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Review Article

Breeding for Resistance against Leaf Folder in Rice

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ABSTRACT

Breeding for insect resistant varieties has been central to the integrated pest management as it offers an ecologically viable approach against biotic constraints. Considerable progress has been made in the past to incorporate resistance to insect pests of rice using conventional breeding approaches. However the diversity in insect pest population, continuous selection of virulent biotypes, lack of resistance sources in cultivated rice (Oryza sativa and O. glaberrima) gene pool, want of efficient insect rearing and varietal screening protocols and inherently complex genetics of resistance further necessitates supplementation of conventional breeding techniques with advanced molecular approaches. Among different types of insects attacking rice, leaf feeding insect have major importance because of their ability to defoliate or to remove the chlorophyll content of the leaves leading to considerable reduction in yield. Hence, this review briefly discusses the current progress and future prospects in different breeding approaches for enhanced varietal tolerance to insect pests of rice.

Keywords: *Breeding, Leaf folder, Rice, Pest, Screening.*

INTRODUCTION

Rice (*Oryza sativa*) acts as a staple food for much of the global population (FAO 2004 & Kumar et al., 2009) particularly in Asia where about 90% of people live on rice (Khush & Brar, 2002) Uttar Pradesh is responsible for the production of 14.5% of the country's rice (McCarthy et al., 2008). However, in commercial production, rice productivity and quality are adversely affected by many biotic stresses, particularly insect pests. Insect pests damage rice crop at different stages of its growth. Yield losses in global rice output to pests (diseases, animal pests, and weeds), range from up to 20% to at least 30% of the attainable yield (Savary et al., 2000b). For instance, some 500 species of insects and spiders may appear in a rice field in a particular season out of these, only few are potential threat. The stem borer, rice gandhi bug, brown plant hopper, white backed plant hopper, rice leaf folder etc cause damage to rice fields.

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Among them, leaf feeding insect have major importance because of their ability to defoliate or to remove the chlorophyll content of the leaves leading to considerable reduction in yield. Paddy leaf folder is one of the most important insect pests (Gunathilagaraj & Gopalan, 1986). Lepidopteron insect-pests are the main class of pests causing significant damage to crop plant yields. The rice leaf folder (RLF), *Cnaphalocrocis medinalis* (Guenee) (Lepidoptera: Pyralidae), is a predominant foliage feeder and one of the most destructive pests, affecting in all the rice ecosystems in Asia (Luo, 2010). Rice leaf folder was considered as pests of minor importance have increased in abundance in late 1980's and have become major pests in many parts of India. The yield loss is from 30 to 80 per cent due to leaf folder epidemic situation (Nanda & Bisoi, 1990 & Shah et al., 2008). The rice leaf folder was considered as minor or sporadic pest in the past in many Asian countries. However, now it has been assumed as one of important insect pests and become a major threat to rice production in tropical and subtropical Asia. (Kushwaha & Singh, 1984 & Shrivastava, 1989).

An increase in *C. medinalis* population could be attributed to the large scale cultivation of high yielding varieties, application of fertilizers, and continuous use of insecticides leading to outbreak of this pest in several countries, including India (Khan et al., 1988; Shanmugam et al., 2006 & Kaushik, 2010). The larvae fold the leaves longitudinally by stitching the leaf margins and feed by scraping the green mesophyll tissue from within the folded leaves. This feeding causes linear, pale white stripes that result in membranous patches. Out of the eight species of leaf folder, the most widespread and important one is *Cnaphalocrocis medinalis* cause significant losses to rice ecosystem (Bhatti, 1995). In their studies, 17.5% damaged leaves resulted in 16.5% yield loss, and 21.3% yield loss corresponded to 26.6% damaged leaves (Bautista et al., 1984). Second instars leaf folder larvae glues the growing paddy leaves longitudinally for accommodation and feeds on green foliage voraciously which results in papery dry leaves (Khan et al., 1989). A single larva can damage a number of rice leaves, disturbing photosynthesis and reducing the rice yield (Alvi et al., 2003). Loss incurred to the growing paddy crop is insurmountable (Ahmed et al., 2010). Feeding often results in stunting, curling or yellowing of plant green foliage (Alvi et al., 2003). The extent of loss may extend up to 63 to 80 percent depending on agro-ecological situations as reported by (Rajendran et al., 1986 & Muragesan & Chellish, 1987). The heavy use of insecticides and high fertilizer rates seem to favors leaf-folder population outbreaks (Gottfried & Fallil 1986).

Bio- ecology of Rice leaf folder (*Cnaphalocrocis medinalis*):

The heavy use of (nitrogen) fertilizer persuades rapid multiplication of the leaf folder population in rice field. High humidity, high temperature and shady areas of the field favor their growth and developments. The presence of alternate host in rice fields and around the field provided shelter for insect and create favourable environment for complete several generation in one growing season. Expanded rice areas with irrigation systems, multiple rice cropping and insecticide induced resurgences are important factors in the leaf folder's abundance. The adults of leaf folder are nocturnal they hide in rice leaf during the day time to escape predation. They are active year-round and moths fly short distances when disturbed.

Life cycle of leaf folder:

For control of rice leaf folder there is very important to know about their life cycle because it's played a significant role to manage the population of *C. medinalis* in field and increased the yield.

Adult: Adult female moth is golden yellow in colour with brown margins on both the wings. While resting, the body shape is like that of an equal-sided triangle. It has three bands traversing entire forewing. Middle band was short, comma like and curved outside. The adult moths are 10-12 mm long. Wing expanse is 13-15 mm. Male moths are smaller than female moths and have a prominent patch of dark brown scales along the mid Costa of forewing. They generally mate between dusk and midnight. Oviposition starts two-three nights after mating. Adults usually emerge in the evening and mating occurs at night. Pre-oviposition period of 3 days and oviposition period of 4 days was observed.

Egg: Eggs of leaf folder are transparent, yellowish white, 0.90 mm long and 0.39 mm wide, and almost flat with a slightly convex surface. The eggs hatch 3-4 days after oviposition. Eggs are laid singly or in groups of 3 to 8 along the midrib of young leaves. A female lays about 135 to 175 eggs.

Larva: Larvae are yellow, turn yellowish-green with brown head as they mature, and are about 12-25 mm long. Immediately after hatching, neonate larvae move to the unopened leaf at the center of the plant and feed gregariously by scraping the green matter. From second instars onwards, the larva folds the leaves by stitching with silken threads keeping open both the ends of the fold. Larval feeding by scraping the green matter staying within the fold results in the development of longitudinal white streaks. Sometimes 2-3 leaves were stitched together and larvae feed from within this fold. Larva turns pinkish white just before pupation. *C. medinalis* completes its larval development in 14 to 18 days after passing through five instars. The caterpillar secretes a series of threads and uses these to connect the two margins of a leaf blade.

The threads contract as they dry and bring the two leaf margins together, turning the leaf blade into a tubular structure. The full-grown larva is yellowish green with a dark brown head and is 20-25 mm long and 1.5-2 mm wide.

Pupa: Pupa is light brown to bright brown and turns reddish-brown just before adult emergence. The larva cuts the leaf margin transversely up to the midrib, folds the cut portion of the leaf lamina over the other half and pupates inside the white silken webbing in leaf fold after stitching it completely on all sides. Pupation occurs mostly at the base of the plant and a single leaf was folded for pupation. The newly formed pupa is light brown, but turns reddish brown toward moth emergence in 6-10 days.

Nature of Damage:

The leaf folder damages the crop in its larval stage. Mostly Damage is caused by the Second instars larvae due to the folding of leaves and feeding on the green mesophyll tissue which caused the loss of output by 20% to 30% generally (Shen et al., 1988 & Shepard et al., 1995). From within the folds which results in papery dry leave (Chatterjee, 1979) However, the young larvae feed on open leaves but later feed inside the rolled leaf formed by folding the leaf longitudinally with a sticky substance. The larvae chew inside the fold by scraping the green matter. The scraped leaves become membranous, turn whitish and finally wither (Mishra et al., 1998). This results in longitudinal white streaks causing reduced photosynthesis and plant vigour, ultimately affecting the plant growth and yield. At vegetative stage, crop generally recovers from the leaf folder damage but at reproductive stage, feeding damage on the flag leaf significantly reduces the grain filling resulting in yield loss. Generally one larva was found in each leaf fold and after feeding on that leaf it moves to another leaf. Thus single larvae feeds on a number of leaves can damage during its growth period. Heavily infested fields show many folded leaves and a scorched appearance of leaf blades. The damaged plants also pre-dispose the plants to fungal and bacterial infection. Severe infestations may annihilate the plant totally (Ramasubbaiah et al., 1980). Losses that incurred to the growing paddy crop are insurmountable (Singh et al., 2003).

Seasonal occurrence and abundance:

Although moths are recorded in the warm tropics region around the years but during the rainy season they usually are most abundant. In cool regions, the insect is active from May to October, during these periods they completes four to five generations; the later generations usually overlap. High humidity and optimum temperature are the important factors for the insect's abundance. Every year the initial population migrates to these temperate countries from tropical regions. Leaf folders have importance both in upland as well as lowland rice growing fields in the last few decades, particularly in areas where modern and scented varieties are extensively grown. Expanded rice areas with new irrigation systems, multiple rice cropping, reduced genetic variability of the modern semi dwarf varieties, application of high levels of nitrogenous fertilizers, and insecticide resistance and insect resurgence is increased the leaf folder problem.

Sources of Resistance

Host plant resistance has been recognized as one of the major tactics in integrated pest management. As a result, most of the national and international institutes have put their concerted efforts for breeding resist-ant varieties. Screening of rice genotypes for insect resistance at IRRI (International Rice Research Institute) Philippines began in 1962. The screening methods have now been developed with some improvement and modifica-tions for more· than 30 rice insect pests throughout the world (Al1onyrnous, 1988 & Heinrichs et al., 1985a). The advances in studies for resistance in rice against rice leaf folder, *Cnaphalocrocis medinalis (Guenee)* is reviewed here under two headings.

Field Screening

In early (1970) leaf folder was a sporadic pest of rice crop. Thus the screening of cultivars for resistance to it did not receive much attention. However, later on Heil1l1chs et al. (1985c) emphasized the need of identification/breeding of resistant varieties to combat this pest menace in Asia. Thereafter, identification of sources of resistance against this pest became the major objectives of most of the studies.

Screen house/green house screening

Screening for insect resistance under natural multichoice field conditions is a long term process. At the Same time, it is difficult to identify reliable and stable sources of resistance due to variation in insect populations in space and time (Dhaliwal & Arora, 1996). To overcome these problems, it is essential to develop and standardize multi or no-choice screening techniques where test cultivars can be subjected to uniform insect pressure at the most susceptilble stage of the crop.

Mechanism of resistance

Investigations on antixenosis and antibiosis mechanism have been emphasized in relation to rice leaf folder.

a) Oviposition mechanism

b) Larval feeding preference

c) Antibiosis mechanism

Molecular and biochemical markers associated with leaf folder resistance

- Association of molecular markers like isozyme and SSR and various biochemical markers have been found in leaf folder resistance.
- Soluble protein content, protein profile and peroxidise, PAL activity were the various biochemical markers studied against leaf folder.
- Decrease in leaf protein content was observed in each line due to insect infestation.
- Protein profiling revealed an enhanced expression of a high molecular mass protein in all the infested lines.
- Besides there is an increase induction of a

38KDa protein in infested resistant parent and resistant RILS.

- Significant increase in peroxidise and PAL activities was observed after infestation.
- Isoform 2 was found in resistant lines and isoform 1 was observed in susceptible lines.
- Bulk segregant analysis (BSA) With 25 RM resulted in identification of 3 polymorphic markers between bulks RM11 and RM432 located on chromosome 7 and chromosome 10 of rice.

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