9). The reasons for this are uncertain, but may reflect poorer farmer cultivation practices. All trial farmers were provided with inputs such as fertiliser and seed to prevent any bias in results, although herbicides were only applied to check and IPM plots. No insecticides were applied in any trial sub-plots because of the low larval infestation levels observed.

Table 9. Rice grain yield in Trials I and II, 2002 T. Aman

Treatment	Mass trapped sub-plots		Non-mass trapped sub-plots	
	Average Yield (kg/ha)	SE	Average Yield (kg/ha)	SE
Trial I (Doulatpur)				
Check plots	7,700	47.09 b	7,973	101.32 bc
Syngenta IPM	7,786	45.44 b	8,120	46.68 c
Farmers' practice	6,186	134.70 a	6,226	68.62 a
Trial II (Adampur)				
Check plots	4,159	187 a	4,155	236 a
Syngenta IPM	4,096	303 a	4,007	176 a
Farmers' practice	4,000	194 a	4,045	175 a

[1] Laksham, Comilla District, T. Aman 2002 season, 5 replicates.
[2] Means followed by the same letter are not significantly different *P* < 0.05 by Newman-Keuls multiple range test.

Yields obtained from the mass trapped plots were not significantly different from the non-mass trapped plots apart for the Syngenta IPM plots where the non-mass trapped plots had a significantly higher yield. The reasons for this are unknown but were not due to larval infestation of the crop because in each case stem borer damage was lower in all mass trapped plots compared to corresponding non-mass trapped sub-plots.

Yields from Trial II were markedly less than obtained in Trial I ranging from 4.0 to 4.1 and 6.2 to 8.1 tonnes per ha respectively (table 9). Nevertheless, unlike Trial I there were no significant differences in the yields obtained with any of the treatment sub-plots in Trial II (ANOVA, $F = 0.26$, $P = 0.62$). The yield data reflected the uniformity of larval damage estimates (table 20) and the reduced impact of mass trapping on the proportion of *S. incertulas* to *S. inferens* in mass trapped and non-mass trapped plots.

Boro 2003 Season, Comilla District

As in the previous seasons two 10 ha plots were laid out at Adampur, one mass trapped and the other acted as a check. Pheromone trap catches and larval damage estimates were essentially zero throughout the season, although of the few damaged tiller and panicles observed *S. incertulas* constituted between 92 and 100% of the stem borers.

Table 10. Percent damage incidence caused by rice stem borers in trial plots, Boro 2003

Treatment	26 DAT 8 March 03 %DH	42 DAT 24 March 03 %DH	58 DAT 8 April 03 %DH	78 DAT 28 April 03 %WH
Mass trapped				
Check	0	0	0.002	0
Syngenta IPM	0	0	0	0
Farmers' practice	0	0	0.005	0.01
Not mass trapped				
Check	0	0	0.007	0.01
Syngenta IPM	0	0.003	0.002	0.01
Farmers' practice	0	0	0.008	0.01

Yield data as in previous trials showed that the Syngenta IPM and Check were comparable with the farmers' practice sub-plots recording slightly less yield although the differences were not significant.

Table 11. Rice grain yield, 2003 Boro

Treatment	Mean catch / trap / treatment	Average %DH	Average % WH	Yield (tonne/ha)
Mass trapped		0	0	
Check	2.63			4.09
Syngenta IPM	1.75			4.26
Farmers' practice	1.63			3.91
Not mass trapped		0	0.01	
Check	0			4.55
Syngenta IPM	0			4.60
Farmers' practice	0			4.43

ANNEX 3 RICE STEM BORER SPECIES COMPLEX

Rice Stem borers: a dynamic species complex in Bangladesh

Introduction

The area of land under rice production in Bangladesh is gradually decreasing, in part because of use for non-agricultural activities but also because of the increased acreage of competing crops that are more profitable for farmers, notably wheat and vegetables. Nevertheless, there is considerable scope for improved yield as evidenced by the yield gap between what is achieved by researchers under well-defined conditions and farmers. In order to benefit from the yield potential of improved varieties farmers are increasingly resorting to the use of fertilisers and herbicides. However, in order to protect their investment in the crop they are obliged to guard against pest and disease attack.

More than 175 insect and vertebrate pest species have been recorded on rice (Anon, 1995). Of the phytophagus species observed on rice 32 are considered to be capable of causing significant economic damage, notably rice stem borers, rice hispa, brown planthopper, white backed planthopper and two species of bandicoot rats (Islam *et al*., 2001). Throughout Asia five species of rice stem borer are thought to be economically important (Pathak & Khan, 1994), but in Bangladesh economic damage is only caused by three species, yellow stem borer, *Scirpophaga incertulas* (Walker) (Lepidoptera: Pyralidae), dark headed borer, *Chilo polychrysus* (Meyr.) and pink borer *Sesamia inferens* (Walker) (Lepidoptera: noctuidae) (Islam 1996).

Many of the biotic factors that affect the incidence of rice stem borers on crops are well understood. Thus, late planted crops sustain higher levels of damage than early planted (Khan, 1967), the choice of variety and season also affect stem borer damage incidence. Of the stem borer species that occur in Bangladesh the larvae of Pyralid stem borers are thought to be more economically important than the larvae of Noctuid species because they are more host-plant specific and cause more damage while feeding than the related Noctuid stem borers (Pathak and Khan, 1994).

Damage caused by larval feeding in the early stages of the crop often results in the central leaves of the culm drying up, a condition known as 'deadheart'. While larval feeding by the second generation prevents nutrients from entering the caryopses resulting in 'white heads' or panicles that are devoid of grain. The rice plant is generally thought to be capable of recovering from moderate levels of DH because the damage is sustained in the early stages of the vegetative phase of the crop. However, it was generally assumed that damaged panicles could not be fully compensated for because the loss occurred at a late stage in the crop cycle. Nevertheless, plants have been shown to convert ineffective tillers to effective ones (Islam and Karim, 1997) and by increasing photosynthesis in undamaged leaves they can produce heavier grains in effective panicles. Such compensatory mechanisms can reduce the potential impact of stem borer damage by up to 25% (Islam & Karim, 1997).

In order to develop a strategy for control of rice stem borers based on pheromones (Cork & Basu, 1996; Cork 1998; Cork & Krishnaiah, 2000) it is important to have an understanding of the relative impact of the larvae of different species of stem borer on the rice crop. The work was been based on the assumption that *S. incertulas* was the predominant species (Catling *et al*., 1978). However, because late infestation by one species could have a disproportionately larger impact on crop loss than those attacking at earlier stages of development. The present study describes the results of our investigation into the incidence and species of larvae of rice stem borers within and between seasons in Basngladesh.

Materials and methods

Survey sites
Samples of rice tillers that had typical DH or WH symptoms were collected with intact root systems from the BRRI farm, Gazipur (40 km north of Dhaka), Dhirasram (20 km south-east from Gazipur), Kapasia, Comilla (100 km east of Dhaka), Barisal (277 km south of Dhaka) and Rangpur (335 km north of Dhaka).

Field Trials
Rice is grown in three seasons in Bangladesh, Boro, Aus, and T. Aman with crops grown typically from, November to end of May (140 - 155 days), March to September (135 - 150 days) and July - December (130 - 150 days) respectively. Rice varieties planted for the different seasons include BRIdhan 28, BRIdhan 29 for the Boro, BR26 in the Aus, and BR11, BR14, BRIdhan 27 and BRIdhan 30 duringT. Aman seasons.

One hundred stem borer damaged stems were collected twice weekly at the BRRI research farm, Gazipur and weekly at other locations. Sampled stems were bundled and dissected on the same day by splitting the stem open longitudinally from base to tip with a sharp blade to expose stem borer larvae and pupae. Counts of the number and species of stem borer larvae were recorded. Damaged stems containing immature stages of the stem borers were expressed as a percentage

$$\frac{\text{Number of stems with stem borer larvae or pupae}}{\text{Total stems dissected}} \times 100$$

Sampling diapausing rice stem borer larvae
The population of diapausing rice stem borers was assessed at weekly intervals at the BRRI farm, Gazipur between December 2001 and January 2002. Stubble from a total of 4,048 rice stems were dissected with a total of 222 stem borer larvae found.

Results

Seasonal abundance of stem borer species

In the 2001 T. Aman season *S. incertulas* was the predominant rice stem borer species in Gazipur accounting for almost 70% of the population (table 1). In contrast *S. inferens* was the predominant species in the following Boro 2002 season, averaging, 56% of the larval population with *C. polychysus* and *S. incertulas* accounting for 30.1 and 14.2% respectively. However, analysis of the species composition of larvae in DH and WH collected during the 2002 Boro season showed that *C. polychysus* was predominant in the DH stage while *S. inferens* was predominant in the WH stage (table 1). Similarly, in the 2002 Aus season *C. polychysus* was predominant in the DH stage, accounting for almost 60% of the larvae counted but in this season it was also the predominant species in the WH stage of development accounting for 59% of the larvae overall.

The relative composition of the three stem borer species observed in damaged rice from Dhirasram was similar to that found in Gazipur during the 2001 T. Aman. However, the situation was quite different in the 2002 Boro season with a relatively high proportion of *S. incertulas* in both DH and WH and the proportion of *S. inferens* decreasing from DH to WH and the reverse being the case for *C. polychrysus*. On average the proportion of *S. incertulas* larvae was similar to that of *C. polychrysus* during the 2002 Aus season. However, underlying trends were different with the proportion of *S. incertulas* increasing from 32% of to 79% of the larvae causing DH and WH respectively while the proportion of *C. polychrysus* declined from 57 to 20% respectively. In contrast the proportions of *S. incertulas* and *C. polychrysus* remained essentially constant throughout the 2002 Aus season in Gazipur. Throughout the sampling periods the level of infested tillers in Gazipur and Dhirasram remained essentially constant and below the economic thresholds, ranging from 2.6 to 4.4% DH and 2.7 and 3.8% WH

Table 1. Seasonal abundance of rice stem borer larvae at two locations in Bangladesh

				Percent stem borer species		
Season	Damage	Tillers sampled	%Tillers infested	*S. incertulas*	*C. polychrysus*	*S. inferens*
Gazipur						
T. Aman 2001	WH	1850	2.8	69.6	14.8	15.6
Boro 2002	DH	1,000	2.6	13.1	56.1	30.8
	WH	1,500	2.7	11	4.1	80.7
Average			2.6	14.2	30.1	55.7
Aus 2002	DH	900	4.4	22.6	59.9	17.5
	WH	1,000	3.7	38.5	57.9	3.6
Average			4.1	30.5	58.9	10.6
Dhirasram						
T. Aman 2001	WH	250	2.9	86.4	2.3	11.3
Boro 2002	DH	400	2.9	39.0	7.3	53.7
	WH	600	3.1	49.6	28.4	22.0
Average			3.0	44.3	17.9	37.8
Aus 2002	DH	500	3.1	31.8	57.0	11.2
	WH	400	3.8	79.3	19.8	0.9
Average			3.5	55.6	38.4	6.0

Species composition in one season at different locations in Bangladesh

In addition to the samples taken in Gazipur and Dhirasram during the 2002 T. Aman season stem borer damaged tillers were sampled in Kapasia, Gazipur, Comilla, Barisal and Rangpur. The results (table 2) showed that *S. incertulas* was, on average, the pre-dominant species although the incidence of *C. polychysus* and *S. inferens* varied between 0 - 58% and 0 - 25% respectively with no *C. polychysus* and *S. inferens* observed in WH sampled in Comilla and DH sampled in Barisal respectively. However, the percentage of rice stems infested with larvae was low ranging from 2.5 to 3.9%.

Table 2. Species composition in 2002 T. Aman crop at different locations in Bangladesh

				Percent stem borer species		
Season	Damage	Tillers sampled	%Tillers infested	*S. incertulas*	*C. polychysus*	*S. inferens*
Gazipur	DH	1000	2.5	82.8	16.6	0.6
	WH	500	3.2	29.4	58.0	12.6
Average			2.9	56.1	37.3	6.6
Dhirasram	WH	400	2.8	69.2	12.3	18.5
Kapasia	WH	400	2.7	59.0	16.5	24.5
Comilla	DH	400	2.6	85.7	14.3	00
	WH					
Barisal	WH	400	3.9	97.6	00	2.4
Rangpur	DH	1000	3.3	89.6	7.3	3.1

Species composition of rice stem borer larvae in diapause

The relative proportions of rice stem borer species diapausing in rice stubble at the BRRI farm in Gazipur was sampled weekly during the 2001 Aman season. The percentage stubble containing larvae was found to be essentially constant over the winter period with 73.9, 18.9 and 7.2% containing *S. incertulas*, *C. polychysus* and *S. inferens* larvae respectively (table 3). A further 4,000 rice stubbles were dissected after the winter (December and January 2001) and continued until no diapausing stem borer larvae were observed.

Table 3. Incidence of stem borer in damaged stem at BRRI farm, Gazipur, 2001

	Frequency of occurrence								
	S. incertulas			*C. polychrysus*			*S. inferens*		
	Boro	Aus	T. Aman	Boro	Aus	T. Aman	Boro	Aus	T. Aman
1	176	2	378	172	45	66	370	77	68
2		42	33	5	155	4	31	15	6
3		88	9	2	140	0	87	10	2
4		34	5	2	64	5	17	33	1
5		20			35		6		
6							1		
7							2		
8									
9							2		
10				1			1		
11									
12				1			1		
13							1		
14				1					
15							1		
22							2		
32				1					

Population density of stem borer larvae in damaged rice stems

Data from the 2001 Aman samples collected in Gazipur, Dhirasram and Kapasia were analysed for the number of larvae of each species present in each tiller. Of the 2,629 stems sampled 866 larvae were observed suggesting a 32.9% incidence of larvae but the actual incidence was 24.6% because 8.8% of the stem borer damaged stems had more than one larvae present representing 20.0% of the larval population. Of the total number of tillers found to contain stem borer larvae, 1.9% of tillers contained larvae from more than one species, representing 21.6% of all tillers with two or more larvae (table 4).

Table 4. Incidence of stem borer in damaged stem at Dhirasram, Gazipur 2001

	Frequency of occurrence								
	S. incertulas			*C. polychrysus*			*S. inferens*		
	Boro	Aus	T. Aman	Boro	Aus	T. Aman	Boro	Aus	T. Aman
1	3	6	22	0	11	0	46	0	0
2	31	63	56	13	21	2	82	0	2
3	78	76	53	3	5	2	37	0	2
4	34	31	19	4	1	2	12	1	2
5	11	5	5			1	1	1	1

Impact of stem borer damage at the DH stage on total number of panicles per hill.

Studies were conducted in Gazipur and Dhirasram to investigate the effect on stem borer infestation on the average number of tillers in hill. The study (table 5) clearly demonstrated that in hills were tillers showed evidence of stem borer damage there were on average one more tiller per hill than in hills where there was no infestation. This data confirmed that rice plants produce extra tillers in response to stem borer damage. Further work will be undertaken to determine whether infestation impacted on yield.

Table 5. Effect of stem borer damage on number of stems per hill

Location	Season	Total hills counted	Average tillers per hill			
			Infested hills		Un-infested hills	
			Mean	SE	Mean	SE
Gazipur	Boro 2002	1,300	13.8	0.08	12.6	0.08
	Aus 2002	950	9.7	0.05	8.05	0.05
	T. Aman 2002	950	13.2	0.07	12.3	0.07
Dhirasram	Boro 2002	950	12.0	0.05	11.0	0.05
	Aus 2002	500	9.5	0.03	8.9	0.04
	T. Aman 2002	450	15.2	0.06	13.1	0.06

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ANNEX 4 SOCIO-ECONOMIC STUDIES IN TRIAL AND NON-TRIAL AREAS TO UNDERSTAND FARMING PRACTISES, RESOURCES, CONSTRAINTS, AGROCHEMICAL USE, AND RELEVANCE OF ICM AND PHEROMONES TO RICE FARMERS

Contents

Abbreviations

BRRI	Bangladesh Rice Research Institute
BS	Block Supervisor
DAE	Department of Agricultural Extension
DFID	Department for International Development
FFS	Farmers Field School
GoB	Government of Bangladesh
ICM	Integrated Crop Management
IPM	Integrated Pest Management
MoA	Ministry of Agriculture
NGO	Non Governmental Organisation
NRI	Natural Resources Institute
SB	Stem Borer
UAO	Upazilla Agriculture Office
YSB	Yellow Stem Borer

Terms

Word/Term	**Meaning**
Acre	Unit of land measurement, 1 acre = 100 decimal
Adompur	Village site in Comilla; one mass trapping trial.
Aman/ T. Aman	Winter rice season
Aus	Rice season prior to Aman
Bepari	Storekeeper
Bhatora	Name of a place in Comilla district where one mass trapping trial (non pheromone site) was set.
Bigha	Land measurement
Bish	Means poison but locally used to signify insecticides
Bondhok	Form of land relation where one farmer receives land for various Cultivation practices from the landowner by paying money. Until the Owner farmer pays back the money the receiver farmer will run different cultivation practices.
Borga	Form of land relation where one farmer receives land from the landowner for a fixed period of time. Both the landowner and the land receiver gain the yield on a fixed share basis.
Boro	Summer rice growing season
DAT	Days after transplanting
Decimal	Small unit of land measurement, 100 decimal = 1 Acre
Digikata	One of the local names of Stem Borer
Doulatpur	Village in Comilla district where one mass trapping trial was set.
Gonda	Local land measurement unit, 1 gonda = 6 decimal of land
Ha	Hectare, unit of land measurement, 1 ha = 2.45 acre
Holee	One of the local names of Stem Borer
Katha	Land measurement,
Laichcha	Form of land relation where one farmer receives land by money for various cultivation practices from the land owner for a certain period of time. Used in Mymensingh
Majra	Bengali name for Stem Borer
Medi	One of the local names of Stem Borer
Meoua	Local name of Rice bug
Mon	Weight measurement, approximately 40 kg.
Pheromone	Pheromones are substances secreted by an individual and received by an individual of the same species in which they cause a specific behavioural reaction.
Poshani	Form of land relation where one farmer receives land for money for various cultivation practices from the land owner for a certain period of time. Used in Mymensingh. Same as *Laichcha*
Poush	Local name of Aman season
Ren	Land tenure term for renting, used in Comilla
Sceam	Local name of Boro season
Sheesh kata	One of the local names of Stem Borer
Taka	Local Currency, one pound sterling = 90 taka
Tekhondo	Local name of Aus season
Tia	One of the local names of Stem Borer
T aman	transplanted aman
Tonko	land tenure term Comilla

1. **Background**

Rice stem borers are thought to be the most deleterious pests of rice throughout Asia[2]. The yellow stem borer (YSB), *Scirpophaga incertulas*, is a moth whose larvae are thought to reduce rice yields by between 10% and 40% through its feeding activity in rice stems. A DFID-funded workshop in 1999 identified YSB as a major constraint to rice production in Bangladesh. The damage caused by larval feeding in the rice stems may cause death of the growing shoot, which is called *dead heart*, and death of a growing panicle called *white head*. The damage caused by YSB can be very severe in sub-tropical and tropical areas where there is a build-up to five or six generations in one year and there is overlapping of paddy crops throughout the year.

Chemical management with systemic insecticides may be the only course presently available to rice cultivators for management of YSB, although farmers also use cultural practices and tolerant varieties to suppress pest populations. These insecticides are relatively cheap and readily available but invariably toxic to a wide range of organisms apart from the target pests. The indiscriminate use of such insecticides can and does expose man and his environment to these compounds both during application and through subsequent ground water contamination. Insecticides can also cause a resurgence of secondary pests by killing predators and parasites that would normally manage them. (Cork, 2002)

The infestation of YSB could be managed by mating disruption at levels comparable to or better than that obtained with conventional pesticides resulting in a 10% increase in yield compared to areas that had been treated with conventional pesticides and in excess of 25% in areas where farmers did not apply insecticides (Cork and Krishnaiah, 2000). This mating disruption could be an effect of pheromone based management strategy. Pheromones are secretions that are involved with chemical communication[3].

Farmers' situation

Rice production is the dominant component of the agricultural sector in Bangladesh with an estimated 60 to 70% of its population being directly dependent on rice cultivation for their main source of livelihood. Demand for rice in developing countries is expected to increase by 1.8% per annum. In Bangladesh more than 75% of the total cultivated land of 13.5 million ha is devoted to rice production, yielding 19 million tons per year. Since the available land for rice cultivation is expected to decrease over the foreseeable future (Islam, 1999) increased demand can only be met by increasing productivity. This can be achieved with currently available high-yielding varieties but they require additional inputs, in the form of fertiliser and pesticides, to reach their yield potential. Such crop intensification inevitably leads to an increased dependence on pesticides for management of key pests (Geddes & Iles, 1991).

[2] The YSB (*Scirpophaga incertulas)* (Walker) (Pyralidae: Lepidoptera) is a major rice pest in Bangladesh (Catling *et al.* 1971) and it is also considered a major pest of rice in other parts of Asia (Pathak 1978).

[3] The term 'pheromones', in general, refers to chemical substances, which when released to the outside by an individual cause a specific behavioural or physiological response from individuals of the same species. They are species-specific, have no adverse effects on the biota or the environment, are unaffected by rainfall and hence would be fully compatible with an integrated pest management (IPM) approach to management rice pests in both dry and wet season crops. By permeating the air with a synthetic blend of female pheromone components male moths are prevented from following odour trials of pheromone released by co specific females. This results in a reduced level of mating, or mating disruption, that can subsequently lead to a significant reduction in the larval population of the next generation and hence a reduction in the damage sustained by a crop.

Currently smallholders rely on the use of systemic insecticides such as phorate or carbofuran for management. These offer a relatively cheap and readily available method of management but are non-specific, highly toxic to aquatic life and expose man and his domesticated animals to risk of poisoning both during application and through subsequent contamination of water supplies. The use of insecticides also encourages resurgence of secondary pests such as leaf-folders and plant-hoppers, as experienced in a related project in India (R6739). That DFID-funded on-farm research conducted with farmers in India also showed that farmers found pheromone technologies for the management of YSB an acceptable means of managing the pest. However, they were only willing to adopt the technology if it was provided as part of an overall package of inputs capable of tackling their range of pest problems.

The use of pesticides in the management of pests in rice is increasing. In 1965, Bangladesh used 3 metric tonnes of pesticides to manage pest and diseases. During early 1970s the government gave pesticides free of cost to farmers to manage pests and diseases. The subsidy was reduced to 50% in 1974 and withdrawn completely in 1979 leaving pesticides to the private sector. After the withdrawal of the subsidy, although the use of pesticides declined during early years, their use again continued to increase reaching 11,000 metric tonnes in 1996. At present 83 pesticides with 211 trade names have been registered in Bangladesh (Draft IPM Policy Paper).

Many farmers in Bangladesh are illiterate, have very little training on the safe use of pesticides, are ignorant of the dangers of pesticides, do not follow safety procedures in pesticide applications e.g. no protective clothing or equipment worn, after application of pesticides they wash their contaminated clothing and pesticide application equipment in public water sources, have no safety storage of pesticides, do not dispose pesticide containers safely and do not have adequate supervision or advice. Every insecticide application exposes the labourers and applicators to potentially toxic poisons. Bangladesh farmers have been dependent on pesticides for a long time. This discourages farmers from becoming skilful decision makers with an ecological understanding for management of their farming on a sustainable basis.

Syngenta, under guidance from Bangladesh Rice Research institute (BRRI), developed an integrated crop management (ICM) programme for rice, now actively promoted through Farmers Field Schools (FFS). The aim of this project is to assist Syngenta to adapt and promote pheromones as part of a commercially viable component of their ICM strategy for rice production in Bangladesh. Two inter-related components were in the project: a technical one, which tested options for field-release of the pheromone and a socio-economic one, designed to understand the farmer’s context.

This report deals with the socio-economic component and how an understanding of the farmer’s context can and has influenced the development of farmer-appropriate technology. The study collected information in the project area on farmers' resource-bases, production constraints and perceptions as they relate to existing crop pest problems and their management, with particular emphasis on the implications for the adoption of pheromone technology and alternative IPM approaches.

2. Objective of the study

The objectives of this study are to understand:

- the socio-economic dimensions of rice cultivation;
- the effect of pheromones as a component of ICM strategy on rice cultivation and
- local farmer’s attitudes towards alternatives to chemical pesticides in selected project areas.

Assessment of the impact on rice crop of incorporating mass trapping with pheromone is made possible through the collection and analysis of current information on the social and economic dimensions of rice cultivation through farmers practices, resources, constraints to production, use of agrochemicals and acceptability of pheromone traps (PT) within the project area.

The inter-disciplinary approach adopted for the research allows a two-way exchange of information, ensuring that the social research obtains information to help shape the way the technology is developed and marketed to farmers, and also that it is relevant to farmers' situations.

3. Methodology

Area Selection

The areas - Sakholla and Comilla - where the socio-economic surveys were conducted were already selected for research. The villages were selected on the basis of possibility of predominant infestation of YSB in rice fields. Respondents were selected by random sample for baseline survey. Availability of larger rice fields with hybrid variety was another pre-condition for the selection of project area. Follow up in-depth studies were completed in same area with combination of methodological tools. The researcher first introduced the study during preliminary meetings with farmers. After discussing the project at a few local farmers meetings, the technical trials were set up in farmer's rice fields. Local farmers were involved with the trials. Two small-scale trials were set up in T. Aman 2001 at Laksham, Comilla; one mass trapping trial and three small scale trials in Boro 2002 at Phulpur, Mymensingh; one mass trapping trial and three small scale trials in T. Aman 2002 at Laksham, Comilla.

Socio-economic research		**Technical research**	
Period	**Details**	**Period**	**Details**
October 2001	Reconnaissance Laksham, Comilla	T. Aman 2001	Two small-scale trials Laksham, Comilla
Boro 2002	Baseline survey conducted to gather general views about rice cultivation practices Phulpur, Mymensingh	Boro 2002	Three small scale trials Phulpur, Mymensingh
T. Aman season 2002	Baseline survey conducted at Adompur/Vatora and Daulatpur Laksham, Comilla		
May-June 2002	In-depth observation and interview Phulpur, Mymensingh	T. Aman 2002	One mass trapping trial + three small scale trials, Laksham, Comilla

Project technical researchers were regularly present in the trial fields during the social research period.

Data Collection

Related literature and research reports were reviewed during and after the field study. In order to create an appropriate information database from which to develop appropriate recommendations, it was decided to use a combination of methodological tools. The methods used to collect data for analysis and subsequent write up are presented in chronological order below.

(i) Farmer baseline survey.

First a village survey (at Phulpur, Mymensingh in Boro 2002) was conducted to gather general views about rice cultivation practices (December 2001) then in the second phase an in-depth observation and interview based field work was completed (May-June 2002) at the same village. In T. Aman season 2002 during September a village survey were conducted at Adompur/Vatora and Daulatpur (Laksham, Comilla) and an in-depth observation was completed on November-December 2002. Respondents were selected using random sampling methods.

(ii) Key informant's survey

A number of key informants were selected to collect data for this survey. Purposive sampling criteria were based on their occupational status and level of land ownership, as well as their willingness to be interviewed. These key informants were interviewed with the help of a checklist and a tape recorder (permission was taken prior to the interviews).

Questionnaire development
The survey was directed at farmers' practices, resources, constraints to production, agrochemical use and applicability of pheromone as a component of an ICM strategy (see appendix 1: The Questionnaire). Previous field experience had helped to develop the survey formats. The format was pre-tested during a short field trip. Necessary amendments were made from the field experiences and then the final format of the survey was developed.

The questionnaire contains five main topics. Every topic has different sub-topics. They are:

1. <u>Respondent's Personal Information:</u> It intended to gather data/information about respondent's biography such as farmer's name, age, sex, educational qualification, source of income and family composition.
2. <u>Resources:</u> This provided an estimate of the lands that an individual farmer possessed. It was intended to determine the equipment owned and used in cultivation.
3. <u>Cultivation Practices:</u> This section of the questionnaire was intended to provide a:
   -List of main crops that farmer usually cultivate in a year
   -List of main rice insect pests
   -Knowledge of Stem Borer
   -Cost of rice production in Aman season
4. <u>Constraints:</u> This section of the questionnaire was concerned with trying to understand farmers' views on the constraints to rice production.
5. <u>Others:</u> It plans to seek information about the farmer's knowledge of IPM, Agro-chemical use and their interest to use IPM.

(iii) In depth study

In-depth studies were undertaken with a small number of the key informants as a follow up to the baseline survey to understand farmer's perception on PT as a new technology to manage YSB instead of pesticides in their rice fields.

A number of key informants were selected purposively by type of farmer to collect data for this survey. Sampling criteria were based on the willingness of interviewees to provide data, their occupational status and level of land ownership. These key informants were interviewed with the help of a checklist and a tape recorder (permission was taken prior to the interviews).

Interviews and Checklist

The interviews were unstructured in nature although a checklist was used as a reference point. The checklist was created according to the study objective and focused on farmers' perception about PT and a willingness to use/adopt them with their rice cultivation practices in the near future. Detailed results are presented in the appendices (see Appendix-2).

Case studies

Sampling criteria were based on the willingness of interviewees to provide data, their occupational status and level of land ownership. These key informants were interviewed with the help of a checklist and a tape recorder (permission was taken prior to the interviews). Four case studies were undertaken in the study area which reflected the rural/local agricultural practices in rice, pest management behaviour and agro-business. The results of the case studies are presented in Appendices 4 - 6 of the report.

4. Research Outputs

The information generated during this study comprises quantitative and qualitative data gathered by observation of farmers, pesticides retailers and other informants from the project area.

Quantitative outputs

Following the pre-testing of a questionnaire, two baseline surveys were conducted among farmers in Phulpur (Boro 2002), Adompur/Vatora and Daulatpur (T. Aman 2002) to collect data about rice cultivation practices, cultivation expenses, constraints to rice production and use of agrochemicals.

The respondents

Eighty-nine farmers were selected as representative of their communities for baseline survey interviews. All the respondents were male. Although women were involved in post-harvest and household activities they could not be interviewed as they veiled their faces with their *ghomta* on arrival of the (male) researcher. Some preliminary information about the respondents is presented in Table 1, which shows that respondents represented different categories regarding location, age group and educational qualification in approximate proportion to their frequency in the population.

Table 1: Preliminary information about the Respondents*

Location		**Age Group**		**Educational Qualification**	
Name of the Location	Farmers Interviewed	Age Limit	No. of Farmers	Educational Level	No. of Farmers
Sakholla	37	Below 20	08	None	26
Adompur	24	21 - 40	42	Primary	22
Bhatora	16	41 - 60	34	Secondary	21
Doulatpur	12	61 - 80	05	Higher	20

* Total number of respondents = 89

Land holding

There were differences among the farmers about the quantity of land held and two types of tenure were identified, land owning and tenancy (see Figure 1 below). Most of the farmers had small landholdings although there were also a few ‘big’ landholdings. The majority of farmers cultivated their own land. Some farmers who have adequate land, but a shortage of manpower for cultivation, rented out their land to other farmers who are landless or smallholders. The study found that approximately 1/3rd (31.5%) of farmers were tenants. Respondents’ land area was distributed as shown in Table 2. The data shows that most of the farmers had less than 200 *decimal* of land (approximately 0.8 ha.). Farmers from Sakholla had larger landholdings than those in Comilla.

Table 2 : Land allocation of informant farmers Comilla and Sakholla

Cultivated land (in decimal)	No. of Farmers land Inside Trial	No. of Farmers land Outside Trial	No. of Farmers land Total Ownership
1-50	24	17	7
51-100	8	13	15
101-200	3	7	11
200+	1	3	10
Landless	----	---	9

Table 3: Farmers land size distribution in project area (in decimal)*

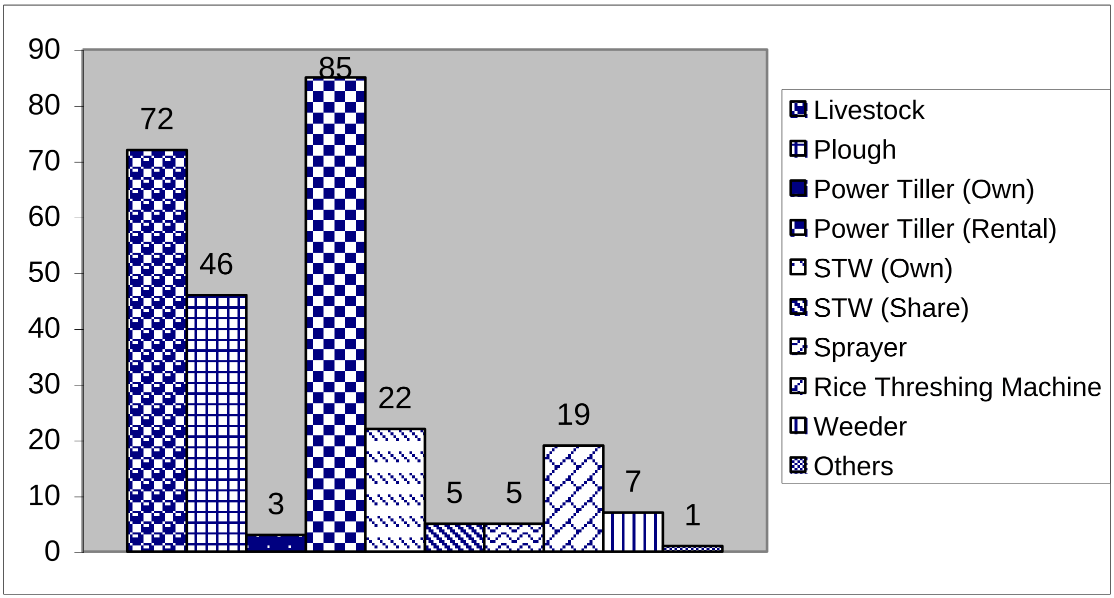
* Land owner farmers = 78 (87.64%)
Landless farmers = 11 (12.35%)
Tenure farmers = 28 (31.64%)
Trial farmers = 63 (70.79%)
Non-trial farmers = 16 (29.21%)

Cultivation

Farmers cultivated land with draft animals, implements and hand tools. Almost every farmer interviewed had cattle (including cows, bullocks and calves) or goats. Interestingly the farmers interviewed did not plough with livestock. Most of the animals were used for milking and post-harvest work and as a capital asset, being particularly useful during periods of crisis when they could be sold for cash. The farmers ploughed with power tillers, which were owned by a few farmers and rented out to others when required. The hire charge s 30-35 Taka for 1 *gonda* (1 gonda = 6 decimal of land), equivalent to 12,500 – 14,700 taka/ha. Cultivable land was usually ploughed twice a season.

Equipment included ploughs, power tillers, shallow tube-wells (STW), rice threshers, pesticide sprayers and others. Figure 2 shows that few farmers owned cultivation equipment and that most hired it when required. Within the project area there was significant use of paddy threshers, an appropriate technology that reduces the cost of paddy threshing labour, it was quicker and was produced locally. Few farmers had pesticide sprayers or mechanical weeders. In the 2001 Aman season there was a lack of water in the rice fields and farmers weeded manually because it was inappropriate to use herbicides.

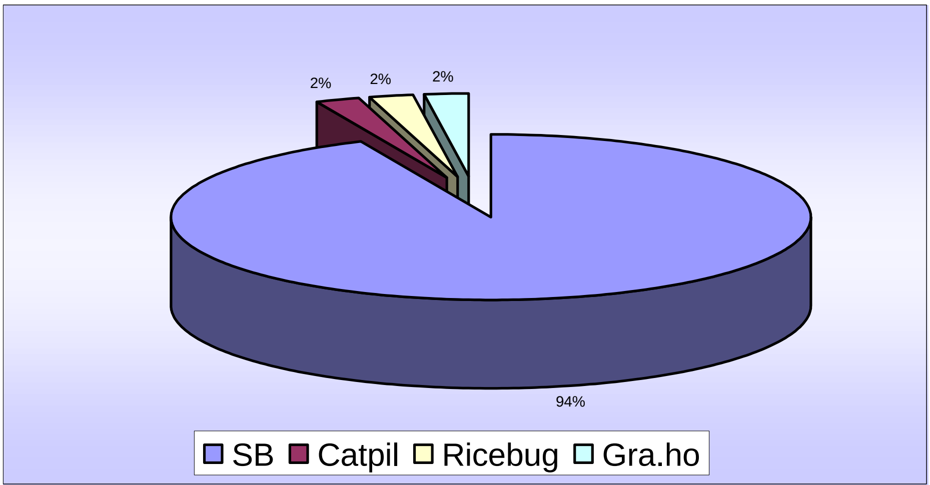
Figure 1: Cultivation Equipment



Major rice pests

Farmers were asked to categorize the main insect and other rice pests. SB was seen as the main insect pest for rice Figure 3. Most of the farmers (94%) in the project area perceived that yellow stem borer (SB)[4] was the main insect pest , while a few farmers listed other insect pests such as caterpillar, rice bug and grass hopper.

Figure 2: Main insect pests for rice



Farmers' perceptions regarding the infestation season for SB can be seen in Table 3.

Table 4: Main stem borer seasons: farmer perceptions

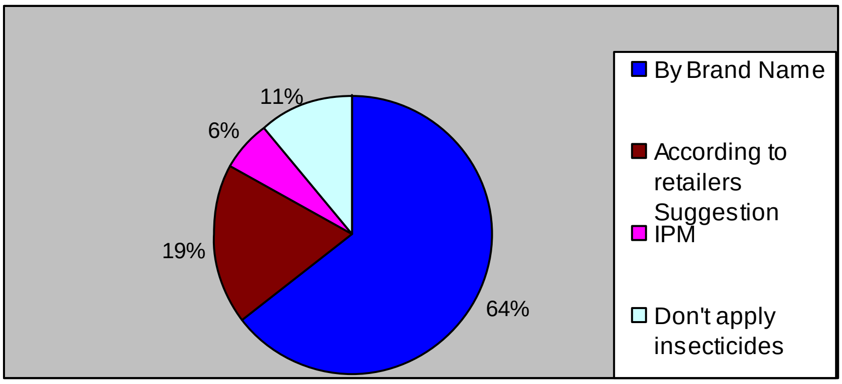
Season perceived as most important	**Percentage of farmers**
Every rice season	31
Mainly in Aman season	25
Mainly in Boro season	17
Not sure	27

[4] The local names of SB include *majrapoka holee*, *digikata*, *sheesh kata*, *medi*, *tia*.

Farmer preferred method of SB management

The farmers' first step in managing infestations of SB was to ask local pesticide retailers what insecticides were available. Many asked by brand name, checking with the retailer if they were right or required other measures. Some farmers practised IPM and a number of farmers did not apply insecticides for SB management. Farmers who did not apply insecticides felt that their crop did not require any management treatments against the infestation of SB.

Figure 3: Farmers management measures against SB



The above figure presents the usual measures taken by surveyed farmers against the infestation of SB. The retailers played an important role in this process. Many farmers know the brand name of pesticides but seek suggestions from the retailer, whereas the others depended totally on the latter. Although a small number of farmers practised traditional IPM (normally they put sticks in their rice fields to encourage insectivorous birds to perch and did not apply pesticides), most farmers applied insecticides. Although Dimecron is banned, the study found that a number of farmers used it in their rice fields. The pesticides used by farmers are shown in Table 4

Table 5: Pesticides used by farmers

Pesticide	Number of farmers using
Basudin	31
Dimecron	15
Furadan	10
Sunfuran	09
Rison	08
Melathion	06
Diazinon	05
Others	23

Other Major Rice Pests

Table 6: Major rice pests

Pest	Farmer reporting (percentage)
Grass hopper	33
Rice bug	28
Rice hispa	15
Caterpillar	13
Leaf folder	11

Some farmers thought that pests attacked their rice crop almost every season, others that it was mainly in the Aman season. The exception was rice hispa, which they thought did not attack every season or even every year, and possibly only once in three to five years. Farmers did not have adequate knowledge about the management of these pests so they applied pesticides suggested by retailers. The study found that farmers do not apply pesticides for all insect pests. They think that the pesticides they use in their fields will kill all insect pests. If they felt that insecticides were not working and the infestation symptom was different or similar to those for rice hispa, then they would go to the retailers for an appropriate treatment. Otherwise for the other major rice pests they used the same pesticides as those purchased for SB.

Knowledge of SB

Farmers gave the following opinions regarding their knowledge of SB symptoms:

- Cut stem from middle
- Absorbed the milk in panicles
- Panicles become white
- Heard the name before
- Most harmful insect of rice
- Green small larva inside stem
- Like black thread inside stem

A number of farmers said that they do not know anything about SB. From this it would appear that farmers had no consistent perception about SB.

Knowledge of YSB

Farmers were asked if they were familiar with YSB specifically. Farmers were fairly evenly divided between those who said they recognised it and those who did not. But a significant aspect was that a few farmers, who either said that they knew or did not know YSB, could all identify it. The remaining farmers neither said they knew, nor were able to identify the insect. It seems that there was some overlapping perception among farmers about SB and YSB in particular. The following tables shows that farmers had overlapping observations regarding their knowledge of YSB; particularly in traits of identification, yield loss measurement and infestation period. This confirms that the farmers interviewed had a poor knowledge about insect pests; their identification and the damage they caused. This result implies that sound technical information is lacking in rice farmers in Bangladesh.

Table 7: Farmers Knowledge about YSB

Farmers perception		No. of Farmers	Percentage
Familiar with YSB	Yes	46	52
	No	43	48
Identify as YSB	Larvae inside stem	42	47
	Looks like butterfly	12	13
	Don't know	19	21
	Others	5	6
Yield Loss	Unable to estimate	12	13
	1-10%	11	12
	11-25%	52	58
	Above 25%	14	16
Infestation Period	Unable to tell	16	17
	0-20 DAT	14	16
	After 20 DAT	36	40
	At pre-booting stage	23	26

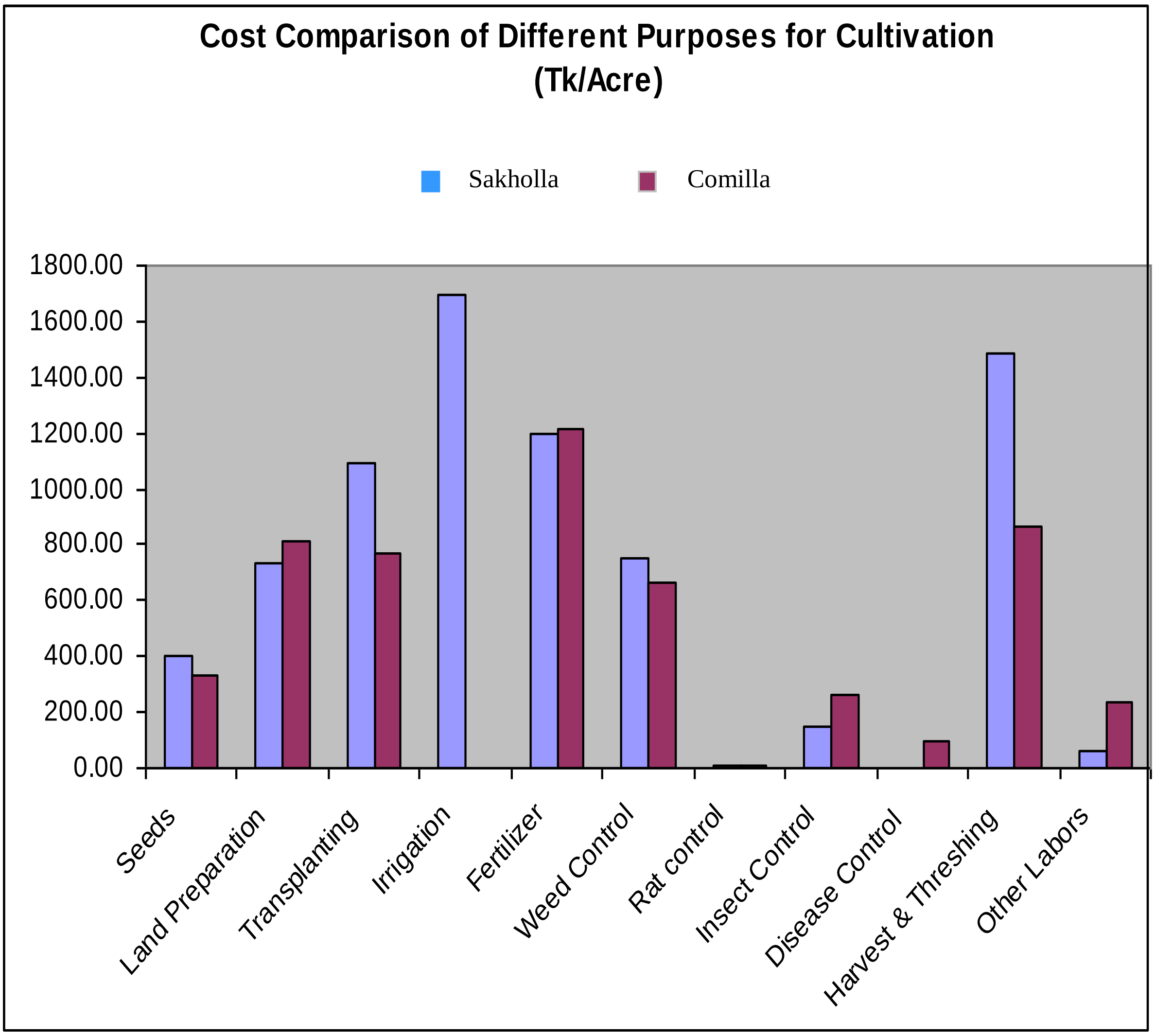
Costs of rice production

Farmers were asked about costs for different cultivation activities. The most expensive activities for farmers:

- in the boro season were irrigation, fertilizer, harvesting and threshing, weed management, transplantation and land preparation, whereas
- for the aman season they were fertilizer, harvesting & threshing, land preparation, transplantation and weed management.

It was evident that the cost of all activities (apart from fertilizer and irrigation) was directly linked to the cost of labour; labour costs made activities expensive. So if farmers received appropriate/intermediate technologies that were cheaper than current labour intensive practices, then their average cultivation cost would be reduced significantly. In Figure 5, the costs of different activities are presented for one acre of land in the project area. The data shows that farmers spent on average 7,382 Taka per acre (£205 per ha) during the Boro season. The range of cost for one acre in the Boro season is 5140 - 11129 Taka (£143-310) and in Aman season 3167-12717 (£88-353), or an the **average cost of production of 5277 Taka per acre (£147 per ha).**

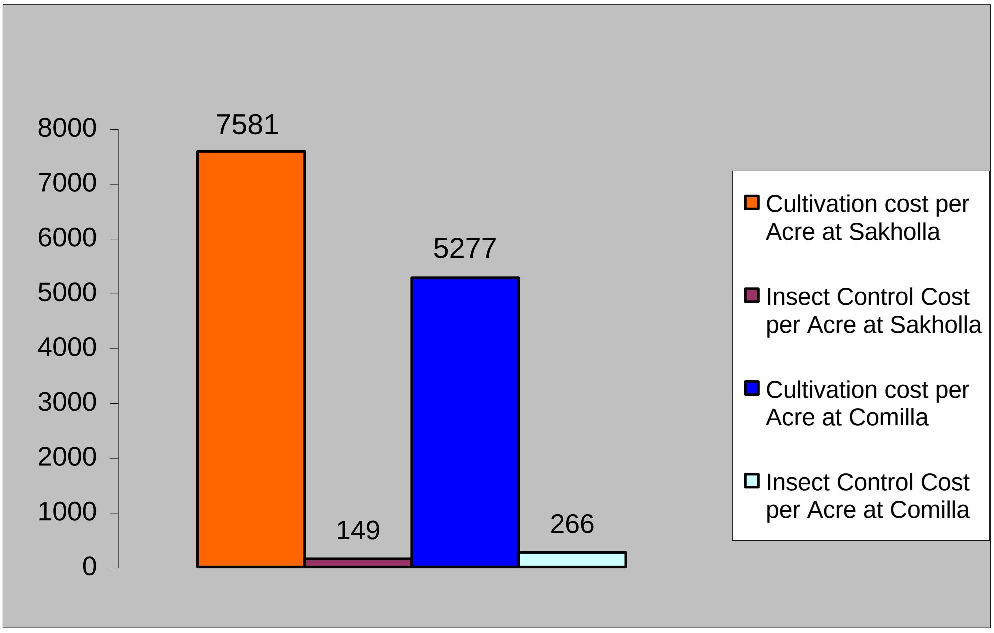
Figure 4: Cost comparison of different purposes for cultivation (Tk/acre)



Costs of insect pest management

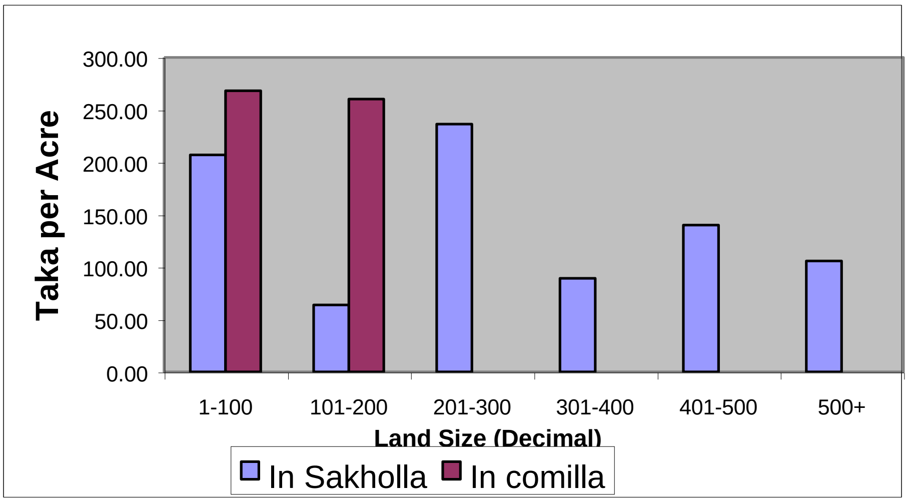
Although the respondents did not use large amounts of money for insect pest management as a proportion of the total cost of production, their expenses were nevertheless significant. It was calculated that to manage insect pest infestation in their rice fields farmers spent less money in the Boro season 149 Tk/acre (£4 per ha) (2% of total cost) than in the Aman season 266 Tk/acre (£7.5 per ha) (5% of total cost). It would appear significant that though the farmers interviewed spent less money in the Aman season on crop production, they spent more to manage insects because they were aware that the Aman was the main season of YSB infestation, although this was not apparent from the results of the farmer interviews (table 4).

Figure 5: Cost comparison between cultivation and insect management (Tk/acre)



The study of insect pest management costs found that farmers with small landholdings spent more money per unit area than farmers with large landholdings. Figure 6 shows that those farmers with up to 0.8 ha of land spent the most on insect management (in both Boro and Aman seasons) and specifically Boro season farmers who had 1 - 300 decimal of land spent more per unit of land than those farmers with larger land holdings. It is clear from Figure 7 that farmers with small and medium size land holdings would be the best target group for adopting mass trapping.

Figure 6: Comparison of insect management costs according to area of cultivated land



IPM knowledge

The agrochemical industry is becoming increasingly concerned that their commitment to IPM must extend beyond the search for selective 'IPM' compatible compounds, to the voluntary modification of marketing techniques and customer services for established products. Messages of support and highly publicized token gestures are not enough to bring companies into line with the demands of IPM – friendly marketing (Vorley, 1990). In this respect the Project attempted to observe the effectiveness of mass trapping as a component of IPM.

Within the project areas the study found a number of farmers involved in Department of Agricultural Extension (DAE) IPM activities conducted by Block supervisors (BS).

Farmers who were familiar with IPM thought that IPM was an effective method for the following reasons: .

- birds sat on sticks and ate insects so their crops were protected
- production was better than usual
- crops could be protected in low cost
- insect infestation was decreased
- insects were caught in sweep nets

Although farmers expressed their views on IPM as an effective method of insect control, interestingly the study found that they did not practise IPM the following season (see details in Qualitative Outputs, p. 81). As the DAE IPM programme was not running in the project area farmers applied insecticides to manage insect pests. However, when the pheromone project was implemented farmers said they were interested in adopting methods like IPM. Table 8 depicts farmers' knowledge, perception and additional interest to use IPM in their rice fields for managing insect pests.

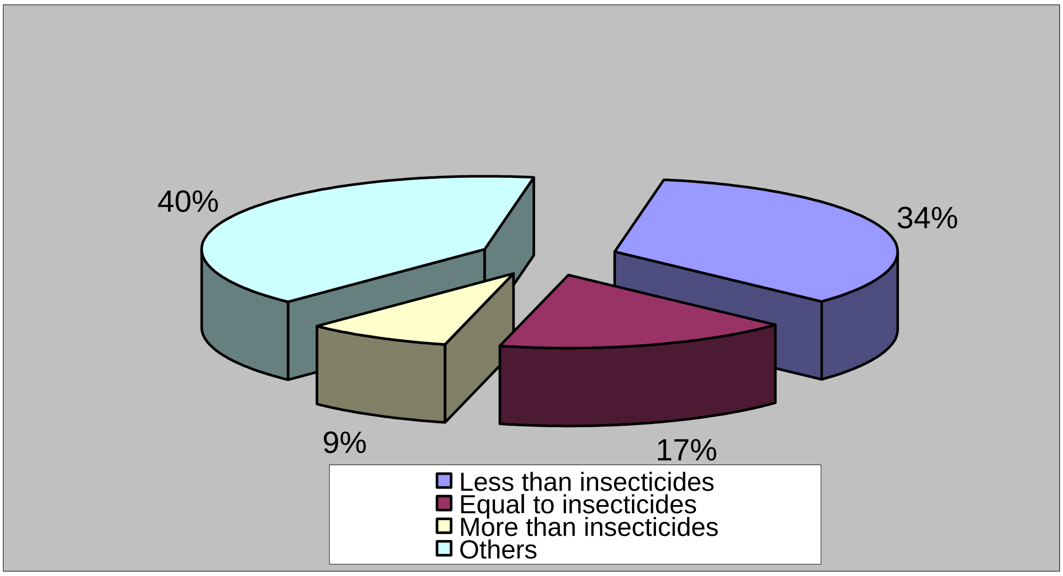
Table 8: Farmers IPM Status

	Farmers response	No. of Farmers	All farmers %	Trained farmers %
Received Training	Yes	34	38	
	No	55	62	
Opinion about the training	Effective	29		85
	Not sure	5		15
Current IPM Status	Practitioner	5		15
	Non-practitioner	29		85
Interest in using new technology/PT	Interested	78	88	
	Uninterested	3	3	
	Not sure	8	9	

Farmer's price assumption about pheromone traps

Researchers explained to farmers how mass trapping operated and who it was compatible with IPM and asked them to indicate their willingness to use it. Most of the respondents informed the study researchers that they are very interested to use mass trapping. They were then asked farmers to provide a tentative price for PT (the study made it clear that this was not the real price of PT but what the farmers expected the technology to cost) and this information was passed to the project planners. It is clear from the data presented in Figure 8 that most farmers wanted PT to be cheaper than insecticides. Whereas some farmers expected PT price to be equal to that of insecticides and only a few thought that PT's price would be more than insecticides and they would use it when it became available in the market.

Figure 7: Price assumption of PT by the farmers



Farmers in the 'Others' group said that PT price should be:

- low priced so that farmers can benefit most
- within the range of farmer affordability
- 200-250 Tk/acre (£5.50 - £6.94 per ha) of land etc.

Qualitative Outputs

Source of Income

The study found that farmers were engaged with various income earning activities in addition to crop cultivation. Cash income and agricultural activities were very important for their livelihoods. Most of the farmers interviewed in the project areas have cultivation as their main source of income, but other income-generating activities included teaching, banking, running grocery shops, purchasing agri-inputs, seasonal paddy business, day labouring, rickshaw driving, small business, craftsmanship etc. These activities signified additional sources of cash for cultivation and emergency family expenses. Most farmers were engaged in secondary activities because it provided money on a regular basis whereas otherwise, they have to wait until harvest with rice cultivation. Farmers who did not have a secondary source of income were looking for secondary incomes.

Houses

Most of the houses in the project area were made of bamboo and tin (corrugated iron sheet) while some were semi-buildings (brick walls, tin roofs and earth floors). There were a few huts and buildings as well. Among the houses there were one or two big rooms that were segmented by some kind of partition. Usually these rooms were used for living in and there was also a store (*'Macha')* for crops. Most houses have their own tube wells and sanitary latrines. Usually there were two parts to a house; an inner and an outer *(Kachari* or *Bairbari*). Courtyards were common for all houses and farmers used them to thresh and dry crops and other activities. Farmers with cattle housed them in a *Goalghor* beside the courtyard. Some of the houses have separate kitchens whereas others cooked their meals under a *Chala* (outside kitchen) which was usually located in the courtyard. In most cases there was a kitchen garden where seasonal vegetables were grown for family consumption.

Family Members

Most of the families were nuclear, although there were a few joint families as well; living under the same roof but with different cooking arrangements. Mostly, the oldest male member was the family head. Family members were identified as ‘working’ or ‘non-working’, the former indicating the availability of labour within the family. If more labour was required, it needed to come from outside the family and usually the head of the family hired them. Non-working members of the family provided for dependents[*] that were unable to work. Respondents identified those as ‘working person/member’ whose work had a paid value. Females were directly involved with household and post-harvest activities. Although it has no paid value this plays an important role in their livelihood strategies, and so these females were considered working members of the family.

Purpose of Production

Amongst the farmers of Comilla, the main purpose of producing rice, from all three seasons, was for home consumption and to sell surplus. For those growing vegetables, the purpose was always for sale in the market. The situation was essentially the same for Sakholla.

Agricultural Practices

To prepare a seedbed for rice cultivation farmers usually purchased seed from the local agricultural office or neighbouring market, although some used their own seed. Nowadays they used a power tiller to prepare land. Farmers who did not have their own power tiller rented one from others at a cost of 25-30 Takas per *Katha*[5] of land. According to its condition land may need two or three treatments with a power tiller during a season. After the preparation of land farmers transplanted seedlings using hired labourers and/or family members. They needed at least 2 day labourers per *Katha* /day to do this. Two - three weeks after transplantation they needed to weed the rice. Before this project most of the farmers of Sakholla were not familiar with the use of herbicides and at Comilla farmers did not use it because they thought herbicides were harmful for crops and soil. According to the farmers weeding was crucial for a good crop but expensive because it was labour intensive. At this stage of cultivation day-labourers were not readily available and their rates were considered very high. They needed to remove weeds two or three times a season. Fertilizers were applied in two instalments although they provided an average of 5-6 kg of Urea, ½ kg of MP, 1-2 kg of TSP and 2 kg of Gypsum per *Katha* of land. During land preparation they applied the second instalment of fertilizer 25-30 DAT. In the Boro season after preparing the land farmers irrigated their fields.

After all these activities farmers regularly monitored crop progress. Many farmers visited their fields every morning. When they saw symptoms of infestation they discussed tentative control measures with the local retailer and nearby farmers. The research found that some farmers did not take any measures against insect pest and disease infestation. Most of them thought that they did not need to take any measures against infestation – that almighty Allah will keep their field safe from severe damage, although a few farmers did not apply pesticides because they practiced IPM. Some farmers did not use any insecticides due to a feeling that *‘it is very painful to kill a creature’*, although in cases of severe infestation they top-dressed with common salt as a manage measure.

After paddy ripening their fields were harvested by day-labourers and/or family members. After threshing and drying paddy was marketed in two stages; firstly a little was sold to pay day-labourers and other costs and secondly when the price of paddy had increased sufficiently

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[*] Dependents’ – too young or elderly to work. Although these members were involved in drying, threshing and other small works, they were considered as dependent family members.

[5] The measurement may vary in different areas of Bangladesh. Such as 1 *katha* of land could contain, 5.0, 9.5, 10.0decimal of land whether in Sakholla 1 Katha= 9.5 decimal of land.

they would sell the entire crop. To maximise income farmers normally sold the best quality rice in the market and retained lower quality paddy for family consumption. From land preparation to harvest all work was conducted by men while women were observed to be actively involved in threshing and drying. Poorer women worked in *bepari*'s rice stores at local markets but the study was unable to interview them or to photograph them working. Farmers cut and stacked their rice straw mainly for cattle food.

Land Tenure

A diversified system of land tenure was found in project areas and various terms used to describe them. At Sakholla these were known as *Borga, Ren* and *Tonko* and at Comilla *Borga, Bondhok, Poshani, and Laichcha*. With *Borga* and *Tonko*, if a farmer rented some land from another farmer (normally the owner of the land) for crop production, then the total production was distributed between the owner and the cultivator on the basis of a prior (oral) agreement. Usually both of them received an equal share from the total production, although the proportion varied in some circumstances. If the owner-farmer provided some money for seeds or fertilizer or any other cultivation requirement, he would receive a higher proportion of the crop. Different kinds of oral agreement may operate within these arrangements. If the owner only contributed the land he may receive half or one third of the total production. Even the owner-farmer can also choose not to take any risks with his return according to the production of crop. He can demand a fixed amount of paddy per unit area of land e.g. 1 mon (40 kgs.) per katha in a season.

Land *ren* is a system where the owner rents out his lands to other farmers for money. Until the owner pays back the money, the renting farmer gains the right to use the land for various cultivating practices. *Ren* and *Bandhok* are similar land tenure arrangements. Farmers at Sakholla called them both *"Ren"*.

Poshani and Laichcha tenure arrangements were similar, although renting farmers rented for a fixed period of time, usually one year. In the middle of the year the owner-farmer cannot pay back the money in these arrangements as cultivation costs vary from season to season so that renting farmers have an opportunity to use the land for making up the dry season's production costs during the wet season. If the owner-farmer wanted to regain management of his land he can pay back the money at the end of year or very early in a new year.

Constraints to Rice Production

The major constraints identified for the farmers to produce rice were given as insufficient day labourers, scarcity of money, insufficient fertilizer and high prices of inputs. The crisis over day labourers was severe within the project areas because of their high cost, due to a shortage of day labourers at the time they are required, which was linked to the availability of other work. They knew how to cultivate rice properly but as they did not have enough money they could not put their knowledge into practice. A good transportation system enabled poor villagers to move seasonally to towns or other places for better-paid work.

A few farmers also thought that there were technological limitations to cultivation. They thought that it is now a 'scientific era' (*Bigganer joog*), but that not enough scientific methods for cultivation have been introduced into Bangladesh. Natural calamities are another serious problem constraining successful cultivation (farmers of Sakholla had suffered severely from hail storms in Boro, 2002) and could do nothing but rely on Allah's mercy.

It was clear that farmers' status differed according to the types of constraints they faced. There was no unique way to overcome these constraints. Most farmers said that they could overcome/remove major constraints if they had enough money. They thought that it would be helpful if the government provided loans for farmers. There are few government loan programmes for farmers in local agricultural banks but the farmers said that gaining a loan from these banks was not an easy task and it was not available during crises. Also, in most cases farmers had to provide bribes to bank officials to secure a loan. Farmers have had bad experiences with local credit programmes operated by NGOs. They needed to pay higher interest rates than from banks and that often created further unease/economic crises.

Farmers felt that they invested a lot of money into cultivation because agro-inputs rates were very high, for which they got a low return. It would be helpful if there was a fair market system and fixed prices for paddy that ensured that benefits passed to farmers. In the current market system middlemen got the major benefits. Government/local administrators should be vigilant about businessmen and retailers who provided agro-inputs because they stored inputs for long periods in order to create artificial shortages and when prices inevitably rose they sold them and made excessive profits. It was assumed by farmers that locally operated agricultural training programmes could help them to minimize their cultivation costs.

Pattern of insecticide use and views about the side effects

Applications of pesticides are different in Boro and Aman seasons. In the Boro season there was normally enough water for irrigation. During the land preparation period farmers usually applied the first treatment of insecticides as granules mixed with fertilizers. In the Aman season they applied the first treatment of pesticide with the second application of fertilizer. Subsequent insecticide treatments depended on pest infestations (both in Boro and Aman). If farmers saw signs of infestation then they would go to the local pesticide retailers, describe the condition of the field and seek suggestions for management measures. Only a few farmers knew the brand names of insecticides that they used. Most farmers used whatever the retailers suggested. They believed that the retailer would not recommend anything harmful to their rice fields. Some farmers followed the measures taken by nearby farmers.

Some farmers needed sprayers for foliar application of pesticides. The study did not find a farmer owning a sprayer. Farmers rented sprayers from retailers. If the farmers sprayed the pesticides themselves it costs 1 Taka per Katha of land. It cost 3 Taka per Katha of land if someone was hired to do the spraying. The quantity of granular insecticide used may vary for different reasons. Farmers use 2 to 4 kg of granules per acre of land. They claim it was not possible to use the correct dosage as suggested by the retailer or as written on the cover of the packet because it cost too much. Very few farmers knew about appropriate pesticide doses.

Farmers views were mixed about the side effects of insecticides although the majority were aware of some drawbacks. The study found that generally farmers called pesticides ‘ *Bish*’, which means ‘poison’. Some farmers referred to the side effects of pesticides as ‘*Bish manei kharap*’ ‘poison means bad’ others said there are no bad effects of using pesticides but that they were an effective way to manage infestations.

Farmers who believed that pesticides had various side effects thought it may cause sickness in humans such as; giddiness, vomiting, asthma, weakness and other symptoms. Others felt that pesticides have great potential for indirect impact on human health, citing their use for suicide. Pesticides were also considered to be harmful to soil, beneficial insects, frogs and earthworms. They also thought that the fish crisis all over the country may have been caused by using pesticides. There were plenty of species of fish in Bangladesh before pesticides were used, whereas nowadays the numbers were in decline. The farmers interviewed thought this situation should be changed in order to:

- save the environment and human health
- prevent the loss of fish and
- prevent the reduction in soil fertility.

Some farmers thought there were no bad side-effects of pesticides, although they had heard about the bad effects of insecticides, they had not experienced them themselves. The farmers thought the problems could be overcome by taking precautions before applying pesticides, eg. by covering the face and not spraying into the wind. They noticed other farmers put the cover of the pesticides packet on a stick to alert others to the fact that the crop had been sprayed, because they were responsible if cattle of another farmer entered the field and then died.

Perception about the effectiveness of Mass Trapping

The research found a range of opinions from the farmers regarding the effectiveness of pheromone traps. A number of farmers interviewed thought that the traps were very effective in protecting rice from insect infestation whereas a few farmers considered the traps ineffective. There were very clear differences in perceptions between Sakholla and Comilla. Some of the farmers from Sakholla thought mass trapping was ineffective or were unsure about the effectiveness because the pest infestation was very low that season and most farmers in Adompur and Daulatpur (Comilla) felt that mass trapping was very effective as they had seen plenty of catches in the traps. Some of the farmers from both areas considered mass trapping was unsuccessful in respect of dealing with the complete pest complex of rice, even though researchers had made it clear that the technology was only meant for management of yellow stem borer.

Most of the farmers thought that the traps were very effective because there were very few whiteheads or dead hearts in their fields. Many of these farmers had seen insects in the traps (although the farmers at Sakholla also found the traps filled with mosquitoes and other insects). Usually they applied pesticides to keep rice field safe from insect infestation but during the trials they did not need to do that. They found the fields safe and yield was higher than for non-trial farmers. There were very few whiteheads or dead hearts in comparison to other seasons. Their view was that *"dhaan hoilo krishoker jibon* (rice is the life of farmers*)*. Farmers really suffer from severe infestation of stem borers. Rice fields were free from infestation due to PT. As traps seemed effective, this seemed to them the way to future improvements. When told that some farmers thought the traps were not only ineffective but also a *Hibijibi* (complicated process), they said that they had also argued with other farmers that it does not a matter if insects were not in the traps. They wanted their rice fields to be free of the symptom of YSB infestation. If they find very few dead hearts and whiteheads in their fields then number of catch was not their concern. The important thing was that there were very few dead hearts and whiteheads in the fields. As they had not used any pesticide, this was due to the effectiveness of the traps. They raised one further point that if the traps were ineffective then why did farmers not return the traps to the trial team and why were there quarrels between farmers when traps were stolen.

…traps were not effective because there were many stem borers in my field although there were four traps in my field.

Farmer, Sakholla, Mymensingh

…effectiveness of traps was not very clear to the farmers because infestation was very low (almost none) in this season. So how can farmers understand the effectiveness of the traps.

Farmer, Vaitkandi Bazaar, Mymensingh.

A few farmers (mostly from Sakholla) were unconvinced about trap effectiveness because:

1. they observed that infestation was very low during the Boro season throughout their locality. Whenever there was a very low infestation they could not be certain whether the traps were effective or not, because they did not know how they could assess the effectiveness of a new method in this situation.
2. They thought that there were very few dead hearts and whiteheads inside the trial area and very good yield in trial fields but weren't sure what was happening in other fields where no traps or even pesticides were used, and yet infestation was low and yields were good. For this reason they were not certain that traps were very effective.
3. Also, their own good yields could have resulted from better cultivation during the trial by the trial team, through the usage of herbicides, correct dosage of fertilizer and general management.
4. They also said that the weather was not in favour of stem borer infestation whereas stem borer caused less damage during the Boro season than during the Aman season.

The process for using traps was more complicated than applying pesticides. Providing glue in the traps and removing insects regularly appeared to be a problem to farmers. Quick and visible impact of insecticides on insect pests was another important reason why some farmers insisted on staying with pesticides. When farmers applied pesticides in their fields they were used to seeing that all insects were dead, whereas in the case of traps, they had not seen any insects (in the Boro season). Seeing dead insects was a very important factor in the psychology of farmers and their perception about the effectiveness of a technology. As there were only a few insects in the traps in Boro season, some farmers thought that the traps were ineffective. They will not use the trap again for these reasons. At best they will observe the process and effectiveness again when some other farmers use it. If they find it appears to work then they will adopt it.

A difference of opinion/perception regarding the effectiveness of mass trapping for control of SB amongst the farmers in Sakholla and Comilla was apparent. Because infestation and trap catch were low during the Boro season many trial farmers were not sure about the effectiveness mass trapping. In Comilla there was a very good trap catch and farmers' perception was clear. It can be said that due to a low infestation and comparatively complicated trap design, a number of farmers were unsure about the effectiveness whereas in Comilla trap catches were higher with another type of trap design implemented in the trials and this was felt to be effective. Therefore trap design, particularly easiness of use, needs to be considered if farmers are to adopt them.

Role of Local Retailer

A range of agricultural inputs and pesticides were freely available to farmers in local markets, which plays an important role in Bangladesh agriculture and agribusiness. There was at least one agricultural store in each local market in the project areas, sometimes more. Normally these are open every day but more farmers come to these shops during the weekly *haat* (market day). The study observed that many farmers came to the retailer shop with different cultivation problems. Most explained to the retailer the condition or symptom of their fields, seeking remedial measures and usually accepting their suggestions. Only a few farmers were buying pesticides with brand names or were trying to select according to the price and their knowledge of the effectiveness of various products and different companies. Farmers relied on retailers' suggestions because they believed that for the sake of their own businesses he would not suggest anything that might cause damage to crops. Farmers believed that as people go to the doctor or physician because of health problems, they go to the pesticide retailer with rice cultivation problems. Farmers often said to the research team that, '*retailers are doctor/physician of pest or rice field'*. For local pest management practices the research observed a very strong role for pesticides retailers.

The research found that no retailers in the project areas had any agricultural pest management or other relevant training, although one of them had formerly received short training on pest management from Ciba-Geigy (forerunner of Syngenta). This is the general scenario throughout Bangladesh where only a few retailers have any agricultural background or training in pest management. Dealers are running their businesses on the basis of their experience and knowledge developed through providing farmers with information and pesticides. If they received proper training it would enhance the pest management measures and programmes (i.e. IPM, PT etc.).

Missing Pheromone Traps

Traps and some other inputs were provided to trial farmers throughout the project period. Although watchmen were appointed to every trial a number of traps were lost, pulled out or stolen from project trials. It may appear to be a problem of using pheromone traps but probably reflected a general problem with introducing any new technology. Farmers who had lost traps thought that it may have happened for the following reasons:

a. Jealousy
b. Made of good quality wood
c. Uninformed about proper use
d. For personal use
e. Curiosity

Some farmers thought that there was a lack of carefulness in looking after traps because they were provided free of cost. They thought that when farmers buy them they will be well informed about the method and effectiveness of the traps and be more careful to protect and look after them in their fields. Once a farmer knows the method, process and the effectiveness of trap then their consciousness will increase to prevent such mishaps. Also if farmers were able to make traps with relatively cheap local materials then a stage may be reached where theft was less likely.

…think about the shallow tube wells when it was initiated, farmers were very careful about its handling and they did not allowed the children around it. Nowadays it has become very easy for farmers to obtain and they just leave it in the field for the whole season and they are sure that no body will create any problems. When traps are available and popular to the farmers then the possibility of theft will be removed.

Farmer and Schoolteacher, Sakholla, Mymensingh

Price Assumption of PT by The Farmers After Observing The Project Trials

Pricing is important when marketing a new technology. People do not indicate their interest for an expensive technology at the start no matter how effective or exclusive it is. The farmers interviewed thought that if it was possible to fulfil their requirements with conventional methods, why pay additional money for the same purpose. They can turn to new technology if it appears cheaper to them. The study observed that effectiveness and toxicity level are the other aspects involved in introducing a new technology. As the majority of farmers were either smallholders or those with modest incomes, price was the key issue and they would usually compare it with other available products in the market. To understand the farmers' views on this, they were asked to assume a price for PT even though they were well aware that they had no role in pricing PT, which is dependent on production costs and company policy. Farmers responded very well with different opinions but significantly they expected that its price should be lower than pesticides. Some other farmers thought that as they had not realized or felt any side effects of PT so if the price is equal to pesticides they would buy it. Only a few farmers felt that if pesticides were banned in the near future they would pay a higher price for PT than currently paid for pesticides. Farmers would have to buy it because then there would be no alternative.

Farmers based their price calculations on what the material costs could be expected to be for a trap. That is, there are many plastic containers or jars available in market for household use from which to construct a trap. In comparison the plastic cylinders used in the trials were at least 5 taka each and the highest price for one pheromone lure should be 10 taka. As two lures are needed each season, this incurs an additional cost of 10 taka; so according to their calculation for the whole season one trap would cost 25 taka. Although there might have been some problems in their calculations, if one trap requires 25-30 taka for a whole season then farmers would buy them. With 8 traps/acre of land farmers would spend 200-240 taka/acre for mass trapping which is a bit less or close to their usual pesticides costs. Insecticides are only generally applied to control YSB.

The average cost of insect management per acre for all farmers Comilla was 177 taka per acre which rises to 184 taka per acre if we take out those farmers who don't undertake insect management. The average cost insect management per acre all farmers in Sakholla was 102 taka per acre and this rises to 140 taka per acre if we take out those who don't undertake insect management.

So in both cases the cost of mass trapping would be significantly higher than current insect pest management costs, although it is similar to pest control costs employed by farmers in Comilla. Nevertheless, if farmers believed the technology was efficacious then they may well adopt the technique but use less traps per unit area to reduce costs much in the same way as they under-dose with insecticides and this process would be helped if they reduced their cost of weeding by adopting herbicides.

…. farmers are unable to assume traps price and what they assume that will not have any impact on company's pricing. Because only company knows what is the manufacturing cost of these traps but they should consider the farmers side and try making it within the farmers affordability.

Farmer and businessman, Adompur, Comilla

…for implementing a new technology, pricing is very important. A company should fix the price lower at initial stage and when it will be popular to the farmers then they can increase its price gradually. One more thing is very important that the company should be very careful about the adulteration of the product other wise farmer will suffer for that and ultimately they will not use it.

Farmer and day labourer, Adompur, Comilla

The main objective of introducing a new insect pest control technology in the agricultural sector is to help resource poor rice farmers produce a better crop at a sustainable production cost whereas farmers are conscious of the business policy of pesticides companies, which is to make profits. What the farmers feel is that profit is a must for a business company but they should consider the farmers side and fix the price so that farmers can be benefited. If farmers feel they are deriving benefit, a company's business should be enhanced, all things being equal. From the farmers point of view adoption of a new technology also depends on a product's quality and the provider's good standing. So companies should be careful about quality and prevent adulteration of active compounds by other companies.

Social interest

The pheromone trials created social interest and were a topic of discussion among farmers and villagers. Farmers who had not received any components from Syngenta or did not participate in the trials were greatly interested in them and all it they entailed. People from other villages and many passers-by were also very curious. They wanted to know what it was for, how it worked, is it useful, does it work etc. The villagers have tried their best to answer all these questions and often discussed the trials among themselves. Some of the farmers who participated of the trials told the researcher that they were tired of answering all these questions from other people. They said that they had tried to inform other people as far as they knew about it and in addition to this they suggested that it would be better to inform more people about the trial and trial results. They believed that if the entire community of farmers become well informed about the trials then it will be easier to implement this technology. Once people were aware about the technology, the level of their social interest would increase and more farmers could adopt mass trapping as a result.

I have explained about your project to many other farmers and passers-by from other villages.

Grocery shopkeeper, Vaitkandi, Mymensingh

…farmers made me tired about asking all about it and I listened to discuss themselves in tea stalls or other small gathering. …they told me that I have to sell it near future.

Pesticides and agro inputs retailer, Adompur, Comilla

5. Discussion: factors influencing farmer adoption of IPM

5.1 Review

The research has shown the importance of a range of factors which influence farmer's adoption of technology as it relates to pest management. These include: farm size; availability of labour; access to credit/cash; training; the role and training of pesticide dealers; price and perception of pest importance.

From this research, it can be seen that for farmers to adopt a new technology such as IPM, it must fit with their social behaviour, cultural attitudes/practices and financial abilities otherwise they may refuse/reject it after one or two seasons/years. For successful implementation of mass trapping sound technical back-up, information and advice are essential for farmers because the methods and processes are new to them. The training of local retailers will be useful to motivate local farmers as they play a key role in local pest management practices and farmers trust them (see role of local retailers). Syngenta FFS can provide significant support in this regard and partnership with DAE and other NGOs could be another pathway for the implementation of mass trapping. This is very important as mass trapping requires collective decisions. It is essential to select a user-friendly trap design that provides farmers with a visual and direct impact of its effectiveness. As price is one of the key factors for farmers, it needs to be considered carefully (see farmers price assumption) and should be fixed lower than conventional pesticides.

5.2 Other recent adoption-related research in South Asia

Other socio-technical studies in the region are largely consistent with the findings of this research.

In earlier CPP-funded socio-technical research on the application of mating disruption to management YSB in India (Cork and White, 1999; R6739) a range of factors were found to influence farmer's pest management behaviour. These confirmed the pre-eminence of pesticides, the importance of folklore pest knowledge and investment risk aversion. Poor farmer understanding of alternative technology tested by the researchers and an approach by intermediaries that was insensitive to the central importance of farmers perceptions were found to limit the prospects for adoption.

A socio-economic study contribution to the understanding of pest and natural enemy interactions in low input rice systems in Bangladesh (Robinson and Das, 2002), confirmed the importance of pesticides and found that for pest management: poorer farmers were constrained by cash for inputs; simple decision rules were used; symptoms, not pests were looked for, and all insects were grouped as pests with their limited concept of natural enemies. Farmers were classified as either: risk averse and unconstrained; risk averse but cash constrained; choose only to use pesticides after pest attack, or were trained not to use pesticides. It was recommended that this latter group would also 'require top-up training'.

5.3 Mass Trapping as a Component of IPM

Farmers believed that SB/YSB was the most harmful pest for rice production. Because infestation was low in Boro 2002 farmers were not sure about the efficacy of the mass trapping trials. However, after observing the huge insect catch in the 2002 T. Aman trials (*Choudhury and Motaleb*, 2003) they believed that it was possible to manage the infestation of YSB by using mass trapping. Farmers have shown a high level of interest about the project and using mass trapping as a component of IPM/ICM. They realised that conventional pesticides have many side effects on human health and the environment. Because of the activities on crop protection and IPM in particular of the DAE and NGOs, a number of farmers were aware of the IPM concept although their knowledge was neither complete nor uniform. Many of them thought that IPM could be an alternative to conventional pesticides but the dilemma was that, although they thought that IPM was effective or 'good', they did not practise it (see IPM knowledge).

Although IPM can be said to provide the basis for traditional agriculture, its importance grew over the past 40 years as the side-effects of chemical pesticides became better understood and that reliance on chemicals for insect management was unsound. It is now generally accepted that IPM is an approach to pest management which minimises reliance on agrochemicals and combines, integrates, a mix of appropriate technologies, which will differ according to the farmers, pest and crop context.

Formal IPM activities started in Bangladesh in 1981 with the introduction of the first phase of Food and Agriculture Organization (FAO)'s inter-country programme on rice IPM. Initially DAE staff were trained by FAO and then FFS were set up to train farmers. NGOs took over training at a later stage and they themselves undertook projects with foreign funding to popularise IPM (Main Uddin Khaja 2002).

Major programmes for introducing IPM were the DAE-UNDP/FAO IPM Project (operated by DAE and selected NGOs), Strengthening Plant Protection Services (SPPS) Project (funded by DANIDA and Gob; executed by DAE), No pesticide approach of CARE Bangladesh etc. Syngenta Bangladesh Limited has its own IPM training programme that teaches farmers to adopt cultivation using all available means of combating pest and disease attack. These programmes tried to transfer the following messages to farmers:

1. Preserving Useful Insects
2. Using HYV
3. Modern Cultivation System
4. Mechanical Management
5. Using Insecticides

Although it was meant mainly for the farmers, it would appear that this group was the least familiar with the concept of IPM (Khaja, 2002). Most of IPM programmes encouraged farmers to estimate the economic threshold level (ETL)[6] before applying pesticides. The research found that farmers find the IPM approach complicated and do not follow it. For them, the use of pesticides has become popular and they were not inclined to practise IPM if it required more time. Through research the study has not found 5% of infestation or more in any area or in any season. Generally, there was a higher infestation in the Aman season and a

[6] ETL indicates the level of infestation when farmers require applying pesticides in their rice fields. The farmers are suggested to apply pesticides if there are 5% or more dead hearts in rice fields. IPM programmes teach the farmers to determine ETL - farmers should go through one hundred hills (rice plant sites) in their rice field and if they found five or more dead hearts then they have to perceive that the infestation has crossed the ETL level and requires applying pesticides.

low infestation in the Boro season. If the farmers realized the IPM training messages properly, they would appreciate that there was no need to apply pesticides, especially during the Boro season when less infestation by SB occurs. The study observed that farmers applied pesticides in both seasons from their ***fear of risk***. When farmers find a few dead hearts in their field they go to the pesticide retailer and apply pesticides to avoid a greater risk at the end of the season.

Another important issue is sustainability of training programmes. It is expected that farmers will learn a process and adopt it within their pest management strategies. But the study found that although farmers believed that IPM is *good* and *effective*, they did not practise it, but continued to depend on chemical pesticides. Programme planners have the notion that they have operated the programme effectively with the statistics of their success. In the SPPS, it was claimed that the programme has reduced pesticide use by 90 per cent. But the question is, "How many farmers were practicing IPM after the completion of IPM training in that particular season?"

The present study found that only a handful of farmers were trained within the population of the area, of which only a small percentage were still practising IPM. Some of the farmers have the idea that application of mass trapping appeared quite complicated (*hibijibi*). When asked about their pest management practices, they agreed that the use of alternatives to pesticides were troublesome whereas they are familiar with pesticides. So it can be expected that they would gradually accept mass trapping as a management technique. For mass trapping to be effective, price relative to the farmers' economic affordability and clear information about the method of use, need to be ensured. Farmers expressed the view that IPM required a proper care and lot of time but often it was impossible for them so after feeling IPM was a useful method of pest control they did not practise it. Monitoring programme adoption is needed to ensure that farmers practise the methods learned during training.

> *Bangladesh farmers, except a few of those who have received season long practical training in Integrated Pest Management (IPM) are less capable of taking decisions on pest management and pesticide application. They do not survey the fields on a regular basis for pest problems. Often they apply pesticides when there is no real need. Prophylactic application or pesticides are common. Many times they end up using wrong chemical at wrong dose and time wasting their money. Sometimes they depend on the local pesticide dealers for the selection of the type of pesticides.*
>
> Draft IPM Policy Paper

In respect of IPM, farmers may be giving answers they think programme staff want to hear. During the study, it was found that among the total respondents 34% of farmers received IPM training and only 14% of them (5% of total respondents) were practising the technique. On the other hand 85% of farmers interviewed said that mass trapping was effective and 88% showed their interest on using it when it became available. The validity of this high interest was then checked by offering farmers the option of purchasing PT at a token price that was very closely related with farmers' price assumption. The project team as well as the local retailer had done initial groundwork by helping farmers to understand the method and promoting purchase. At first farmers said that they would buy PT but most of them did not. Only eight farmers from two different fields bought traps. Farmers who had changed their minds informed the study that they did not want to take the risk and use a new technology with their own money. On the other hand those farmers who had purchased PT's were very happy about their effectiveness and eager to use them in following seasons. There were some farmers who having observed the successful adoption of mass trapping by neighbours were interested to try themselves next season. The user farmers wanted to motivate neighbouring farmers to use mass trapping rather than take risks with the environment by using pesticides.

The aim of this project was to implement mass trapping as a component of rice pest management. Syngenta Bangladesh Limited have their own FFS programme and this could be used for transferring messages about mass trapping but there was no FFS in last T. Aman and Boro season at Comilla where the trials were conducted. To ensure sustainability Syngenta should design its FFS with sound technical information to be presented in an understandable way to farmers. Proper monitoring of this training is a pre-condition of successful technology transfer.

5.4 Interest in using herbicide

Management of weeds is one of the most expensive activities of rice cultivation. Good weeding is a pre-requisite of a better crop. The project used herbicides in pheromone trials. Farmers gained direct experience of its use and showed a high level of interest in adopting it.

Farmers usually hired day labourers for pulling weeds. Day labourers were either unavailable or not sufficient at the weeding stage of the rice crop. As a result farmers have to pay high day labour costs during those periods. Good weeding requires two day labourers per *Katha* of land and may need to be done two or three times in a season. Farmers have to pay 80-100 Taka/day per labourer plus lunch (or 1 kg rice) whereas in other parts of the season, a day labourer can be hired at 60-80 Taka/day. Before the trials there were very few farmers in project areas familiar with the use of herbicides because this was a new technology. Farmers liked the herbicides that had been used in the trials. There were no weeds in the fields inside the trial area, so they felt relieved from high cost of weed management. They felt it was the best among the products that have been used in the trial. They will use it from the very next season. Some of the farmers thought the trials were only on weed management and use of herbicides. The important issue was that farmers had seen the effectiveness of the herbicide and this was reflected in their quick and positive comments on the technology. When asked about their interest of using mass trapping in their rice fields they said, "*if the trap is as effective as Rifit*[7] *then we will use it".*

5.5 Comparison between the farmer's view of herbicides and pheromones

The farmers in the project areas were sure that they will use herbicide *(specifically, those used in the trials)* from next season but not sure of using mass trapping immediately. From project trials farmers perceived that herbicide was very effective to the management weeds. Farmers rice cultivation practices were in favour of herbicide using i.e. high day labour cost and crisis of day labourer. Application of herbicides was easier (similar to pesticides) and usefulness was very clear whereas some farmers felt that using mass trapping was complicated and they were not very sure about their effectiveness.

Price was an important factor in farmers' interest in using herbicides. Herbicides required only 1/3 to 1/4 of the cost of total day labourer cost in a season. That meant that use of herbicides would reduce farmers' total production costs significantly. It was clear to the farmers that ultimately they would derive more profit using herbicides. In case of mass trapping farmers were not sure about its price so they are unsure about using it. When farmers are informed about the price of traps they will use it if they feel it is within their range of affordability.

Another significant issue was the autonomy of decision making. If one farmer decided to apply herbicides he does not need to convince other farmers to use it. Mass trapping, on the other hand, requires collective use and farmers are not sure about the effectiveness of mass trapping if used individually (even the project team do not have any idea in that regard). No one would want to take the responsibility for a collective decision and the risk for oneself by using mass trapping individually.

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[7] *Rifit* (a product of Syngenta) is the herbicide that was used in the weed management trials.

It is essential to select a trap design that has the potential of visual and direct impact of its effectiveness and cost-effective price (farmers perception are highly relevant in this regard). From past experience in using fertilizer, STW and Power tiller it can be assumed that if the farmers feel the technology is effective/useful and cost-effective, most of the farmers will adopt it into their cultivation practices. It may take few seasons/years but it is possible to implement mass trapping by considering above issues and with appropriate monitoring.

5.6 Collective action

Using pheromone traps requires a certain level of collective action. In this regard the farmers were asked if they would be able to use it collectively or not. Their responses were very interesting. They believed that recently in Bangladesh there has been a considerable increase in farmers' awareness about the agricultural practices. Although, they were not disposed to using anything that may cause damage to crops but on the contrary they said they were always in search of a better options. If one farmer observed his nearby farmer using something new that was useful and cost effective then he will ask that farmer about the process. If it seemed to be an appropriate technology then he would try to use it in his field the next season. They also indicated that, if all of them think that this method/technique was useful and cost effective they could use it collectively. NGO's can also help them to make collective decisions.

5.7 Farmers' interest on using a new technology instead of insecticides

Most of the farmers said that they would use the pheromone technology; while few farmers said they would not and some farmers did not answer the question. Farmers would use a new technology instead of pesticides for the following reasons:

- If it seems effective
- If it is cost effective
- To management insect pest without pesticides
- Human health and animals must be protected as well as crops
- If other farmers use it

After the T. Aman season in 2002 farmers of Adompur felt that mass trapping was effective and expressed great interest in using it from the next season or when it becomes available in the market. From the discussions with farmers it was observed that although earlier they had indicated that IPM was effective, they did not practise it in their fields with the exception of very few farmers within the project area. So, two questions had arisen from the research

- 'Would similar thing occur for the implementation of PT' and
- 'Is it the general picture for farmers that they appreciate a new technology or programmes (as they get some benefit in that particular season) and express interest in using it?'

To get the answer to these questions the project decided to sell 50 PT through a local retailer at a token price of 10 taka/lure and 5 taka/plastic cylinder. This price was based on farmers' price assumptions. A local retailer was there to assist the farmers to use the PT. Initial promotional groundwork was undertaken with farmers and the retailer by the project team. The retailer was requested to try to sell it based on a farmer's willingness.

Initially farmers were very happy that PT's would be available at an affordable price. Later however, they requested the retailer to sell them PT's in credit. Although the retailer expected to sell 30 PT's to farmers for 3 acres of land in one field, eventually this figure was reduced to 7 farmers who purchased 17 PT's with cash. Another farmer, who was absent earlier, was convinced and very keen to buy PT's. After discussions with the principal researcher, this farmer persuaded three other farmers to use PT and together they bought 13 PT's from the retailer.

Farmers who initially agreed to buy/use PT and did not subsequently use them were not sure about its effectiveness. They wanted to observe what happened to other farmers and not to spend money with uncertainty. This uncertainty implied that sound technical back-up information for the farmers is mandatory for PT implementation. Because of their significant role in local pesticide application practices training of local pesticides retailer's would be very useful for farmers' motivation. Partnership with DAE and local NGOs could be built up to assist monitoring the progress as the study had found that there are too many trials and projects for farmers *(non-sequitur)*. Most of these projects were failing to sustain their achievements within next few seasons.

Some farmers said that they would not use IPM because they thought it was difficult. IPM is a time-consuming pest management strategy and they said they did not have enough time to care intensively for their crops. A new technology like IPM also requires collective decision, and it is much more difficult to get other farmers to act in concert than individually, especially when it is directly related to crop production. Who will be responsible if an individual suffers from yield loss or some thing else. No one will take the risk of bringing a new technology to other farmers for a collective decision. It is easy for those farmers who were directly involved in the project trials to use a new technology for themselves only. But quite hard to convince other farmers if they were not well informed about the new technologies or its effectiveness, in particular. So, without the assurance of certain benefit, farmers who are not well informed about the new technology would have difficulty in adopting mass trapping instead of a conventional pest control method.

6. Further research

Possible areas for further research

The central questions are:

- was the technology appropriate to farmers, and
- will farmers adopt it?

The considered view of all stakeholders is that the technology is appropriate:

- Farmers say they will use it, but it seems more complicated. They ask if seasonal variation in pest levels are the real reason PT appears effective.
- Researchers believe it is appropriate in seasons where YSB is a problem, with some fine tuning. There is a need to monitor pest populations with the technology in order to establish early enough in the season whether there is a problem.

The dilemma here is that with rice pest management, farmers are used to taking remedial rather than preventative action. With PT's, because of its 'slower' action, the manifestation of the problem comes too late for the technology to be effective. The technology needs to be used as an insurance rather than for post-attack pest management.

Natural scientists do not accept this view because farmers were found to apply granules at the same time as fertiliser which is a 'preventative' action. If farmers applied insecticides once having seen crop damage symptoms, and in particular white-heads, it would already be too late and the remedial action would be ineffective. By monitoring the crop with pheromone traps mass trapping can be applied later in the season, if required, thus avoiding the cost of taking a preventative action.
Training for farmers and pesticide retailers.

Adoption process
Further study of the dichotomy between farmer's statements and actions. IPM is appropriate, but farmers were not using it this season. Pheromone traps (PT's) were seen as appropriate,

and although they were expected to adopt it few farmers took up the offer. They may be waiting to see if the pest arrives, but if it does, by that time it may be too late to use PT's.

Farmers believe adoption will take some time. What factors influence this?

Reasons for the mixed perceptions among farmers about PT's.
The quality of IPM training and IPM training material. Also review effectiveness of existing NGO training in rice IPM: CARE, DANIDA IPM, SAFE, Proshika and RDRS.

The effect of pesticide dealers on IPM adoption; if Syngenta has trained 10,500 over 5 years in IPM-related technology; what effect has this had?

Marketing issues; is there potential to exploit crops produced under IPM systems?

Collective/community-based adoption of mass trapping technology.
Costs of training with different options, and are they appropriate?

Explore models for partnerships between private sector, government and NGOs in assisting farmer adoption. Comparative studies with other countries within the SE Asia region where Syngenta is marketing products to help throw light on the adoption issue and also point the way to the potential for the adoption of the mass trapping technology. Could be a Y2 activity. Possibilities for Nepal, Vietnam, China, Laos?

A similar project in India, directed at the same pest and using an associated technology, had uncannily similar results. Farmers stated their interest in adopting the technology, but these intentions were largely un-sustained after the project withdrew, although, the lack of sustainability was primarily due to an absence of product in the market place. Can any lessons be drawn by comparing the two projects?

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Appendix-1 The Survey questionnaire

NRI/SYNGENTA/ BRRI PHEROMONE PROJECT FOR RICE STEM BORER

QUESTIONNAIRE FOR BASE LINE SURVEY, September 2002

INTERVIEWER DATE LOCATION

1.RESPONDENT'S PERSONAL INFORMATION

Farmer's Name	Age	Sex	Edu. Qualification.	Main source of income	Secondary Source of Income

FAMILY MEMBERS

Working Male	Working Female	Working Total	Non-working Male	Non-working Female	Non-working Total	Total Family Members

2.RESOURCES

QUANTITY OF LAND

Distribution of land	*Cultivated for rice (Aman)*	*Others (specify)*
Inside Trial area		
Outside Trial area		
Cultivated by own		
Rent From Others		
Rent To Others		
Total Ownership		

EQUIPMENT For CULTIVATION (In Numbers)

Animals	**Implements**		
Livestock	Plough	Tractor	Others

3. CULTIVATING PRACTICES

LIST OF MAIN CROPS THAT YOU CULTIVATE IN A YEAR (ROTATION OF ROPS)

No.	Name of the crops	Duration	Purpose
1			
2			
3			
4			

ACCORDING TO YOUR OPINION THE MAIN INSECT OF RICE IS

Name of the Insect	Season	What measure do you take against this insect?

LIST OF OTHER RICE INSECTS

No.	Name of the Insects	Season	What measure do you take against these insects?
1.			
2.			
3.			

KNOWLEDGE OF STEM BORER

Do You know about stem borers	Yes No
Do You know what is YSB	
If yes, How to identify it?	
Approximate yield losses caused by YSB	
Frequency of damage: Every season?	
-Any particular season?	
-What part of the season?	

COSTS OF RICE PRODUCTION IN AMAN SEASON

Components	Amount	Notes
Seeds		
Land preparation		
Transplanting		
Fertilizer		
Labour (Permanent or Seasonal)		
Weed management		
Rat management		
Insect management		
Disease management		
Harvesting and threshing		
Total		(Per unit)

4.CONSTRAINTS

No.	What are the main constraints to produce rice?	Your suggestion: How could this constraint and difficulty be removed
1.		
2.		
3.		

5. OTHERS

IPM KNOWLEDGE

►Do you know about Integrated Pest Management?

□ Yes □ No

If Yes,

What do you know	Source	Your opinion	Reason

►Are you interested to use an IPM method to management insect (e.g.YSB)?

□ Yes □ No

If yes, why?

►Do you know of any side effect in chemical or current insecticides?

□ Yes □ No

If yes, what are they?

___

___

►Do you think this situation should be changed?

□ Yes □ No □No Comments

If yes, then why

___

___

►Do you have any comment or suggestion for this change?

___

___

►Are you interested in using any new technology instead of insecticides?

□ Yes □ No □No Comments

If yes, then why

___

___

►What should be its price (if respondent's previous answer is yes)?

□ Less than insecticides □ More than insecticides

□ Equal to insecticides □ Others

Thank you.

Appendix-2: The checklist for in-depth interviews

- General personal information (family members, source of income, educational status) resources, land inside/outside trial area, cultivation equipment, livestock.
- Cultivation practices throughout the season
- Knowledge of SB/YSB and other pests
- Informed about the trial/project? What does he know?
- Does he know the name of Pheromone traps? What does he know about its structure, methods and usage?
- Has he seen any pests in the traps? What are they?
- What does he think about the effectiveness of traps? Why?
- Is he interested in using pheromone traps during the next season when it will be available in the market?
- Then what should be its price? Assumption could be made in comparison to conventional pesticides?
- Does he think there are any limitations of pheromone traps (its structure, method, application, efficacy, collectiveness, theft possibilities etc.)?
- Is he aware about the side effects of pesticides? What are they?
- Compare different aspects between pheromone traps and pesticides such as price, usefulness, side effects, longevity etc. and then ask the informant farmer about his interest in using pheromone as a component of ICM.
- Knowledge of IPM→source→opinion→reason→current status→reason. Will the same thing happen as with pheromone traps? Why not?
- Constraints of rice production? Their suggestion how these can be reduced?
- Suggestions for the implementation of pheromone traps
- Will the necessity of collective using be a bar for pheromone traps? What does he think?
- How does he buy pesticides?
- Did the trials created any social attention?

Appendix 3: Case Study: DAE's Agricultural programmes in the project area

Upazilla Agriculture Offices (UAO) are actively concerned with local agricultural practices. UAOs working with grass root level farmers through the department of agricultural extension (DAE) on behalf of Ministry of Agriculture (MoA) in different programmes collaborated with NGO/INGOs. These programmes are designed to improve the awareness of farmers or implement new technologies relevant to farmers' practices in agriculture. Processes and outputs of these activities/programmes **can provide significant insight into how mass trapping could be implemented** at the farmers level.

IPM Training Programme

A collaborative programme with DAE and DANIDA was implemented from 1998 to 2000. In this programme they provided training to farmers on how to identify useful and harmful insects and information about proper cultivation methods, diseases and fertilizer. The practical information was passed to farmers in 14 three to four hour practical sessions. There were five main components to the programme. Those were:

1. Preserving Useful Insects - By using sweeping nets insects were collected from the fields. Then they destroyed the harmful insect pests and made the useful insect pests free, as it will destroy the harmful insects again.

2. Using HYV - Trainings insisted the farmers to use high yielding variety (HYV) seeds as these have some good capacity to be safe from different diseases and insect pest infestation.

3. Modern Cultivation System - Farmers suggested from the training the need for knowledge on 'modern' practices that are effective and ensure better yields. They suggest the farmers' use line sowing, using same variety, sufficient fertilizer (not to apply excessive or very little fertilizer), transplanting and harvesting in the same time.

4. Mechanical Management - The trainers informed the farmers about mechanical measures such as leaf cutting and using of sweeping net etc.

5. Use of Insecticides - this programme requested farmers not to use pesticides as the first management measure of low infestation but only in case of emergency (severe infestation by the insect pests) and when there is no other alternative then farmers can apply pesticides to their fields.

They trained farmers to use insecticides in the proper manner. They provided a local principle, *OSMANI*, who insisted on using insecticides at the right time, right dose and according to the rules.

Soil Fertility and Fertilizer Management Programme (SFF)

This programme was conducted to ensure and increase the existence of nitrogen and other components. Main objective of this programme was to ensure the good health of soil and then according to the condition of soil determining the dose of fertilizer and the crop cultivation pattern. Wherever there is a limitation of adequate soil test due to technical support "*Fertilizer Guide*" has been followed in this programme. **Women** were included in this programme as they play an important role in harvesting and threshing as well as kitchen gardening. Biofertilizer making process was another objective of this programme as alternative to chemical fertilizer.

Smallholder Agriculture Improvement Project (SAIP)

This is a joint project collaborated with International Fund for Agricultural Development (IFFAD). There are two main objectives of this project. One is poverty elimination and the other is increasing the nutritional value. This programme is designed to improve the smallholding farmers of Mymensingh, Jamalpur and Sherpur district. IFFAD, Government of Bangladesh (GOB) and DAE have selected some NGO's for this purpose. NGO's having previous experience on community development works selected number of groups of farmers and provided training to them how in small area cultivation could reach towards maximum benefit.

All these activities are maintained, organized and conducted by the Block Supervisors (BS). A number of BS were working in the project area by segmenting the area in different blocks. BSs play an influential role to the grass root level farmers as they work; teach/train these farmers very closely. Although farmers blame some BSs that they can not found the BS once in a season but those BSs who works properly farmers seek and rely on their suggestion regarding different agricultural and pest management practices. UAOs run these programmes as demonstration work that must be conducted in farmers field trail. Before starting a demonstration necessary training would have been provided to the related farmers.

Beside these, UAOs are working with other small projects like vegetable farming; kitchen gardening and proper application of fertilizers. Agricultural officers, Additional Agricultural Officers, Agricultural Extension Workers, Agricultural Engineers and Field Monitoring Officers are involved with these activities.

Appendix 4: Case Study - Purchasing pesticides in project area

Farmers of the project area generally buy pesticides from the local retailer shops. Some of the farmers travel frequently to a nearby town and buy pesticides. There is at least one or two pesticides and fertilizer shop in every local bazaar. Pesticides from different companies are available there. One can find the products of Syngenta Bangladesh Limited, Shetu Pesticides Limited, Corbell International, Padma Oil corporation etc. Products of Shetu and Corbell are mainly available in these shops because the retailers receive the highest commission from these companies. Retailers get these products in credit from these companies. Retailers can pay their price after selling their products. It could take time, which varies from two weeks to one month. In Vaitkandi bazaar one retailer purchases the product of Syngenta Bangladesh limited but the other one does not. Retailers said that it is just a little problematic to purchase the product of Syngenta because they have to pay some advance to the dealer of Phulpur as security money.

Hence, profit from Syngenta product seems to them as very marginal as they perceive (built on their own experience as well as the experiences of other farmers) that the product of Syngenta and the other companies are more or less same. So they are more interested to sell the products of those companies who did not require an advance payment. Some of the farmers are very keen to use Syngenta products by brand name, as it seems that Syngenta products are the best. The name of *Basudin* and *Rifit* could be mentioned at this point. These farmers are not any more interested to use the alternative of these products. If those products are unavailable at Vaitkandi bazaar they buy it from Phulpur. Though the costs of these products are comparatively high, they are not interested in using other products. One example could be cited here. From last two years farmers of Sakholla have started to use herbicide (not every farmer but many farmers) to management weed in their field. First year they have used *Machete, Ronstar* but they were not totally satisfied with its effectiveness as there were some weeds in their field even after using these herbicides. This year they have used '*Rifit*' and they were totally satisfied with *Rifit*'s effectiveness as there were no weeds in their field according to their opinion. Farmers' impression of a product's effectiveness is quite important at this example as they are not yet sure to use pheromone traps but they are very sure of using Rifit from next season. Rifit costs highest among the herbicides available at local market but farmers are ready to pay higher price for the best to get the best results as well.

Usually farmers do not know what measures they have to take in a particular problem. They do not know the symptom of infestation and disease accurately. But from their long-term experience they can perceive the problem of their rice field. According to these perceptions they reach to the retailer for suggestion. Retailers suggest them what measures need to be taken in particular cases. The retailers have no formal training/academic background on pest management/management. They gather their knowledge from the representatives of the pesticides companies and from the label of pesticides containers. Only two retailers received training from Syngenta Bangladesh limited. There is a testimonial in their shop from that training, which they received from the former Ciba-Geigy company. Farmers of the locality trust the retailers because they think that the representatives from the companies brief them about pest management measures. So the retailers have the idea what measure should be taken due to different insect pest infestation and diseases. They strongly believe that just as in human health they go to a doctor, similarly for rice field problem, they go to see '**Doctor pest**', on whom they rely and would not expect advice that might damage their business.

Appendix 5. Case study: Research trial - Farmers' experiment

The study was concerned about the sustainability of different IPM programmes and farmers advanced interest on using PT. For ensuring their opinion the study initiated an experimental trial in the same area to sell PT in a very reasonable token price. The objective of this experiment was to rationalize their interest on using PT. Target was to sell fifty numbers of PT in the same field by the local retailer who involved with the whole process. Eight farmers from two different field bought PT from local retailer although few other farmers ensured the local retailer that they will buy it. After applying PT in their rice field farmers expressed their views as follow.

In this season there were few SB moths caught in the PT. Fewer moths were caught in the traps set inside the field than the traps in border area. Although there were few dead hearts in their fields but it was less than other farmers' fields. They saw SB moths in almost every PT in this season.

Some of the farmers were influenced by the local pesticides retailer as well as nearby farmers. They watched the trials before conducted by Syngenta scientists and felt (by observation and listening from other farmers who were involved in those trials) that the method of PT was effective to management SB. So they bought PT to apply practically by themselves. Few of these farmers were trail farmer of previous season. They perceived PT as *good*, *less laborious, having no known side effects* and lastly *in this season it was cheaper than of pesticides* so they used it.

Farmers' perception was very clear regarding the effectiveness of PT. In the most recent season the application process of PT was not very clear to them because they were not directly involved at that time but in the season they had to apply it themselves. After buying the pheromones from the local pesticides retailer they made the traps, set them in their fields and observed them over the whole season. They learned and understood the application and maintenance of it and by doing so found the total process easy to handle and understandable.

They saw SB in their traps. Although the number was not very high but they were sure about its effectiveness. They were very well aware that in Boro season usually there occur low infestation of SB and other insect pests. They realized, as the infestation was low so was the trap catch. Their view was as many SB were in the field among those male moths were attracted by the PT and caught there. They found in the traps that there was only one type of moth and local BS assured them those were male moths of YSB. If there were a high population of SB then the traps would certainly catch the higher number of moths.

Farmers expressed that earlier they had observed the research trial from others but it was their chance to experiment the new measurement for managementling SB. They perceive that their experiment was successful. All of them saw the moths caught in the traps. Most of their nearby farmers applied pesticides but they did not. They found their rice fields having less dead hearts and white heads than those of other farmers who applied pesticides. So it was clear to them by applying PT it could management the infestation of SB. They were eager to use it when it will be available in market and will not use pesticides as it has many health and environmental side effects.

Farmers requested to the researcher to make available the PT in next Aus (monsoon rice) and Aman season, as the infestation of SB is higher in these seasons and damage a significant percentage of yields. They will also try to motivate/insist their nearby farmers to apply PT. They indicated two reasons for this. Firstly, they would not like to take the risk of their own loss. They think that if nearby farmers do not apply PT then SB from nearby fields can breed in their field and damage crops. So they will try their best to motivate them to use it. In this regard they think that may be not all the farmers will be motivated but if the nearby other farmers feel/found PT effective and cheaper then they will be motivated automatically to use it even they need not to motivate them. Secondly, to be safe from the side effects of pesticides. They believe that most of the farmers have the realization that pesticides have lot of side effects to human health, environment and livestock. So to be relieved from these hazards they would like to motivate other farmers to use PT because so far they did not feel any side effect by it for human health, environment and livestock.

Appendix 6: Socio-economic research activities of the Project

Year-1

Activities	Duration											
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
Research orientation and preparation of Baseline survey (Boro ’02)												
Field work and data collection												
Data entry, data analysis and start writing												
Completion of Baseline survey report (Boro ’02)												
Review & comments incorporation of baseline report (Boro ’02)												
Preparation and design for in-depth study, start fieldwork												
Fieldwork, Data entry												
Data analysis, start report writing												
Completion of in-depth study report (Boro ’02)												
Review & comments incorporation of in-depth study report, fieldwork for baseline survey (T. Aman ’02)												
Data entry, data analysis and start writing												
Completion of Baseline survey report (T. Aman ’02)												

Year-2

Activities	Duration											
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
Review & comments incorporation of baseline report (T. Aman ’02)												
Preparation and design for in-depth study, start fieldwork												
Fieldwork, start data entry												
Data entry, Data analysis												
Start writing the project report												
Completion the draft report												
Field work for latest situation of field and Report editing												
Report finalisation and presentation preparation												

ANNEX 5 PROCEEDINGS OF FINAL WORKSHOP

PROCEEDINGS OF AN INTERNATIONAL WORKSHOP
ON THE
MANAGEMENT OF THE YELLOW RICE STEM BORER

16-18 June 2003, Dhaka, Bangladesh



Reporters:

Md. Nazmul Bari, Scientific Officer, Entomology Division, BRRI
Dr. Ramijuddin, Senior Scientific Officer, Entomology Division, BARI

Organised by:

Syngenta Bangladesh Limited
Natural Resources Institute
Bangladesh Rice Research Institute

Sponsored by:

United Kingdom
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Mr Malcolm Iles
Social Scientist

…………………………………………….

CONTENTS PAGE

WORKSHOP PROGRAM

16 June 2003	Rigs Inn Hotel, Gulshan-1, Dhaka	Speaker/Convenor
1400	Registration of participants & Honourable Guests	
1430	Participants and guests take their seats	
1435	Recitation from Holy Quran	
1440	National Anthem	
1445	Welcome and Introduction	Mr S Ahmed
1450	Workshop Inauguration	Dr M. N. Alam
1500	Overview of Pheromone based technology	Dr A Cork
1540	Results of stem borer pheromone project	Mr J C S Choudhury
1545	Social context of pheromone project	Mr M Iles
1600	Tea	
1615	Review of pheromone research in vegetables in Bangladesh	Dr S N Alam
1645	Review of global commercialisation of pheromones	Mr E Casagrande
1700	Review of commercialising pheromones in India	Dr K P Jayanth
1715	Open Discussion	
1745	Comments by Honourable guests	
1830	Close	Dr M Nurul Alam
1900	Dinner	

17 June 2003	Technical session: Rigs Inn Hotel, Gulshan-1, Dhaka	Speaker/Convener
0930	Welcome	Mr J C S Choudhury
0940	Experience of mass trapping *S. incertulas* in India	Dr A Cork
1000	Rice stem borer complex in Bangladesh	Dr N Q Kamal
1020	*S. incertulas* Lure optimisation	Mr M Rahman
1030	*S. incertulas* Trap optimisation	Mr M A Motaleb
1040	Multi-species lure optimisation	Mr J Osmani
1050	Mass trapping *S. incertulas* in Bangladesh	Dr A Cork
1120	Tea	
1140	Socio-economic studies with rice farmers	Mr M Kamruzzaman
1210	Open Discussion	
1300	Summing up and Recommendations	Dr A N M Rezaul Karim
1320	Closing	
1400	Lunch	

18 June 2003	Field Visit: Bhuschibazar, Laksham, Comilla
1000	Farmers' rally
1200	Farmers' meeting
1400	Refreshments & return and Dhaka

OBJECTIVES OF THE WORKSHOP

1. To bring farmers, NGOs, researchers and industrialists together to discuss matters of common interest relating to rice stem borer management.
2. To present the progress made on the Yellow Stem Borer project.
3. To get feedback from farmers, NGOs, researchers and industrialists on the way the project has been conducted and how best to carry the work forward to commercialise the technology for the farmers' benefit.
4. To get feedback from industrialists on their interest to produce and market the technology in Bangladesh.

PREPARATION

Syngenta Bangladesh Limited, Natural Resources Institute (NRI) and Bangladesh Rice research Institute (BRRI) developed a workshop programme comprising three sessions, overview (inaugural), technical and field. Stakeholders were identified as researchers and representatives from commercial and government bodies involved in policy, development and commercialisation of technologies to improve the livelihoods of rice farmers in south Asia and Bangladesh in particular. Syngenta invited 60 key stakeholders to the inaugural and technical sessions and 100 stakeholders to the field session, including 70 farmers. Identification of venues and logistics associated with provision of meals and transport were organised by Syngenta.

CONTENT

The Inaugural Session provided participants with an overview of the technology from both research and commercial perspectives. The second day consisted of a Technical Session in which detailed results from the current project were discussed in a semi-formal manner. At the end of each session a small discussion took place between presenters and participants and among participants. The Chairmen provided their concluding remarks and recommendations at the end of each session. The third day was designed to provide participants with an opportunity to visit a typical field location used for project trials and interaction with farmers, extension personnel and pesticide dealers involved in the project. The Inaugural and technical sessions were conducted and facilitated in English and the field day was conducted in Bengali with translations in English for participants from overseas. Participants from all stakeholder groups actively participated in the discussions, although some farmers were reticent to come forward in the field session.

The proceedings are set out with a summary of each of the presentations together with workshop recommendations. A full text of the presentations is provided in an attached CD in the form of word files or Powerpoint presentations. In addition the CD includes a copy of the excellent multi-media presentation developed by Syngenta to promote pheromone technology to farmers and extension personnel and shown by Mr Sarwar Ahmed in the Inaugural and Field Sessions.

ACKNOWLEDGEMENTS

We are particularly thankful to the chief guests and chairmen of the sessions who provided guidance, critical assessment and recommendations. The organisers would like to thank the speakers for the time and effort they put into providing such high level presentations. Together they produced an excellent review of the project's achievements and put them into context with related work on other crops in other countries and, where appropriate the farmers' context. Finally, the Organisers are particularly thankful to the Crop Protection Programme of the UK, DFID for their foresight and encouragement to enable this unique partnership between industry, technical and social researchers and farmers to work together on a common platform.

ABBREVIATIONS

AVRDC	Asian Vegetable Research and Development Centre
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BCRL	BioControl Research Laboratories Limited, Bangalore, India
BRAC	Bangladesh Rural Agriculture Committee
BRRI	Bangladesh Rice Research Institute
BSRI	Bangladesh Sugar Research Institute
CP	Dark headed borer, *Chilo polychrysa*
CPP	Crop Protection Programme of DFID
DAE	Department of Agricultural Extension
DFID	Department for International Development
IPM	Integrated Pest Management
IPM CRSP	IPM Collaborative Research Support Program
NGO	Non-Governmental Organisation
NRI	Natural Resources Institute
PTAC	Pesticide Technical Advisory Committee
SI	Pink borer, *Sesamia inferens*
SME	Small and Medium Enterprise
YSB	Yellow stem borer, *Scirpophaga incertulas*

SUMMARY OF PRESENTATIONS

INAUGURAL SESSION

The three-day international pheromone workshop on the management of yellow stem borer (YSB) in rice was held at Hotel Rigs Inn, Gulshan, Dhaka on 16-18, June, 2003. Dr. Nurul Alam, Executive Chairman, Bangladesh Agricultural Research Council (BARC) was the chief guest of the workshop. Dr. Nurul Islam Bhuiyan, Director General, BRRI presided over the inaugural session. Dr. Shah Md. Farauk, Former VC, Bangladesh Agricultural University, Mymensingh, Mr. E. H. Khandaker, DG, Department of Agricultural Extension (DAE), Dr. Md Shahidul Islam, DG, Bangladesh Agricultural Research Institute (BARI) , Dr. A. B. M. Mofizur Rahman, DG, Bangladesh Sugar Research Institute (BSRI), Dr. M. A. Hamid Miah, International Rice Research Institute (IRRI), Liaison Scientist, Bangladesh, attended the inaugural session together with scientists, extension officers, university teachers, donors and representatives of non-Governmental Organisations (NGO) (Annex 1).

The inaugural session started at 15.00 h with the recitation of Holy Quran followed by the National Anthem. **Mr. Sarwar Ahmed**, Managing Director, Syngenta Bangladesh Ltd., conducted the welcome and introductory addresses. In his welcome speech Mr. Sarwar Ahmed suggested that high food quality and good environmental health were essential if people across the world were to achieve their aspirations and that was why Syngenta Bangladesh Ltd., were actively engaged in developing alternative pest control options to conventional pesticides. During his deliberations, Mr Sarwar Ahmed, showed the nature of the damage caused by the yellow stem borer (YSB) and how the male moth was attracted and ultimately trapped by a synthetic female sex pheromone lure using a multi-media presentation developed by Syngenta Bangladesh Ltd., to promote the technology. Mr Sarwar Ahmed envisioned that pheromone traps could be used to replace insecticides to control noxious pests such as YSB and emphasised the potential role of pheromones as a monitoring tool to assist farmers and extension personal predict when and where rice crops were at risk from the pest. Mr Sarwar Ahmed enthusiastically welcomed and this new era of IPM and wished the workshop well in its deliberations. Seven papers were presented in the inaugural session.

During his presentation **Dr. A. Cork,** Project Leader and Reader in Chemical Ecology, NRI, UK talked about the uses of insect pheromones. Dr Cork recalled that insects are important pests of crops all over the world and that farmers spend 9,000 million US dollars on insecticides to protect them. However, it is widely recognised that insecticides not only kill the target pest species but also beneficial insects, and in particular natural enemies. Besides insecticides, farmers use cultural practices such as crop rotation, crop hygiene, resistant varieties *etc*. to manage insect pests but these have limited effectiveness in the intensified cropping patterns associated with the use of high yielding varieties. Pheromones have a powerful influence on the behaviour of insects. Males are highly attracted to females of the same species when they secrete a pheromone so they can be used as lures in traps to monitor insect populations and to control them by mass trapping or mating disruption. Dr. Cork went on to describe the use of pheromones in USA and Egypt on cotton pests, tsetse fly in Africa, palm weevils in central America and south Asia, and reviewed recent progress on their use in south Asia on rice and vegetable pests.

Mr. J. C. Saha Choudhury, Syngenta Bangladesh Ltd., provided an overview of the work conducted in collaboration with NRI and BRRI on the development of mass trapping for control of rice stem borers in Bangladesh. He stated that among the three stem borer species, 70-80% were YSB, *Scirpophaga incertulas*, and that yield losses of up to 10-15% were caused by this species. Syngenta Bangladesh Ltd., had conducted field trials to adopt pheromone-based YSB control technologies to local farming conditions and to better understand the social and commercial constraints to introducing such a technology in the marketplace. Extremely low stem borer populations hampered progress throughout the duration of the two-year project period. Nevertheless, researchers were able to develop a highly effective trapping system. Sleeve traps provided by Bio-Control Research Laboratories (BCRL), India, baited with a 1 : 3 blend of (*Z*)-9- and (*Z*)-11-hexadecenal in polythene vials were found to give the highest catches. The traps were so effective that Mr Saha Choudhury recalled one occasion when, despite low crop damage data three traps had caught 580 moths over a ten-day period. The fieldwork generated considerable attention and interest among neighbouring farmers. Project farmers considered pheromone traps to be an effective substitute for insecticides but insisted that they had to be equal or cheaper in price than insecticides. Farmers also said they preferred single-plot solutions to their pest control problems and wanted pheromones for other pests too.

Mr. M. Iles, Principal Scientist (Development) NRI, UK gave a presentation on the socio-economic studies associated with adoption of pheromone technology in rice. The aim of the work was to understand the farmer context as it related to adoption of new technology. The research had investigated farmer resources, perceptions and constraints. Mr Iles suggested that there were parallels between the adoption of transgenic cotton in China and pheromones in Bangladesh and noted that transgenic cotton had been widely adopted in China once farmers had realised its full potential. Mr Iles emphasised that adoption is most successful where farmers are involved in technology development and that appropriate training and marketing strategies were important to enhance adoption.

Dr S. N. Alam, Bangladesh Agricultural Research Institute gave an excellent presentation on recent work conducted by BARI in collaboration with NRI, Asian Vegetable Research and Development Centre and IPM Collaborative Research Support Progam (IPMCRSP) on the development of IPM technologies for control of brinjal shoot and fruit borer, *Leucinodes orbonalis*, and fruit fly pests of cucurbits. The technologies were based on the use traps baited with a sex pheromone and parapheromone for control of *L. orbonalis* and *B. cucurbitae* respectively. In addition Dr Alam described the results of their work on the importance of natural enemies that compliment the use of mass trapping. In this case the wasp *Trathala flavo-orbitalis* Ichneumonidae was shown to be a highly effective parasitoid of *L. orbonalis* in Bangladesh but that its effectiveness was compromised by the indiscriminate use of insecticides by farmers.

Mr E. Casagrande, Agrisense-BCS Ltd. provided workshop participants with a view of how the international business in insect pheromones and related biopesticide products is organised and has flourished during the last ten years. The market is apparently dominated by about a dozen companies, half of which are in North America, and currently worth 294 million dollars, of which pheromones account for 95 million dollars. Most of the companies involved in the business are classed as SMEs and although Agrisense is structured as an SME it is in fact part of Certis, which is wholly owned by Mitsui Japan. Agrisense itself operates in 50 countries and provides monitoring systems for 120 insect species and traps and controlled release systems for use in managing a wide range of pest species in field crops, domestic and commercial premises and storage facilities.

Dr. K. P. Jayanth, BCRL, India presented a lecture on the commercialisation of pheromones, biopesticides, natural enemies and parasitoids in India. BCRL had developed or were in the process of developing lures for nine insect species and these have been mainly used since the late 1980's for monitoring insect pest populations as part of Government sponsored IPM promotion programmes. Dr Jayanth was particularly enthusiastic about the prospects for using pheromones to control *L. orbonalis* and sugarcane borers.

TECHNICAL SESSION

Dr A Cork, NRI presented a lecture on behalf of Dr I. C. Pasalu, Head of Entomology, Directorate of Rice Research, Hyderabad, India on work conducted in India to develop pheromone-based control technologies for YSB in rice. Dr Cork described how over the course of a ten-year period the YSB sex pheromone had been chemically characterised, formulated in controlled release formulations and found to be efficacious for control both by mating disruption and mass trapping. However, given the relatively low value of the rice crop only mass trapping was cost-competitive with insecticides in India, particularly in areas where YSB infestations commonly exceeded 10% and farmers applied more than six applications of insecticide to achieve control.

Dr. Nazira Quraishi Kamal, CSO & Head, Entomology Division, BRRI, presented the results of her work in two parts. The first part concerned the distribution of rice stem borer species both within and between seasons and at different locations. The highly detailed study revealed that the species complex was highly dynamic with species changing in abundance both within and between seasons. Three species were identified yellow stem borer, *S. incertulas* (YSB), pink borer, *Sesamia inferens* (SI) and dark-headed borer *Chilo polychyrsa* (CP). Dr Kamal stated that as YSB populations were predominant in the T. Aman so mass trapping would be most effective in that season for controlling rice stem borers. The second part of her presentation concerned the effect rice stem borers had on the development of rice tillers and ultimately yield. The work clearly showed that where rice tillers were infested an average of one extra tiller was developed to compensate for the loss irrespective of the original number of tillers in the hill.

Mr M. Rahman, Syngenta, demonstrated how over the course of the two year project period he and co-workers had optimised the pheromone blend and dispenser to produce a lure that was highly attractive, highly specific, long-lasting and economical for catching YSB. The lure comprised a 1 : 3 blend of (*Z*)-9- and (*Z*)-11-hexadecenal in polythene vials.

In related work **Mr M A Motaleb**, Syngenta, described how he and co-workers had optimised the trap design for YSB. More than six trap designs were compared, many of which were of indigenous design, but finally a commercial trap developed by BCRL, India had proven to be the most effective at catching and retaining insects. It was also convenient for farmers to use, robust, required a minimum of maintenance and was highly cost-competitive.

As discussed by Dr Kamal, it was apparent that YSB was not the only stem borer to affect rice in trial areas. In order to ensure that farmers were adequately protected from all stem borer species there was a need to develop effective lures for the other two species, *S. inferens* and *C. polychrysa*. **Mr J Osmani**, Syngenta, described how trials were conducted with the pheromones of YSB and SI to assess how best to use them. The trials confirmed that combining the pheromones in the single lure or in separate lures but both placed in the same trap significantly reduced the catches of both species. The pheromone of CP has not been identified to-date. Where mixed species were expected to exceed the action threshold Mr Osmani recommended providing farmers with traps for both species. However, further work is required to assess the probability of SI and CP causing significant yield loss in Bangladesh.

Dr A Cork, NRI gave a presentation on the results of large scale mass trapping trials that pulled together the lessons learned from the small-scale trials in which the various components of the technology were refined. Many of the underlying assumptions in the project had been found to be incorrect during the course of the project. While stem borers are generally considered to be economically important in Bangladesh, research conducted by the project suggested this was only true in project areas during the T. Aman season. Similarly, YSB was not always the predominant species, which complicated both the development and application of an effective mass trapping technology in Bangladesh. None of the trials conducted during the project provided clear evidence that mass trapping had increased farmers yields this was mainly because stem borer damage had not exceeded economic thresholds in any of the trials. Nevertheless, project results clearly demonstrated reductions in white head damage in mass trapped areas compared to checks and there was good evidence from the distribution of trap catches to suggest that the male population was being suppressed inside the treated plots. Given the high level of farmer interest and the ability of the pheromone traps to catch and retain large numbers of male moths the technology would appear to offer farmers with a viable alternative to currently used insecticides.

Mr. M Kamruzzaman, Syngenta reported on the socio-economic influences on farmer adoption of pheromone traps on rice in Bangladesh. The presentation had three objectives: to understand the socio-economic dimensions of rice cultivation, farmer perceptions of the effectiveness of pheromones as a component of the IPM of rice, and farmers' attitudes towards alternatives to chemical pesticides. Some 89 respondents were chosen from a wide range of ages, educational backgrounds and land ownership. The farmers clearly identified rice stem borer as the major pest of their rice with over 90% considering it to be the most important with 58% of the respondents citing damage levels in excess of 10%. Farmers had a good knowledge of the effect of stem borer on rice but did not distinguish between different species and were uncertain about which season it was most abundant. Pesticide dealers were considered to be a main source of knowledge on stem borer control although 65% of farmers indicated they chose the insecticide based on its brand name. Despite the apparent importance of stem borers farmers' only spent between 2 and 5% of their crop production costs on insecticides, although this was significantly higher than other pests apart from weeds, although most of the weeding was undertaken by family members and the costs were in-kind. Over 60% of the farmers had received IPM training and over 80% believed it was effective although few practised it. Pesticides were considered to be generally effective and although most farmers were aware of side effects over 80% of farmers surveyed used insecticides for control of stem borers. Farmers were unclear about the effectiveness of pheromone traps, in part because of the low infestation levels. To test their interest farmers were offered a chance to purchase traps. Seven farmers bought 27 traps between them and on seeing the moths they caught and low infestation levels were generally pleased with the technology. They suggested they would purchase them again and motivate their neighbours to use them, but price was an important criterion in their choice of stem borer control technology.

Dr. A. N. M. Rezaul Karim, Research Co-ordinator, IPMCRSP was the Chairman of the technical session and announced that eight papers were presented in the session including two papers on socio-economic aspects. In total 15 papers were presented at the workshop.

Before closing the session Mr. J. C. Saha Choudhury, Dr. N. Q. Kamal and Dr A Cork on behalf of Syngenta, BRRI and NRI respectively expressed their gratitude and deepest thanks to all participants for making the workshop such a great success. Finally, Mr. Chairman closed the session.

OPEN DISCUSSIONS

In the open discussion session, a question was raised on registration of pheromones in Bangladesh. Mr. Ruhul Amin, Director (Plant Protection), DAE, confirmed that there were no existing pesticide rules and regulations by which pheromones could be registered. Pheromone registration had been discussed in the previous PTAC meeting and the tremendous affect of eco-friendly pheromones for controlling YSB had satisfied everybody. From the point of view of pheromone registration Mr. Ruhul Amin requested the workshop to provide some recommendations that could be used at the next PTAC meeting and in particular on the issue of assuring the quality of pheromone products.

Dr. Wahiduz Zaman, Manager (R&D) East West Seed Company, commented that a lot of vegetables were being exported from Bangladesh but if they are found to have high insecticide residues the produce was returned. For this reason Dr. Zaman felt that pheromones for controlling vegetable pests would find a ready market with exporters anxious to avoid the use of insecticides. He also suggested that a team should be formed to investigate this issue.

The honourable chief guest, Dr M Nurul Islam, Executive Director, BARC**,** compared pheromones with homeopathic medicine. The homeopathic medicine works slowly and has no adverse effects on the body. Likewise, pheromones work effectively without any residual effects. He suggested that we could share the Indian experience of adoption of pheromones in farmers' fields and that will provide an entry point for IPM. He thanked Syngenta for conducting the trials with pheromones. In his view, the partnership between Syngenta-NRI-BRRI was very effective. He also suggested that we compile all the papers presented in the workshop and publish them as proceedings for interested people. On the question of registration for pheromone he stated that he was also a member of the PTAC committee and desired that the committee considered the registration matter positively. The honourable Chairman mentioned during his closing speech that pheromones would become one of the main components for IPM.

During the discussion session Dr. A. B. M. Mofizur Rahman, DG, BSRI stated that many good technologies had been invented by scientists and others but not necessarily adopted by farmers. Dr Rahman suggested that more research should be conducted to look at the issue of farmer acceptance of new technologies using pheromones as a model, since it was undoubtedly a good technology.

Dr. Chancellor of CPP-DFID asked why women farmers' perceptions of pheromone use had not been reported. Mr Kamruzzaman indicated that despite his best efforts he had been unable to hold interviews with women in the villages.

Professor, M. Hossain, Director (R & E) BRAC, mentioned that small and poor resource farmers were very cautious about adopting any new technology. If pheromones were really cheaper than insecticides and ecologically sound then farmers would adopt them.

Dr. Syed Nurul Alam, SSO, BARI, suggested that observations should be made on the effect of using pheromone traps on natural enemies and pest resurgence.

The Honourable chairman of the technical session mentioned that in many cases farmers did not understand technologies developed by scientists and that this resulted in late adoption. Pheromone technology should be accepted socially, environmentally and biologically although the technique may not be useful in all situations, particularly where insect populations were low.

One questioner asked whether control of YSB with pheromones might result in an increase in the number of other stem borer species. Dr Cork commented that there was no evidence to suggest that this would be the case bearing in mind that when YSB populations had been low in the Boro season other stem borer species had not increased in number to replace them. This was presumably because natural control systems exerted a considerable pressure on all stem borer species. The questioner went on to suggest that in the case of vegetable cultivation there was considerable sharing of responsibility with female farmers. So, women's opinions should also be included in the socio-economic study. He mentioned that if pheromone tactics were included in IPM then they would be very effective.

FIELD SESSION

The field session was conducted at Bhuschibazar, Laksham, Comilla on 18 June 2003. More than one hundred participants including scientists, extension officers, foreign delegates, NGO personnel, block supervisors, farmers' representatives and pesticide dealers visited the mass trapping demonstration field. The demonstration enabled delegates to understand how the trap worked in practice and the way in which they should be distributed in the rice field. The demonstration was well received by participants.

After the field visit a big farmers' rally was conducted from the demonstration field to Sharifpur High School. After the rally participants attended an experience sharing discussion session with 72 farmers from four villages about pheromone trap technology in the Sharifpur High School.

Mr. Ali Hossain, farmers' representative of the locality presided over the meeting. Mr. Md. Entajul Islam, DD, DAE, Comilla Sadar, Mr. Sarwar Ahmed, Managing Director, Syngenta Bangladesh. Dr. T. C. B. Chancellor, CPP-DFID and Dr. A. Cork, NRI were requested to join the chairman. Before starting the meeting Mr. J. C. Saha Choudhury, Syngenta, explained the background and use of pheromones in rice.

Mr. Sobhan a farmer of Daulatpur village mentioned that he had got some benefit from using pheromones for stem borer control. At first he observed the activity of pheromone trap in Syngenta's demonstration field. Afterwards he had bought the pheromone trap and used it in his field resulting in no stem borer infestation in the field.

Mr. J. C. Saha Choudhury responded to a question from a block supervisor of the area to say that pheromone traps were complimentary to IPM and did not in any way adversely affect the effectiveness of IPM techniques being promoted for controlling other rice pests.

Mr. Harunur Rashid a pesticide dealer and farmer stated that he observed the demonstration of pheromone traps and felt it was a really good thing for controlling YSB. However, he observed it would be more effective if neighbouring farmers also used pheromones.

When asked about the cost of the pheromone traps most farmers felt that because they spent 300 taka/acre (£8.50 per ha) for insecticide, mass trapping had to be the same price but ideally cost less.

One farmer asked how long pheromone lures were effective in the field and was informed that the current lures had a field life of 1.5 - 2 months although it was possible to provide lures that lasted considerably longer if needed. As a subsidiary question the farmer asked whether wind direction could affect the efficiency of the pheromone trap. Dr Cork suggested that the current trap design was 'omni-directional', that is to say it was equally effective whatever the direction of the wind, although at high wind speeds male moths would not fly. Mr. Nazrul Islam, Agriculture Officer, Sadar Comilla, suggested that polythene bags should be avoided for the pheromone traps because they were not eco-friendly and later suggested a trap design based on discarded water bottles.

One farmer from Adompur village explained his experience with the use of the pheromone trap. He had placed a trap in one bigha (33 decimal, 0.13 ha) of land and insecticide in another one bigha and got the same yield. He remarked that as he got the same yield so it is better to use pheromone, but the cost of pheromone should be reasonable.

Mr. Entajul Islam, DD, DAE, Comilla Sadar explained that use of pheromone traps is not contradictory with IPM. It might be also a part of IPM. He told participants that when IPM tactics did not control YSB then they should use pheromone traps that might be more effective. He also mentioned, we should produce a crop in such a way as to protect the environment and it was clear that pheromone traps were not harmful to environment. Before closing, Dr. Moinul Islam, Product Development Manager, Syngenta expressed his gratitude and deepest thanks to all participants on behalf of the Organiser's of the workshop and finally the Chairman, Mr. Ali Hossain, closed the meeting.

Outcomes of the workshop

The participants discussed the following issues:

- Importance of rice stem borers in Bangladesh.
- The relationship between pheromone application and yield.
- Possibility of using pheromone traps to monitor pest incidence.
- The involvement of women farmers in the project.
- Registration of pheromones.
- The expected cost of the pheromones by the farmers.
- The availability of the pheromone traps in Bangladesh.
- Compatibility of pheromone traps with IPM technology promoted by DAE.
- Effectiveness of Syngenta, BRRI and NRI partnership.

Recommendations

- Mass trapping is recommended for use in the T. Aman crop when rice stem borer populations are high and insecticide is problematic to apply because of rain.
- Stem borer control is not recommended in the Boro season because of low infestation levels.
- Pheromone traps should adopted into IPM practice to provide farmers with early warning of YSB infestations.
- YSB pheromone should be made available to rice farmers in Bangladesh and promoted through the efforts of Syngenta's marketing system and the DAE.
- Pesticide use in rice cultivation is relatively low in Bangladesh, adoption of pheromone traps would help to educate and reassure farmers that they do not need to apply insecticides.
- Further work is needed to understand the impact of the rice stem borer complex on yield and develop the potential of pheromone traps for monitoring populations.
- Technical and social science support should be provided to Syngenta to assist them market the pheromone product and in particular assess the impact of marketing and pesticide dealer training on the attitude of risk adverse farmers.

ANNEX PARTICIPANT LIST

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Annex 6: New Agriculturalist 03-4: Pheromones - the trappings of sustainable pest control?

Sustainable control of the yellow stem borer, a pest that is threatening Bangladesh's rice crop and food security, may be possible through the use of pheromones and traps.

According to scientists from three organisations working in collaboration to find a sustainable control method, sleeve traps with a pheromone lure are both effective and cost-efficient in controlling the insect which is responsible for 70 to 80 per cent of pest damage to rice crops. The Natural Resources Institute (NRI), the Bangladesh Rice Research Institute and the multinational agrochemical company Syngenta are all involved in the project that is being funded by the Crop Protection Programme of the UK's Department for International Development (DFID). Pheromones are used to lure the male stem borers into the trap where they eventually die thus preventing females from reproducing, explained J. C. Saha Choudhury of Syngenta-Bangladesh. "We trialed five different types of traps, but came to the conclusion that sleeve traps are the most appropriate for our country," he explained. The traps used in the trials are being imported from India but could easily be made locally when demand develops. "We have had a good response from the farmers. They were very interested because in one treatment we saw about 175 male moths caught in one trap," he said. There are 10 major pests threatening rice production in Bangladesh, but the yellow stem borer (*Scirpophaga incertulas*) is the most damaging. Overall damage from pests and disease currently creates losses of 10 to 40 per cent of Bangladesh's rice yield. With the current 130 million population set to increase to 160 million by 2010, alongside decreasing amounts of land available for rice production, the existing rice deficit can only get bigger said Mr Saha Choudhury. "By making crop protection measures you cannot increase the yield but you can save the damage," he explained. And there are reasons other than food security to investigate alternative methods: "Economically this is a terribly important pest," said Dr Alan Cork from NRI. "Because the larva is actually inside the stem of the rice it is well protected from pesticides. So farmers in Bangladesh have to use fairly toxic granular pesticides to control the pest. These pesticides are becoming redundant because of the development of resistance to them, but more importantly because governments are becoming aware of the negative environmental and health aspects associated with the use of these compounds, so there is a now an urgent need for the development of alternative control technologies."

Disseminating the idea to farmers is already underway through local demonstrations, explained Dr Nazira Kamal, head of entomology at the Bangladesh Rice Research Institute. "We have some participating farmers and are working in their fields already to demonstrate how to use it," she said. It is also important that neighbouring farmers are prepared to work together if the technology is to work. "If the farmers are illiterate they can still learn the benefits of using the lures around the traps through demonstrations. They know that the natural enemies [of stem borers] are saved, that the danger of insecticide use is avoided, their environment is safe and that they can have a good crop." And the money that farmers save in reducing their use of pesticides can be spent instead on herbicides which are less toxic and give a more effective return, says Mr Saha Choudhury. Work continues to test the effectiveness of the pheromone lures over comparatively small areas. If individual or small groups of farmers can use the technology to protect their own crops, this would take care of the problem of encouraging large groups of farmers to collaborate in mass trapping. This is an interesting project, not only because of the technology involved but because it involves partners from both the public and the private sector. As Sarwar Ahmed, Managing Director of Syngenta-Bangladesh, points out that: "If the objective is the same, then the collaboration can be very well co-ordinated. The public institutions want to bring in benign technologies for crop protection. We also want to do the same thing because, in the long run, it's in our interest that we look into the interests of farmers today."

Annex 7: Mass Trapping: An alternative to insecticides for control of rice stem borers in Bangladesh

RICE farmers in south Asia are familiar with the *yellow stem borer* (YSB), they know it as a yellow worm that lives inside rice stems.

Female yellow stem borer moth

Many farmers are not aware that the worm will mature into a moth, but they do know that if they do not control it the rice grains that form will be empty (white heads) and have no nutritive value.

Throughout much of south Asia farmers use insecticides to control this yellow worm. In the past they would apply granular insecticides that have a systemic action (phorate or carborfuran) but more recently they have resorted to foliar applications of insecticide. Fortunately, in many rice growing areas the frequency of insecticide use is low. In Bangladesh it is typically less than one application per season. Nevertheless, in areas of south Asia where rice cultivation is intensive and produced as a cash crop spray regimes of up to six applications a season are not uncommon.

Such activities are not sustainable and lead to the development of resistance in pest and non-pest species. Insecticides invariably suppress the activities of natural enemies and insect parasitoids. Indeed many development agencies promote the concept of 'no action' to maintain the natural balance of pests and their predators for as long as possible in a crop season.

White head damage caused by yellow stem borer larvae

YSB is not the only constraint facing rice farmers. They require good quality seed, efficient water management, high soil fertility and effective control of weed and other rice pest and disease problems. To enable farmers to grow rice sustainably,

Predators work for free!

Syngenta Bangladesh Ltd., developed, in collaboration with the Bangladesh Rice Research Institute (BRRI), a basket of technologies that is presented to rice farmers during a series of farmer field schools (FFS) with pest management experts in the field.

Syngenta farmer field school

FFS provide a means of presenting farmers with appropriate technical information in an informal setting that encourages participation and debate. Such an approach was developed by the FAO and has achieved great improvements in farmers' understanding of crop protection throughout much of the developing world.

In Bangladesh the adoption of the FFS system by Syngenta has been paralleled by the Government of Bangladesh's adoption of the concept of *Integrated Pest Management* (IPM), whereby the more toxic pesticides are replaced by sustainable and environmentally benign means of pest and disease control.

IPM involves the use of cultural methods of pest control and methods for enhancing the impact of natural enemies and parasitoids. It also provides a role for alternatives to pesticides such as resistant varieties, antifeedants, insect pheromones and viruses. Pheromones are naturally-occurring compounds produced by insects that act as messages to other insects. Adult female YSB attract their mates with a pheromone. If female YSB can be stopped from mating then the pest population can be checked.

Mass trapping is a simple technology in which male YSB moths are caught in traps baited with the female pheromone. Building on work conducted by scientists in India, Syngenta has been collaborating with the BRRI and the University of Greenwich, U.K. to adapt the technology for use in Bangladesh.

A wide range of trap designs, pheromone blends and concentrations were tested with farmers' in their fields in Comilla and Mymensingh Districts in 2001-2003 alongside a socio-economic study of farmers' resources, constraints and perceptions to ensure the resulting technology was appropriate for adoption. The work showed that eight plastic funnel traps per acre baited with 3 mg of the YSB pheromone caught the highest number of male moths, with up to 120 moths per trap per week recorded in Comilla District in the 2001 T. aman crop.

Predatory birds and pheromone traps work together to control insect pests

The traps are inexpensive (20-30 taka), easy to maintain and catch only male YSB. Farmers involved in the trials were so enthusiastic that they want pheromones for use on other crops.

Mass trapping complements the IPM approach to pest control. It provides farmers with confidence that the time and effort they spend cultivating a rice crop is not lost to the voracious appetite of the yellow worm that hides in their crop.

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