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Applying ecological engineering for sustainable and resilient rice production systems

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Abstract

Global changes will affect rice ecosystems at local levels. Although issues of climate change have received most attention, other global changes will have more immediate impacts on crop productivity and health. These changes include the phenomenal advances in modern industrial output, especially in China and India, in mechanization, in communications technology and advertizing, in transportation networks and connectivity, as well as demographic shifts toward urban centers. Driven by policies around food security, market impacts on crop production, and trade regulations, these changes will define crop production systems into the future, impacting rice biodiversity and ecosystem function and giving rise to new pest and disease scenarios. This paper presents a framework for a holistic approach to 'rice ecosystem health' aimed at securing food production while protecting farmer, consumer and ecosystem health. Recent advances in environmentally friendly agriculture, including ecological engineering, are central to the sustainability and resilience of rice ecosystems; but require support from policy to ensure their best effects. This paper introduces some recent advances in the methods of ecological engineering based on research conducted in the Philippines.

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Keywords: Agroecology, climate change; flower strips, global changes, planthoppers, vegetable strips;

1. Introduction

1.1. Rice production in a changing World

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Rice is the principal staple food for more than a third of the world's population. Over 90% of the world's rice is produced and consumed in Asia and between 40 and 46% of all irrigated cropland in Asia dedicated to rice production[1,2]. As the World's human population continues to grow and the availability of agricultural lands decline, estimates are that the World must produce an additional 115 million tons of rice by 2035 to meet increasing global demands[3]. Whether these estimates are correct or not, they have been responsible for driving science and policy around rice production since the beginning of the new millennium, particularly in Asia. This has led to calls for greater investment in science and technology for rice agriculture, an emphasis on intensifying rice production and on strengthening partnerships engaged in rice production, rice provisioning, and marketing[4,5].

Emerging agricultural policy in the 21st century will be implemented amidst a backdrop of rapid global changes in society and the environment: changes in society include changes in the ways in which humans use resources, in human productivity and in social connectedness[6]; environmental changes include climatic anomalies such as increasing global temperatures and the frequency of extreme weather events, as well as declining biodiversity and eroding ecosystem functions[7]. As these factors continue to change, they will impact the nature of rice production from global to local (farm) scales. Furthermore, given the instability of the global economy, particularly since 2008 (when the World experienced global food and economic crises at the same time), demands for increased food production have been met with calls for greater involvement of the private sector in developing strategies and guiding science[5]. As a result, the current production scenario for many rice farmers consists of demands to increase productivity with increasing pressure through advertising and efficient marketing to intensify inputs. In many regions, this has contributed to tremendous changes in rice landscapes, particularly in lowland irrigated rice systems, and often drives farmers toward questionable intensification methods[8,9]. Without proper regulation of farming practice and especially regulation in the nature and use of farm inputs such as pesticides, intensification could lead to global food insecurity by reducing the efficiency of key rice ecosystem functions.

1.2. Increasing insecticide use and its consequences

Trends in the imports of agricultural inputs to rice producing countries show a sustained increase in the availability and use of agrochemicals, including fertilizers and pesticides, over the last 50 years. However, between 1995 and 2002, China and India both shifted from being net pesticide importers to major exporters, as both countries invested in their chemical industries[10]. At the same time, pesticide imports into several Asian countries including Bangladesh, Thailand, Indonesia and Vietnam began to grow exponentially (Fig. 1.)[10]. Chemical insecticides made up much of these imports. With such a high availability of insecticides, new tools in social connectivity and advances in marketing strategies have been used to efficiently deliver the insecticides to farmers and encourage them to increase their applications[11]. One common strategy has been to create demands for pesticides by developing prophylactic application schedules which are distributed to retailers or directly to the farmers. The sudden increase in insecticide use by rice farmers from the beginning of the 2000s, is thought to underlie the simultaneous occurrence of pest outbreaks, including planthoppers (Homoptera: Delphacidae) and leaffolders (Lepidoptera: Pyralidae), at several sites throughout Asia[12,13]. For example, it is estimated that since 2000 China has lost about 1 million tons of rice production annually because of planthopper damage; over 3 million hectares of rice was damaged in Thailand between 2009 and 2011[14]; and an estimated 200,000 hectares of rice was destroyed in Central Java (Indonesia) in 2011 alone (Horgan and Stuart, unpublished data). The outbreaks of planthoppers in particular were so bad, that many regions experienced 'hopper storms' at the time of rice harvest, as displaced planthoppers were attracted to city lights becoming a public nuisance and affecting economic activities including restaurants, cafes and retailers (personal communications with farmers in Indonesia and China).