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Sustainable Management of Rice Insect Pests by Non-Chemical-Insecticide Technologies in China

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Abstract: Chemical pesticides play crucial roles in the management of crop diseases and pests. However, excessive and irrational use of pesticides has become a major concern and obstacle to sustainable agriculture. As a result, the quality and security of agricultural products are reduced, and the ecological and environmental integrities are threatened. Recently, environment-friendly pest management measures have been introduced and adopted to manage rice insect pests and reduce the use of insecticides. This paper reviewed the advancements in development and application of non-chemical technologies for insect pest management during rice production in China.

Key words: rice; chemical insecticide; reduce insecticide; non-chemical pest management; ecological and environmental integrity

In China, rice is the staple food for more than 60% of the population and of crucial importance to national food security (Yuan, 2014). Insect pest attacks frequently occur with varying intensities and frequencies possibly induced by the changes in climate and cropping systems in modern rice cultivation. Intensive rice production with the primary goal of achieving high yield is often characterized by the excessive application of fertilizers and pesticides. It has led to many negative environmental effects, such as the reduction of biodiversity and natural biological control, high pesticide residues in rivers, drinking water and agricultural products, rapid and high insecticide resistance in pests, secondary pest outbreaks, environmental pollution and ecological imbalance. These severe negative effects will damage the ecosystem, lead to frequent pest outbreaks and in turn require an increased pesticide dosage, which form a vicious circle (Conway and Pretty, 1991). Excessive and irrational use of pesticides has become a major obstacle to sustainable agriculture in China and is also threatening food safety and human health.

Recently, new principles, technologies and strategies of pest management have been developed. One of the principles is 'green plant protection', which has been widely accepted in China (Lu et al, 2012; Ye, 2013). Ecological control practice is another set of strategies introduced to reduce the insecticide use, and one of the strategies is ecological engineering. This paper reviewed some of the recent progress in developing such non-chemical strategies for rice insect management in China.

Reduction of initial population sizes of rice insect pests

All rice pests are exogenous, and thus the initial insect

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population size will directly affect the population development of the next generation. One strategy of pest management focuses on reducing the initial insect population size of the overwintering or immigration generations.

Low-stubble harvest, killing pupae by tillage, and submerged irrigation before field preparation

Rice stubbles after harvest usually serve as the main overwintering sites for rice stem borers, such as the striped stem borer (SSB) *Chilo suppressalis*, yellow stem borer *Tryporyza incertulas* and pink stem borer (PSB) *Sesamia inferens*. Their population sizes during the following season are largely determined by the survival rates of rice stubbles after the overwintering immature stages. Mechanized harvesting plays a significant role in stubble removal and thus can significantly reduce the overwintering sites (Wu et al, 2014). The harvesting machines adjusted to reduce rice stubble heights have been effectively applied. For instance, if rice stubble heights are adjusted to a range of 5–10 cm, the survived stem borers can be reduced by 70%–90% (Xu et al, 2015). Furthermore, approximately 70% of the overwintering stem borers can be killed by plowing and irrigation. These measures can significantly decrease the initial population sizes of stem borers (Guo et al, 2013a).

Adjust rice sowing time

In the areas infested by rice virus diseases (rice stripe virus disease and black streaked dwarf virus disease) and transmitted by the small brown planthopper (SBPH) *Laodelphax striatellus*, the sowing time of rice has significant effects on the occurrence of virus diseases. Early sowing is generally associated with the occurrence of these virus diseases during the rice seedling period and growing period. In the growing regions of one-season, japonica rice in northern Zhejiang Province, such as Jiaxing City, the occurrence of SBPH and the virus diseases transmitted by SBPH are significantly reduced by postponing the sowing time to late May or early June with no significant difference in the grain yield (Sun et al, 2008; Zhu et al, 2008). Postponing sowing and transplanting time can also significantly reduce the density and damage of SSB in transplanted and directly seeded rice fields (Zhu et al, 2011).

Escape from virus vectors during rice seedling cultures

To control the rice virus diseases, such as rice stripe disease and rice black-streaked dwarf disease, insect-proof nets (> 20 mesh) or non-woven fabrics (15–20 g/m^2) have been used to cover the seedling bed during the entire seedling period in place of the seed treatment using insecticides (Guo et al, 2013a). In the regions where rice virus diseases annually occur, the fields far away from virus sources may be selected for rice seedling culture place to 'escape' from virus infections. For example, rice seedlings can be cultured in upland fields where the south rice black-streaked dwarf disease seldom occurs, greenhouses, or the strips of land intercropped with fruits or vegetables (Guo et al, 2013b; Song et al, 2014). Commercial factory-mintensive rice seedling culture is also a favorable option.

Light trap of overwintering and immigrating insect pests

Light traps designed for pest killing may be set in fields to trap adult pests, such as rice stem borers and planthoppers. The frequency-vibration-based pest lamps are suspended 1.3–1.5 m above the ground in a checkerboard pattern with an interval of 200 m between lamps (Xu et al, 2015). The lamps are switched on at sunset and switched off at dawn during the immigration periods of rice stem borers and planthoppers. However, these lamps may cause high lethal rates for beneficial insects and neutral insects, and thus should not be used during non-immigration periods. He et al (2013) reported that a pest-killing lamp fitted with an exhaust fan is more suitable than frequency-vibration pest-killing lamps because the survival rates of beneficial insects and neutral insects can be more than 70%. The insects caught in these lamps could also be the food for fish culture (Xu, 2010). In addition, the occurrences of SSB and rice planthoppers near pest-killing lamps should be monitored and used to determine the pest management options.

Decreasing population growth rates of rice insect pests by enhancing resistance of rice varieties

In an agro-ecological system, the growth of insect pest population depends on the initial recruitments, natural population growth rate, and the impacts of control measures. Pest management strategies should focus on limiting the initial pest recruitments to reduce the future generations (Cheng et al, 2008). Pest management strategies may include genetic resistance, acquired resistance during cultivation practices, improved