Enhancing and Protecting Biological Control Services in Rice Ecosystems

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ABSTRACT

Traditionally rice ecosystems in Asia are well endowed with a diversity of arthropods that provide the fundamentals of naturally occurring biological control. Typically an unsprayed rice field has 41 % predators, 35 % parasitoids, 11 % detritivores and 13 % herbivores and very few species of the herbivores are pests[1]. The demands for higher production using modern cultivation methods however have driven rice ecosystems into large monocultures with reduced biodiversity in varieties and habitats. Coupled with intensive use of chemical fertilizers and pesticides through government subsidies and sales promotion campaigns, the naturally occurring biological control services have been compromised resulting in frequent pest outbreaks. Recent analyses of farm insecticide use and yields showed that farmers have little or no productivity gains from their insecticide sprays.

Devastating pest outbreaks especially from planthoppers (primarily the brown planthopper (BPH, the white back planthopper (WBPH) and the small brown planthopper (SBPH)) continue to threaten rice production in many parts of Asia. For instance in January 2010 the Thai government had to announce a 16 % reduction in rice export forecasts as thousands of farmers lost their crops to the BPH. In 2011 Indonesia lost a million tons of rice to BPH and in China in 2012 the southern provinces suffered the worst losses to planthoppers in 20 years. Besides production and economic losses, thousands of farmers suffered crop failures, bankruptcy, pesticide poisoning and had forced some into poverty and even suicides.

Planthoppers are r strategists that are normally under natural biological control. The outbreaks are symptoms of unsustainable practices that destroy the vital biodiversity and ecosystem services that trigger the abnormal exponential growth in populations. Although weather factors like drought and floods can also trigger pest outbreaks, the most consistent factor in the planthopper outbreaks in Asia has been insecticide misuse[2]. The rampant misuse of pesticides in Asia is due

[1] Pests are organisms that can cause economic loss when their population densities are sufficiently high.
[2] Misuse is defined as improper or incorrect use

to the weak marketing regulations that permit pesticides to be sold as "fast moving consumer goods" or FMCGs, like tooth paste, soap and candies. In addition pesticide active ingredients are marketed in hundreds of trade names in sachets packaging, like instant coffee and shampoos, promoted through multitier marketing schemes and retailed by village level general stores. Often the local village store keeper will act as the pest control advisor as well. To promote sales aggressive marketing campaigns are launched using new fear appeals (like climate change, new strains), sales incentives (like free gifts, free trips and even a free trip to Mecca).

Field experiments have shown that insecticide sprays generally reduced the arthropod community average food chain length[3] by 25 %. Although the chain length gradually recovered the spray disruption had caused "catastrophic asynchrony" in predator-prey relationships rendering predators and parasitoids ineffective. When insecticide sprays were withheld for an extended period species biodiversity of functional groups in the rice ecosystem could be restored and sustained. For instance in IRRI farm in the Philippines when insecticide use was reduced by 95 %, total arthropod species richness increased by 125 % and the species richness of herbivores, predators, parasitoids and detritivores increased by 165 %, 73 %, 122 % and 436 %, respectively. The "new" herbivore species were non pest species, like aphids and leaf mites and low in densities while the "new" predator and parasitoid species were natural enemies of pests. One of the factors that triggered continuous BPH outbreaks in Central Thailand was the rampant misuse of abamectin and cypermethrin that have adverse effects on natural enemies, especially the hymenopteran parasitoids. In June 2011 the government in collaboration with the private sector launched the "Stop abamectin and cypermethrin in rice" campaign using printed materials and the mass media. This created awareness among farmers and their reduced uses of the 2 insecticides had contributed to the reduction in BPH outbreaks from 2013.

Pioneering field experiments in China showed that the growing of sesame which provided a rich source of nectar around rice fields benefited planthopper egg parasitoids, *Anagrus* spp. The sesame flowers also increased the efficiency of *Cyrthorhinus*, a planthopper egg predator. In addition the growing of the vertiver grass as a trap crop to attract the striped stem borer to lay eggs on them helped farmers in reducing stem borer attacks as the larvae were unable to survive on vertiver.

Enhancing and protecting biological control services should now form the foundation of rice pest management strategies in Asia using ecological engineering methods. The growing of selected crops or nectar-rich flowering plants around rice fields can provide the **S**helter, **N**ectar, **A**lternative hosts and

[3] Mean food chain length is the average length (or links) of all maximal food chains from basal species to a top predator.

Pollen (abbreviated SNAP) for natural enemies that will restore and sustain biological control services. In order to be effective the flowering habitats need to be grown in large scales at the landscape level. Since in most Asian countries rice farmers have small farm sizes, strategies to motivate thousands of farmers to adopt flower growing can be challenging. The use of entertainment-education[4] TV programs called the "Ecological Engineering TV" *("Cong Nghe Sinh Thai"* in Vietnamese) series has been found to be effective in modifying farmers' attitudes towards cultivating flowers on rice bunds in Vietnam. In addition some provincial governments are considering paying farmers to grow flowers instead of providing pesticide subsidies. In South Korea, the enactment and implementation of the Environmental Friendly Agriculture Act shifting subsidies towards "paying farmers for environmental services" had encouraged rice farmers to adopt sesame and soybean growing on rice bunds.

At the same time, increased efforts to reduce insecticide sprays in rice fields especially in the early crop stages (for instance first 40 days after sowing) need to be emphasized. In addition the use of active ingredients that are detrimental to natural enemies, especially the hymenopteran parasitoids, like the pyrethroids, abamectin and the neonictotimoids should be avoided. The TV series in Vietnam had educated farmers about the benefits of flowering plants and at the same time also educated farmers about the negative effects of insecticides on natural enemies and had motivated TV viewers to reduce their insecticide sprays by 60 %.

While the technical aspects pertaining to enhancing and protecting biological control services may be further researched to refine field techniques, a parallel process for changes at regulatory and educational levels has to be in place for successful implementation. Among the reforms that need to be considered are

1. Pesticide marketing regulations that will control distribution and marketing in accordance to the FAO International Code of Conduct for Pesticide Management, 2007, revised 2013. Pesticides (some have acute and chronic toxicities to humans) should be sold by certified retailers and not village general store owners.
2. Plant protection services that will need to focus on general ecosystem health practices in preventing pests occurring rather than "fighting pests" when they occur. The main principles will be based on "pests are not guilty until proven" and that "insecticides are NOT needed and should only contemplated as the last resort".
3. Professionalization of plant protection services to a system similar to that of medical services where plant protection professionals (like doctors) are trained and certified and pesticide retailers (like pharmacists) are also trained and certified.

[4] Entertainment education (E-E) is the process of designing and implementing a program (example a TV series) to both entertain and educate so as to increase audience members' knowledge, create favorable attitudes, shift norms and change behavior.

4. An Act similar to that of Korea's Environmentally Friendly Agriculture (EFA) that will shift support, organization, benefits, funds and subsidies to favor the enhancement and protection of biological control services.

Keywords: Rice Planthoppers, Pest outbreaks, Biological control, Pesticide misuse, Ecological engineering, Entertainment-education