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Decreased use of pesticides for increased yields of rice and fish-options for sustainable food production in the Mekong Delta

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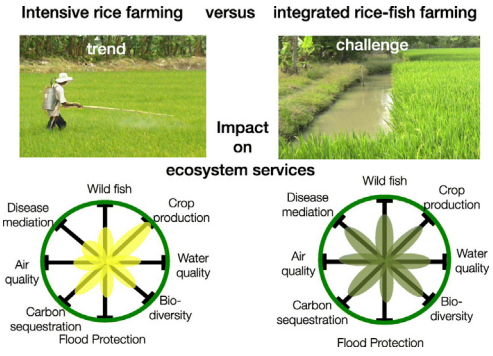
HIGHLIGHTS

- 85% of all farmers had experienced health effects from using pesticides.
- 75% of the farmers said that the fish yields had decreased, mainly due to pesticides.
- For rice-fish farmers the fish and rice yields increased with decreased pesticide use.
- Rice-fish farmers with a low use of pesticides had significant higher yields than rice farmers.
- These farmers had also a higher net income and rate of return compared to rice farmers.

GRAPHICAL ABSTRACT



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ABSTRACT

This study assesses the use of pesticides and the attitude to pest management strategies among rice and rice-fish farmers in the Can Tho and Tien Giang provinces in Vietnam. Interviews were made with 80 farmers. The farmers were divided in to farmers cultivating only rice with a high use (RHP) and low use (RLP) of pesticides, and farmers cultivating rice and fish with a high use (RFHP) and low use (RFLP) of pesticides. 80% of the HP farmers relied mainly on pesticides to control pests, while >80% of the LP farmers also applied IPM strategies. Insecticides were the most commonly used pesticides. 85% of all farmers experienced health effects from using pesticides. 80% of the farmers felt that the yield of fish had decreased over the last three years, and that this mainly was caused by pesticides. The RFHP farmers had lower fish survival and fish yields as compared to the RFLP farmers. The RFHP farmers also had significant lower rice yields than the RFLP farmers, and there were significant correlations between both decreased fish yields and rice yields with increased use of pesticides among rice-fish farmers. Increased rice yields were positively correlated with increased fish survival, indicating the synergistic effects between rice and fish production. Overall, the RFLP farmers had the highest income of the four farmers´ groups, while RFHP farmers had the lowest income. This shows that rice-fish farming provides a competitive and sustainable alternative to intensive rice-farming, but only if the farmer restricts the use of pesticides. This would not only help to reduce the production costs, but also to decrease environmental and health effects, and it is proposed that rice-fish farming with a low use of pesticides provides an attractive alternative to rice-monocropping for a sustainable and diversified food production in the Mekong Delta.

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1. Introduction

Rice production plays an important role in the agriculture economy of Vietnam and is the main livelihood of 80% of the rural population (Tam, 2016). More than 50% of the rice in Vietnam is produced in the Mekong Delta, even though it occupies only 12% of the land area (Tong, 2017). During the last three decades, rice farming in the Delta has been intensified to satisfy the food demand of the increasing national population and to generate export earnings (Tong, 2017).

Strategies for increased rice production have mainly relied on intensified farming methods, supported by high yielding rice varieties and increased use of agrochemicals, especially pesticides (Huan et al., 2008; Phong et al., 2010). The amount of pesticides imported to Vietnam increased from 100 tons per year in the 1950s (Hoi et al., 2016) to the highest of approximately 150,000 tons in 2008 and then dropped to 103,500 tons in 2012 (Tam, 2016). The outbreak of brown planthopper (*Nilaparvata lugens* (Stål)) during 2005 and 2007 was the main reason for the high pesticide imports in 2008 (Hoang et al., 2011; Normile, 2013). The number of active ingredients increased from 294 in 2002 to 1085 in 2011 (Tam, 2016). The total cost of pesticides imported to Vietnam reached US$ 744 million in 2012 (Hoi et al., 2016).

The increased use of pesticides has helped to increase the rice yields, but also proved to be unsustainable and cost ineffective, due to negative effects of pesticides on human health and the environment (Berg et al., 2012, 2016; Dasgupta et al., 2007; Hu et al., 2013). Tam et al. (2015) reported that farmers spraying organophosphates on rice fields, resulted in both reduced growth and survival rates of fish. Dasgupta et al. (2007) found that over 35% of 190 rice farmers in the Mekong Delta, experienced acute pesticide poisoning, and that 21% were chronically poisoned. Several other studies have also found negative impacts of pesticides on human health in the north of Vietnam (Phung et al., 2012a, 2012b, 2013).

Anh et al. (2003) indicated that the wild fish resources, such as climbing perch (*Anabas testudineus*) and snakehead fish (*Channa striata*), in rice fields and floodplains of the Mekong have declined by 70% compared to 30 years ago, partly because of a high use of pesticides. However, official information about the negative side effects of pesticides on aquatic organisms from rice fields in the Mekong Delta is scarce.

In order to sustain a high and healthy production of rice and fish from the Mekong Delta it has increasingly been argued that there is need to "rethinks" current agriculture methods, and find more sustainable rice-farming strategies (Berg et al., 2016; Tong, 2017; Xie et al., 2011). Integrated rice-fish farming has been suggested to provide economically, ecologically and socially sustainable alternatives to intensive rice monoculture, since these systems require less agrochemical, provide a diversified income from both fish and rice, and have less negative impacts on the environment and people's health (Berg, 2002; Hu et al., 2016; Luo et al., 2014; Xie et al., 2011; Zhang et al., 2016; Zheng et al., 2016). An increased mixture of rice and aquaculture systems could also increase the farmers' income and their adaptability to climate change and up-streams dams (Smajgl et al., 2015; Xie et al., 2011).

This study assesses the use of pesticides and the attitude to pest management strategies among rice and rice-fish farmers with a high use and low use of pesticides in the Can Tho and Tien Giang provinces in 2012, and to what extent these have changed compared to 2007 and 1999, when similar surveys were conducted in the same provinces (Berg, 2001, 2002; Berg and Tam, 2012 and Berg et al., 2012). The study aims to show that integrated rice-fish farming can provide a competitive and more sustainable alternative to intensive rice mono-cropping, if the farmer restricts the use of pesticides. Also by comparing the rice and fish yields, growth rates and survival rates of fish among rice-fish farmers with a high and low use of pesticides, the study aims to assess to what extent pesticides can contribute to an increased food production from these integrated systems, or if pesticides rather lead to a decreased productivity because of their negative environmental side effects.

2. Methods

2.1. Study areas

The Mekong Delta is located in Southern Vietnam (8°60′N to 10°N and 104°50′E to 106°80′E) and covers an area of 39,000 km^2 (Fig. 1). It is the most important agricultural region in Vietnam (Tam, 2016; Tong, 2017). Triple and double rice cropping are the dominant farming systems in the Mekong Delta, occupying up to 70% of the agricultural land (Tong, 2017). The total rice farming area in the Mekong Delta has increased from approximately 1.2 million ha in 1995 to approximately 1.7 million ha in 2013, and the rice yield has increased from 4.0 to 5.8 tons/ha/crop during the same period of time (MARD, 2014).

Large areas of the Mekong Delta are suitable for freshwater aquaculture, but <10% of the area is used for this purpose (Duong et al., 1998). However, aquaculture is becoming increasingly important, as exemplified by the quick expansion of *Pangasius* Catfish farming (Nguyen et al., 2017). Currently the Delta accounts for some 70% of Vietnam's aquaculture production (Johnston et al., 2009), which calls for a more restrictive use of pesticides and other agrochemicals, to assure an acceptable water quality for a sustainable and healthy fish production (Berg et al., 2012; Tong, 2017).

This study was carried out in the Can Tho (Thoi Lai district) and Tien Giang (Cai Be district) provinces, representing two major rice producing regions in the Mekong Delta. Both areas have very good irrigation systems consisting of dense networks of canals and rivers. The first rice crop is usually grown from November to February, the second crop from February to May, and the third crop from May to August (Berg et al., 2016). The total area of rice-fish farms in the Cai Be and Thoi Lai districts were 180 and 1509 ha, respectively. The total number of rice-fish farmers in the Cai Be and Thoi Lai districts, were 437 and1200 respectively, representing 6–7% of all the rice farmers.

2.2. Farmers survey

A total of 80 farmers in the Can Tho and Tien Giang provinces were randomly selected for interviews (40 farmers per province). Selected farmers were divided into four groups: farmers cultivating only rice with a high use (RHP) and low use (RLP) of pesticides, and farmers cultivating rice and farming fish with high use (RFHP) and low use (RFLP) of pesticides. Each group in each province consisted of about ten farmers. Interviews were made with farmers who had two or three rice crops per year, as these were the systems with the highest use of pesticides. Structured interviews about farming practices (e.g. agrochemical use), yields and the farmers' perception of environmental and health effects, were conducted with pre-tested questionnaires in Vietnamese. To be able to make a comparison over time, the same questionnaires were used as in similar studies from 1999 and 2007 (cf. Berg, 2001; Berg and Tam, 2012).

The data was analyzed by dividing the farmers into the four different categories (RHP, RFHP, RFLP, RLP) in each province. As the answers between farmers from the different provinces often were similar, they were pooled into the same categories. Attributes of the interviewed farmers are found in Table 1. Differences between categories were investigated using one-way analysis of variance (ANOVA) with Turkey's HSD (honestly significant difference) used as the post-ANOVA test. Data was checked for normal distribution and transformed when necessary, before the statistical analyses were performed. SPSS for windows (Ver 17.0; SPSS, Chicago, IL, USA) was used to analyze the data.