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HOST PLANT RESISTANCE FOR RICE INSECT PESTS

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Rice is known as one of the most popularly grown cereal crops in terms of cultivated land and its vast consumption. It is a significant staple food for more than 3.5 billion people all over the world. Like all other field crops, rice is also affected by several insect pests. On a global scale, crop productivity of approximately 14% is misplaced by insect pests (Kebede, 2020). Different type of pests attacks in rice like from borer to sucking pest. So, it is challenging to control all kinds of pests at a time by adopting single management tools. Moreover, excessive application of insecticides causes huge economic imbalance and makes the environment polluted also.

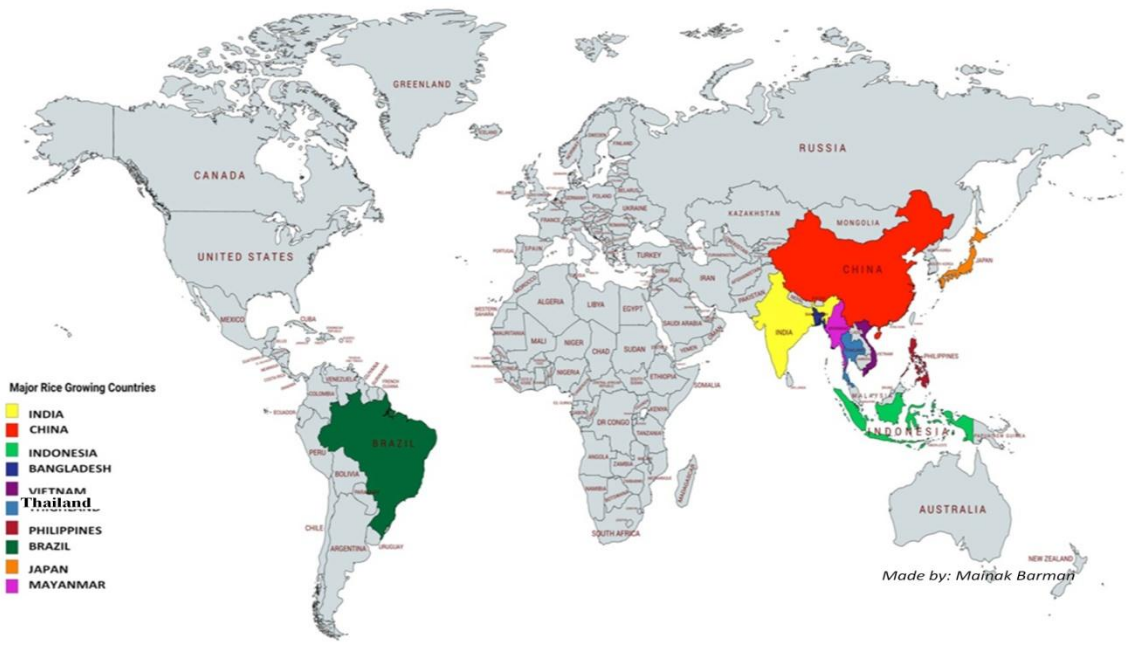

Fig1. Major ten rice-growing countries in the world (Data source: FAOSTAT 2020)

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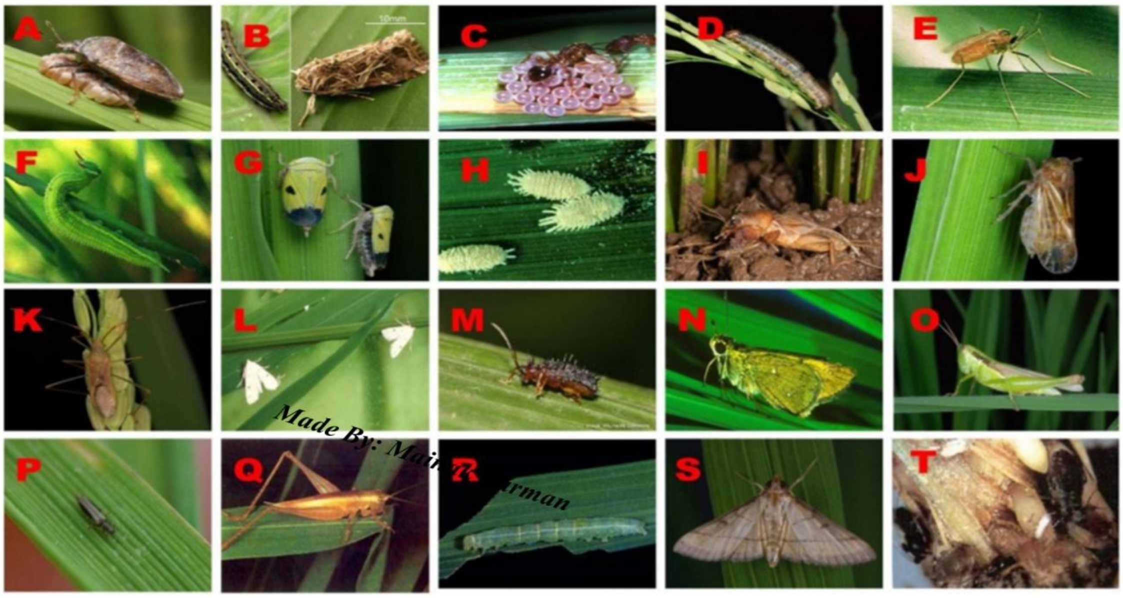

Fig 2. Major insects that attack rice plants. (A) Black bug, (B) Cutworm, (C) Ant, (D) Armyworm, (E) Rice gall midge, (F) Green-horned caterpillar, (G) Green leafhopper, (H) Mealy bug, (I) Mole cricket, (J) Planthopper, (K) Rice bug, (L) Rice caseworm, (M) Rice hispa, (N) Rice skipper, (O) Grasshopper (Short-horned), (P) Rice thrips, (Q) Field cricket, (R) Green semilooper, (S) Rice leaffolder, (T) Root aphid, (U) Rice whorl maggot, (V) Stem borer, (W) Zigzag leafhopper (Image source: Rice Knowledge Bank, IRRI).

Host plant resistance (HPR)

It is the incorporation of some novel heritable traits into the plants so that the plants can avoid, tolerate, or defend the attack of various types of pests in the field condition. Painter (1951) beautifully defined HPR as "The relative amount of heritable qualities possessed by the plant which influence the ultimate degree done by the insect in the field."

Role of HPR in rice IPM

- HPR has excellent compatibility with the other pest management tactics. It easily combines with the different tactics of pest management, due to:
- Resistant host will make the pests weak or will suppress the population so that less quantity or lesser rounds of chemicals or botanicals will control the pest.
- Due to the weakening or suppression of the pest population, the efficiency of predators, parasitoids, or microbes on the population is increased.

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- The changes, during incorporating resistant genes in the host, make the host physiologically and biochemically strong to resist the attack of insect pests. Host plant resistance can also prevent the biotype development of different insect pests, which is one of the significant problems in rice cultivation.

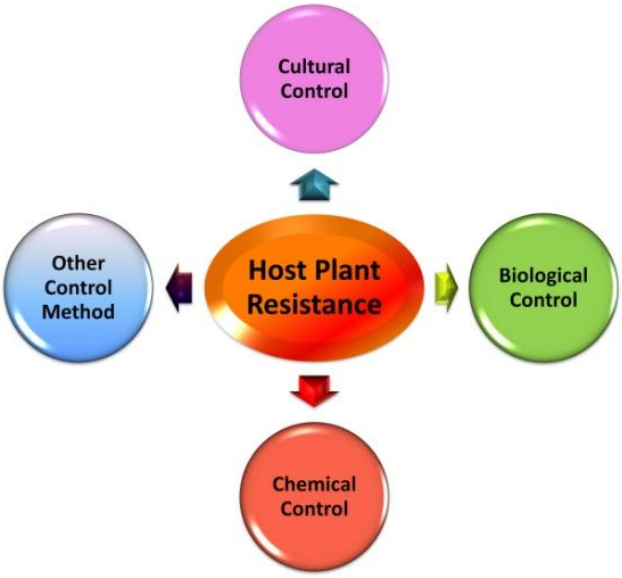

Fig 3. Approaches of Host Plant Resistance

HPR and Cultural control

It involves modification of agronomic practices in cropping system of rice by sowing the early maturing varieties and planting synchronously to avoid heavy insect attack. Synchronous planting of rice reduces potential heavy load dispersal of YSB and BPH (Loevinsohn *et al.* 1988). Planting early maturing rice cultivars efficiently suppress different pest population of rice. BPH generally starts to attack heavily from its 3rd generation. Planting rice plants in the very of the season or by planting early varieties of rice can save the plants from the attack of BPH.

HPR and Biological Control

HPR increases the activity of different biological agents generally that are already present in the fields. Resistant cultivars increase the predation rate of the spider *Lycosa pseudoannulata* on BPH (Kartohardjono and Heinrichs 1984). When BPH attacks on any resistant rice cultivar, due to the incorporated resistant gene, BPH cannot suck the sap from

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the plant properly thus, it becomes restless on the plant, and it becomes easy for the spider to detect BPH.

HPR and Chemical Control

HPR increases the efficacy of several types of insecticide. With a lower amount application of insecticides, it is possible to kill WBPH and BPH, which feed on resistant or moderately resistant rice cultivars compared to those feed on susceptible cultivars. Varieties Naveen, Lalat, and IR-36 have lower YSB and gall midge incidence with the application of HPR and cautious insecticides (Prasad *et al*. 2018).

Major Rice Breeding and Gene Deployment Strategies

1. Sequential release

- It is a gene deployment strategy
- A cultivar with a single major resistance (R) gene replaces a variety with an R gene that has been overcome by the selection for a virulent biotype.
- ***E.g.*** Replacement of IR26, a *Bph 1* gene cultivar, with IR36, a *bph2* gene cultivar (Heinrichs, 1994).

2. Gene Pyramiding

- Strategy of incorporating two or more major R genes into the same cultivar using the pedigree method of breeding is called as gene pyramiding.
- It is an effective method now in rice to develop pest-resistant lines.
- BPH resistance gene *Bph27(t)* and *Bph3* successfully pyramided into commercial *japonica* variety Ningjing3 and *indica* variety 93-11 using this approach (Liu *et al*. 2016).

3. Multiline

- It is the incorporation of a number of collected R genes into isolines and cultivating them in that same field like a mixture.
- These can be used in the field as resistant cultivars also after proper screening (Heinrichs 1994).

4. Biotechnology

Several biotechnological tools and applications can aid rice breeders to develop new insect-resistant cultivars quickly, and these are gradually becoming popular.

4.1. Wide hybridization

This is an important biotechnological tool where resistance (R) genes are collected from the wild rice and incorporated in the *O. sativa*, edible rice because, in *O. sativa*, R genes are not found.

Table 1. Agronomically important characteristics identified among the wild *Oryza* species

Species	Genome	Chromosome No. (2n)	Characteristics
O. minuta	BBCC	48	BPH, WBPH, GLH, blast, and bacterial blight resistance
O. brachyantha	FF	24	Whorl maggot and stern borer resistance
O. australiensis	EE	24	BPH resistance, drought tolerance
O. punctata	BB, BBCC	24, 48	BPH, WBPH, GLH resistance
O. longistaminata	AA	24	Floral characteristics for outcrossing
O. barthii	AA	24	Bacterial blight resistance
O. glaberrima	AA	24	GLH resistance, early vegetative vigour
O. rufipogon	AA	24	Source of cytoplasmic male sterility, tolerance to stagnant flooding
Oryza. Nivara	AA	24	Grassy stunt virus resistance
O. eichingeri	CC	24	BPH, WBPH, GLH resistance
O. officinalis	CC	24	BPH, WBPH, GLH resistance
O. ridleyi	-	48	Whorl maggot resistance

4.2. Molecular Genetics

These techniques were first applied in rice by the Rockefeller Foundation International Program on Rice Biotechnology established in 1984. Performance of world's first insect-resistant genetically modified (IRGM) rice in China of two *Bacillus thuringiensis* (Bt) lines of cry1Ab/Ac has been impressive fairly with commercial production approval from the Chinese Ministry of Agriculture during 2009 (Chen *et al*. 2011). He *et al*. (2019) showed that transgenic microRNA-14 rice had high resistance to the devastating insect rice stem borer. A new gene *BGIOSGA015651 is reported in* Rice varieties TN1 and BG1222 which can regulate the resistance of rice planthopper (Li *et al*. 2020).

Conclusion

HPR is one of the most important management tactics of insect pests in rice. It is a vastly exciting and explorable arena of science. A collaboration of different disciplines when comes across, it becomes best management tactics utilizing resistant cultivars in the fields. Innovative conventional plant breeding techniques and molecular genetics approaches may provide means of developing commercial varieties with stability to variable insect populations.

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