Indian Council of Agricultural Research

NATIONAL AGRICULTURAL INNOVATION PROJECT

Component 4

Basic and Strategic Research (BSR)

in Frontier Areas of Agricultural Sciences

Launching of

Consortium Project on November 28th 2008

Development of Decision Support Systems for Insect Pests of Major Rice and Cotton based Cropping Systems

(http://www.crida.ernet.in/naip/comp4/dss_pest.html)

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Background

The goal of **National Agricultural Innovation Project (NAIP)** launched under the aegis of the Indian Council of Agricultural Research (ICAR) is to facilitate accelerated and sustainable transformation of Indian agriculture by collaborative development and application of agricultural innovation by the public research organizations in partnership with the farmer's groups, the private sector, the civil society organizations and other stakeholders. NAIP aims to achieve the objectives by supporting four components. Component 4 under NAIP ensures that investments are made in basic science in order to sustain the flow of knowledge and innovations essential to keep the technology development process responsive to the ever-changing needs of agriculture. The Component 4 aims at making such investments in those frontier science areas of agricultural research that are strategically important for Indian agriculture.

Agriculture in India is a gamble with weather. Pest associated crop losses are higher in the tropics which are currently estimated between 10-30% of the total agricultural production valued at Rs 1400 billion in 2007. There are additional costs in the form of pesticides applied for pest control, currently valued at Rs 68 billion. Knowledge and information is the key to correct pest management decisions. Integrated Pest Management (IPM) is a system that emphasizes appropriate decision-making, depends heavily on intensive, accurate and timely information for field implementation by practitioners. Pest forecast are an important component of the broad IPM philosophy. Forewarning models provide lead time for managing impending pest attacks and thus minimize crop loss and optimize pest control leading to reduction in cost of cultivation. A Decision Support System (DSS) integrates a user-friendly front end to often-complex models, knowledge bases, expert systems, and database technologies. DSSs have emerged as essential tools to bridge the gap between science-based technology and end-users who make day-to-day management decisions. An IPM-DSS provides user all necessary information on pest developmental models including sampling, decision making criteria and management options. Such systems are essential to enhance the adoption and spread of IPM in the country. This sub project aims at integrating pest database, generated data from field, laboratory and remote sensing studies through a decision support system to strengthen the implementation of on-going integrated pest management programmes in rice and cotton.

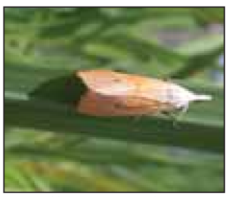
Objectives

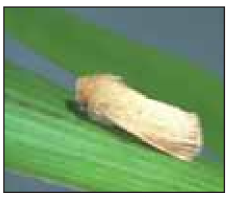
1. Generation of cropping system based information on population biology of major insect pests of rice and cotton required for robust model development.

2. Development of pest forewarning models and decision support systems in rice and cotton for use at micro and macro levels.

In India rice is grown in 43.7 m ha with a production of 93 m t and a productivity of 2.1 t ha^{-1} of which, rainfed rice is grown in 22.5 m ha (ca 50%) with a productivity of about 1 t ha^{-1}. Pest outbreaks are common in rice growing regions, which result in 20-30% yield loss. About 18% of the total pesticide consumption in the country is on rice.

Among the insect pests of rice, yellow stem borer (*Scirpophaga incertulas*), pink borer (*Sesamia inferens*), brown plant hopper (BPH) (*Nilaparvatha lugens*), white backed plant hopper (WBPH) (*Sogatella furcifera*) and leaf folder (*Cnaphalocrocis medinalis*) are the most important pests. Yellow stem borer is the most predominant species distributed throughout the country. The outbreak years of stem borer are associated with low rainfall. Infestation at the heading stage is assessed based on rainfall received during October-November. In addition to rice, the pink stem borer survives on maize, sorghum, barley and wheat. Therefore, the dynamics of this pest is of significance in the rice-wheat belt.

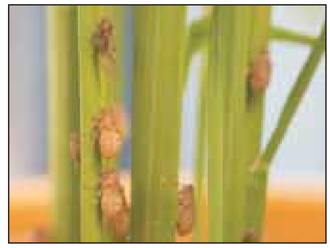

Yellow stem borer


Pink stem borer


Dead hearts


White ears

Nymphs and adults of plant hoppers suck sap from plants. Under favourable conditions they multiply very fast. Both BPH and WBPH are known for their resistance to commonly used insecticides including the neonicotinoids. Hence crop failures due to severe pest outbreaks is very common in many rice growing tracts of India. Temperature >30 °C, relative humidity >70% and prevailing wind direction determine the severity of incidence and spread of BPH.


BPH

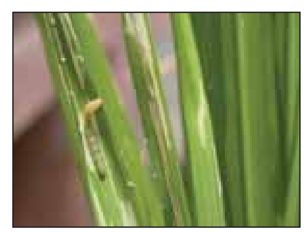

WBPH

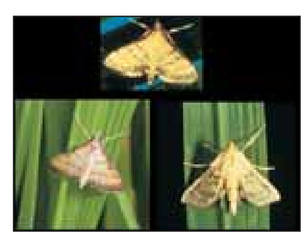

Hopper burn


Spectroradiometry

Several simulation models developed in China for BPH are based on occurrence patterns over locations, seasonal temperatures, transplantation time and immigration pattern. Attempts have been made to differentiate healthy and affected plants using spectroradiometry.

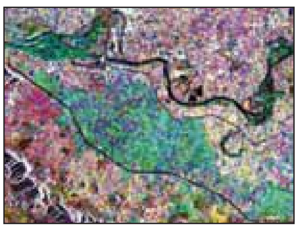
Leaf folder, which was considered as a minor pest few years back is now causing severe damage in many rice growing regions. Heavy use of insecticides and high fertiliser rates seem to favour leaf folder outbreaks. Attempts have been made to simulate the population dynamics of leaf folder under the influence of weather. Temperature has a negative impact on leaf folder incidence. Models developed at the International Rice Research Institute, Philippines were mostly aimed at simulating the yield losses due to several rice pests under a range of specific production situations in tropical Asia.


Leaf folder larva

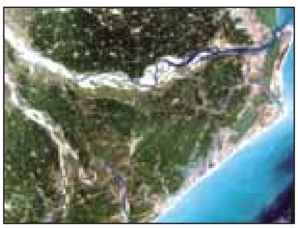

Leaf folder adults

Prevalent cropping systems and associated weather in the region influence the pest population dynamics to a greater extent. Remote sensing data will be useful to generate information on cropping systems, crop phenological stages and crop condition including spatially distributed weather data at regional level. In this context, a detailed study of the prevailing agro-ecosystems will help understand the ecological processes that are in operation.

Satellite Imagery



Hyperspectral



Multispectral

There is a research gap in integrating this knowledge on cropping systems and weather in the form of models for forecasting the timing and intensity of pest attacks. In the sub-project three major irrigated rice and two rainfed rice based cropping systems have been selected for study at six locations targeting four major insect pests for generating information required for the development of a DSS.

Cropping Systems	Location	Target pests
Irrigated rice		
Rice-Wheat	Ludhiana	Stem borers
Rice-Rice-Pulse	Maruteru Hyderabad	Plant hoppers Plant hoppers Stem borer Leaf folder
Rice-Rice-Rice	Coimbatore	Leaf folder
Rainfed rice		
Rice-Pulse	Cuttack	Stem borer
Rice-Vegetable/ Pulse	Mohanpur	Plant hoppers

India has more acreage in cotton than any other country, about 9.1 m ha, but the yields are among the lowest in the world- about 421 kg lint ha^{-1}. Cotton cultivation in the country has been revolutionised with the release of Bt-cotton for commercial cultivation in the year 2002. The coverage of this new technology has been spectacular (0.038 m ha in 2002 to 5.5 m ha in 2007-08, 60% area). The number of Bt-cotton hybrids permitted by GEAC now stands at 134 (cf 3 hybrids in 2002). A rapidly changing pest scenario in cotton is being witnessed with the advent of Bt-cotton. While the target pest, American bollworm, has been reduced substantially, new pest problems have cropped up and are spreading quickly to all the cotton growing areas. The cases of mealy bug and mirid bug menace in cotton are testimonies to this trend.

American bollworm

Pink bollworm

Mealybug, *Phenacoccus solenopsis* Tinsley, is emerging as a key insect pest on Bt cotton since 2005. White waxy build-up on terminals, stems and branches of infested plants accompanied by intense activity of ants is a sure sign of mealybug attack. The bugs suck sap from affected plants leading to stunted growth and drying. Black moulds grow on the honeydew secretions of the mealybug. Its natural spread by wind, water, ants and other human activities in the form of intercultural operations and movement of infested material contributed to its quick colonization of new areas. High temperatures along with low humidity are congenial for its rapid growth and multiplication, while high intensity rains and wet spells adversely affect its infestation.

Mealybug on cotton


Mealybug on Parthenium

Mealybug survives in soil, on cotton stalks, barks of trees, several weed and alternate host plants during the off-season. Extent of natural regulation through several biotic and abiotic factors is yet to be established for understanding yearly fluctuations in its build-up on cotton in different growing regions.

Mirids assumed economic significance with the advent of Bt cotton. Changed pesticide use pattern in Bt cotton mainly contributed to the flare-up of mirids. Despite their sap feeding habit, they cause significant damage to fruiting structures leading to shedding of squares and young bolls; and deformation of mature bolls. Mirids comprising of three species viz., *Crenotiades biseratens* Distant, *Campylomma livida* Reuter, and *Hyalopelpus lineifer* Walker are prevalent in

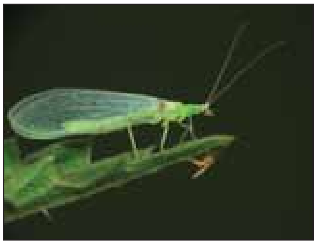

Mirid adult


Nymph

both sole cotton and mixed cropping systems although the dominant species may vary. The extent of yield loss on cotton due to mirids is reported between 50 and 95 kg ha^{-1}. Cloudy weather and warm temperatures favour rapid mirid build-up within a short time frame in Australia, while high mid-season rainfall coincides with peak mirid population during flowering and fruiting stages in China. Correct species identification, appropriate sampling strategy, estimation of developmental rates and generation time; extent of natural regulation and off-season biology are crucial to understand the population dynamics and management of mirids in cotton based cropping systems.

Natural Enemies


Coccinellid


Chrysopid


Syrphid


Nomuraea

Therefore, there is an urgent need to generate research data on the dynamics of emerging pests in a holistic manner and develop models that can predict the timing and likely pest intensity along with decision support systems for their effective management. In the sub-project three major cotton based cropping systems have been selected for study at four locations targeting four major insect pests.

Cropping Systems	Location	Target pests
Cotton-Wheat	Sirsa	Mealybug
Cotton + Pigeonpea-Fallow	Nagpur	Mealybug Miridbug Pink bollworm
Cotton + Pigeonpea Cotton-Fallow/Maize	Warangal	Mealybug Pink bollworm American bollworm
Cotton-Groundnut/ Cotton-Maize	Coimbatore	Mirid bug Pink bollworm

Objective 1 : Generation of cropping system based information on population biology of major insect pests of rice and cotton required for robust model development

Activity planned	Partner	2008-09		2009-10				2010-11				2011-12			
		III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Recruitment of staff	All	*	*												
Field cum laboratory studies on field growth rates	CRIDA CICR DRR	*	*	*	*	*	*	*	*	*	*	*	*		
Effect of temperature on each life stage of selected insect pests	CRIDA	*	*			*	*								
	CICR DRR	*	*		*	*	*		*	*	*				
Cropping system based field studies on population dynamics of target pests	CRIDA CICR DRR NCIPM	*	*	*	*	*	*	*	*	*	*	*	*		
Generation of spectral library using hand held hyper-spectral pest specific crop damage	CRIDA	*	*		*	*	*		*	*	*				
	CICR DRR	*	*			*	*		*	*					
Understanding ITKs on pest forewarning for possible use in model development	CRIDA NCIPM	*	*												

Objective 2 : Development of pest forewarning models and decision support systems in rice and cotton for use at micro and macro level

Activity planned	Partner	2008-09		2009-10				2010-11				2011-12			
		III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Compilation and analysis of historical data sets on pest bio-ecology for all pests including diseases on cotton and rice	All	*	*	*	*										
Development of pest forewarning models through use of generated key biotic and abiotic parameters and existing database	CRIDA CICR DRR NCIPM			*	*	*	*	*	*	*	*	*			
Using sounder data for meteorological parameters and crop stage identification using optical data for extrapolation of pest prediction models at macro level	SAC	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	CRIDA									*	*			*	*
	NCIPM									*	*	*	*	*	*
	DRR CICR		*			*				*			*	*	
Development of decision support systems for rice and cotton	All				*	*			*	*	*	*	*	*	

Project Innovations

- Cropping systems perspective that accounts for bio-ecological variables like off-season survival, pest-carry over and natural enemies which when coupled with the driving weather variables can better explain variability in pest populations and lead to pest forewarning models that are practical and useful
- Novel hyper-spectral technique for early detection of crop damage in rice and cotton due to insect pests

Outputs

- Field population dynamics for four major insect pests: stem borer, BPH, WBPH and leaf folder in rice based cropping systems (Rice-Wheat, Rice-Rice-Pulse, Rice-Rice-Rice); four insect pests: mealybug, mirid bugs, Pink bollworm, and American bollworm in cotton based cropping systems (cotton-wheat, cotton+pigeonpea-fallow and cotton-groundnut/maize)
- Establish relationships between ambient temperature and growth rates of different developmental stages of mealybug, mirid bug in cotton; WBPH and leaf folder in rice
- Establishment of spectral signatures for crop damage due to cotton mealy bug; BPH, WBPH, and leaf folder in rice using hyper-spectral radiometry
- Development of pest forewarning models for target pests in six cropping systems
- Integrated decision support systems for rice and cotton pest management in six cropping systems

Expected outcome and impact

- The most important outcome of the project would be an understanding of the cropping system based population dynamics and development of more robust pest forewarning models.
- Combining ground level studies on crop and pest damage; satellite borne remote sensing data and derivation of spatially distributed meteorological variables will lead to extrapolation of pest forewarning models at macro level.

Project Duration : July 2008 to March 2012

Budget : Rs. 322.60 lakhs

Consortium Advisory Committee (CAC)

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