CONSERVATION AND DEVELOPMENT OF THE FLOATING RICE BASED AGROECOLOGICAL FARMING SYSTEMS

IN THE MEKONG DELTA

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FORWARD

In response to global and regional shifts in agroecology, a series of research projects on conservation of floating rice-based agroecological farming systems in the Vietnamese Mekong Delta were undertaken. Project activities were conducted between 2013 and 2016 and were co-designed by scientists from An Giang University, and local decision makers, private sector partners, business leaders, and farmers. Research activities were led by Dr Nguyen Van Kien from the Research Center for Rural Development (RCRD). Subsequently, RCRD received funding to edit this book from three sources. Over ten small supported by a research grant from An Giang Department of Sciences and Technology. Five international research agencies: Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), Pesticide Action Network Asia Pacific (PAN AP), Rufford Foundation, Sustainable Mekong Research Network (SUMERNET) and Agro-ecological Learning Alliance in South East Asia (AliSEA) provided research funding. Further support to produce and publish this book was from on going collaboration between RCRD researchers, local governments of Tri Ton, Cho Moi Districts of An Giang province and Thanh Binh District of Dong Thap province, Mekong Delta, Vietnam. Gratitude is expressed to the several hundred farmer sproducing floating rice and who contributed greatly to the knowledge presented in this book.

As a multi-disciplinary research project, social, economic, and ecological scientists were all part of this team. Projects studied different aspects of the floating rice agroecological farming systemsby investigating: the biophysical condition of each farm (soils, minerals, and waters), socio-economic conditions of farm households and the value chain for farm products. Areas of research included: several crops (floating rice, cassava, leeks), common pests, adaptation to climate change (floating rice varieties), and assessment of agrobiodiversity. An important finding was that the economic, social, ecological and biodiversity richness of floating rice-based farming systems provided far greater benefits than the economic returns of mono rice cropping systems. In fact, floating rice systems exhibited greater flexibility, diversity, and adaptive capacity and resulted in more sustainable outcomes than conventional intensive rice cropping systems.

This book is a systematic presentation of a collaborative multi-disciplinary and multi-institutional study and informs the development of future policiesin agriculture conservation and development. The intention is to provide readers, especially our international colleagues in agriculture research, scientific data on agroecological farming systems in the upper floodplain of the Mekong Delta. This book is also a reference resource for university students from the fields of agricultural sciences, agroecology, food systems, human ecology, sociology, environmental management and climate change. Hopefully, this book will initiate more sustainable agroecological farming system research and further uptake in Vietnam and Mekong countries.

We wish to acknowledge the significant contributions of the many scientists involved who together produced high quality research. Special thanks to donors at An Giang Department of Sciences and Technology, Department of Finance, SEARCA, SUMMERNET, Rufford Foundation sau PAN AP and AliSEA for funding the research, and our International Relations and Scientific Research Office of An Giang University for support to establish the scientific committee to defend the projects. Our thanks to Dr Charles Howie, for co-editing the entire of manuscript, Dr. Kim Alexander, Ms Sarah Huang, and Ms Phuong Nguyen for proof reading of chapters, and Ms Truong Ngoc Thuy to arrange logistics with the contributors. We are grateful to the Vietnamese funders and international donors who provided financial support for these projects Finally, we give special thanks to AliSEA to fund the printing costs and to the Agriculture Publisher for their keen interest in publishing this book.

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Collaborative research: linking science and policies into agro-biodiversity conservation and development in the context of floating rice-based farming systems in the Mekong Region

Nguyen Van Kien, PhD

Abstract

Floating rice-based (FR) farming system in the Mekong Delta reduced significantly from 0.5 million ha in 1970s to 46 ha in 2012. Before the 1990s the FR based farming, system was wildly developed in Asian Deltas, supporting the livelihoods of over 100 million people. Farmers cultivated only one low yield floating rice crop per year, harvested wild fish and aquatic animals to maintain their livelihoods and rotated dry season vegetable crops for selling. However, the cultivated areas of FR were mostly replaced by, the introduction of short-term high yield variety HYV (High Yield Variety) rice into Vietnam in 1968, the impact of the so-called Green Revolution. HYV rice arrived from the International Rice Research Institution (IRRI) and were adapted by Vietnamese researchers and spread quickly across the delta until now. However, the floating rice-based agroecological farming systems were wildly recovered in recently because it improves livelihood diversity for farmers and recovering inland wildish for local food security. This paper describes the outcomes of collaborative research projects and presents the technical, economic, social and environmental outcomes of several floating rice conservation projects in the Mekong Delta. It suggests research and agricultural policies that integrate food security and agrobiodiversity into restructuring rice policies in Vietnam and the Mekong Region could be advantageous for both farmers and the environment.

Key words: Collaborative research, science and policies, floating rice, agroecological farming systems, Mekong Delta.

Introduction

Floating rice or deep-waterrice, grown in flooded conditions with long stalks and maintaining foliage on top of the water, was a major dietary component for populations in Asia and West Africa prior to the 1980's. According to Castling (1992), during the 1970s there were 5.0 million hectares (ha) of floating rice grown in Ganges-Brahmaputra basin of India and Bangladesh, 1.28 million ha along the Irrawaddy of Burma (now Myanmar), 0.76 million ha in Chao Phraya of Thailand, 0.57 million ha in the Vietnamese part of the Mekong Delta, 0.41 million ha in Cambodia part of the Mekong Delta, and 0.16 million ha in Central Niger of West Africa. Floating rice was found to be cultivated in Stung, Siem Reap province of Cambodia in the eight century (Liere 1980).

During the pre-colonial period in Vietnam, in the Nguyen Dynasty (1705-1858), floating rice was grownin flood prone areas of the Mekong delta (Long Xuyen Quadrangle and Plains of Reeds areas in Cambodia and Vietnam). During the French colonial time in 1911, Chau Doc province had 275,876 ha of land, of which only 24,039 ha was planted with floating rice (Biggs 2003: 91-93). Floating rice varieties were a source of high quality dietary nutrition for people living in the MRD. During the colonial period, people harvested floating rice, they also fished and hunted wild animals for their home consumption (Biggs 2003: 81). Areas of floating rice plantings during 1960s in Cambodia and Vietnam along the Mekong Delta are illustrated in Figure 1. Floating rice remained as the most important rice variety produced and consumed until the 1980s, when the green revolution introduced different rice varieties that outperformed floating rice production (Biggs 2003; Vo and Matsui 1998; Vo 1975; Brocheux 1995).

History of floating rice agro-eco systems in the Mekong Delta

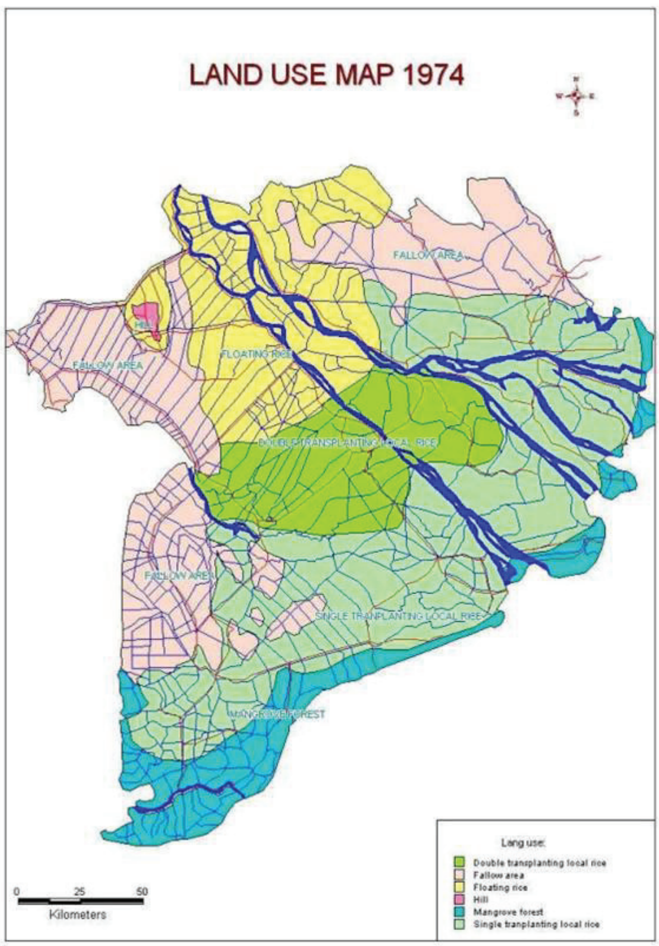

Figure 1. Planted areas of floating rice in 1960s.
Source: Adapted from Vo Tong Xuan and Matsui (1998)

Since high yielding varieties (HYV) of rice were introduced into the Mekong Deltain the1960s, cultivation of floating rice has reduced significantly (Chiem 1994; Kakonen 2008). For example, by 2012, the Vinh Phuoc commune estimated that only 41.2 ha of floating rice remained with a further 20 ha in Luong An Tra commune of Tri Ton district, 46 ha in Cho Moi district of An Giang province, and 43 ha in Thanh Binh district of Dong Thap province (Nguyen et al. 2013).

The conservation of floating rice-based farming systems provides alternative options for living with floods while adapting to climate change. Because of the plants ability to elongate, the stem can extend its length by up to 25 cm per day during the flood season, so it can adapt well to rising water levels in Asian deltas. Farmers often rotate floating rice with dry season profitable vegetables crops that use less water, also thanks to the use of the long-stemmed rice straw as mulch (Nguyen and Huynh 2015). Additionally, the floating rice-based systems provide habitats for freshwater wild fish and other aquatic animals that are a rich protein source for rural people in the Mekong region. Finally, floating rice is perceived as safe, chemical free, and nutritious for local people in the Mekong region.

The Research Centre for Rural Development (RCRD) at An Giang University conducted a three year research program for the recovery of floating rice-based farming systems (Research Centre for Rural Development 2013). RCRD has collaborated with multiple research team (social science, ecology, soil, economics, water, food sciences and farming systems) to undertake the long-term research (3 years), also linking with international researchers via several international research grants. RCRD actively engaged with local government, farmers, local academia, media and business partners to promote floating rice conservation in the Mekong Delta and extended this conservation work further into the Mekong Region (Cambodia) also in Myanmar. Both research and development activities have been implemented and social, technical, nutritional and economic analysis of the floating rice-based farming systems were undertaken. Training for farmers and local decision makers about ecological farming practices and marketing of these products were repeated over several years. In addition, the first Vietnam rice festival was organized to attract international, NGOs, local decision makers, students, and researchers and farmers to recall the traditional ways of living with floods through the flood-based floating rice systems.

Socio-economic conditions of floating rice growers

Since floating rice has not been depicted in current Mekong delta land use maps, very few local people know the existence of floating rice in the flood prone parts of the Mekong Delta. Floating rice production has not been included in the annual socio-economic reports by the Department of Agriculture and Rural Development in either An Giang or Dong Thap provinces. Fortunately, researchers at An Giang University have discovered that floating rice was stil being cultivated in Vinh Phuoc and Luong An Tra commune of Tri Ton District of An Giang province, and Tan Long commune of Thanh Binh district of Dong Thap province.

Table 1. Lists of floating rice farmers in Vinh Phuoc and Luong An Tra communes of Tri Ton district, 2014.

Full names	Gender	Locations	Cultivated areas (ha)	Cultivated years
Nguyễn Văn Thống	Male	Luong An Tra-Tri Ton	3.0	Over 20
Huỳnh Minh Đông	Male	Luong An Tra-Tri Ton	3.5	Over 20
Huỳnh Minh Phương	Male	Luong An Tra-Tri Ton	3.5	Over 20
Nguyễn Văn Gõ	Male	Luong An Tra-Tri Ton	3.0	Over 20
Nguyễn Văn Tồn	Male	Luong An Tra-Tri Ton	4.5	Over 20
Trần Thanh Hiền	Male	Luong An Tra-Tri Ton	4.0	Over 20
Đoàn Văn Thanh	Male	Luong An Tra-Tri Ton	10.0	Over 20
Nguyễn Văn Trống	Male	Vinh Phuoc-Tri Ton	3.2	Over 30
Lê Hùng Tâm	Male	Vinh Phuoc-Tri Ton	4.6	Over 30
Nguyễn Văn Nào	Male	Vinh Phuoc-Tri Ton	5.0	Over 20
Nguyễn Thanh Hồng	Male	Vinh Phuoc-Tri Ton	2.0	Over 20
Bùi Bích Tiên	Male	Vinh Phuoc-Tri Ton	4.5	Over 20
Trần Văn Mang	Male	Vinh Phuoc-Tri Ton	3.0	Over 20
Nguyễn Văn Phước	Male	Vinh Phuoc-Tri Ton	1.5	Over 20
Nguyễn Văn Lạc	Male	Vinh Phuoc-Tri Ton	2.8	Over 20
Nguyễn Thanh Vũ	Male	Vinh Phuoc-Tri Ton	2.5	Over 20
Lê Thị Pha	Female	Vinh Phuoc-Tri Ton	1.0	Over 30

Source: In-depth interview with Mr Nguyen Van Nao, a floating rice farmer in Vinh Phuoc Commune of Tri Ton District in January 2013.

The research team found there were about 17 floating farmers live in a remote village of Tri Ton district who continued cultivating this crop in 2012. The average of land ownership is 3.6 ha per household (min is 1.0 and max is 10 ha). Only one female headed households among 17 households was cultivating floating rice (Table 4). Some of the farmers had been growing floating rice for more than 30 years. Most of them have cultivated it for over 20 years and just one had been planting it for just five years. Most of those farmers were immigrants from other districts or provinces in the Mekong delta and had arrived more than 15 years ago. In the 1980s, pioneer farmers came to reclaim the melaleuca forest before cultivating floating rice. However, the exposed soils were so acidic these farmers sold on their land to immigrants (who came from Chau Phu district). There are still some unused land areas in the village which are unsuitable for rice cultivation because it is too acidic. Farmers recalled that floating rice was the only crop adapted well to acid soils, so they have kept on with production. Some farmers have grown floating rice to aid production of upland crops after the floods have subsided, as floating rice provides a thick layer of rice straw, mulch for crops such as cassava, leeks, maize, pumpkin and chilli. Rodents, rats, are problematic to floating rice production, but many continue to cultivate floating rice regardless.

Floating rice and its adaptation capacity

Rice growing areas in the Mekong River Delta (MRD) are vulnerable to the impacts of anticipated climate change. Climate change adds the new risk of flooding to low lying deltas around the world (IPCC 2007). South and South East Asia are most vulnerable to flooding because of the concentration of low-lying populated deltas (Nicholls et al. 1999). There is more evidence that sea level rise will add a new risk of flooding in the MRD which will affect the livelihoods of millions of people (Eastham et al. 2008; Wassmann et al. 2004; Dasgupta et al. 2007; Pham and Furukawa 2007). Sea level rose by 20 cm in the past 50 years and is expected to increase by 75 cm by the end of 21st century in Vietnam's Mekong Delta (Ministry of Natural Resources and Environment 2009). Wassmann et al. (2004) estimated that 2.3 million ha (60% of the MRD) was highly vulnerable, while 0.6 million ha (15%) and 1 million ha (25%) experienced medium to low vulnerability respectively due to sea level rise. Wassmann et al. (2004) concluded that these adverse impacts could affect all three rice cropping seasons in the delta. It is predicted that in the next century, with a sea level rise of one meter, about 10.5 per cent of Vietnam's population or about 20 million people will be displaced (Dasgupta et al. 2007). The livelihood of the rural people will be negatively impacted, if adaptation measures are inadequate.

Recovering the floating rice based agroecological systems is a real option for adaptation to climate change. The current approach in living with the floods should be re-examined in order to enhance ecological – social resilient farming system (Nguyen 2013). Floating rice adapts well to shallow and deep seasonal riverine flood events in Southeast Asian Deltas (Cuny 1991; Catling 1992). The growth of floating rice initially depends on rainwater, providing moisture for germination and early growth until flooding occurs in mid-August. The flood water level usually rises gradually, and the rice plants follow up the rising water through stem elongation at approximately 25 cm/day, though long stubble elongates by~1.5 – 3.0 m (Kende et al. 1998). When the water level recedes in November (lunar calendar), the rice plants lie flat on the ground and flowers during November and harvest in December. According to a group of floating rice growers in Tri Ton district of An Giang province, each rice plant can produce around four tillers, each with two or three panicles (personal communication with Mr Hao on 10 Sep 2013). Vo (1975) claims the average yield of floating rice to be one ton/ha, though yields can be greater in the deeper region. However, the aver age yield is estimated from 1.50 - 2.0 tons/ha in Luong An Tra commune of Tri Ton district, 2.5 to 3.0 ton/ha in My An commune of Cho Moi district and Tan Long commune of Thanh Binh district (personal communication, 28/02/2013). In December, farmers harvest rice, store rice seeds for future crops and begin vegetable cropping A special feature of floating rice-based farming systems is the varieties' ability to adapt well to floods, and thus requires less investment for dikes and polders designed to prevent flooding of the crop.

In particular, floating rice can adapt well to the rise of flood water in deep flood prone areas of Asian Deltas. The traditional floating rice varieties and its farming systems are described by Vo and Matsui (1998) as follows:

> *Floating rice can elongate its culm rapidly when the water level rises during floods. In December, farmers burned rice straw and plough their fields by using two water buffaloes. When the first rain fell in April, they began to harrow the land and broadcast floating rice at a rate of 100 kg rice seeds/ha. The farmers once again used buffaloes to harrow the soil in order to cover the seed to prevent bird, and mice damage and to guarantee good soil moisture for seed germination. During the flood, the rice plants elongated together with the rising water (up to 25 centimes per day) (Figure 2). When the water went down in November, the rice plant falls flat on the ground and flowers. The rice was harvested by sickle between December and January. The water buffaloes or cows play an important role to transport the harvest rice to the higher lands and farmers also used these animals for threshing the rice. Using remaining moisture in the soil and silt deposit, the farmers then cultivated upland crops (sesame, water melon, mung bean etc), which were harvested before the floods (June) (Vo and Matsui 1998:41).*

Figure 2. Floating rice is elongating during the flood peak in Oct 2013, in Vinh Phuoc Commune, Tri Ton District of An Giang province, Vietnam. @Huynh Ngoc Duc.

Dry season crops are rotated in the paddy fields after the floating rice is harvested

The seasonal calendar of floating rice varies by location. An example of dry season vegetables crops in Vinh Phuoc and Luong An Tra communes of Tri Ton district (An Giang province, Vietnam) where farmers start sowing rice seeds in June and harvest floating rice at the end of December or early January. Farmers immediately grow one crop of leeks (*Alliums chinese* G. Don) followed by chilli or pumpkin. Alternatively, after harvesting floating rice in early January, farmers can grow cassava, to harvest in May (Figure 3). The rotation is repeated yearly. However, Tan Long and My An communes (Cho Moi District, An Giang province) are located closer to the Mekong River and land is more elevated. Farmers sow floating rice in June and harvest it in early December (a month earlier than in Tri Ton district). After harvesting floating rice farmers usually grow chilli crops in Tan Long commune and rear cattle all year round. Each family can rear up to 4 or 5 cattle[1]. The floating rice-based farming system in My An commune is even more diversified. After harvesting floating rice in early December, farmers grow one crop of traditional sticky corn, followed by two young corn crops integrated with cattle rearing. The by-products, plant remains, from young corn are used to feed cattle.

Figure 3. A thick layer of remaining floating rice straw provides a natural mulches for upland crops – e.g., cassava in Vinh Phuoc Commune, Tri Ton District of An Giang province, Vietnam. @Van Kien Nguyen

[1] *Cattle is reared in the high ground pens during the flood season*

After harvesting their floating rice, almost all farmers apply the rice straw on their vegetable fields in order to reduce weed, reduce evaporation and so reduce the need for watering the succeeding crops. On the other hand, the mulch reduces fertilizer inputs due to having rich alluvial soil which benefits to the next crop. As a result, farmers can save much money, for example by reducing the need to hire labour for hand watering. Overall this reduces their input costs and increases their profits.

The economic benefits of floating rice-based dry season vegetable crops versus the conventional two-three crops of non-floating rice were estimated.

Table 2: Costs-benefits analysis of the floating rice-based crops vs the conventional HYV rice crops in An Giang province, Vietnam (2014)

Locations	Farming Systems	Net return (VND/1000m^2)	Benefit/ Cost Ratio
Chau Phu District, An Giang province	3 rice crops/year(*)	4,827,200	0.71
Thanh My Tay commune, Chau Phu District, An Giang province	2 rice crops/year	2,484,363	0.62
	2 rice crops + one cattle/year	3,959,780	0.56
	Chili + one cattle/year	15,685,217	0.54
	Chili + one Sesbania sesban crop	7,858,700	0.62
	2 rice crops +one Sesbania sesban crop	6,133,263	0.71
My Phu Commune, Chau Phu District, An Giang province	2 rice crops	2,620,881	0.57
	2 rice crops + one cattle/year	11,960,101	0.50
	Maize – Mung bean	11,047,000	1.07
	Mung bean-pumpkin-rice	4,496,826	0.40
	Maize- maize	21,014,000	1.75
Tri Ton district, An Giang Province	Floating rice - cassava	4,425,000	1.81
	Floating rice - leeks	24,895,000	1.68
	Floating rice - chili	17,745,000	2.68
Thanh Binh District, Dong Thap province	Floating rice - chili	16,763,314	1.12

Cho Moi District, An Giang province	Floating rice – sticky corn- baby corn- baby corn- cattle (**)	18,557,500	0.48
	Floating rice – sticky corn- baby corn- baby corn	11,025,000	1.24

Source: Nguyen et al. (2015)

Floating rice and the ecosystem services it provides

Floating rice plants do not only adapt to rising flood waters but they also provide habitats for fish, aquatic animals and wildlife (Nguyen and Huynh 2015). Farmers reported that there are diverse varieties of plants, fishes, and vegetables available in their floating rice paddy fields. These resources supply important nutrition forrural households' daily meal. The diversity of fish and other aquatic animals are illustrated in Figure 4.

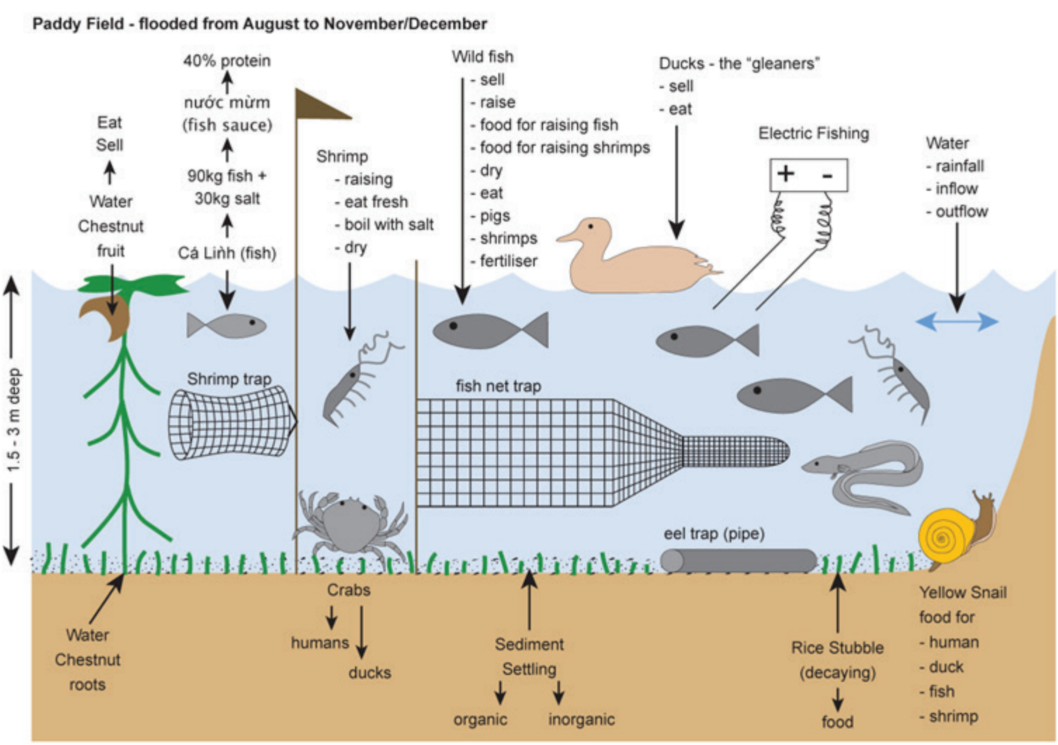

Figure 4. Fish, aquatic animals in the flooded paddy fields
Source: Howie (2011)

Native fish resources on floating rice paddy fields

There are various kinds of native fish in the floating rice paddy fields, including white fish and black fish (Focus Group Discussion, Sep 2015). These species are set out in Table 2. According to Mr. Nguyen Van Du, a local farmer in Tan Long Commune, local farmer scatch fish daily for their meals while other professional fishermen and women catch and sellfor VND 100.000 (USD 05)/day (personal communication with Mr Triem in Tan Long Commune on 15 Sep 2015).

Table 3. Common local fish in floating rice based agroecological system

Local Vietnamese name	English name	Scientific name
Cá Linh	Mud carp	*Cirrihinus Juillinni*
		Cirrhinuss molitorella (Sauvage,1878)
Cá lóc	Snakehead	*Channa Striata* (Bloch,1793)
Cá rô	Tilapia	*Anabas testudineus* (Bloch, 1792).
Cá trê	Vietnam catfish	*Clarias batrachus* (Linnaeus, 1758)
Cá chốt	Striped dwarf catfish	*Mystus vittatus* (H.M.Smith, 1945)
Tôm	Shrimp	*Macrobrachium rosenbergii*

Source: Focus Group Discussion in Tan Long Commune, Thanh Binh District, Sep 2015

Vegetation in the floating rice paddy fields

Table 4. Common local vegetation in floating rice based agroecological system

Local name	English name	Scientific name
Điên điển	Sesbania	*Sesbania aculata*
Rau muống	Morning Glory	
Rau dừa		*Ludwigia adscendens* (L.) Hara
Gạt nai		*Xanthophyllum glaucum* Wall ex Hass
Cỏ chỉ	Green couch	*Cynodon dactylon* ((L.) Pers.
Lục bình	*Water hyacinth*	*Eichhornia crassipes*

Source: Focus Group Discussion in Tan Long Commune, Thanh Binh District, Sep 2015

There are also various kinds of vegetables to supply farmers with their daily meal, such as morning glory and water lily. Furthermore, different kinds of weed also appear on floating rice field (group discussion, 2015). Some herbs also appear in Thanh Binh district (Mr. Nguyen Van Phieu in Thanh Binh district, 2015); table 3 is illustrates the diversity of vegetation community in floating rice farming areas in the Mekong delta during flooding.

Wild birds

When the flood level increases, many kinds of birds appear in the floating rice fields. In particular, thousands of Anastomus oscitans (Asian open billed stork) from Tram Chim National Park in Dong Thap province fly to thisfloating rice area in 2012 and 2013 when the rice was nearly ready to be harvested. Farmers in Luong An Tra Commune of Tri Ton district saw the Red Sarus Crane landed in 2012 December (Interview with Mr Tu Khau, a farmer at Luong An Tra Commune, in January 2013).

Sediment

Where floating rice is cultivated, the amount of sediment deposited increases year by year. However, each year, depending on the height of water level (low or high), the amount of deposited alluvial will be more or less. Sediment is perceived good for soil and yields. With the benefits from rich sediment, farmers use less fertilizer in their vegetable crops, rotated on the floating rice paddy fields, about 20% less (Focus group discussion with a farmer group in Tan Long Commuen, Thanh Binh District, Dong Thap province on 20 September 2015).

Floating rice is a safe and chemical free food for local people

- Floating rice has high protein: 11.3-11.5%, higher than normal short-term white rice, Vitamin E: 56.5-69.9 mg/kh, five times higher than short-term white rice.
- Protein content in floating rice is more than by 3% compared with data from USDA (USDA, 2014).
- The rice contains high in anthocyanin, particularly for 0% milled rice (43.6±3.12mg/kg).
- Vitamin E content is also high (56.5-68.90mg/kg) as compared with normal rice (12mg/kg).
- Amylose content ranges from 18.83±0.61% (0% milled rice) to 27.96±0.61% (16% milled rice).
- This could be referred to as high amylose rice and medium GI rice.

Source: Zambrano et al.(2016) and Ho and Tran (2015)

The local farmers usually keep floating rice to eat in their daily meal because they trust it is safe, without using pesticides or chemical fertilizers (Personal communication with Mr Triem in Tan Long commune on 15 Sep 2015, and Mr Nguyen Van Nao at Vinh Phuoc Commune of Tri Ton District on 20 September 2015). Floating rice wassold in HCM market in 2017 by a small enterprise. it was selling for VND95,000/kg (Figure 5).

Figure 5. Floating rice was sold in Phu My Hung Complex in HCM City, VND 95,000 (USD4.0)/kg

Figure 6. Local consumers purchased floating rice at Long Xuyen market fair in Dec 2014, farmers sold rice directly to consumers. RCRD staffs assisted farmers for packing and marketing.

Local consumers are aware of the floating rice products in Long Xuyen market, the administrative centre for An Giang Province. The local traders collected paddies from growers, processed, packed and supplied directly to consumers.

Progress of floating rice recovery in the Mekong Delta and Mekong Region

The existence of cultivated areas of floating rice have not been of interest nor mentioned in annual socio-economic reports by local communes, districts and provincial government. Rice production is considered to be essentially the quantities of short term rice varieties and high yielding rice varieties produced in the Mekong delta, made possible by the introduction of massive canal systems and irrigation, many of which were constructed after reunification in 1975.

Since floating rice has not been depicted in current Mekong delta land use maps, very few local people know the existence of floating rice in the flood prone areas of the Mekong Delta. Floating rice production has not been included in the annual socio-economic reports by the Department of Agriculture and Rural Development in either An Giang or Dong Thap provinces. Fortunately, researchers at An Giang University have discovered that floating rice were still cultivated in Vinh Phuoc and Luong An Tra commune.

Yet farmers still keep producing floating rice. The RCRD started a preservation project aiming to maintain existing areas of floating rice in these two communes in 2013, which has interested local governments, international NGOs, researchers and media. From 2013 to 2016, RCRD implemented 20 small research grantsand six international research grants for floating rice farmers. The floating rice has been quickly accepted by local and urban consumers who are happy to pay more than 3 times the price of usual rice varieties, owing to its perception as being chemical free. Farmers in Tan Long commune of Thanh Binh district, and My An commune of Cho Moi district have continued to cultivate floating rice during the flood season and grow upland vegetables crops during the dry season. In Tan Long commune, 53 households still cultivate floating rice, which occupies 35 ha. My An commune has 46 ha of floodplain without high dikes, and there are more than 50 households engaging in floating rice production during the flood season, while growing vegetable corn (Zea maize) and sticky rice in the dry season, and integrating cattle rearing using the corn by–products for additional livestock feed (personal communication, January 2015) (Figure 7).

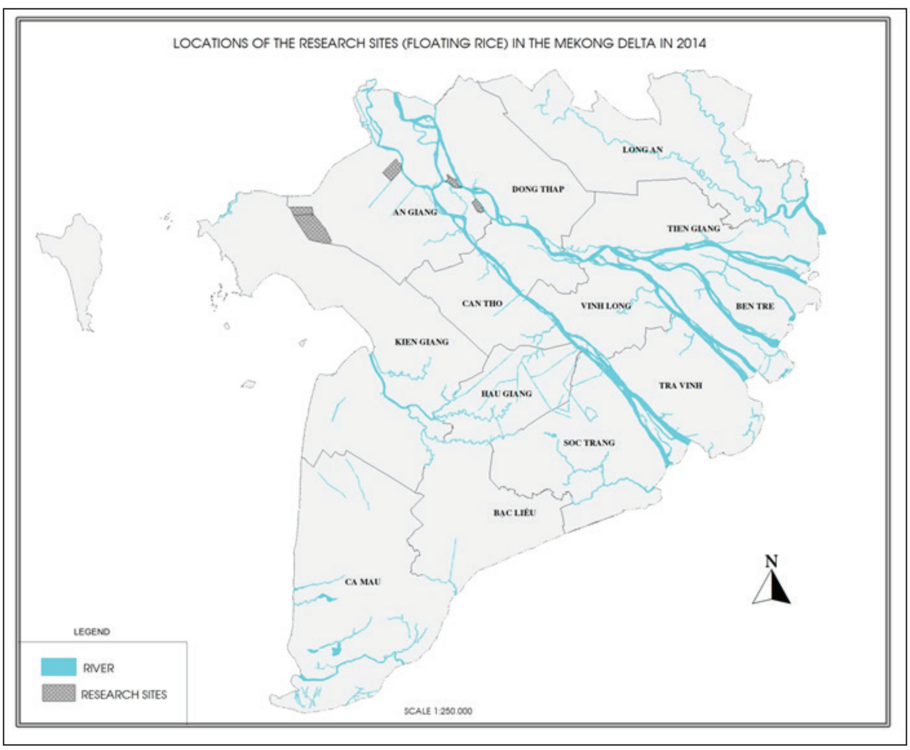

Figure 7. Floating rice area in Mekong Delta, Vietnam (2015)
Source: Nguyen et al. (2015)

Most of these farmers were immigrants from other districts or provinces in the Mekong delta arriving more than 15 years ago. Earlier, pioneer farmers came to reclaim the Melaleuca forest for cultivating rice. However, the soils were so acidic, and farmers could not make a living, fell into debt and sold the land on to immigrants. Currently, cultivation is by third or fourth generation immigrant farmers. There are still some unused land areas which are unsuitable for rice cultivation in this village. Farmers recalled that floating rice was the only crop adapted well to acid soils, so they have kept on with production. Farmers also rotate floating rice with cassava (*Manihot esculenta*), chilli (*Capsicum* spp.) and leeks. Some farmers have grown floating rice for more than 30 years, continuing for several generations. Some farmers have grown floating rice to aid production of upland crops, as floating rice provides a thick layer of rice straw, for crops such as cassava, leeks, maize, pumpkin (*Cucurbita pepo*) and chilli (Figure 8). Rodents are problematic to floating rice production, they eat the seed heads, but many continue to cultivate floating rice regardless.

Figure 8. Dry season vegetables crops were rotated in the floating rice paddy fields. @Nguyen Van Thai (2015).

Avenue for the future: from stakeholder's points of view

Initially, the Research Centre for Rural Development at An Giang University conducted a three year research program for the recovery of floating rice-based farming systems (Trung tam Nghien cuu & PTNT (Research Centre for Rural Development) 2013). Both research and development activities have been implemented and an economic analysis of the floating rice-based farming systems has also been undertaken. Nutritional analysis and chemical free-floating rice promotion in urban and rural markets have been undertaken.

After the first year (2013-2014), several benefits of floating rice farming systems were recognized by farmers and local authorities. This opportunity promoted the first floating rice harvest festival to be organized in Vinh Phuoc commune on 11 January 2014 which attracted more than 200 visitors from local farmers, local authorities, research institutions, university students, NGOs, and provincial leaders (Figure 9).

Figure 9. Visitors at the first floating rice harvesting festival at Vinh Phuoc commune, Tri Ton District of An Giang province, on 11 Jan 2014. @Nguyen Van Kien (2014).

In early 2015, ten farmers in Luong An Tra commune of Tri Ton district and neighboring farmers in Giang Thanh district of Kien Giang province intended to produce floating rice. The key reason for restoring floating rice production was the fact that farmers have received fewer benefits when cultivating two or three crops of short-term a year instead of growing one crop of floating rice followed by upland crops. When the market price of rice is drops down, some farmers lose out financially because the cost for producing the summer-autumn crop is much higher.

Public opinions about the floating rice-based agro-ecological farming systems in An Giang

Forty-five respondents were questioned using a Likert scale from 1 to 5 (lowest agreement-highest agreement) (Table 5). Results showed that a very high proportion of the participants agreedor strongly agreed to eight statements. Most people agreed that floating rice-based farming was very ecological friendly andadapted well to climate change. Floating rice-based farming systems were perceived as a restoration of culture of living with floods, and agreed that the harvesting festival should be organized each year and used as a vehicle for eco-tourism. Integrated farming systems of floating rice with fish, and organic vegetable proved promising because more people are demanding organic products such as rice and vegetables. Importantly, more than 80% of people questioned (n=45) supported the expansion of floating rice systems in the Mekong Delta.

Table 5. Respondents' satisfaction on nine items (N=45) This data would be much more valuable if you can say how many of the sample were farmers, traders, officials, landless people. Is that possible?

Items	Strongly disagree	Disagree	Do not know	Agree	Strongly Agree
	%	%	%	%	%
Floating rice -based farming system is very ecological friendly.	1.92	1.00	5.77	13.46	78.85
Floating rice -based farming system adapts to climate change.	1.92	1.00	11.54	26.92	59.62
Floating rice-base farming system restores tradition of living with floods.	1.96	1.00	5.88	21.57	70.59
Floating rice-based farming system is attractive for eco-tourism.	1.92	1.92	17.31	34.62	44.23
Integrated wild fish into floating rice will improve livelihoods for farmers.	3.85	0.00	5.77	32.69	57.69
Development of organic vegetables on the floating rice fields is very promising.	1.92	1.00	1.92	21.15	75.00
Consumers start to demand organic rice.	1.92	1.92	13.46	30.77	51.92
The harvesting festival should be organized yearly.	1.92	1.92	5.77	21.15	69.23
The floating rice-based farming system should be re cultivated in the flood prone of Mekong Delta.	1.92	1.00	13.46	19.23	65.38

Note: The questionnaires were randomly given to 45 participants during the participation of the floating rice festival on 11 Jan 2014 at Vinh Phuoc Commune, Tri Ton District, An Giang province.

International and national concern about research and development of the floating rice system in Vietnam's Mekong Region

From 2013 to 2018, RCRD received international funding for 8 projects, one national project together with 20 small research grants funded by An Giang University for research and development of the floating rice based agro-ecological farming systems (Table 6). RCRD led 5 projects, and co-partnered 4 projects with international researchers.

Table 6. Selected research grants received by RCRD[6].

Project titles	Funders	*Period*	Budget	P Investigators
Promoting floating rice-based agro-ecological farming systems for a healthy society and adaptation to climate changes in the Lower Mekong Region and Myanmar. This project aims to identify the needs and commitment from governments to extent floating rice-based farming systems in the Mekong region and Myanmar.	Mitsui Environment Fund	2017-2019	AUD 320,000	Van Kien Nguyen & Jamie Pittock **Partners:** RCRD/AGU ECOLAND/RAU Yangon University
Selection of high quality traits of floating rice in An Giang province. This project aims to purify two traits of floating rice seeds in An Giang province.	**An Giang Department of Sciences and Technology**	*2015-2019*	**AUD 66,000**	Faculty of Agriculture and Natural Resources & RCRD – Dr N.T.T.Xuan
Towards non-toxic environment in Asia Pacific. This project supports community-based floating rice seed selection activity.	**PAN AP**	*2013-2018*	**AUD 17,000 annually**	RCRD, An Giang University Dr. Van Kien Nguyen
Resources Governance for Future Livelihoods in the Mekong Delta. This project supports testing farming systems of the floating rice and other upland crops such as chilli, cassava and sesame.	**LMPPI-USAID**	*2015-2017*	**AUD 177,000**	Fulbright Program in Ho Chi Minh City Can Tho University RCRD (Dr. V.K. Nguyen)

Conservation of the floating rice –based agro-ecological farming systems in the Mekong Delta, Vietnam	AliSEA	2017	AUD 12,000	RCRD, An Giang University Dr. Van Kien Nguyen
Scoping floating rice-based agro-ecological farming systems for a healthy society and adaptation to climate changes in the Lower Mekong Region and Myanmar. This project aims to identify the needs and commitment from governments to extent floating rice-based farming systems in the Mekong region and Myanmar.	**Mitsui & Co., Ltd. Environment Fund Fiscal 2015**	*2016*	**AUD 43,000**	Van Kien Nguyen & Jamie Pittock RCRD/AGU (VN), ECOLAND/RUA (Cambodia), Cooperative University (Myanmar)
Long-term biophysical and socio-economic monitoring of floating rice-based and intensive rice farming systems in Mekong Delta. This project supports baseline monitoring of soils, water, biodiversity, and socio-economic indicators of the floating rice farmers in three project sites (Vinh Phuoc & Luong An Tra communes of Tri Ton district, and My An commune of Cho Moi district.	**Rufford Foundation**	*2015-2016*	**AUD 8,000**	Dr. Van Kien Nguyen, RCRD, An Giang University
Recovering and valuing wetland agro-ecological systems and local knowledge for water security and community resilience in the Mekong Region. This project investigates the capacity of community to recovery and adapt to water scarcity and shortage in the Mekong Delta.	**SUMERNET**	*2014-2015*	**AUD 118,000**	Dr. Carl Middleton, PI (Chulalongkorn University, Thailan) Dr. Van Kien, co-PI Nguyen (RCRD)

Enhancing Resilience of the Community through Climate Change Adaptation: Research and Training Activities for Preservation and Development of Floating Rice-Vegetables Farming Systems in Vinh Phuoc Commune, Tri Ton District, An Giang Province, Mekong Delta, Vietnam. This project supports studying resilient farming systems of the floating rice, and provides trainings on economic, safe production and biodiversity for the farmer group.	**SFRT - SEARCA**	*2013-2014*	**AUD 17,000**	Dr. Van Kien, PI Nguyen, RCRD, An Giang University

The research outcomes of the projects have been published in both national journal magazines, international journals and reports. The topic of floating rice was presented in many international workshops in Asia, Australia, Europe and the US (see below).

Pittock J, Nguyen KV (2017). *Rice: The role of traditional floating rice systems*. ACIAR.

Nguyen VK (2017). *Conservation of floating rice in the Mekong Delta, Viet nam: implication for local food security and community resilience*. Paper presented at the Wisconsin University _ Madison (Seminar), Wisconsin University (Nelson Institute of Environmental Studies).

Nguyen VK (2017 (Accepted)). *Conservation of floating rice in the Mekong Delta, Vietnam*. Paper presented at the 28th International Congress for Conservation Biology, 23-27 July 2017, Cartagena de Indias, Colombia.

Nguyen, V. K., & Pittock, J. (2016). *Floating rice in Vietnam*, Cambodia and Myanmar: The Australian National University and An Giang University.

Nguyen, V. K. (2016). *The values and recovery progress of floating rice-based agro-ecological systems for adaptation to climate change in the Vietnamese Mekong Delta.* J Earth Sci Clim Change 7:170 doi: https://www.omicsonline.org/conference-proceedings/2157-7617.C1.028_028.pdf.

Zambrano AD, Bhandari B, Binh Ho, Prakash S (2016). *Retrogradation – digestibility relationship of selected glutinous and non-glutinous fresh and stale cooked rice*. International Journal of Food Properties 19:2608–2622.

Nguyen, V. K., Duc, H. N., Thanh, N. T., Quyen, L. C., Vu, T. H., Thich, L. T., et al. (2016). *Long-term biophysical and socio-economic monitoring of floating* *rice-based and intensive rice farming systems in Mekong Delta* (pp. 6). United Kingdom: Rufford Foundation.

Nguyen, K. V., V. O. Vo and D. N. Huynh (2015). *Comparing the costs and benefits of floating rice-based and intensive rice-based farming systems in the Mekong Delta*. Asian Journal of Agriculture and Rural Development 5(9): 202-217.

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Ho, B. T., & Tran, K. N. (2015). *Quality characteristics of floating rice (Oryza sativa L.) in the Mekong Delta of Vietnam: a preliminary study*. Paper presented at the Tropical Agriculture Conference 2015, Brisbane, Australia.

Nguyen, K. V. (2014). *Human-earth relationship: social and cultural dimensions of floating rice conservation in the Mekong Delta, Vietnam*. The Sustainability Science Congress 2014. Copenhagen, Denmark.

Nguyen, K. V. and H. N. Duc. (2015). *Conserving the benefits of floating rice in Vietnam*. Retrieved 28/3/2015, 2015, from http://www.mekongcommons.org/conserving-the-benefits-of-floating-rice-in-viet-nam/

Nguyen, K. V. (2013). *Còn không lúa mùa nổi ở Miền Tây [Existing floating rice in the South-west of Vietnam]*. Thời báo kinh tế Sài Gòn (Saigon Times Online). HCM City, The Saigon Times.

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Conclusions

Floating rice-based farming systems declined after the introduction of high yielding rice varietiesin the late 1960s, early 1970s and later the use of high dike systems in some parts of the Mekong Delta. Floating rice produces low yields but provides good opportunities for developing profitable upland crops when used in combination with rearing cattle. Financial returns of several combinations of floating rice-based farming systems can provide greater financial benefits than other intensive high yielding rice crops. Farmers diversify their cropping systems in the same land area for many crops and cattle year-round. Farmers also benefit from the ecosystem services such as wild fish and other aquatic animals in the floating rice paddy, sediment and mulches for the vegetable crops. There is a sign that farmers are likely to return to floating rice in the Mekong Delta. It is important to maintain and expand this area for sustainable agriculture.

Acknowledgement

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A study of household economic conditions, knowledge and practices of farmers in Vinh Phuoc Commune, Tri Ton District, An Giang Province, Mekong Delta

Dang Thi Thanh Quynh* and Tran Van Hieu

Abstract

This study provides a baseline assessment of the current state of household economy and the situation for comparison with agricultural production development in the future.It does so through a survey and evaluation of the knowledge, attitude and practice (KAP) of farmers, and the economic efficiency of two production models: floating rice followed by upland crops; and three rice crops, with no subsequent crop.

The results show that: (1) Farmers' livelihoods in the study area are largely based on income from agricultural activities. In particular, the present model of floating rice, followed by upland crops is economically more efficient than the model of rice production of 3 crops per year. (2) With farmers having experience on average of more than 16 years, the cultivation of rice is still sometimes difficult, for example because of damage by mice they plant at higher densities than recommended.

Overall, however, the floating rice-vegetable model has twice the economic efficiency than the three rice crops per year model. Therefore, this is the basis for providing solutions to promote the region's socio-economic development, particularly in agricultural production. This research is also intended to provide a baseline against which to determine the effectiveness of models of production.

Keywords: household socio-economic, KAP, floating rice, three rice crops.

Background

Since 1975, the area of floating rice fields has significantly decreased. In 1975 the area of floating rice cultivation in the Mekong Delta was 500,000 ha, of which 250,000 ha were in An Giang Province (Xuan and Matsui, 1998). By 2002, the area of floating rice was only 3,200 hectares (Nguyen Van Kien, 2010), and in the year 2012, only about 60 hectares are still growing floating rice, mainly in Luong An Tra and Vinh Phuoc communes of Tri Ton district, An Giang province (People's Committee of Vinh Phuoc Commune, 2012). According to Käkönen (2008), the reason for this decline was the need for national food security, land use change, land reclamation and irrigation. Therefore, floating rice has been gradually replaced by high yield rice varieties.

Vinh Phuoc commune has natural conditions, land, water source and a canal system which is very suitable for agricultural production, especially for floating rice cultivation. In recent years, the area of floating rice cultivation in the region has declined sharply aspeople became aware of the short-term economic benefits and changed from growing one crop of floating rice to threecrops of faster growing rice per year. In order to facilitate the socio-economic development of a poor commune in Tri Ton district, and to conserve the remaining area of floating rice in An Giang province, the people of Vinh Phuoc commune and many researchers are attempting to implement several solutions. This socio-economic assessment of the floating rice paddy area, based on household economic status and knowledge, attitude and practice (KAP) of farmers in Vinh Phuoc commune. Tri Ton district is very necessary as a baseline for future evaluation.

Research Methods

Approach

The study adopted methods based on the KAP survey approach to identify the perceptions, attitudes and practices of farmers in agricultural production before impact, there by formulating the baseline for later evaluation. KAP tool tells us about perceptions, attitude and human practice on a particular issue (WHO, 2008). According to Vandamme (2009), KAP is a useful tool in methods of collecting quantitative information through the measurement of human practice and thinking.

Study sites

The study area is Vinh Phuoc Commune of Tri Ton District. This is a poor agricultural commune established in 2003, which has the largest remaining area of paddy rice floating in An Giang province.

Method of data collection

Secondary data: Collecting reports on socio-economic development, local agricultural production, and research and related journals.

Primary data

In-depth interviews: Key Informant Panel (KIP) with officials who understand the information related to agricultural production resources, socio-economic efficiency through local agricultural cultivation models and related policies. The interviewees were representatives of agricultural managers in Tri Ton and Vinh Phuoc communes.

Group discussion using two tools: seasonal calendar and semi-structured interview. Seasonal calendars are intended to identify the cycle of major agricultural activities and the associated constraints. Semi-structured interviews are to collect information pertaining to farmers' perceptions of agricultural production in the area. Two group discussions (one with a group of floating rice farmers and one with group of three rice farmers); groups of 10 to 15 people participated in the discussion.

Farmer interviews were designed with questionnaires designed to collect information related to farmer's resources, agricultural productivity and farmer's knowledge, attitudes and practices in agricultural production. Samples were randomly collected from 13 households growing floating rice, 37 from households growing 3 rice crops in a year, giving atotal sample of 50 households.

Data Analysis Methods

The study used Excel and SPSS software to synthesize, analyze and process data, descriptive statistical analysis and T-Test analysis methods to compare agricultural production of two farmer groups (one with a group of floating rice farmers and one with group of three rice farmers). In addition, the method of economic accounting was used to calculate the profitability and efficiency of farmers in the cultivation process.

Results

Agricultural activities in Vinh Phuoc commune

Vinh Phuoc commune has a large area of agricultural land, with 4,669 ha, accounting for 86% of the total land area of the commune. Tangerine cultivation occupies 3,269 hectares which is undertaken by 2,107 households living outside the commune. Only about 1,400 hectares are cultivated by 142 local households.

The main crops cultivated in the commune are high yield rice, floating rice and some kinds of vegetables, particularly chinese onion, cassava, watermelon, mushrooms, taro, peanuts, corn, chilli, and pumpkin. The area of cultivation is dominated by 11,165 ha of high-yield rice, the floating rice is only 35 ha and the upland cropsare 500 ha (People's Committee of Vinh Phuoc Commune, 2012). High yielding rice is grown three timesper year, a winter-spring crop (months 12-3), a summer-autumn crop (months 4-7), and an autumn-winter crop (months 8-11). However, theone floating rice per year is grown from July to January (months 7-1). Floating rice plants grow up with the rising flood waters, this produces much longer plants stems which later become straw and play an important part in the production of upland, or dry season, crops. After harvesting this floating rice the farmers continue cultivation of upland cropsfor the next 5 months (months 2-6).

Table 1. Seasonal calendar of agricultural production in Vinh Phuoc Commune, 2012 – 2013

Activities	**Month**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Cultivationofthree rice crops per year	WS 2012- 2013			SA 2013				AW 2013				
Cultivationoffloatin g rice-and uplandcrops		Upland crop					Floating rice (6-7 months)					

Source: Group discussion, 2013

Recent crop pests are very complex, affecting crop yields. Each year the summer-autumn rice crop in the three-rice area experiences extensive rice blast disease, which reduces the crop yield by about 20%. On the other hand, however, in the flood zone, once the floods are drained, as the harvest time approaches, mice attack the plants causing great damage (KIP, 2013).

Resources and livelihoods of farm households

Household resources

Labor resource: At household level female workers involved in agricultural production make upabout 45% of agricultural workers. In terms of education level, the majority of workers 82% participating in agricultural production are limited to mainly primary and secondary. These workers lack professional skills but they have experience of agriculture production techniques. People directly involved in agricultural production are experienced farmers, with an averaging age above16 years.

Land resources: Area of agricultural production of farmers is large scale in study area. For households have growing 3 ricecrops per year, the average area of agricultural production is 7.8 ha per household, of which 55% is land owned and the remaining land is rent from other. For households have growing floatingrice – upland crop of agricultural production is 2.2 ha per household, of which the land owned only 36%. In term of soil quantity this area has some field low soil is affected by alum this is due to the field irrigation system and drainage system.

Financial capital: According to the analysis, the capital used in agricultural production of the household is mainly the farmer's own capital (46%), the remaining capital is borrowed. Because of the large area of agricultural land, most farmers do not have enough capital to invest, therefore they have to borrow more capital for production, in order to buy materials like fertilizer and pesticide, and return money to the retailer of after selling their produce. The average interest rate is 10% per month.

Policy advice: Farmers in An Giang Province are urged to follow two policies in particular. The first of these referred to as “3 Reduction 3 Increase”, recommends farmers reducing seed, reducing fertilizer, and reducing pesticide in order to increase yield, quality, and economic efficiency. The second is called “1 Must 5 Reduction”, in which farmers must use certified seed varieties, reduce seed densities, reduce fertilizer, reduce water, reduce losses post-harvest, and reduce production costs.

Livelihood and household incomes

According tothese results, the livelihoods of people in Vinh Phuoc commune are mainly from activities such as rice cultivation, upland crop cultivation, animal husbandry, small businesses and hiring out their labor. In particular, agricultural activities play a very important role for household income, accounting for 86% of household income.

The income from rice cultivation of 3 crops accounts for 62%, the cultivation of upland crop accounts for 17% and the cultivation of floating rice is 7%. As reported by People's Committee of Vinh Phuoc (2012), the per capita income of the commune is 15.6 million VND/person/year, and people's life is still difficult, the percentage of poor households (4.8 million VND/person/year)in the commune is 23.36%.

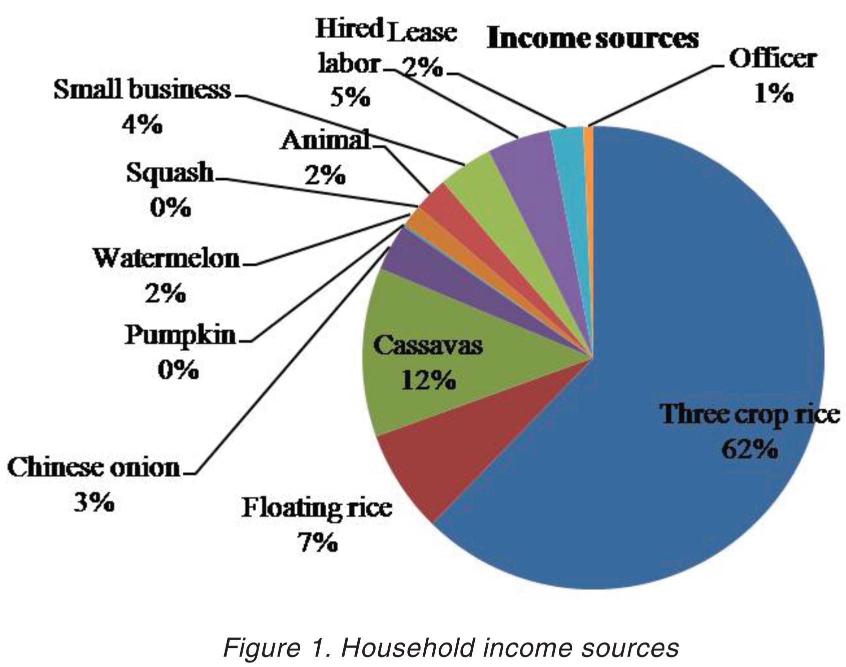

Figure 1. Household income sources

Economic efficiency in agricultural production of households

Analysis results (Table 2) show that the model of floating rice crop integrated with upland crops is very efficient. In the floating rice - cassavas model the benefit-cost ratio (BCR) is 4.31, in thefloating rice – chinese onion model the ratio is 3.36, much higher than that of the three-crop rice cultivation, where the ratio is only 1.64, see.

Table 2. Economic efficiency of some models of farming in the study area

Unit: 1,000m²/year

Indicators	Units	Patterns of production in one year		
		Three rice crop	Floating rice - cassavas	Floating rice – chineseonion
Number of days cultivated	Days	276	321	315
Total revenue	1,000 VND	9,443	7,136	53,147
Total cost	1,000 VND	5,743	1,655	15,840
Net profit	1,000 VND	3,700	5,481	37,307
BCR		1.64	4.31	3.36

Source: Household interviews, 2013

The reason for this greater economic efficiency in the three rice-upland crop system is that during the cultivation of floating rice, farmers do not use fertilizers and pesticides, thus saving much on production costs. According to the KIP (2013) interview, the investment cost for floating rice crop is 340,000 VND/1,000m^2, much less than that of high yield rice, which accounts for only 20% of the cost compared to 1 crop of high-yield rice crop. On the other hand, farmers also reduce the cost of the next crop by taking advantage of the rice straw of floating rice for fertilizer, also the crop is very good and has high yield. Specifically, the total investment cost of cassava is VND 1,314 million/1,000m^2 /crop, the average productivity is 1,784 kg/1,000m^2. Particularly for the chinese onion, which is cultivated on the ground of floating rice, this also yield a very high yield, about 5,500 kg/1,000m^2.

Knowledge - attitudes - practice of farmers during rice cultivation

Most of the farmers are aware of the importance of the experience, knowledge and techniques of rice cultivation. However, the average education level of farmers is not high (grade I and grade II accounts for 82% of them), rice cultivation is based on experience (over 16 years), so the application of new technology in to agriculture production is difficult.

In rice cultivation, sowing density is seldom as recommended by scientists, but mainly based on experience. Thisis due to causes such asalkaline soils which are infected with mice, so people plant higher densities of seedsthan recommended, with15- 20 kg/1,000m^2, instead of 8 – 10 kg/1,000m^2. This is also one of the reasons why most people, although aware of the need to apply "3 Reduction 3 Increase" and "1 Must 5 Reduction" practices in the production of 3 rice crops do not implement them.

Table 3. Knowledge – attitudes - practices of farmers during rice cultivation

Factors	Knowledge	Attitudes	Practices
1. Need production experience	4	3	3
2. Need higher education level	3	3	**2**
3. Need to know how to prepare land and soil	4	3	3
4. Need to know land should be sownat the same time	4	3	3
5. Need to use original varieties /certified seed	3	3	3
6. Planting density should be as recommended	3	**2**	**2**
7. Need to apply 3 Reduction 3 Increase, 1 Must 5 Reduction	3	**2**	**2**

Note:

- Knowledge:	*1 = do not know,*	*2 = know less,*	*3 = know,*	*4 = know much*
- Attitude:	*1 = disagree,*	*2 = neutral,*	*3 = agree,*	*4= strongly agree*
- Practice:	*1 = never,*	*2 = rarely,*	*3 = often,*	*4 = very often*

In addition, for the three-crop-per-year rice model, people have to regularly use fertilizers and chemical fertilizers to replenish soil and control weeds and pests. Meanwhile, for the floating rice – upland crop cultivation model, the use of rice straw of floating rice for cultivation is very effective, not only good for the soil, but also helps to improve the productivity of the next vegetable crop.

Particularly for floating rice, due to its breakage characteristics when harvesting and when the rice head is located close to the ground, the application of mechanization during harvest is very difficult, it can only be harvest by hand.

Conclusions

Farmer's livelihoods are based mainly on agricultural production, with two main models, these are three ricecrop models and floating rice integrated with vegetable crops. People's life is still difficult, and the percentage of poor households in the commune is 23.36%.

In terms of resources, labor is engaged in agricultural production, but most of them have a low level of education, based mainly on experience. The farm land area of agricultural production is relatively large, but many households do not have enough capital to operate so they have to borrow more capital to produce.

In terms of economic efficiency, the pattern of floating rice - cassava cultivation and floating rice-chinese onion has amuch higher efficiency than the three-crop rice cultivation model. This is due tothe use of rice straw from floating rice for cultivation, it provides soil nutritional supplements, reduces fertilizer costs and increases crop yields.

In term of rice cultivation of 3 rice crops per year, the application of science technology to production is difficult. As the alkaline soil provide a positive environment for mice, which damage crops, so people cultivate rice with higherdensities than recommended. This makes it difficult to apply recommended practices, such 3 Reduction 3 Increase and 1 Must 5 Reduction. Moreover, chemical fertilizers are often used to supplement soil nutrition, weed control and pest control. All of these increase production costs for the farmer.

Acknowledgement

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Value chain of floating rice- and vegetables crops in Vinh Phuoc commune of Tri Ton district, An Giang province, Mekong Delta

Tran Van Hieu*, Nguyen Van Kien, Dang Minh Man, Vo Van Oc

Abstract

The trend of consumption of the people in this country (Vietnam), as well as of the people in countries importing food from Vietnam, changes in the direction of ensuring food hygiene, food safety and high quality of the foods they eat. To meet that require, agricultural production needs to be based on a clean development process, one that improves the quality and value of agricultural products. The aim of this research on value chain analysis of floating rice and vegetable in Vinh Phuoc, Tri Ton, An Giang is to improve the economic value of the chain, improve incomes for the people, and other actors in the chain, through using the concept of value chains and qualitative and quantitative data collections. The results of the study show that, (1) The distribution channel of floating rice and vegetables emerged as very simple with only four actors in the channel; (2) There are no links between the actors, other than when they meet for the exchange of produce for money, in the chain of production so actors lack information; (3) The actors in the floating rice and vegetables chain experience different costs and benefits; (4) No technologies are used in the production of these products; farmers sell their products in crude forms, unprocessed; and the unique diversity of these products is not recognized; (5) Especially, Floating rice has not only good potential economic value, it also has environmental and agricultural eco-tourism values.

Introduction

At the present time, the trend of consumption of the people in this country (Vietnam), as well as of the people in countries importing food from Vietnam, changes in the direction of ensuring food hygiene, food safety and high quality of the foods they eat. To meet that require, agricultural production needs to be based on a clean development process, one that improves the quality and value of agricultural product (Henriksen et al. 2010). The floating rice crop of An Giang Province is special because it is produced using less or no chemical fertilizers, so the products of this floating rice area are clean and safe for consumers. However, the producers of this floating rice and vegetables crops grown there in the dry season face many difficulties in the market place because their products only have low values. Poor agricultural producers often struggle to gain market access because they lack knowledge of market requirements or the skills to meet them (Ho and Nguyen 2006). Furthermore, poor information flow and other obstacles in value chains prevent them from entering into new markets, or reduce the benefits they may obtain, once they gain access (Antonio 2010) and (Do and Nguyen 2006). Therefore, the aim of this research on value chain analysis of floating rice and vegetable in Vinh Phuoc, Tri Ton, An Giang is to improve the economic value of the chain, improve incomes for the people, and other actors in the chain, through using the concept of value chains and qualitative and quantitative data collections. The finding of this study is to identify the cost-benefits and value chain of each farm undertaking and identify strength, weaknesses, opportunities, and threat in this systems in other to increase the productivity and consumption of rice, as well as improve the linkage between farmers and businesses, contribute to the sustainable development of the commodity chain, and thereby improve the livelihoods of rice and vegetables farmers.

Materials and Methods

Recently, the concept of value chains has been applied to the analysis of globalization (Gereffi 2015). Therefore, this study also used the theory of "Linking the value chain - ValueLinks" (Springer-Heinze 2007) and "The market for the poor - analytics value chain" (Van den Berg 2004), including its 8 tools, but the study focused on 7 specific tools: mapping the value chain; market channels; costs and profits; technology; knowledge services; the actors; and the links in the chain of actors. The main content of the analysis on the value chain of rice floating vegetables include (1) mapping the current value chain of the product; (2) describe the function of value chain and actors, market channels; (3) economic analysis of value chain. During the dry season, after the rice has been harvested, the same farmers grow vegetable crops on the same ground. Crops grown in the dry season are referred to as ‘upland crops’, and in this research the upland crop studied was cassava.

Both qualitative and quantitative data collections were used.

Secondary data: to refer the previous researches and reports this related to the status of production, processing and consumption of rice and vegetables products and the related research on value chain of agricultural products from a variety of sources.

Primary data: group discussion with farmers, who are cultivating a floating rice-vegetables model, and in-depth interviews with key informants and chain actors who are involved in the existing value chain. The ‘snow ball’ method was used to explore chain actors in value chain. Stakeholder workshop were carried out in An Giang University to present the findings from value chain research and receive feedback from stakeholders to improve the value chain and lead to the development of these farming practices.

Table 1. Sample for interview

Floating rice		Vegetables	
Actors	**Samplesize**	**Actors**	**Samplesize**
Farmers	13	Farmers	7
Middle man	2	Middle man	4
Firm	1	Whole sellers inside	1
Business	1	Whole sellers outside	1
Whole sellers	1	Retailers	2
Total	18	Total	15

Research finding

Value chain of floating rice

Mapping of activities and actors in core process of floating rice production

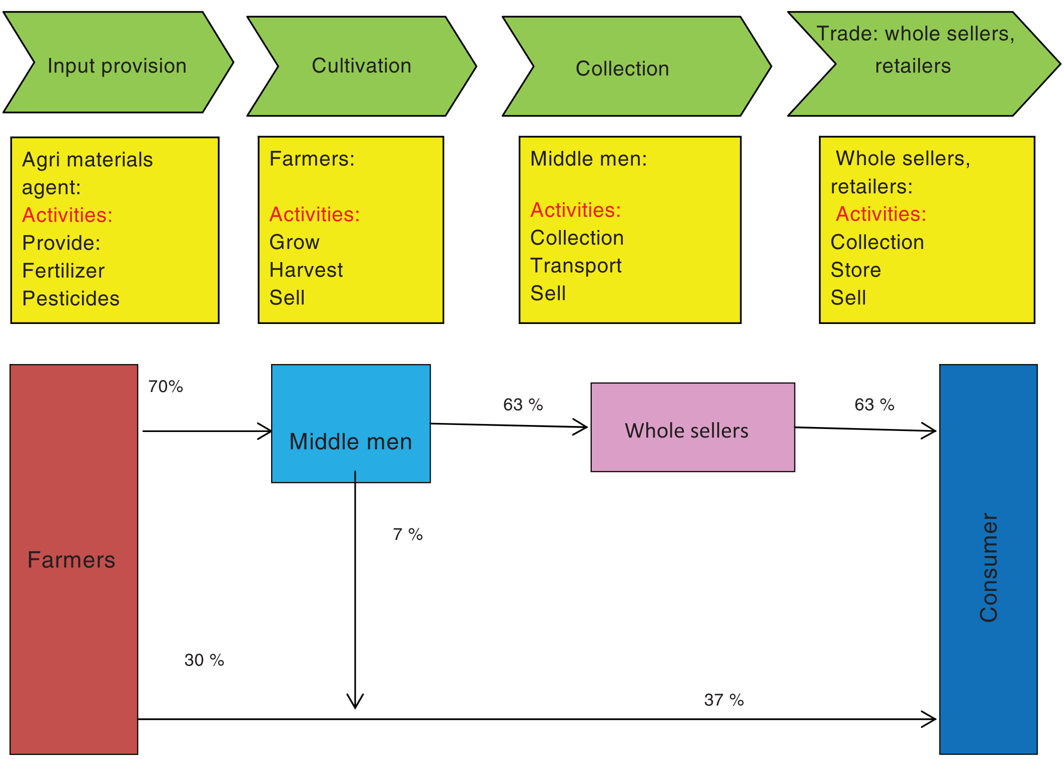

Chart1: Consumer channel and core processes of floating rice

The four main processes involved in the value chain of floating rice are as follows: (1) Provision of inputs, (2) Cultivation, (3) Collection of produce (4) Trade. Each agent has different organizational functions and activities in the chain: the providers provide inputs as supply of raw materials, such as seed, fertilizer, and other inputs; the producers' (farmers) functions include soil preparation, sowing, tending and harvesting, and sale of the products; middleman have a role in purchasing products from farmers, transportation and sale of products to consumers and whole sellers; and whole seller purchase the rice from middleman, then undertake transportation, storage, handling and sale to the final consumer (see chart 1). The floating rice is consumed in fresh form, so far it is not being processed.

Floatingrice is distributed through three channels, depending on the area of arable land, and the situation of each household in particular harvest seasons. The following three distribution channels are averaged from interviewing several farmers of floating rice.

Channel (1) Farmers ➡ Middle men ➡ Whole sellers ➡ Consumer

Channel (2) Farmers ➡ Consumer

Channel (3) Farmers ➡ Middle men ➡ Consumer

The channel 1 is the dominant channel, it accounts for nearly 70% of floating rice supplied to middleman every season; channel (2) accounts for 30%; and channel (3) the lowest proportion accounted for just 10%. The rice sold to middle mangene rates profits which fund the next crop. Rice has been sold directly to middleman for many years. In term of selling rice, most agreements had negotiated directly between farmers and middle men. This result is similar to the findings of (Hoang Thanh Tung, 2012) and (Nguyen Ngoc De, 2013) who showed that 90% of rice farmers sell their products primarily to middlemen.

Cost and benefit of actors in floating rice value chainin Vietnam dong (VND) per kilogram of rice

Table 2

Chain actors	Unit total cost of production	Unit price at point of sale	Unit profit	BCR
Farmer	2,690	7,000	4,310	1.60
Middle men	8,500	9,000	500	0.06
Whole seller	9,500	12,000	2,500	0.26

According to the result distribution channels, there are three primary distribution channels, however we focused our analysis on channel 1, cost and profit of each actor's participation in the value chain. The result shows that the cost per unit of production is different for each actor. The whole seller has the highest cost, 9,500 VND/kg, the cost of purchasing rice purchase from the middle man, while rice farmers' production costs are 2,690 VND/kg. Profit per unit of production of farmer is higher than other actors in the value chain which is 4,310 VND/kg. Selling prices is also different for each actor in the chain: The farmers sell rice for 7,000 VND/kg, the middle man sells for 9,000 VND/kgand the whole seller sells to consumers for consumers at 12,000 VND/kg.

Value chain of Cassavas

Mapping of actors and their activities in the core processes of cassava production

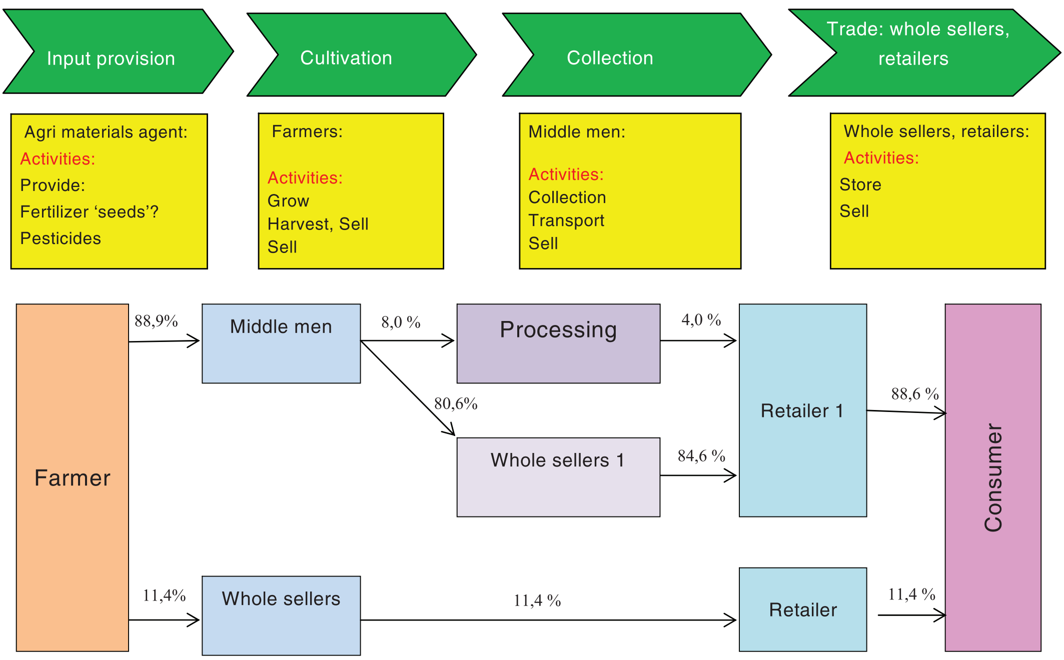

Chart 2: Consumer channel and core process of cassava

Channel ***(1):*** Farmer→ Middle men→Processing→Retailer→ Consumer

Channel ***(2):*** Farmer→ Middle men1→Whole seller1→ Retailer1 → Consumer

Channel ***(3):*** Farmer → Whole seller→ Retailer → Consumer

The main upland crop in study site is cassava. The survey identified four core process starting with the provision of inputs, cultivation, collection of product, and trade by whole sellers and retailers leading to the consumer at the end of the chain. Each stage has specific functions of production, performed by different actors in the chain (chart 2).

Channel 1: This commercial channel includes 4 actors: farmer, middle man, processor and retailer and accounts for nearly 8% of total volume of cassava supplied to the market each year. The through put of cassava in this channel is low, it accounts for 8% and is used as powder for making cake for eating.

Channel 2: This is the largest channel of cassava, accounting for nearly 89% of all cassava produced by farmers in Vinh Phuoc Commune. The chainhas 4 main stakeholders: farmer, middleman, whole seller1 and retailer1. It is estimated that this channel holds about 80,9% of products.

Channel 3: This channel includes 3 main actors: Farmer, whole seller and retailerinside the province. This channel accounts for a small proportion, 11,4% of cassava produced.

Cost and benefit to actors in cassavas value chain in Vietnam dong (VND) per kilogram

Table 3. Cost and benefit to actors in cassavas value chain in Vietnam dong (VND) per kilogram

Chain actors	Unit total cost	Unit price	Unit profit	BCR
Farmer	1,228.3	2,800.0	1,571.8	1.28
Middle men	2,850.9	3,000.0	149.1	0.05
Whole seller	6,000.0	7,000.0	1,000.0	0.17
Retailer	9,000.0	17,000.0	8,000.0	0.89

Through cost and benefit analysis, the result show that the costs and profits is uneven, with high disparity between the actors in the chain. The retailer has the highest costs, 9,000 VND/kg, while farmers'costs are lowest at 2,690 VND/kg. Profit per unit of production for retailers is also higher than other actors in the value chain, at 8000 VND profit per kilogramme sold. Selling prices is also different form each actors in the chain. The farmers sell cassava at 2,800 VND/kg, the whole sellersells at 7,000 VND/kg retailers sell tofinal consumers for 17,000 VND/kg.

Discussion and Analysis for floating rice

Based on the information gathered from focus group discussions, interviews and interviews with households which cultivated floating rice, a table of the strengths, weaknesses, opportunities, and threats (SWOT) in floating rice and vegetable cultivation in Vinh Phuoc was constructed, see Table 2.

Table 4. SWOT analysis for floating rice and an upland crop (cassava) in Vinh Phuoc commune

Strengths	Weaknesses
- Floating rice is cultivated use little or no agricultural chemicals and chemical fertilizer. - Rice is sold without processing and traders are eager to buy. - Natural conditions in Vinh Phuoc commune are favourable for the development of a floating rice system. - Floating rice produces a thick layer of straw, and this is important as a mulch for growing upland crop.	- The products are sold primarily through a chain of intermediary traders. - No clear link between the actors in the chain. - Infrastructure is poor, therefore transport costs are high. - No technological equipment is used and there are no tools for processing and packaging, only hand labour. - There are no cooperating groups and no cooperatives. - The products have not been protected by trademarks. - The yield is lowers than the mono- rice farms, which produce several crops each year.
Threats	**Opportunités**
- There was a lack of capacity and experience in the establishment of cooperating groups and cooperatives and no experience in developing a trademark. - The area experiences erratic weather events, and flood water levels are unpredictable and change from year to year. - Market prices for rice are unstable, affecting the sales of floating-rice from year to year. - Natural hazards such as birds, mice, insects? harm productivity. - To meet the targets for An Giang province production, many farmers are choosing to convert to short duration, high-yielding rice, growing 2 or 3 crop per year, instead of one.	- Floating rice system has the potential to develop clean rice, free of most chemicals, and possibly organic rice. - Consumer trends in domestic and foreign markets are for clean rice and organic rice. - Business is gradually becoming more interested in selling floating rice paddy. - Possibility of developing of eco-tourism farming. - The local government and commercial organizations are interested in supporting the development of these products.

Conclusions

Mapping of floating rice and vegetable value chain revealed four processes which are input supply, crop cultivation, product collection, and commercial sales.

The distribution channel of floating rice and vegetables emerged as very simple with only four actors in the channel. The farmers sell their products primarily through middle men. They are not associated with any commercial companies or enterprises in the production and distribution of their produce.

There are no links between the actors, other than when they meet for the exchange of produce for money, in the chain of production so actors lack information about each other's activities and how much the next actor receives for the produce. This is a market failure.

The actors in the floating rice and vegetables chain experience different costs and benefits. This research revealed a high disparity between the actors in the value chain.

No technologies are used in the production of these products; farmers sell their products in crude forms, unprocessed; and the unique diversity of these products is not recognized.

Floating rice has not only goodpotential economic value, it also has environmental and agricultural eco-tourism values.

Acknowledgement

We the authors would like to extend their gratitude to the key informants and farming households in Vinh Phuoc commune Tri Ton district, An Giang province; for their time and participation in providing information for this study. We would also like to acknowledge valuable comments from two Dr Charles Howie. Especially, many thanks are given to Alisea and Searca, which has provided funding for the scholarship for the research for this study.

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The quality of topsoil in floating rice area in Vinh Phuoc Commune, Tri Ton District, An Giang province, Mekong Delta

Huynh Ngoc Duc* and Pham Van Quang

Abstract

This study was carried out in Vinh Phuoc Commune, Tri Ton District, An Giang Province from August 2013 to April 2014. The aim of the study is to investigate and compare the basic physical and chemical properties of soil layers between the floating rice and the intensive rice cultivation area. The samples were taken in six farmers' fields (three in the intensive rice cultivation and 3 in the floating rice) and analyzed for pH, bulk density, electrical conductivity (EC), cation exchange capacity (CEC), percentage organic carbon, total nitrogen and NH^{4+}*, total phosphorous, available phosphorous, potassium exchange, total iron, aluminum exchange. The results showed that both two rice cultivation area in Vinh Phuoc were still in good conditions for plant growth in term of soil compaction. However, soil bulk density in floating rice was much lower in the triple rice cultivation. Soil pH was rather low (ranked as strong acid) and EC values were relatively low. The soils were high in organic matter, amounts of total nitrogen and phosphorous.*

Key words: soil fertility, soil properties, soil monitoring, rice cultivation.

Introduction

Vinh Phuoc commune, Tri Ton district, An Giang Province is located in relatively low-lying terrain. The land in this commune is contaminated with acidity, especially in the dry season. Most of the land is surrounded by a system of high dikes, but some of it is not within dikes, and this is likely to be covered with flood water to depths of 1.2-1.7m between July and December each year. Within the dike system construction in 2011, farmers have cultivated rice continuously, raising three rice crops per year: December to February (crop 1), March to May (crop 2) and June to August (crop 3). Meanwhile, in the areas outside the dyke system, water enters from upstream and one crop of floating rice is grown in the flooding season (July - December) followed by an upland crop (mainly cassava, but also tapioca and other crops) during the dry season (January to June).

The aim of the study was to investigate and compare the basic physical and chemical properties of soil layers of the area where floating rice and cassava cropsare grown with soil layers in the continuous rice area in Vinh Phuoc commune.

Materials and Methods

Six plots were selected in the year 2011, three in each area: plots numbered 1, 2 and 3, with areas of 16.0, 2.6 and 18 ha respectively, were selected in the continuous rice area, and plots numbered 4, 5 and 6, with areas of, 2.5, 2.5 and 3.0 ha respectively were selected in the floating rice area.

On each plot, soil cores were taken to a depth of 20 cm for the topsoil and from 20 to 40 cm for the subsoil in a zig-zag pattern within the sampling area. 10 soil samples were distinctly collected for topsoil and subsoil layers, then mixed into a single sample representing that layer, one sample for topsoil, one sample for subsoil. Sampling was conducted 1 to 2 days before crop harvest, that was about the end of September for the continuous ricecropping areas and the middle of January for the floating rice area.

Soils were analysed for the following criteria: pH H_2O, pH KCl with 1:2.5 soil - water extracts; electrical conductivity (EC) with 1:5 soil - water extracts; cation exchange capacity (CEC) with 0.01M $BaCl_2$ and 0.05M $BaCl_2$, pH 8.1; percentage organic carbon with Walkey-Black method; total Nitrogen and NH_4^+ by Kjeldahl method; total phosphorous, by spectrophotometer); available phosphorousby Bray 2 method; potassium exchange with 0.01M $BaCl_2$; total iron andaluminum exchange by flame atomic absorption spectrometry (AAS).

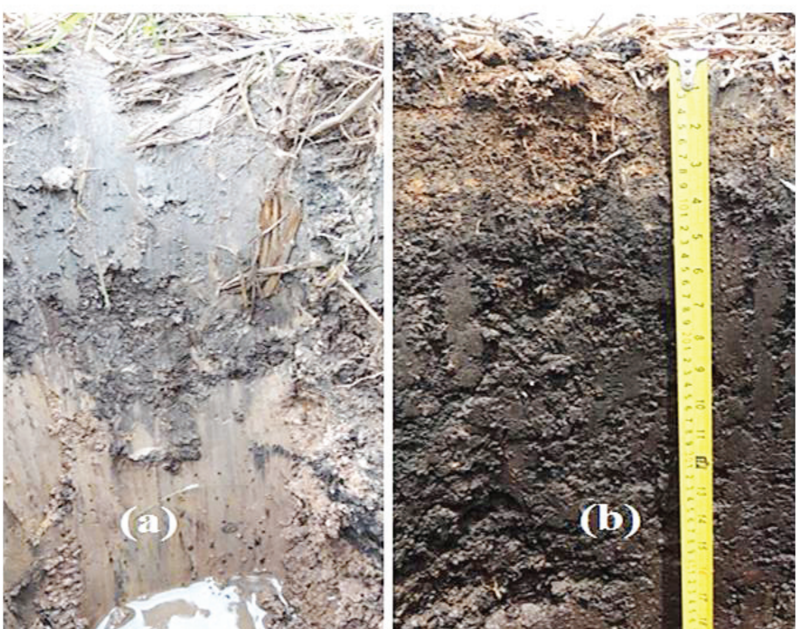

Figure 1. Soil profiles (a) triple rice cropping area, (b) floating rice area

Results

Soil properties of the observed sites

The layer of topsoil in the triple rice cropping areas is about from 15 to 20 cm deep with a clear boundary to the subsoil, the second layer is bright brown and hard. The floating paddy area has a thinner surface layer (about 10 cm in depth) which includes much semi-deciduous vegetations, showing signs of accumulation of sediment brought by floods to the fields, especially near the canal. However, fields that are far from the canal, the thickness of this sediment is not appreciable. The subsoil in the floating rice area contains many dark coloured organic substances and has a thickness of about 45-50cm.

Bulk density, pH and EC

Soil bulk density is important for evaluating soil physical properties. If the bulk density is greater than 1.3g/cm^3, this may cause difficulties for cultivation, and result in a significant reduction in crop production due to limited root growth. The good soil bulk density forroot plant systems ranges from 1.0 to 1.1 g/cm^3 (Ngo et al. 2004). The bulk density of the topsoil and subsoil observed at all 6 sites was almost always lower than 1.3 g/cm^3, therefore, a compacted soil situation has not yet become a critical condition for the plant roots (Houlbrooke, Thom et al. 1997).

In the triple rice growing areas (plots 1, 2 and 3), the bulk density of the subsoil was higher than that of the topsoil (Table 1), but an opposite trend was encountered in floating rice fields (plots 4, 5 and 6). For most of the rice land, especially for triple rice cropping land, the hard pan is usually formed within the lower layer, and this may be a reason for a higher bulk density of the subsoil (Le and Nguyen 2011), the highest bulk density occurs in the hard pan and then tends to decrease in the deeper soil (Le 2003). Using power tillers in primary tillage, plowing and puddling would produce more mechanical force, that would make the hard pan shift downward in soil. Such land preparation promotes good physical, chemical, and biological environment for better and efficient crop growth.

However, beneath the topsoil layer in the floating rice areas is a very thick organic layer with black colour. It is the result of the decay of the Melaleuca native plant before, which may result in very low soil bulk density in the subsoil, however, it also helps to maintain and provide water for cassava crops (tapioca) during the dry season.

The bulk density in all 6 sites varies in the range from 0.41 to 1.07 g/cm^3 for topsoil, and from 0.26 to 1.21 g/cm^3 for subsoil (Table 1). The bulk density on paddy rice land in Vinh Phuoc was lower than that of many other agricultural areas in the Mekong Delta. The study of Le and Nguyen (2011) on Fluvisol continually cultivated triple rice in Dong Binh and Truong Xuan communes, Thoi Lai district, Can Tho city, revealed bulk density of subsoil layer was 1.37 and 1.34 g/cm^3 respectively; The higher the bulk density, the more compact the soiland the less pore space exists, this reduces root growth and lowers crop yields. Bulk density greater than 1.2 g/cm^3 was also reported on intensive cultivation land in Long Thuong and Hoa Ha hamlets, in Kien An commune, Cho Moi district, An Giang province, by Huynh and Nguyen (2012).

Table 1. Soil bulk density, pH and EC at observed locations

Sites	Bulk density (*gam/cm^3*)		Porosity (%)	pH H_2O	pH KCl	EC (mS/cm)
	Layer 1	Layer 2	Layer 1			
1	0.81	1.21	67.63	3.87	2.64	0.28
2	0.74	1.07	71.54	3.29	2.37	0.71
3	1.07	1.15	58.27	3.32	2.57	0.42
4	0.65	0.26	74.60	3.32	2.78	0.99
5	0.41	0.28	76.90	3.44	2.79	0.59
6	0.72	0.54	69.43	3.73	3.17	0.20

Note: Sites 1,2,3 are in the continuous rice are; sites 4,5,6 are in the floating rice area

Soil porosity is the amount of pore volume, or space between soil particles, used to represent the aeration of soil. Porosity can be calculated by equation Pt = (1 - Pb/Pd) where Pt is the porosity, Pb is the bulk density, and Pd is the sample's particle density (Nguyen et al. 2012), therefore, bulk density can be considered as an indicator of soil compaction and soil health. The results of porosity in all 6 observed sites were relatively high. This means that the soil is still in good conditions for infiltration, rooting penetration and depth, available water capacity and nutrient uptake.

Soil pH at all sites was rated as strong acid, therefore, deficiency of major plant nutrients may occur. In the low range of soil pH, the adsorbed H^+ and Al^{3+} may predominate the cation exchange capacity. Because of low pH, lime and phosphate fertilizers are often applied to improve soil conditions for better rice growth. The pH would be increased by floodwater and rainwater during the rainy season annually, so this may ameliorate the soil condition to become more suitable for cultivation.

Soil electrical conductivity (EC) is a measurement of the amount of salts in soil. It is an important indicator of soil health. For non-saline soils, determining EC can be a good way to estimate the amount of nutrients available for plant growth. The EC values of observed sites were in the range of 0.2-0.99 mS/cm.

These EC values are relatively low, but stillshould not impact the plant growth much. High EC values will prevent the absorption of nutrient solution due to low osmotic pressure. Low EC values will affect the health and yield of the plant.

Organic matter, nitrogen and phosphorus in soil

Organic matter plays a crucial role in soil fertility, buffering capacity, water holding capacity, stabilization of soil structure, and soil microbial activity (Vo 2010). The result of percentage of carbon (%C) for topsoil in floating rice fields (4.43-8.86%, was considered to be rich) was significantly higher than that in triple rice cropping fields (1.43-1.73%, considered to be moderate) (Table 2). This indicated that the decomposition process was faster in triple rice cropping soil; therefore, there is usually a release of mineral nitrogen early in the decomposition process.

A study of Le et al. (2013) on the floating rice areas showed that after harvesting floating rice, a large amount of straw remained on the field (about 1.5 tons/1000m^2 - dry weight), while most of the straw on the triple rice cropping area was removed from the field. This may be a reason why %C in the floating rice is higher, and this also contributes to a good condition for an increase in water holding capacity for the following crop, e.g. cassava.

Table 2. Organic matter and nitrogen concentration in the topsoil on surveyed fields

Sites	Organic carbon (%C)	Total nitrogen (%N)	Available N (NH_4^+ mg/kg)	Total P (%P_2O_5)	Available P (mg/kg)
1	1.73	0.09	40.03	0.02	0.30
2	1.88	0.07	43.01	0.01	0.09
3	1.43	0.07	40.11	0.02	1.99
4	8.86	0.49	31.18	0.10	8.97
5	4.51	0.82	58.47	0.20	10.00
6	4.43	0.37	36.49	0.13	4.66

Note. Sites 1,2,3 are in the continuous rice are; sites 4,5,6 are in the floating rice area

There were significant differences between triple rice cropping and floating rice areas for total nitrogen (0.07-0.09 and 0.37-0.82%N), total phosphorous (0.01-0.02 and 0.1-0.2%P_2O_5), and available phosphorous (0.09-1.99 and 4.66-10 mg/kg); except for exchangeable ammonium (40.03-43.11 and 31.18-58.47 mg/kg), see Table 2. The total nitrogen was rated poor on triple rice cropping fields, but rich on floating rice fields, and the same trend occurred for the total phosphorous; available N was moderate on both areas; available phosphorous was ranked low, which could be because of fixation by Fe^{2+} and/or Al^{3+} ions due tothe low pH conditions.

Figure 2. Floating rice stubble/straw on the floating rice area

Cation Exchange Capacity (CEC) and Exchangeable cations

Cation exchange capacity (CEC) in the observed sites is shown in Tables 3 for topsoil. The CEC of all sites was not significantly different between the two areas. Cation exchange capacity of soil refers to the amount of positively charge ions that soil can retain. When soil becomes more acidic the base cations are replaced by H^+, Al^{3+} and Mn^{2+} and this also produces higher CEC values. The higher the CEC, the higher amounts of nutrients the soil is able to supply. The CEC of the soil depends on the kind of clay, organic matter content, pH and soil formation. The CEC of all study sites was ranked moderate, this may indicate restricted availability of soil nutrients to plants. However, the low soil pH and poor organic matter on the triple rice cropping may contribute to the decrease in negatively charge components and this may then reduce the nutrient holding capacity of the soil.

Table 3. Cation Exchange Capacity (CEC) and Exchangeable cations and total Fe in top soil

Site	CEC ($cmol^+/kg$)	Exchangeable K ($cmol^+/kg$)	Exchangeable Al (meq $Al_3^+/100g$)	Total Fe (%)
1	27.36	0.16	8.81	2.07
2	33.29	0.18	10.13	2.29
3	35.23	0.16	9.38	2.17
4	33.98	0.26	9.81	3.27
5	32.66	0.14	11.63	3.21
6	30.65	0.29	4.00	2.99

Note. Sites 1,2,3 are in the continuous rice are; sites 4,5,6 are in the floating rice area

Exchangeable potassium (K^+) on all study sites varied from 0,14 – 0,29 $cmol^+/kg$ (Table 3) and was rated poor to moderate (Kyuma, 1976); Potassium (K) is an essential macronutrient for plants involved in many physiological processes. According to the study of Li et al. (2014), the rate of K^+ release is significantly greater than the rate of K absorption capacity during the early stage of decomposition. Straw residues could absorb K^+ ions from the surrounding environment. The straw K absorption capacity is a function of the decomposition period and the extra K concentration, indicating an equilibrium between the K pool absorbed on the residue and that in the bulk solution(Li et al., 2014). Plant residues had an especially strong absorption capacity after long-term decomposition. Therefore, as a vast majority of K fertilizer inputs to the soil are one-time events, a portion of these inputs could be replaced by accumulated organic matter (Li et al., 2014).

At low pH (<5), Al dissolves, causing toxicity to the growing rice plants (Elisa et al., 2011); and Fe^{2+} is also known to be toxic to rice plants (Tran and Vo 2004). Therefor, rice grown on a low pH condition, as on the floating rice and triple rice cropping areas in Vinh Phuoc, could be subjected to Al^{3+} and Fe^{2+} toxicity.

Conclusions and recommendations

Compared with the soil in the continuous rice cropping area, the soil for the floating paddy fields is with a low density, low pH (acidic soil), high organic, and has high amounts of total nitrogen and phosphorous.

Floating rice cultivation promotes the replenishment of organic matter for the soil from rice stubble/straw, while triple rice cropping fields should require a good plan to ameliorate the organic materials for the soil.

It should apply appropriate measurements to raise the pH value for contributing to a better promotion of the nutritive potential of the soil.

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Solubilization of ferrous phosphate and aluminum phosphate by becteria isolated from floating rice in Tri Ton District, An Giang province, Mekong Delta

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Abstract

An experiment was conducted to select the phosphate-solubilizing bacteria based on phosphate solubilization ability. All of the bacteria tested showed various levels of the phosphate solubilizing activity in both agar plate and broth conditions using National Botanical Research Institute's phosphate medium (NBRIP) that $Ca_3(PO_4)_2$ replaced by $FePO_4$ or $AlPO_4$. They grew rapidly in the medium liquid at pH 5. However, all the strains possessed ability to produce significant amounts of soluble phosphorus (P) from different P compounds. They have more ferrous phosphate solubilization ability thanaluminum phosphate solubilization abilityin brothassays. The isolated bacteria were identified by 16S rRNA genes sequencing data that B1 strain matched with Enterobacter cloacae and B2 strain as Burkholderia cepacia.

Keywords: Phosphate solubilization, aluminium phosphate, ferric phosphate.

Introduction

Phosphorus is one of the key macronutrients for biological growth and development (Fernandez et al. 2007). Phosphorus is typically soluble or poorly soluble in soil. Although the average P content of soil is about 0,05%, only 0,1% of thetotal phosphorus exists in plant sinaccessible forms (Illmer & Schinmer 1995). As a result, large amounts of soluble P fertilizers are applied to attain maximum crop production. However, the applied P can be formed less soluble compounds as tricalcium phosphate ($Ca_3(PO_4)_2$), $FePO_4$, $AlPO_4$ (Achal et al. 2007). It is well known that approximately 75-90% of applied P fertilizer sareprecipitated by Ca, Fe and Al metal cations and these insoluble forms are not efficiently taken up by the plants. This leads to an excess application of phosphate fertilizer onfields (Khan et al. 2006). Some soil microbes have ability to solubilize these insoluble phosphate forms through the process of organic acid production, chelation and ion exchange reactions and make them available to plants. Improving the efficiency of P uptake by plants through microbial associations would therefore be economically and environmentally beneficial. The existence of soil micro organisms that arecapable of transforming unavailable P to P availability for plants is well documented (Rodriguez & Fraga 1999).

Materials and methods

The bacterial strains for their phosphate solubilising ability from various forms was assessed on NBRIP with modifications, onelitre of distilled water contained (g): 20 glucose, 5 $MgCl_2{\cdot}6H_2O$, 0.25 $MgSO_4{\cdot}7H_2O$, 0.2 KCl, 0.1 $(NH_4)2$-SO_4 and 5 $FePO_4$ or 5 $AlPO_4$, plus 0.5% bromocresol green, pH 7.0. A stock solution of 0.5% dye was prepared by dissolving a corresponding weight of bromocresol green into 70% ethanol and the final pH was adjusted to 6.5 with 1M KOH. Five microliters of each bacterial suspension obtained as described above were added onto a single point of compartmented Petri dish. The plates were sealed and incubated at 28°C for 15 days and the phosphate solubilisating ability was evaluated by the halo/yellow zone surrounding the bacterial colony. The solubilizing index (IS) was considered as an indicator for the isolation efficiency:

IS = (Colony diameter + diameter of halo zone) / Colony diameter.

Mineral phosphate solubilization assays

The P solubilizing activity of isolates was determined by themolybdenumblue method (Murphy and Rilley 1962). The isolates were grown in NBRIP broth containing different insoluble forms of phosphate ($AlPO_4$ or $FePO_4$) for 20 days at 30°C on a IKA Incubator shaker at medium speed (150 rpm). The solubilization efficiencies were determined by there action with ammonium molybdate for phosphorus compounds as ammonium phospho molybdate and reduced with a compound ascorbic acid to molybdenum blue. Then, the isolates were incubated for 30 min at room temperature for color development. Finally, the absorption of light in the wavelength range 880 nm was measured by spectrophotometer.

PCR amplification of 16S rRNA and sequencing

The gene-encoding 16S rRNA was amplified from selected strains by the polymerase chain reaction (PCR) using bacterial universal primers P515FPL và P13B (Zinniel et al., 2002) P515FPL: 5'- GTGCCAGCAGCCGCGGTA A -3'; P13B: 5'- AGGCCCGGG AACGTATTCAC -3'.

The PCR products were purified from agarose and sequenced. The nucleotide sequences were compared using the BlastN program and the closest match of known phylogenetic affiliation was used to assign the isolated strains to specific taxonomic groups.

Results and discussion

Activity of isolates on agar plates

The data in Table 1 indicates the values of colony diameter (n), that of the halo zone (z) and the z/n ratio of the different strains obtained on agar plates contained different insoluble phosphate types. The ratio z/n used to evaluate the activity of strains; The strain obtained the higher the value of this ratio, it can be the greater activity of tested strains. The activity was associated with a pH decrease of the medium, observable through the yellow zone surrounding bacterial colonies. All the two bacterial strains were able to show halo zone on agar plates containing Fe-P and Al-P (Fig. 1).

Table 1. The index of solubilisation by two bacterial strains

Strain	Nutrient agar with $FePO_4$			Nutrient agar with $AlPO_4$		
	Diameter of colony n(mm)	Diameter of halo zone z(mm)	The index of solubilisation (SI) z/n	Diameter of colony n(mm)	Diameter of halo zone z(mm)	The index of solubilisation (IS) z/n
B1	0.58	1.56	2.69	0.5	1.27	2.54
B2	0.54	1.49	2.75	0.48	1.21	2.52

Solubilization of ferric phosphate ($FePO_4$) and aluminum phosphate ($AlPO_4$)

All the two bacterial strains were able to produce soluble phosphate from ferric and aluminum phosphates (Fig.1). In case of insoluble forms of phosphate source, B1 bacteria solubilized can maximisetheamount of phosphorus from $FePO_4$ (28.63 mg P_2O_5) on the 10th day and $AlPO_4$ (26.71 mg P_2O_5) on the 20th day; B2 bacteria solubilized can maximisetheamount of phosphorus from $FePO_4$ (44.19 mg P_2O_5) and $AlPO_4$ (16.78 mg P_2O_5) on the 20th day. In general, the amount of phosphate solubilized decreased in the order $FePO_4$> $AlPO_4$. Two bacterial strains solubilize the insoluble phosphate sources as $FePO_4$, and $AlPO_4$ which were slow initially and gradually increased in the middle period of incubation.

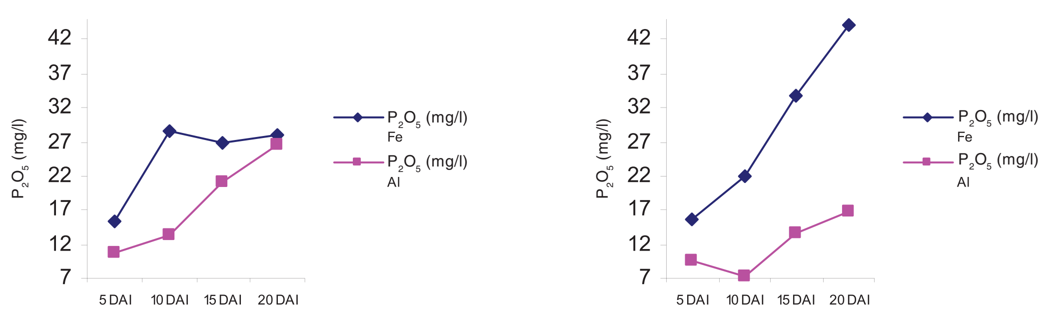

Figure 1: Changes in phosphorus concentration during the solubilization of $FePO_4$ and $AlPO_4$ by 2 bacterial strains.

In case of $FePO_4$ source, the amount of phosphate solubilized increased with incubating time of strain B1. From $AlPO_4$ source, the amount of phosphate released increased with incubating time of strain B2. Strain B1, in case of

$AlPO_4$ source, phosphate solubilization was associated with pH decrease of the media, but thispH decrease was not strictly proportional to the amountof the phosphate dissolved. However, acidification cannot be the explanation for phosphate mobilization in bacterial cultures in other cases (Fig.2).

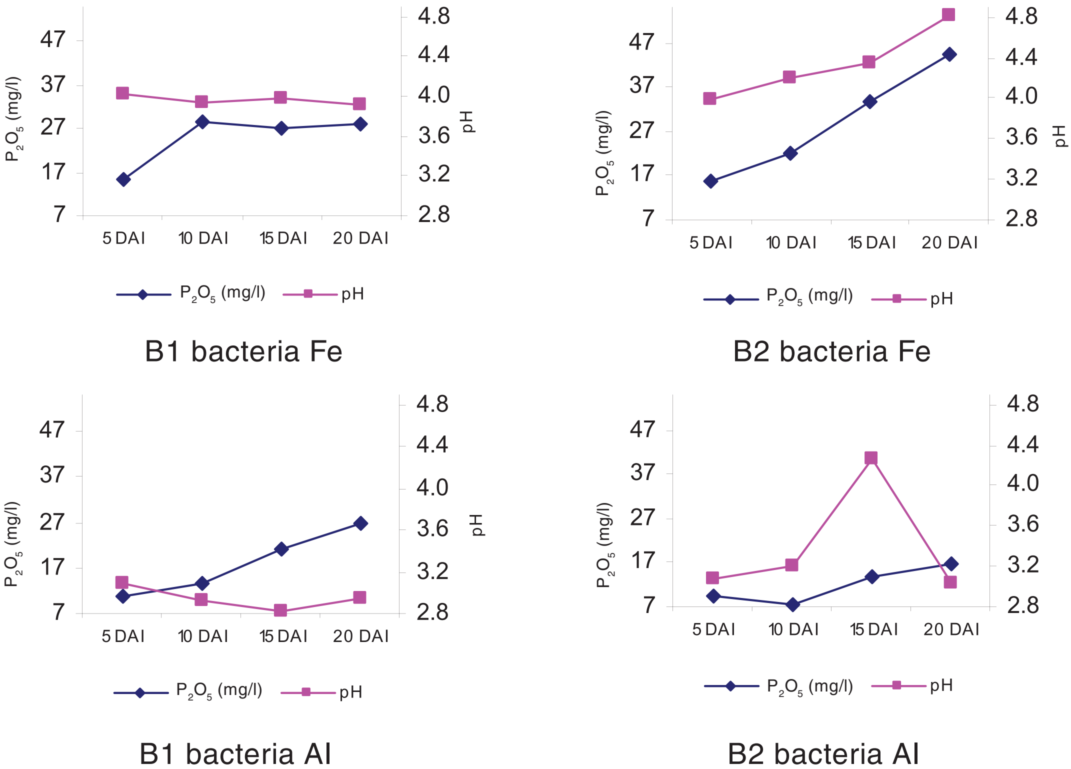

Figure 2: Phosphorus concentration and pH were solubilised by 2 bacterial strains.

All the strains that solubilised phosphate in liquid media reduced the pH of the media compared to the initialvalue, regardless of the source of phosphate. The strains that did not reduce the pH of the media were unable to solubilise phosphate (Marra et al. 2011). P release is mainly based on acidification of the nutrient medium or the soil. It is generally accepted that the major mechanism of mineral P solubilisation is the action of organic acids synthesised by soil microbes (Hariprasad and Niranjana 2009). However, the decrease in pH is not always in the same correlation to the calcium phosphate solubilisation by microorganisms (Mehta and Nautiyal 2001). Deubel et al. (2000) reported that only two of the eight strains showed clear zones on calcium phosphate agar and could be identified as P-solubilisers. However, seven of the eight strains mobilised significant amounts of tricalcium phosphate. Although some strains acidified the nutrient solution remarkably, we found no correlation between pH and P in solution. Hence, acidification cannot be the single mechanism of phosphate mobilisation.

Identification of strains

Two promised isolates of endophyte bacteria in rice were selected to identify; and fragments of the each strains obtained over 900 bp from sequencing.

The determination of nearest phylogenetic neighbor sequences for 16S rRNA gene sequence of the 02 isolates by the BLAST search program showed that they grouped into two groups: Gammaproteo bacteria and Betaproteo bacteria (Table 2).

Table 2. Closest species relative of two bacterial strains

Taxonomic group and strain	Closest species relative	Similarity (%)
Gammaproteo bacteria		
B1	*Enterobacter cloacae*	99
Betaproteo bacteria		
B2	*Burkholderia cepacia*	99

Conclusion

All the tested bacteria showed various levels of P solubilizing activity in both agar plate and broth conditions using modified NBRIP medium. They grew rapidly in the medium liquid at pH 5. However, all the strains were able to solubilizein soluble P depending on the P sources. They have more soluble P fromferric phosphate solubilization ability than from aluminum phosphate solubilization abilityin broth assays. The selected isolates were identified based on 16S rRNA genes sequencing data, with B1 strain as Enterobacter cloacae and B2 strain as Burkholderia cepacia. Using these strains as apossible inoculation for soil with ferrous phosphate in the greenhouse experiments and field trials.

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Local knowledge on the floating rice-based farming systems in the Mekong Delta

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Abstract

Local knowledge has been developed and accumulated over time, by a community and passed on for generations. Over centuries, particularly farmers are knowledgeable about their resources and the environment in so far as these govern their agricultural production, and cultural heritages. The purpose of this chapter is to discuss how local knowledge is accessed and used by floating rice farmers in An Giang province. The study utilises qualitative methods, especially in-depth interview and group discussion tools. The study observed that local farmers have applied their own knowledge and skills in traditional farming practices, in terms of crop varieties selection, cropping seasons, integrated crops, and advatages of natural resource based on floating rice ecosystem. Therefore, local knowledge should be given sufficient attention in constructing livelihood strategies feasible to the local people' capabilities.

Key words: Local knowledge, floating rice, traditional farming practices.

History of floating rice farming in An Giang and Dong Thap provinces

Deepwater rice, also known asfloating rice, is a subsistence crop for about 100 million people living in severe flood-prone areas of Southeast Asia (Kende 1998). This section provides an overview on the history of floating rice cultivation in An Giang and Dong Thap provinces.

Some decades ago in Cho Moi district of An Giang province, farmers could successfully grow floating rice, tobacco, sugarcane, or vegetable because of the Mekong Delta's fertile soil. About 90 percent of the production area wasdevoted to tobacco cultivation (personal communication with a farmer in Cho Moi District in January 2014). In 1995, farmers changed from tobacco to maize cultivation with various kinds of varieties (personal communication with a farmer in Cho Moi District in January 2014). At present, farmers grow acombined floating rice – maize farming system (A group discussion with a farmer group in Cho Moi District in January 2014). Similarly, in Tri Ton district, farmers are able to implement this floatin rice- maize farming system because there has been no dike construction and the presence of acid sulfate soiland deep floods (personal communication with a farmer in Cho Moi District in January 2014).

Many years ago, Tri Ton district of An Giang province was an inaccessible area covered by mangrove swamp forest (personal communication with a farmer in Tri Ton District in February 2014). In 1997, after assignment of land by the State, local farmers bought land for 300,000 VND/1000 m^2 and changed it into cultivated areas. Since then, farmers in Tri Ton rotate between floating rice and white beans, watermelon, or squash (personal communication with a farmer in Tri Ton District in February 2014).

In Thanh Binh district of Dong Thap province, there has been floating rice cultivation since 1945. After agricultural transformation floating rice farming remained in Tan Long commune of Thanh Binh district (personal communication with a farmer in Thanh Binh District in February 2014). The reasons for floating rice cultivation in Thanh Binh district of Dong Thap province until now are (1) advantages for vegetable farming, (2) presence of sandy soil, sufficient only for crops like floating rice, (3) low land, and (4) uneven and flat terrace system (personal communication with a farmer in Thanh Binh District in February 2014). During that time, the agricultural system rotated floating rice and tobacco or bean, such as green peas or soy beans (A group discussion with a farmer group in Thanh Binh District in January 2014). Farmers rotated crops because tobacco cultivation created infertile soil, so farmers grew green peas and soy bean to restore fertility, allowing alluvial deposits to go into floating rice cultivation (A group discussion with a farmer group in Thanh Binh District in January 2014). In 1995, farmers stopped cultivating tobacco and replaced it with scattered chili production, until reaching nearly 100 percent of land devoted to chili production in 2000 (personal communication with a farmer in Thanh Binh District in February 2014). For the floating rice variety, most of “chech cut” variety has been cultivated, but after big flooding in 2000, this variety disappeared after rice crop failure. Then, local farmers bought “Nang Tay” variety from Chau Phu district and have continued to grow it until now.

The local knowledge on floating rice farming practices

The knowledge of food and medicine is closely related to knowledge about agricultural production and resource management (Yos, 2003). According to Yos (2003), these systems require methods such as seed selection, preservation of essential local cultivars, and water management. In this research, some issues related to indigenous knowledge of floating rice practices were explored including: (1) selection of floating rice varieties (2) storage after harvesting, (3) crop calendar and cultivation techniques of floating rice, (4) seedling time, (5) selection ofrotating vegetables, (6) advatages of floating rice buds for cows’ feed , (7) use of floating riceby-products, (8) local indigenous pest control, (9) water management, and (10) alluvial soil levels.

Rice varieties

Some studies have found that farmers maintain genetic diversity of rice variet ies to match local environmental conditions (Watson 1984, Fujisaka 1987, Damus1992, 1995 cited by Setyawati (2003). Others have focused on farmers' practices in plant breeding, their experiments related to varietal changes, their reasons for abandoning or choosing varieties, and their means of obtaining new varieties (Lambert 1985; Richards 1986; Fujisaka et al. 1992 cited by (Setyawati 2003). In this case, the local farmers who have practiced the floating rice pattern in the Mekong Delta understand the relationship between indigenous knowledge and the preservation and selection of local rice varieties.

- **Rice varieties and soil conditions:** According to most of farmers, their purpose of floating rice cultivation is to take back its rice stubble for vegetable growing because rice stubble retainssoil moisture, restricts pests and weeds on vegetables, and heightens vegetable productivity. Floating rice distinguishes itself from most high yielding rice varieties by its ability to survive in water depths of more than 50 cm for at least 1 month (Catling 1992). Among the deepwater rice types, the so-called floating rices exhibit extreme elongation capacity. Soil characteristics in this region is sandy loam, lowland, and fast drainage favoring vegetable cultivation rather than intensive rice farming.

- **Rice variety selection:** There are many different types of floating rice shown in Table 1. Most farmers stated that since 2004, Bong Sen variety was the most popular because of itsalum tolerance, afeature identified with higher survival rates. Some farmers changed to modern rice but did nothave effective production, then they changed back to floating rice. As a consequence, the Tay Dum and Nang Pha varieties have been lost (Le and Le 2015).

Those varieties are classified by local farmers' experiences based on harvesting time or photo-sensitivity. In recent years, floating rice varieties has been gradually declined, so local farmers would like to reinvogate and classify into 08 rice forms with white or red grain rice in every its shape. Therefore, the cooperation of researchers and local farmers in rice selection could classify different floating rice varieties according to flower forms and grain rice color.

To identify varieties from seeds, farmers combine several criteria. They observe the size of the grain and its shape (categorised as 'thin', 'full', 'straight', or 'slightly curved'); the colour of the husk (bright yellow, dusty yellow, blackish or reddish) and of the bran (red, white, milky, patchy red); and certain signs, like the awns in the spikelets or the shape of the sheath on the spikelet. Farmers tended to name varieties after some special feature of the grains. According to a local government official in Thanh Binh district of Dong Thap province), rice selection for the next crop on the paddy field is very hard because all selected rice grain is homogenous.

Table 1. Floating rice varieties/lines have been preserved by local farmers

No	Local name	Bran color	Ripening time	Location
1	Chệt Cụt	White/Red	Early ripening/mid	Tri Ton, Cho Moi, Thanh Binh districts
2	Nàng Chồi	White/Red	Early ripening	Thanh Binh
3	Nàng Tây Bông Dừa	White/Red	Early ripening	Cho Moi, Thanh Binh
4	Nàng Tây Đùm	White/Red	Early ripening/mid	Tri Ton, Cho Moi, Thanh Binh
5	Nàng Tây Nút	White/Red	Mid ripening	Tri Ton
6	Nàng Pha	White/Red	Mid ripening	Tri Ton
7	Bông Sen	White/Red	Mid ripening	Tri Ton
8	Dòng nghi Nếp nổi	Milky	Early ripening	Thanh Binh
9	Hybrid line having awn	White/Red	Early ripening/mid	Tri Ton, Cho Moi, Thanh Binh
10	Some similar to Nang Pha variety	White/Red	Early ripening/mid	Tri Ton, Cho Moi, Thanh Bình
11	Others	White/Red	Early ripening/mid	Tri Ton, Cho Moi, Thanh Binh

Source: Le and Le (2015)

- **Germination test:** Farmers in the locality mentioned that they check rice germination via randomized selection in three rice seed pinches in packages (equivalent to 100 seeds/pinch) to scatter them into cloth bag, then they are soaked in water for one night. After that, they kept in a cloth bag under the damp sand or rice husk ash for 3 days. As a result, farmers can count the seeds germinate to know the germination rate of existing varieties.

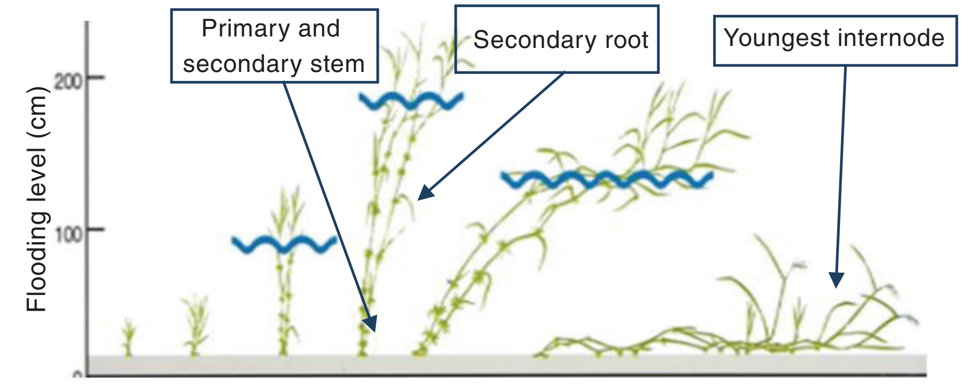
Crop Calendar

- **Crop calendar:** When the first rain fell between May and early June, farmers consider the broadcasting date for their crop calendar. Meanwhile the rice sowing date on terrace land is early June. Farmers who have low land sow seeds in mid-May. After one month, farmers apply about 5kg Urea/1000 m^2 on low land, because they think that fertilizer will support floating rice to be strong and that established seedlings will better cope with the high floods. However, Le and Le (2015) stated that chemical fertilizers don't impact floating rice yields because its sub roots develop to absorb alluvial from floods in order to grow as much as possible.

In general, the sowing date of local farmers affected by vegetable culitvation rotation and flooding time occurs before June. In particular, some farmers define the sowing date depending on the water color of Hau river. Then they will broadcast rice after "nuoc quay", or alluvial soil color during flooding time, which is about 1 – 2 weeks. There are two kinds of broadcasting techniques of floating rice. Local farmers usually sow dry rice after harrowing the field in order to cover the seeds. This prevents dessication during the germination period in the first 6-8 weeks when no rain falls, so as to protect the seeds from birds and mice. Alternatively, local farmers will sow floating rice differently depending on kinds of vegetables and number of crops (Floating rice- vegetable – vegetable). For example, in order to culitvate 1 corn crop before flooding, farmers grow 20 – sowing - days corn. After harvesting corn, floods come to the fields and the floating rice plants have a very rapid growth period in order to cope with the rising water level.

- **Vegetable crop rotation:** Depending on different local areas and market demand, farmers choose which vegetables to rotate with floating rice production. In Tri Ton district they grow green bean, white bean, manioc, sesame, palan queen; in Cho Moi district they grow green bean and corn; and in Thanh Binh district they grow soybean and chili.

- **Water management:** According to local government staff, because of without dike construction, flood management is big challenge in locality. Therefore, most of farmers manage their floating rice crop based on their local knowledge of when waters rise. The productivity of floating rice correlates to the flood level. If the flood is high then floating rice grows significantly. An illustration of this is as shown in Figure 1 with the correlation between flooding water and floating rice growth cycle.



	Pre flood 1-1,5 month	**During Flood 3 months**	**Post flood usually 1-2 weeks**	**1-2 months**
	- Can grow before flooding time from 1 – 3 months. - Today, grow before 1 month	Could be flooded 3-5 months	As the floodwaters rise, rapid internodal growth permits the plants to maintain part of their foliage above the water - Can be in air before water recede	- Flowering and repining - Early repining can flower in flooding time if short day condition.

Figure 1. The correlation between flooding level and floating rice growth cycle
Source: Hans Kende (1998)

- **Pest management:** On the other hand, farmers have many rich experiences in pest management by cutting leaves after 45 days and 80 days from sowing seeds. In Cho Moi district of An Giang province and Thanh Binh district of Dong Thap province, farmers cut leavesto sell for cow feed. As mentioned by Mr. Ngo Van Ngoc in Thanh Binh district, pest management depended on flooding level. Ror example, there is less flood in mid- Juneand floating rice leavesare large enough to cut after 45 days from sowing seeds. If farmers cut too late, then the plants cannot maintain part of their foliage above the water levels. Therefore, Mr. Nguyen Thanh Binhin Cho Moi district notes that this technique will help to considerably reduce pests and create space on floating rice field. This is an effective solution in pest management.

Traditional method of harvesting rice and storage

In the survey results, most local floating rice farmers have awareness and experiences of how to harvest. Because of rice and cultivated land characteristics, sickleis the predominant technique used in manual rice harvesting in the annual monsoon cropinstead of using combine harvesting machine. Rice needs to be dried in the sun after cutting to prevent moisture that could spoil the crop during storage periods. Plastic sheets are commonly used for drying paddy rice. Also, farmers shared their experiences in tasting the raw grain to check whether it is dried. Farmers identified a "bup" (sound in Vietnamese) meaning the grain is dry. After that, they sift the grain to be cleaned before storing it in a bag. Then farmers place all rice bags in cool places and store for next crop (A group discussion with a farmer group in Thanh Binh District in January 2015). Ordinarily, most farmers use half of their harvested rice for daily meal consumption and the other half for sowing in the next crop.

Biodiversity and fish

Mostfloating rice farmers shared varieties of plants, fishes, and vegetables on different stages of floating rice growth (Figure 2). The diversity of cultivars and fishes on floating rice farms contribute to households' daily meal during flooding period time.

Native fish resource on floating rice field

Table 2. Common local fishes on floating rice system

Local name	English name	Scientific name
Cá Linh	Mud carp	*Cirrihinus Juillinni* *Cirrhinussmolitorella* (Sauvage,1878)
Cálóc	Snakehead	***ChannaStriata* (Bloch,1793)**
Cárô	Tilapia	*Anabas testudineus* (Bloch, 1792).
Cátrê	Vietnam catfish	***Clariasbatrachus* (Linnaeus, 1758)**
Cáchốt	**Striped dwarf catfish**	***Mystusvittatus* (H.M.Smith, 1945)**
Tôm	Shrimp	*Macrobrachiumrosenbergii*

Source: (A group discussion with a farmer group in Thanh Binh District in January 2015).

There are various kinds of native fish in the locality, including white fish and black fish (A group discussion with a farmer group in Thanh Binh District in January 2015). In the survey's result, most farmers catch fish for daily meal, even for making fish sauce, and others who are professional fishers catch and sell fish for about 100,000 VND/day. There are some kinds of black fish illustrated in Table 2. Similar to the findings from Le and Trinh (2014) of 35 kinds of fish in flooding in 2014, research team also found a diversity of fish and vegetation. Fish provides a rich source of protein and micronutrients in peoples' diets. Therefore, taking advantage of this natural resource to increase farmers' income and provide meal nutritions, farmers can employ their traditional knowledge in different fishing ways, such as fishing net and bamboo trap.

Vegetation

Table 3. Common local vegetation on floating rice system

Local name	English name	Scientific name
Điên điển	Sesbania	*Sesbania aculata*
Rau muống	Morning Glory	
Rau dừa		*Ludwigiaadscendens* (L.) Hara
Gạt nai		*Xanthophyllum glaucum* Wall ex Hass
Cỏ chỉ	Green couch	*Cynodond actylon* ((L.) Pers.
Lục bình	Water hyacinth	*Eichhorni acrassipes*

Source: Group discussion, 2014

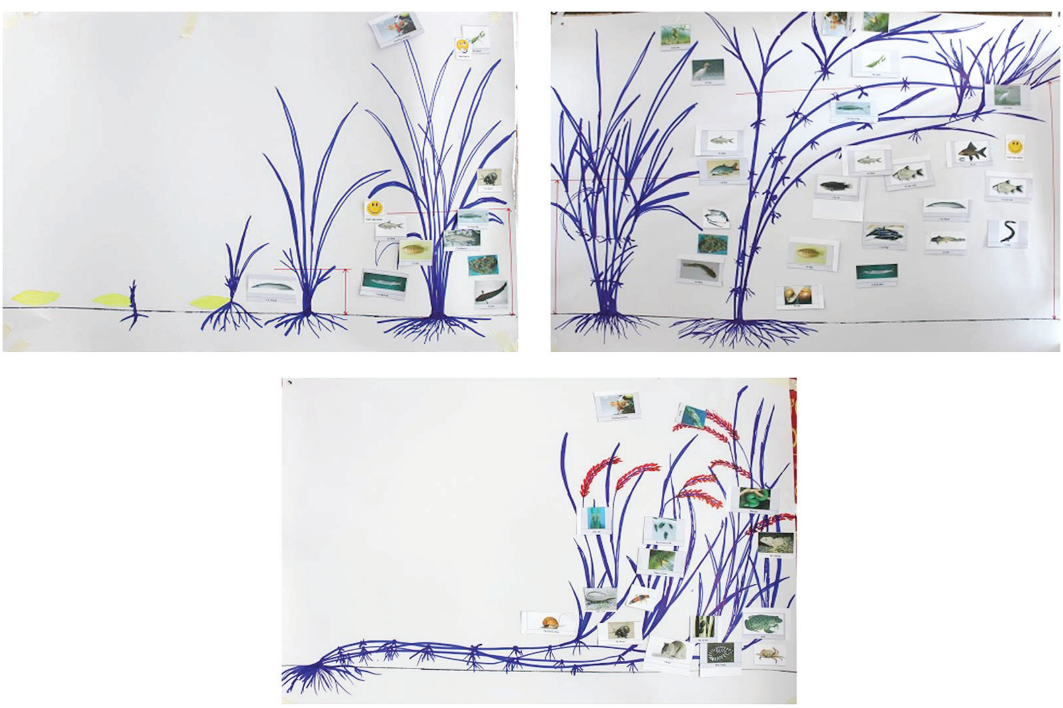


Figure 2. The diversity of fish on the different floating rice's growth stages

Most farmers in the local area recognized and comprehended a high level of biodiversity regarding varieties of plant species in the floating rice fields than intensive rice fields. There are various kinds of vegetables to supplement farmers' daily meals, such as morning glory and water lily. Moreover, some herbs also appear in Thanh Binh district (A group discussion with a farmer group in Thanh Binh District in January 2014). Table 3 displays the diversity of vegetation on floating rice farming in the Mekong delta during flooding.

Wild birds

When flooding levels rise, multiple kinds of birds appear on the floating rice fields. In particular, thousands of Anastomus oscitans from Tram Chim national park fly to here in 2012 and 2013, around harvesting time.

Sediment

Since floating rice cultivation, the amount of sediment has increased year by year Sediment transport relies on water flow, so most of waterway's sediment load occurs during flood events, particularly much sediment during the big flood in 2000. Because of the benefits of flood sediments on soil fertility (Mekong River Commission, 2012) farmers use 20% less fertilizer to rice field and vegetable as well (A group discussion with a farmer group in Thanh Binh District in January 2015).

Organic product

According to local farmers, unpolished rice is very good for health because it contains all the necessary nutrients. When eating this kind of rice for a long-time people reported feeling healthy. Most of the farmers who have practiced floating rice farming keep a half amount of harvested floating rice for their daily meal. In the research of Ho Thanh Binh (2014) illustrates that remarkable floating rice characteristics are high quality of nutrition for people as Nitrogen (9.84%), Fat (2.47%), carbohydrate (74.2%), Vitamin B1 (9.24 mg/kg), Vitamin E (64.74 mg/kg), Anthocyanin (43.6 mg/kg), amylose (31.71%).

Take advantage of floating rice by-products for vegetable cultivation and husbandry

Since cultivating floating rice, mostlocal farmers apply rice straw on their vegetable farms in order to reduce weeds and retain moisture. Covering rice straw on vegetable farm also contributes to decline fertilizer for crop production due to having rich alluvial soil which benefits to cultivars. As a result, farmers can save money normally spent to hire laborers to spray agricultural inputs, by investing low input and obtaining high profits.

Conclusion

Generally, floating rice cultivation is still a traditional rice farming system in the Mekong Delta. The success of this cropping pattern is mainly dependent on the experience of farmers. They can observe the topography, soil and water regime to adjust and diversify their cropping patterns in these natural conditions. In the same vein, according to Nguyen (1994), the most important factors to determine the selection of crop varieties, cropping seasons, combination of crops, and cultivation technologies are water management and soil conditions. Furthermore, local farmers use their knowledge and experiences to utilize local natural resources, such as vegetation and fish diversity on floating rice system as the way of conserving this farming pattern. As Yos (2003) points out, the conservation of traditional agro-ecosystem also preserves the cultural diversity and assists us to learn about how local wisdom applies to sustainable development, production systems, and natural resource management.

Acknowledgement

The success and final outcomes of this paper is from the valuable contribution of all those who have worked with us to ensure the completion and quality of this research. We also gratefully acknowledge the financial support given by the SUMERNET Project.

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The diversity of floating rice phenotypes in An Giang province, Mekong Delta

Le Thanh Phong

Abstract

This research explores the diversity of floating rice phenotypes in the 2014-2015 crop season in Tri Ton and Cho Moi districts in An Giang and Thanh Binh district in Dong Thap provinces. At each site, we selected three farms and collected 1,000 pinnacles perfarm for measuring and observing the phenotype traits. The local knowledge the oldest farmers in localareas was also used to help to classify the floating rice phenotypes. Chi squares test, t-test, correlation and Shannon index were used to calculate and analyses the data.

There were eight floating rice phenotypes that were explored and 187 groups of them were collected for conservation and continuous research. The red color bran is more than the white colour bran. The color of bran is a key trait to classify phenotypes of floating rice. We could collect more floating rice phenotypesin Tri Ton (An Giang) than in both Cho Moi (An Giang) and Thanh Binh districts. Seed sizes are around 18-34.9 gr/1.000 seeds. There were 13% of them having a tail on the seed and 28.6% having more than 200 filled seeds/pinnacle. The filled seeds have a strong positive correlation with their yield, this is a key trait to variety selection. Although Shannon index is not high, it is a genetic resource which plays a very important role in conserving and selecting varieties. Many groups of phenotype and inbred lines had been collected and can be developed to new floating rice varieties.

In the future, it is necessary to have more in-depth research on genetic diversity, adaptation to climatic changes, drought, saltwater intrusion and hybrids of other rice varieties in order to transfer good traits to new rice varieties.

Keywords: Floating rice, phenotype, genotype, inbred lines, conservation.

Introduction

The results from 2013 showed that only “Bông Sen”, a local floating rice variety, was used by farmers to cultivate in Tri Ton district ((Nguyen 2013). In the 2013-2014 crop, at harvesting time, the author and local farmers discussed floating rice varieties and discovered that there were many floating rice varieties which were still remaining in Tri Ton district. These included “Bông Sen” (11,6%), “Nàng Chệt Cụt” (14,6%), “Nàng Tây Nút” (10,78%), “Nàng Pha” (3,82%), floating rice with tails (2,05%) and mixing phenotypes (57,16%) (Le et al. 2014). Also, in 2014, the researcher at Research Center for Rural Development had discovered two areas that were still cultivating floating rice, Cho Moi district of An Giang province and Thanh Binh district of Dong Thap province. By visiting these local sites, the research group recognized the remains of many floating rice varieties and many floating rice shapes on farms of farmers in both Cho Moi and Thanh Binh districts (ref). With a real need for more in-depth research on floating rice varieties to reserve the traditional genetic resource in the Mekong delta, the research group carried out the research on "Restoration and development of local floating rice varieties/inbred lines in An Giang and Dong Thap provinces". The researchers focused on collecting a diversity of floating rice based on their phenotype for conservation of local genetic resources, and for an evaluation of the genetics of these materials for breeding programs at An Giang University.

History of the floating rice variety cultivation

In the history of floating rice cultivation in the Mekong delta, there were many famous floating rice varieties such as "Nàng Tây Đùm", "Nàng Chệt Cụt", "Nàng Pha", "Tàu Binh", "Nàng Tri", "Nàng Tây Bông Dừa", "Ba Bông", "Ba Sào", "Nàng Tây Nút". There were three groups of floating rice, depending on the time of harvest: (1) the Early growth group: "Nàng Chồi", "Nàng Son" varieties. The time of harvest is around middle of December; (2) the Middle growth group: "Ba Bông", "Nàng Tây Đùm", "Nàng Chệt Cụt", "Samo Chùm", "Nàng Tây Lớn". The time of harvest is at the end of December; and (3) the Later growth group: "Tàu Binh", "Nàng Tri". The time of harvest is at the end of January of the next year (Dang Kim Son et al., 1987). According to Huynh Hiep Thanh (1985), almost 29 floating rice varieties still remained in An Giang province in 1984. After 1985, the scientists continued to research floating rice varieties because of their high yield characteristics (HYV) being studied and developed in the Mekong Delta at that time. Since then, the floating rice area has decreased year by year. According to Vo Tong Xuan (1975), there were more than 500,000 cultivated ha, including 250,000 ha in An Giang province. The floating rice cultivating area still remains 41.2 ha in Tri Ton district (Nguyen Van Kien, 2013), 48.2 ha in Cho Moi district of An Giang province, and 33.6 ha in Thanh Binh district of Dong Thap province (Nguyen 2015).

The common floating rice varieties in the Mekong delta were selected by farmers in the past. When cultivating floating rice, farmers looked at the phenotypes and made a choice based on the population or pool selection method. Hence, one phenotype trait of floating rice varieties is used to classify different floating rice varieties. For example: the "Nàng Tây Đùm" variety is a famous type of floating rice with a high density of seeds clustered on pinnacles. The special phenotype traits such as the marker of shape were used to classify other floating rice varieties.

The function of genetics is P = G + E + ICE, whereas P (phenotype), G (genotype), E (environmental effected factors) and ICE (interactive between genotype and environment) (Tran 1992). There are two groups of genetic materials, the natural group and the artificial group. The natural group is local plants. Under pressure of natural selection, local plants are very diversifiedin terms of genetics, phenotype and agronomics. Therefore, local plants are very important for breeding. W.L. Johannsen, a scientist of Denmark developed aninbred-lines theory as follows:

- Self-pollination for many generations will create homozygous traits on genes, these will create more inbred lines.

- Natural population of self-pollinating plants consists of more than one inbred line, and the first selection will be very effective and can choose many different inbred lines.

- Many individuals into one inbred line will have one genotype and variability of phenotype in one inbred line depending on environmental conditions (Tran 1992).

The above theory can be applied in recognizing the floating rice situation. The research group carried out this research to collect all of the phenotypes of floating rice. It is very important to genetic conservation because there have not been any breeding programs on floating rice for over 30 years, farmers have been keeping their floating rice seeds by natural selection.

The Third World Network (TWN) (2008) stated that one of the remarkable features of traditional farming systems was biodiversity, in particular the plant diversity in the form of polycultures. These features include: (1) to mitigate risks by planting several plant species and varieties as an adaptive strategy to climate variability; (2) to resist adverse effects of pests and diseases; (3) to obtain stable crop productivity in the long term; and (4) to promote biodiversity and to maximize profits even with low inputs. Moreover, according to TWN (2008), the observations of agricultural practices after extreme climatic events in the last two decades reveals that resilience is closely linked to levels of biodiversity.

Local/traditional knowledge about floating rice varieties of communities is very important for breeding because they work directly on the farm and keep their seeds. FAO (2004 and 2014), believes that traditional knowledge is a collection of facts related to the entire system of concepts, beliefs and perceptions that people hold about the world around them. Traditional knowledge is formed by production activities, tested by applications, and selected by communication to adapt with living environment (Doan 2009). The farmers who are working on traditional farming systems have applied their local knowledge regarding breeding, cultivation and climate change response. They are conserving the seeds of good varieties and cultivating them by traditional methods. They possess knowledge of agricultural production development and protection from pest and severe weather.

Research methods

Research sites

The research was implemented in Tri Ton and Cho Moi districts of An Giang and Thanh Bình district of Dong Thap province in the 2014-2015 seasonal crop (Figure 1).

Materials and Methods

Step 1 - *Selecting research sites:* At each study site, three floating rice fields were selected, there were 09 floating rice fields selected for the sample collection. On each floating rice field 1,000 panicles were collected for sampling. In total, 9,000 panicles were collected.

Figure 1. Map of research sites
Source: http://www.mdpi.com/2072-4292/5/2/687

Step 2- *Collecting and storing the samples:* The samples were hand cut under the button node of rice stems where the leaf flag appears. The time of harvesting also helps to identify the groups of floating rice. All samples were labelled, dried in the sun and stored for later classification (Figure 2).

Step 3 - *Pinnacle phenotype classification:* Depending on the location of floating rice fields and time of harvesting, samples were divided according to sensitivity to short day length photoperiod. In the Mekong delta, there are three groups of floating rice basedon the time of harvesting: the early harvesting time group, the medium harvesting time group and the late harvesting time group. Panicles were divided according to local knowledge and characters of panicle shapes and seeds, for example: type of panicle branches, arrangement of seeds on panicles, color of husks, color of rice bran, tails, color of albumen, length of panicles and seeds, weight of 1000 seeds (seed size depends on IRRI's definition (IRRI, 1994) and some other special characters. Characteristics of each group of population (group) were checked more than three times before identifying and coding. For identification of each group, the floating rice yieldwas calculated using the following data: number of panicles per group, number of seeds, weight of 1000 seeds and length of pinnacles.

Step 4 - *Biodiversity analysis basedon phenotype characters:* The Shannon index (Kerkhoff, 2010) was chosen to analyses biodiversity index based on color of rice bran and number of each population.

$$H = -\sum P_i \ln P_i$$

P_i is the proportion of individuals found in species i. For a well-sampled community, we estimate this proportion as $p_i = n_i/N$, ni is the number of individuals in species i and N is the total number of individuals in the community. Since by definition the P_i will all be between zero and one, the natural log makes all of the terms of the summation negative, which is why we take the inverse of the sum.

Results

Local knowledge about floating rice phenotypes

Nàng Chệt Cụt phenotype (Figure 3): "Nàng Chệt Cụt" is a kind of floating rice with a special panicle shape with long grains, the ratio of red rice is more than that of white rice, seedsare arranged sparsely, long panicles and tasty rice. (An in-depth interview with a farmer in Tan Long Commune, Thanh Binh District, in January 2014).

Figure 2. Panicles of floating rice after harvesting for sampling

Figure 3. Panicle phenotype of "Nàng Chệt Cụt" floating rice variety

Nàng Tây Bông Dừa phenotype (Figure 4): "Nàng Tây Bông Dừa" is red floating rice. The Time of harvest is later than "Nàng Chệt Cụt". Seed arrangement is sparse. In harvesting time, some young seeds remain, seeds develop simultaneously. (An in-depth interview with a farmer in Tan Long Commune, Thanh Binh District, in January 2014).

Nàng Tây Đùm phenotype (Figure 5): "Nàng Tây Đùm" is white and tasty floating rice. The plants have more panicle branches, short panicles and short branches. Seed arrangement is very thickand likely to clot on panicles (An in-depth interview with a farmer in My An Commune, Cho Moi District, in January 2014).

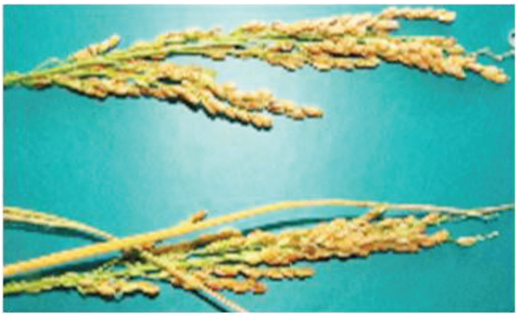

Figure 4. Panicle phenotype of "Nàng Tây Bông Dừa" floating rice variety

Figure 5. Panicle phenotype of "Nàng Tây Đùm" floating rice variety

Nàng Chồi phenotype (Figure 6): "Nàng Chồi" is white and tasty floating rice. Seedsare small, and panicles are short. (An in-depth interview with a farmer in Tan Long Commune, Thanh Binh District, in January 2014).

Nàng Pha phenotype (Figure 7): "Nàng Pha" is red floating rice. "Nàng Pha" variety has red-brown husksand it can adapt with acid sulfate soil (An in-depth interview with a farmer in Vinh Phuoc Commune, Tri Ton District, in January 2014).

Figure 6. Panicle phenotype of "Nàng Chồi" floating rice variety

Figure 7. Panicle phenotype of "Nàng Pha" floating rice variety

Nàng Tây Nút phenotype (Figure 8): "Nàng Tây Nút" is white floating rice. Special traits of "Nàng Tây Nút" are red-brown nodes on the seed coat at the end of seeds,long panicles, sparse seed arrangement (An in-depth interview with a farmer in Vinh Phuoc Commune, Tri Ton District, in January 2014).

Bông Sen phenotype (Figure 9): "Bông Sen" means lotus. "Bông Sen" is a mixture of white and red floating rice with a large seed size. Bong Sen variety is special of its flowering stage, the rice flower looks like a lotus. Bong Sen was named by farmers more than 10 years ago, it dominates all the floating rice varieties in Tri Ton district, An Giang province (An in-depth interview with a farmer in Vinh Phuoc Commune, Tri Ton District, in January 2014).

Figure 8. Panicle phenotype of "Nàng Tây Nút" floating rice variety

Figure 9. Panicle phenotype of "Bông Sen" floating rice variety

Mixing phenotypes: For more than 30 years, there has not been any breeding activities on these floating rice varieties. Under pressure of natural selection and farmers' selection, the lines have become inbred lines, as a result, the shapes of floating rice have become mixed. Some old varieties which previously produced only red or white rice are now producing different shapes with a mixed color (red and white rice).

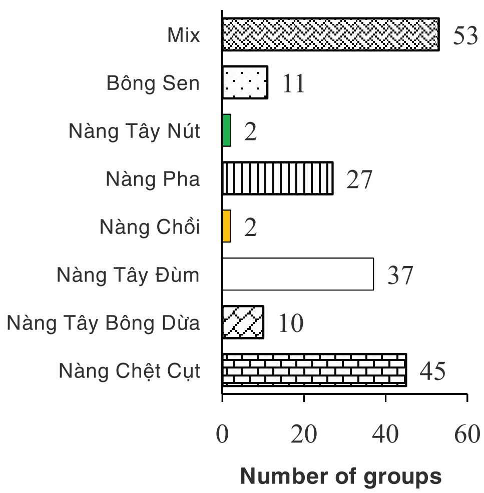

Figure 10. Number of groups of floating rice phenotypes in general

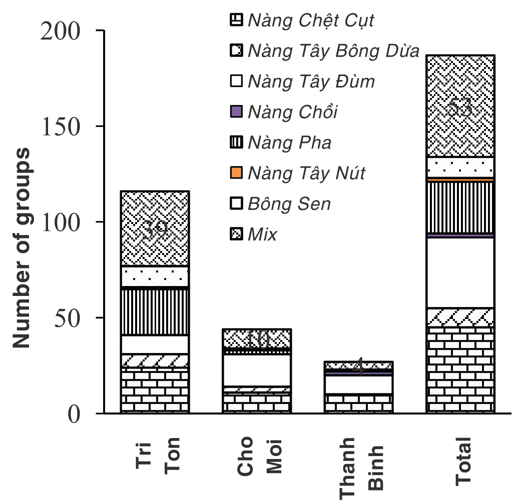

Figure 11. Number of groups of floating rice phenotypes collected from three local sites

In summary, the research had collected 187 groups of floating rice phenotypes, these had consisting of 07 basic groups as "Bông Sen" phenotype (11 groups), "Nàng Tây Nút" phenotype (02 groups), "Nàng Pha" phenotype (27 groups), "Nàng Chồi" phenotype (02 groups), "Nàng Tây Đùm" phenotype (37 groups), "Nàng Tây Bông Dừa" phenotype (10 groups), "Nàng Chệt Cụt" phenotype (45 groups) and mix phenotypes (53 groups) (Figure 10). This research also had collected 116 phenotype groups (62.0%) in Tri Ton, 44 phenotype groups (23.5%) in Cho Moi, and 27 phenotype groups (14.5%) in Thanh Binh district (Figure 11).

Floating rice traits

Color of bran layer: The bran color is a character of floating rice variety, it will be useful for classification. There is afluctuation the color of bran layer from white, white-green, white-opaque, red to red-opaque, but the research had recognized two colors were white and red. Table 1 showed that there was differently between local site about color of bran layer. In totally, the percentage of red bran of floating rice was 54%, which was higher than that of white bran (46%).

Table 1. Colors of bran layers of floating rice phenotype collected in three local sites

Local sites	Number/Ratios	Color of Bran		Total
		Red	White	
Tri Ton	N	65	51	116
	Ratio (%)	56.0	44.0	100.0
Cho Moi	N	20	24	44
	Ratio (%)	45.5	54.5	100.0
Thanh Binh	N	16	11	27
	Ratio (%)	59.3	40.7	100.0
Total	N	101	86	187
	Ratio (%)	54.0	46.0	100.0

Tail trait: This is a trait to recognize the rice varieties. Table 2 showed that Tri Ton district have more groups of floating rice with tail than Cho Moi and Thanh Binh district. There were 11.2% (in Tri Ton), 18.2% (in Cho Moi) and 11.1% (in Thanh Binh). In general, there were 13% (24 groups of floating rice).

Table 2. Classification floating rice shape depending on tail shape in three local sites

Local sites	Numbers/ratios	Tails	No tails	Total
Tri Ton	N	13	103	116
	Ratio (%)	11.2	88.8	100.0
Cho Moi	N	8	36	44
	Ratio (%)	18.2	81.8	100.0
Thanh Binh	N	3	24	27
	Ratio (%)	11.1	88.9	100.0
Total	N	24	163	187
	Ratio (%)	12.8	87.2	100.0

The weight of 1000 seed: Using IRRI's classification book (IRRI, 1994) for seed size traitclassified three groups of seed sizes: large (27-34.9 gr/1.000 seed), medium (23-26.9 gr/1.000 seed) and small (18-22.9 gr/1.000 seed). There were 117 groups (62.6%) of medium seed size, 49 groups (26.2%) small seed size and 21 groups (11.2%) large seed size (Figure 12).

Number of filled seeds/pinnacle: It's depended on number of filled of seeds on pinnacle and depending on varieties. We have classified 6 groups for the filled seeds per pinnacle in Table 3. The results showed that more than 28.6% of pinnacle groups (48 groups) with high filled seeds/pinnacle (200 seeds/pinnacle). They are potential groups seed selection for higher yield.

Correlation between some components of yield and yield: The weight of 1,000 seeds was not correlation with yield (r = 0.062ns), but itnegative correlation with number of filled seeds/pinnacle (r=0.39*) (Figure 13a). The number of filled seeds/pinnacle was strongly correlated with yield (r = 0.94*) (Figure 13b). These results showed that floating rice yield will have been increased when number of filled seeds/pinnacle increasing.The weight of 1,000 seeds will not be affected on floating rice yield. It will be a good condition for floating rice breeding in future.

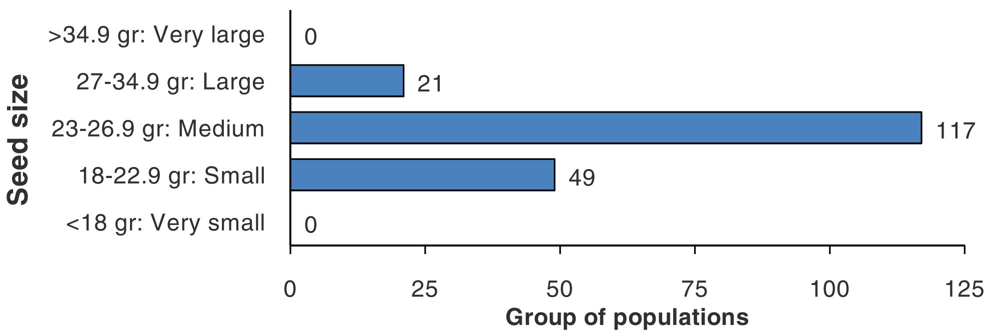

Figure 12. Classification floating rice size based on the weight of 1.000 seeds trait

Table 3. Classification floating rice shape population depending on number of seeds per panicle

No	Number of seeds/panicles	Ratios (%) (n = 168)
1	<100	4.2
2	100-<150	18.5
3	150-<200	48.8
4	200-<250	23.2
5	250-<300	4.8
6	>=300	0.6
	Total	**100.0**

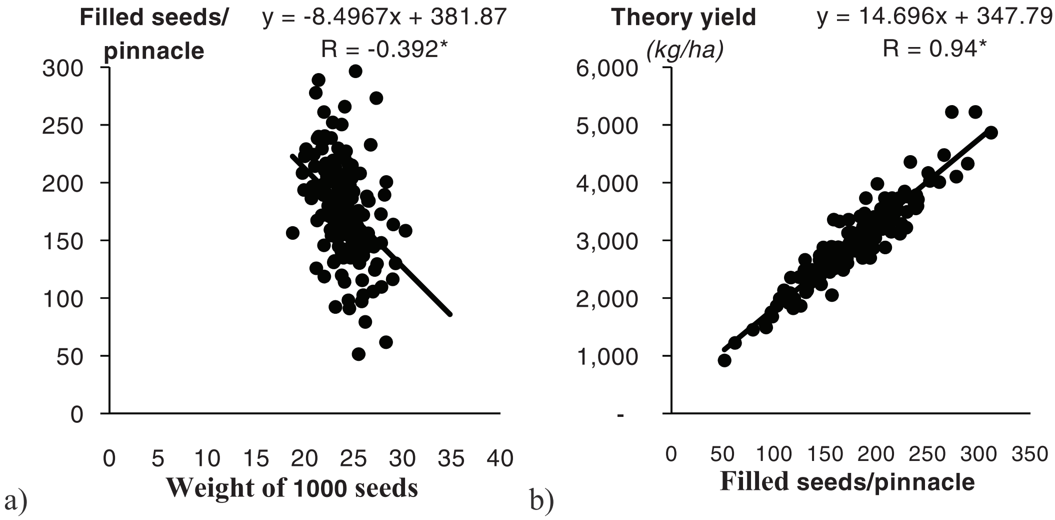

Figure 13. Relation between (a) filled seed/pinnacle and weight of 1.000 seeds, and (b) between filled seeds/pinnacle and theory yield.

Comparison some traits between red and white colorbran: This research did not find statistical significance at 5% level between red and white color on the weight of 1,000 seeds, number of filled seeds/pinnacle and yield (by densities 70, 80, 90, and 100 pinnacles/m^2) (Table 4). The result showed that the red and white floating rice varieties were not difference onyield.

Table 4. A comparison between red and white floating rice varieties.

Contents	Color of rice bran layer	Average values	T_test
Weight 1.000 seed *(gr)*	Red	24.1	*ns*
	White	23.8	
Number of seeds/panicle *(seeds)*	Red	175.7	*ns*
	White	181.9	
Yield of 70 panicle/m^2	Red	2,938.0	*ns*
	White	3,010.9	
Yield of 80 panicle/m^2	Red	3,357.7	*ns*
	White	3,441.0	
Yield of 90 panicle/m^2	Red	3,777.5	*ns*
	White	3,871.1	
Yield of 100 panicle/m^2	Red	4,197.2	*ns*
	White	4,301.2	

Diversity phenotype of floating rice varieties

Shannon index is one type of biodiversity index, itstarts from zero (0) and up. If this Shannon index is high, it will be recognizing the diversity of populations. Figure 14 and Figure 15 shows that there is not biodiversity in phenotypes of floating rice collection, the Shannon indexes are from 1.8 to 3.8 in general. For each color, itdepends on local sites and color of bran. The white color is more diversity in phenotypes in Cho Moi and Thanh Binh districts than Tri Ton district. In general, the white color ofbran is more diversity in phenotypes about than red color. In rice breeding, if any populations are high biodiversity, it will be easily selected more improving varieties.

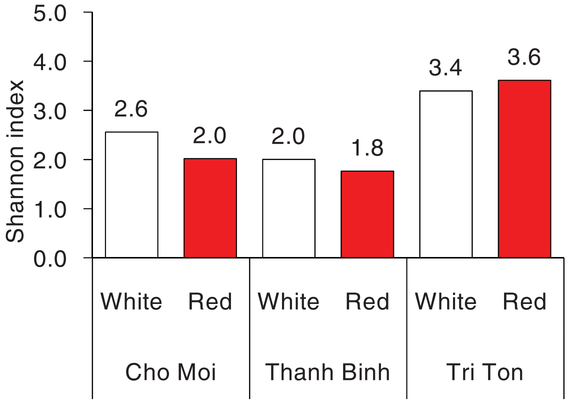

Figure 14. Shannon biodiversity index on color of bran layer by locals

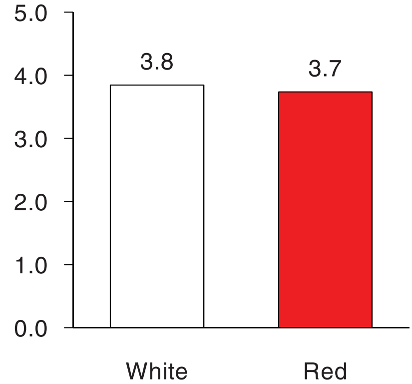

Figure 15. Shannon biodiversity index in general

Conclusion

There were 08 key phenotypes of floating rice that had been collected as "Bông Sen", "Nàng Tây Nút", "Nàng Pha", "Nàng Chồi", "Nàng Tây Đùm", "Nàng Tây Bông Dừa", "Nàng Chệt Cụt", and mixed phenotypes with 178 groups. The red color bran (54%) was more than the white color bran (46%). There were 13% of floating rice phenotype with tails.

The seed size is from a small size (18 gr/1.000 seed) to a large size (34.9 gr/1.000 seed). There were 28.6% of floating rice phenotype having more than 200 seeds/pinnacle. They are potential groups for trait selection with a higher yield. There is not a difference in yield and yield components between white and red color brans.

A slightly negative correlation with number of filled seeds/pinnacle. The number of filled seeds/pinnacle was strongly correlated with theoretical yield. Floating rice breeding depends on a high number of seeds/pinnacles.

Although the phenotype collection is not highly diversified, it is a very important genetic source for breeding programs in the future. It is also the source of seeds to conserve floating rice at the current stage.

The variety resource can help breeders to research more on genetic diversity and hybridsof high yield rice varieties in order to transfer some good traits of floating rice to new rice varieties.

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The effect of salt stress on germination and seedling stages of floating rice in An Giang province, the Mekong Delta

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Abstract

Selection of salt tolerant rice varieties is necessary for adapting to changes in the climate in the Mekong River Delta, Vietnam. Twenty-eight lines of floating rice were collected from Cho Moi and Tri Ton districts, An Giang Province, Vietnam, and were tested for the affect of different concentrations of salt on rate and seedling growth. At the germination stage, germination rate was measured by the length of root and shoot. Root length, plant height and survival rate were measured at the seedling stage. The rice lines were evaluated for salt tolerance in hydroponic nutrient solution of 1, 3, and 5‰ NaCl. Germination rate, shoot and root length of the majority of rice lines reduced with the increase of salinity, especially at 5‰ NaCl. However, 4 lines, TQS140, TQS142, TQS 145 and TDC, were less affected with the increase of salt concentration than the remaining 24. Increasing concentration of salinity led to reduction in the height of rice plants and their survival rates. The survival rate of line TQS 142 was 85% at 5 ‰ NaCl. TQS142 may have the potential for breeding materials or seed resources in salinity intrusion conditions.

Keywords: floating rice; germination; salt tolerance; salinity intrusion; seedling stage.

Introduction

Salinity of water is one of the key environmental factors that limit crop growth and agricultural productivity. Salinisation is becoming a serious problem in several parts of the world. High salinity trouble to worldwide 20% of total cultivated land and may increase to than 50% by the year 2050 (Jamil et al. 2011). Early flooding, drought and salinity intrusion are unusual climatic variations and may cause crop failure. In 2016, severe drought and salinity intrusion strongly affected 11 of the 13 provinces in the Mekong Delta (MD) area of Vietnam. Rice area affected by drought and salinity intrusion was 224,552 ha and cash crops as well as fruit trees were also affected (Sebastian et al. 2016). Rice is one of the most important crops worldwide and is the staple food for over two billion of people. However, rice is a salt sensitive crop and salt impacts strongly on rice productivity (Barus and Rauf 2013; Shannon et al. 1998).

The floating rice plants, grow very fast if floods inundate the field, has been grown in the deep-flooding areas of the MD since 1857 (Can 2002). In 2014, Le Thanh Phong selected varieties of floating rice with different shapes of panicles and grains of rice cultivated in Cho Moi and Tri Ton districts of An Giang Province (Le et al. 2016). Survival of appropriate genetic variation is a requirement for the improvement of any character via natural selection on adaptive traits and breeding (Mahmood et al. 2009). Research on the response of rice to salinity stress may be helpful in breeding salt tolerant cultivars. To provide information about salinity tolerance, a study was carried out on twenty eight lines of floating rice collected in Cho Moi and Tri Ton districts. The objectives of the study were: (1) to determine the variability of different floating rice lines in response to salinity tolerance; and (2), to evaluate the effect of salt concentrations on germination and seedling stages of floating rice.

Materials and methods

The experiment was conducted in the laboratory and greenhouse of An Giang University, Viet Nam from January to April 2017. The plant material was composed of 13 floating rice lines collected from Cho Moi District, and 15 lines collected from Vinh Phuoc Commune, Tri Ton district.

Seed dormancy was broken by immersion in HNO_3 0.1N for 24 hours. After that the seeds were rinsed with water and incubated for 24 hours. Rooting, germinated seeds (300 seeds per treatment were selected and placed on filter papers in plastic boxes with covers. The filter papers were moistened at different concentrations of NaCl: 0, 1, 3, 5 g NaCl/L (NaCl ≥ 99.5% pure) and incubated at room temperature (30^{o}C). The plastic boxes were arranged in block randomized design (BRD) with three replications for each treatment. Length of root and shoot, germination rate were measured 76 hours after the salt treatment. The most tolerant line at the germination stage from each locality was selected for the test of salinity tolerance at the seedling stage, and this was carried out in modified Hoagland nutrient solution. Three first leaf seedlings were sown in holesina Styrofoam sheet placed in the nutrient solution for one week. Then the nutrient solution was salinized by adding NaCl solutions with the desired concentration levels of 0‰, 1‰, 3‰, and 5‰ g NaCl/L. This experiment was arranged in the BRD with two rice lines, 4 levels of NaCl concentration and three replications in plastic boxes sealed. The boxes were filled up with the solution which was high enough to make contact with the Styrofoam. The solution in each plastic box was renewed (nutrient solution added different levels of NaCl concentration) every 7 daysand the pH of solution was 5.5.

The length of root and shoot as well as the mortality percentage were used as criteria for assessing relative salt tolerance. The SPAD 502 Plus Chlorophyll

Meter was used to measure chlorophyll content or greenness of leaves. These were measured on the 7th and 14th days after salinization (DAS). Data analyses were performed with SPSS 17.0 software. Differences between means for germination percentage, shoot and root length were tested at the 5% probability level using Duncan's new multiple range test.

Results

Effect of salt concentration on germination state of floating rice lines

These experiments were undertaken to test the effect of several different salt concentrations on the germination stage of floating rice lines, collected in Cho Moi and Tri Ton districts, in An Giang province, Vietnam.

Effect of salt concentrations on germination state of floating rice lines collected in Cho Moi district, An Giang province.

Table 1. Effect of salt stress on germination rate of floating rice lines collected in Cho Moi district, An Giang province.

Lines	NaCl (‰)			
	0	1	3	5
CQS07	97,0 a-e	96,0 b-f	71,3 lm	50,0 rs
CQS08	98,3 a-d	95,0 c-h	67,7 mn	17,0 x
CQS09	97,0 a-e	94,7 d-i	42,3 t	24,3 w
CQS11	96,3 a-f	96,3 a-f	52,7 qr	50,7 rs
CQS12	96,0 b-f	92,7 f-i	86,0 j	57,7 p
CQS13	95,7 b-g	95,0 c-h	65,7 no	54,7 pq
CQS14	97,0 a-e	86,7 j	84,0 j	51,3 qrs
CQS15	100 a	97,0 a-e	93,7 e-i	73,0 l
CQS17	99,3 ab	95,0 c-h	48,0 s	16,7 x
CQS18	98,7 a-c	95,7 b-g	51,3 q-s	8,7 y
CQS20	98,3 a-d	84,0 j	77,3 k	26,3 w
CDC	98,0 a-d	92,0 g-i	64,3 n-o	16,3 x
TDC	96,7 a-e	91,3 h-i	63,7 o	36,0 u

At 1‰ salinity, the germination stage was unaffected for almost all lines collected in Cho Moi District, except for CQS11 and CQS15. The percentage of germination significantly decreased in all lines due to increases in salinity concentration (Table 1). At a salinity level of 3‰, high germination percentage was observed from the lines CQS12, CQS14 and CQS15 (> 80%). The lowest percentage was found in the lines of CQS09 (40%). The similar decreased trend in germination percentage was also found for salinity level of 5‰ (Table 1). The lowest germination percentage was 8% on CQS18 and the highest was 73% on CQS15. Thus there existed a relationship between salt concentration levels and rice lines for germination rate (P= 0.00).

There was also asignificant difference between inrice lines and there was the interaction between salinity levels and rice lines for root length (P= 0.00). The root length of all the rice lines decreased in all treatments of increased salinity (Table 2). At 1‰ salinity, root length significantly decreased on CQS07 and CQS17. At 5‰ salinity, the root length of all the rice lines were significantly decreased compared to nonsaline treatment, with reduced percentage from 43% to 75%, and the lowest was found on CQS15 (Table 2).

Table 2. Effect of salt stress on root length (cm) of floating rice lines collected in Cho Moi district, An Giang province.

Lines	NaCl (‰)			
	0	1	3	5
CQS07	3.8 a-f	2.0c-n	1.9d-n	1.1 k-n
CQS08	3.1 a-l	4.2abc	2.0d-n	1.8 e-n
CQS09	4.0 a-d	3.0a-n	1.5h-n	1.8 d-n
CQS11	4.4 a	4.0a-e	1.7f-n	1.2 j-n
CQS12	3.8 a-g	2.8a-n	1.8d-n	1.7 f-n
CQS13	3.1 a-l	3.1a-m	1.1k-n	1.6 g-n
CQS14	3.7 a-g	2.6a-n	2.3a-n	1.5 h-n
CQS15	3.5 a-i	2.4a-n	2.9a-n	2.0 d-n
CQS17	4.4 a	1.9d-n	1.3i-n	1.1 k-n
QS18	3.6 a-i	4.3ab	2.1b-n	0.9 mn
CQS20	3.4 a-j	2.4a-n	2.1c-n	1.0 lmn
CDC	3.7 a-h	2.6a-n	1.2j-n	1.2 j-n
TDC	3.7 a-h	3.3a-k	1.2j-n	1.2 k-n

There was a significant difference between in rice lines in their reaction to different levels of salt concentration as indicated by shoot length (P= 0.00) see table 3; shoot was more suppressed than root by salinity at every specific salt concentration level. At 3‰ salt concentration root length was reduced by 43-59%, whereas at 5‰ the reduction increased to 79-93%.

Table 3. Effect of salt stress on shoot length (cm) of floating rice lines collected in Cho Moi district, An Giang province.

Lines	NaCl (‰)			
	0	1	3	5
CQS07	2.43 ab	1.74 a-h	1.00 g-q	0.49 m-q
CQS08	2.35 abc	1.71 a-h	0.93 h-q	0.45 m-q
CQS09	2.19 a-d	1.71 a-h	0.76 i-q	0.43 n-q
CQS11	2.11 a-d	1.67 a-i	0.74 j-q	0.41 n-q
CQS12	2.05 a-e	1.62 b-j	0.69 k-q	0.40 n-q
CQS13	2.05 a-e	1.61 b-j	0.67 k-q	0.39 opq
CQS14	2.02 a-f	1.56 b-k	0.67 k-q	0.34 opq
CQS15	1.95 a-f	1.50 c-l	0.65 k-q	0.28 pq
CQS17	1.94 a-f	1.44 d-l	0.63 l-q	0.23 q
QS18	1.85 a-g	1.35 d-m	0.60 l-q	0.23 q
CQS20	1.83 a-h	1.34 d-m	0.59 l-q	0.22 q
CDC	1.81 a-h	1.30 d-n	0.53 m-q	0.18 q
TDC	1.77 a-h	1.19 e-o	0.52 m-q	0.12 q

Effect of salt concentrations on germination state of floating rice lines collected in Tri Ton district, An Giang province.

The percentage of germination in rice lines from Tri Ton District was significantly affected by salt concentration ($P \leq 0.01$), as the concentration of salt increased, the percentage of germination decreased (Table 4). The higher increase in salinity concentration exposed the different effect on germination percentage while no significant difference was observed on rice lines TQS139 and TQS144 under the salinity levels of 0 and 5‰. The lowest germination percentage was observed under levels (1-5‰) of salinity on TQS146.

Root length of all the rice lines from Tri Ton district decreased in the salinity treatments with the increase of salinity concentration, but only on TQS149 line was significantly reduced from low salinity to high salinity (0 - 5‰) (Table 5). At 3‰ level, the lowest root length reduction was 0% on TQS136, TQS145, TQS154 and TT21 and the highest was 38% on TQS151. At 5‰ level, the lowest root length reduction was 12% on TQS145 and the highest was 60% on TQS149.

Table 4. Effect of salt concentrations on germination of floating rice lines collected in Tri Ton district, An Giang province.

Lines	NaCl (‰)			
	0	1	3	5
TQS135	98.3 a-f	94.3 c-j	94.0 d-k	92.0 hij
TQS136	98.3 a-f	96.7 a-i	94.0 d-k	91.7 ij
TQS139	96.0 a-j	95.7 a-j	95.7 a-j	95.0 a-j
TQS140	97.0 a-h	96.7 a-i	93.3 f-j	94.3 c-j
TQS142	100 ab	100 a	94.7 b-j	92.7 g-j
TQS144	99.3 abc	99.0 a-d	97.0 a-h	97.0 a-h
TQS145	98.0 a-f	98.3 a-f	92.7 g-j	91.0 jk
TQS146	97.7 a-f	84.0 lm	67.7 o	64.7 o
TQS149	98.3 a-f	98.7 a-e	93.7 e-j	91.3 jk
TQS151	98.0 a-f	97.0 a-h	96.7 a-i	76.7 n
TQS154	99.0 a-d	95.7 a-j	83.7 m	79.3 mn
TQS158	95.3 a-j	97.0 a-h	94.7 b-j	94.3 c-j
TT21	97.7 a-g	92.7 g-j	92.0 h-k	84.3 lm
TT45	100 a	99.0 a-d	92.7 g-j	89.0 kl
TDC	98.0 a-f	97.0 a-h	95.0 a-j	94.0 d-k

Table 5. Effect of salt concentrations on root length (cm) of floating rice lines collected in Tri Ton district, An Giang province.

Lines	NaCl (‰)			
	0	1	3	5
TQS135	4.0 a-e	2.9 a-e	2.6 a-e	3.1 a-e
TQS136	3.1 a-e	3.4 a-e	3.4 a-e	2.6 a-e
TQS139	3.7 a-e	3.5 a-e	3.1 a-e	2.8 a-e
TQS140	4.4 abc	4.2 a-e	3.1 a-e	2.6 a-e
TQS142	4.3 a-d	4.4 abc	3.8 a-e	3.4 a-e
TQS144	3.6 a-e	3.8 a-e	3.2 a-e	3.1 a-e
TQS145	3.4 a-e	3.1 a-e	3.1 a-e	3.0 a-e
TQS146	4.3 a-d	2.4 b-e	2.2 b-e	2.1 b-e
TQS149	4.8 a	2.3 b-e	2.0 de	1.9 e
TQS151	4.5 abc	4.8 a	3.0 a-e	3.1 a-e
TQS154	2.8 a-e	2.2 cde	2.2 cde	1.9 e
TQS158	3.9 a-e	3.8 a-e	2.9 a-e	3.0 a-e
TT21	3.8 a-e	3.1 a-e	3.1 a-e	3.0 a-e
TT45	4.1 a-e	3.7 a-e	2.6 a-e	2.3 b-e
TDC	4.6 ab	4.5 abc	4.0 a-e	3.6 a-e

Shoot length of all the rice lines from Tri Ton district gradually decreased in the salinity treatments with the increase of salinity level, but only on TQS146 line was significantly reduced from 0 to 5‰ salinity (Table 6). At 3‰ level, the lowest shoot length reduction was 0% on TQS136, TQS140, TQS154 and TDC and the highest was 22% on TQS135. At 5‰ level, the lowest shoot length reduction was 0% on TQS145 and the highest was 76% on TQS146.

Table 6. Effect of salt concentrations on shoot length (cm) of floating rice lines collected in Tri Ton district, An Giang province.

Lines	NaCl (‰)			
	0	1	3	5
TQS135	2.6 a-e	2.3 a-f	1.8 a-f	1.7 b-f
TQS136	2.5 a-f	2.2 a-f	2.2 a-f	1.5 b-f
TQS139	2.6 a-d	1.7 b-f	1.5 b-f	1.4 b-f
TQS140	3.6 a	2.0 a-f	2.0 a-f	2.0 a-f
TQS142	2.8 a-d	2.6 a-e	2.1 a-f	2.4 a-f
TQS144	2.5 a-f	2.2 a-f	2.0 a-f	1.4 b-f
TQS145	2.1 a-f	2.4 a-f	2.1 a-f	2.1 a-f
TQS146	2.9 a-d	1.0 def	0.8 ef	0.7 f
TQS149	3.2 ab	1.8 a-f	1.7 b-f	1.6 b-f
TQS151	2.8 a-d	2.1 a-f	2.0 a-f	1.1 def
TQS154	2.2 a-f	1.5 b-f	1.5 b-f	1.3 c-f
TQS158	2.8 a-d	2.5 a-f	2.4 a-f	1.7 b-f
TT21	2.9 a-d	1.9 a-f	1.7 b-f	1.6 b-f
TT45	3.0 abc	1.9 a-f	1.5 b-f	1.5 b-f
TDC	2.6 a-e	2.3 a-f	2.3 a-f	2.0 a-f

Effect of salt concentrations on seedling state of floating rice lines from Tri Ton and Cho Moi districts, An Giang Province, Vietnam

The two floating ricelines which grew best at 5‰ salinity, TQS42 collected in Tri Ton, and CQS15 collected in Cho Moi district, were chosen to test the saline tolerance at the seedling stage.

Seven days after salinity treatment, plant heights were affected by different salinity levels. Plant heights of two lines were significantly reduced at 3‰ and 5‰ level. However, root length was not significantly different between rice lines and salinity levels. At 3‰ level, CQS15 had significant survival rate as compared to the control, while all of TQS42 seedlings survived. At 5‰ level, survival rate of both lines was reduced. However, CQS15 was effected more than TQS142 in terms of survival rate. SPAD index (chlorophyll content of leaves) was gradually reduced from low salinity to high salinity and the lowest chlorophyll content of leaves was found at 5‰ level (Table 7).

Fourteen days after salinity treatment, there was a significant difference between the two rice lines in their tolerance of salinity (P=0.00). At 3‰ level, plant growth was seriously affected, CQS15 was entirely dead while TQS142 survived (33%). At 5‰ level, both CQS15 and TQS142 were dead. Plant heights were reduced by about 26% on TQS142 while 100% on CQS15. At 3‰ salinity level the roots of CQS15 were entirely damaged but TQS142 were 13.5 cm in length and there was no significant difference to the control. SPAD index was gradually reduced but there was no significant difference from 0 to 5‰ level (Table 8).

Table 7. Effect of salt concentrations on seedling of floating rice lines, 7 days after salt treated

NaCl (‰)	Lines	Plant height (cm)	Root length (cm)	Survival rate (%)	SPAD index
0	TQS142	16.7 a	13.3	100.0 a	25.4 a
0	CQS15	18.0 a	9.3	100.0 a	25.2 a
1	TQS142	16.0 a	10.5	100.0 a	24.7 ab
1	CQS15	16.8 a	9.5	100.0 a	24.2 ab
3	TQS142	10.6 b	9.5	100.0 a	22.8 ab
3	CQS15	11.4 b	8.3	63.2 c	21.5 bc
5	TQS142	9.0 bc	8.8	85.1 b	18.0 c
5	CQS15	5.0 c	7.7	14.7 d	18.6 c

Table 8. Effect of salt concentrations on seedling of 2 floating rice lines, TQS14 and CQS15 14 days after they were treated with salt solutions

NaCl (‰)	Lines	Plant height (cm)	Root length (cm)	Survival rate (%)	SPAD index
0	TQS142	27.5 b	15.5 a	100.0 a	26.6 a
0	CQS15	33.9 a	14.6 ab	100.0 a	25.7 a
1	TQS142	25.7 b	10.7 b	96.3 a	23.8 a
1	CQS15	26.3 b	12.3 ab	44.4 b	23.6 a
3	TQS142	20.2 c	13.5 ab	33.3 b	19.9 a
3	CQS15	0.0 d	0.0 c	0.0 c	0.0 b
5	TQS142	0.0 d	0.0 c	0.0 c	0.0 b
5	CQS15	0.0 d	0.0 c	0.0 c	0.0 b

Generally, results indicated that germination rate, shoot and root length of most rice lines were reduced with the increase in salinity, and they were strongly decreased at 5‰ concentration level. However, shoot and root length of TQS140, TQS142, TQS145 and TDC decreased very gradually from 1‰ to 5‰ level. These results show that some genotypes are more salt tolerance than the others. Similar results were reported by Ologundudu (2014) and Hakim (2010). Study by (Mahmood et al. 2009) on effect of salinity on growth, yield and yield components in 4 commercial varieties and 17 breeding lines of Basmati rice (*Oryza sativa* L.) also showed significant variation between genotypes.

The salt tolerance ability of Floating rice lines collected from Tri Ton district were stronger than the rice lines collected from Cho Moi district. The reason for this difference is that they may adapt themselves (Majidi-Mehr and Fahliani 2016) and due to natural selection formore difficult conditions (drought and low pH) to be found in Tri Ton compared to those in Cho Moi.

Increase of salinity led to reduce the height of plant and survival rate. The height of plants, as well as survival rate, decreased when plants were cultivated longer in salinity solution; at 5‰ concentration lines 85% of TQS142 seedlings still existed at 7 days though that percentage reduced later. Some report also found a reduction of seedling height under saline conditions (Javed and Khan 1995; Karim et al. 1992). Salinity affected all stages of rice plants and responses to salinity differed with growth stages, concentration and duration of exposure to salt. Flowers and Yeo (1981) and Lutts et al. (1995) also report that the seedlings of commonly cultivated rice varieties, were very sensitive to salinity.

In conclusion, 28 lines of floating rice from two locations in An Giang province, in the Mekong Delta, Vietnam displayed differential sensitivity to a range of saline concentrations during germination, seedling and growth stages. One line, TQS 142, displayed significantly better tolerance than the other 27 lines and will be further tested in saline areas to observe its yield potential.

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The survey of natural insect diversity in floating rice fields in Vinh Phuoc Commune, Tri Ton District, An Giang province

Nguyen Thi Thai Son*

Abstract

The research of natural insect diversity in floating rice was conducted in Tri Ton District, An Giang Province. Natural insects in the field include 86 species and 10 families (Diptera, Coleoptera, Hemiptera, Hymenoptera, Lepidoptera, Orthoptera, Thysanoptera, Odonata, Dermaptera, Homoptera). However, there are four major families such as Hemiptera, Hymenoptera, Diptera, Coleoptera. The survey identified 17 species of spider among which are 16 species of Araneae families and 01 species of Acari families. Significantly, the diversity indicator in floating rice field is higher than that in high yield rice field. This study suggests that pesticides used in high yield rice field has negatively affected natural insect diversity in An Giang Province.

Keywords: diversity, floating rice, Acherontia lachesis species, natural insects, An Giang

Introduction

High yield rice fields or short-term fields are familiar with local farmers. The short-term fields are intensively cultivated and more pesticides are applied which impacts the natural environment and human health status. Floating rice is commonly grown in Tri Ton District, Bay Nui Region, An Giang Province, where the plants grow in accordance with the flooding level. Moreover, floating rice is good for health because it is free of pesticides and fertilisers. Floating rice straws are used as a type of organic fertiliser because they retain moisture for soil. Despite all these benefits, floating rice is an endangered species in the Mekong Delta and must be preserved.

Natural insects can prevent natural epidemics and save plants from pests. If the ecological balance is broken then rice yield will decrease. Thus, the diversity of natural insects is a major contribution to the eco-system balance.

Materials and Methods

Methods of collecting natural insects

This research took place at Vinh Phuoc Commune, Tri Ton District, An Giang Province. We selected 03 floating rice fields and 03 high yield rice fields. We observed each field following 05 diagonal stripes and set up 05 rackets with

1m² in size. The rackets are as high as rice plants with an angle of 180°. We collected insects and kept them in jars as well as plastic bags to count. If there were only a few insects, we counted them on the field. We collected insects after sowing 40, 60, 80 days (the next day) in the floating rice and 40, 60, 80 days in high yield rice.

Then, we counted and identified those insects by their names and families in each field. The worms were collected in the field or raised in the laboratory to identify their names. The identification process applied the work of Borror et al. (1976) and inputted into Microsoft Excel.

Research method of the diversity of natural insects

The number of natural insects was analysed using the diversity indicator of Shannon and Wiener (Rosenzweig, 1995).

$$H = -\sum_{i=1}^{s} p_i \ln p_i$$

$$E_H = \frac{H}{H_{\max}} = \frac{H}{\ln S}$$

H: Diversity indicator Shannon and Wiener.
S: Types of species in population
P_i: Propability of the first species
E_H: Equality indicator

Results and discussion

Natural insects and spiders record in the research sites

The research result in the rice field of Vinh Phuoc Commune, Tri Ton, An Giang identified 86 natural insects species among 10 families (Diptera, Coleoptera, Hemiptera, Hymenoptera, Lepidoptera, Orthoptera, Thysanoptera, Odonata, Dermaptera, Homoptera). However, the majority of insects were Hemiptera, Hymenoptera, Diptera Coleoptera. Among the 86 insects existing in the high yield and floating rice field, we identified 59 dangerous species (68.6%), 19 benefited species (22.1%) and 8 species of unidentified benefits (9.3%) (Table 1).

Table 1. The insects and spiders existing in the high yield and floating rice field in Vinh Phuoc Commune, Tri Ton District, An Giang in 2014 – 2015.

Types of insects	Number of insects	Ratio (%)
Pests	59	68.6
Natural insects	19	22.1
Unidentified advantages	8	9.3
Total	86	100

Spiders and insect species in the high yield and floating rice fields in Vinh Phuoc Commune, Tri Ton District, An Giang Province.

The research result in the growing phase of floating rice and high yield rice revealed that the number of insects in the floating rice field (3,213 individuals) was higher than that of the high yield rice field (856 individuals) (Table 2).

Table 2. The majority of spiders and natural insect's species in the high yield and floating rice field in Vinh Phuoc Commune, Tri Ton District, An Giang Province.

Fields	Species	Individuals
Floating rice	83	3,213
High yield rice	62	856

Many species were collected during the growing phase (40, 60, 80, NSS) in the floating rice field. Among natural insects (food eating and parasite), spiders have a higher number in both quantity and variety than pests (Table 3). Most species were found during 80NSS.

In addition, varieties of species were collected during the rice growing phase (40, 60, 80, NSS) in the high yield rice field. Among natural insects (food eating and parasite), the number of spiders is higher than that of pests (Table 3). During the rice growing phase of 60NSS, there were many types of species in the field because of a large amount of pests.

Table 3. The majority of natural insects and spider ranked as its own capacity in the floating rice and the high yield rice at Vinh Phuoc Commune, Tri Ton, An Giang

Capacity	Floating rice			High yield rice		
	40 NSS	60NSS	80NSS	40 NSS	60NSS	80NSS
Aphids	4	3	4	4	4	3
Other pests	6	5	7	5	8	5
Spider	11	7	8	6	8	6
Ravenous	8	4	7	8	6	6
Parasitic	8	10	14	13	15	11
	37	29	40	36	41	31

The availability of insects and spiders in the floating rice field was higher than in the high yield rice field. There were 348 beetles or may-bugs (including 06 species) in the floating rice field and 69 beetles or may-bugs in the high yield rice field. Similarly, there were 1039 individuals belonging to 12 flora-eating species in the floating rice field and 180 individuals in the high yield rice field (Table 4). Among natural insects (food eating pests and spiders) there were 29 species of pests, 17 species of spiders and 14 species of other food-eating species. Those species in the floating rice field are higher than in the high yield rice field (Table 4).

Table 4. The natural insects and spiders ranked by capacity group, collected in the floating rice field and the high yield rice field at Vinh Phuoc, Tri Ton, An Giang

Rice field	**Capacity group**					**Total**
	Beetles	**Food eating**	**Pests**	**Flora eating**	**Spider**	
Floating rice	348	170	195	1039	474	2226
High yield rice	69	105	114	180	88	556
Total species	6	14	29	12	17	78
Individuals comparision	417	275	309	1219	562	2782
Comparision with totality	14.99 %	9.88%	11.11%	43.82%	20.20%	100.00%

The flora-eating species constitute the highest ratio of 43.82%, spiders are 20.2%, beetles are 14.99%, pests are 11.11%, and food eating species are 9.88%. It revealed that the pests have the same scale of growing as natural insects.

Among 88 collected species, there were 29 species of pests, 14 species of food eating insects, 17 species of spiders, 12 species of flora eating insects, 6 species of beetles and 10 species of unidentified capacity (Table 5). Those species were found in the floating rice field and the high yield rice field, mainly repeated species. There were 60 repeated species among 86 species in Vinh Phuoc Commune, Tri Ton, An Giang.

Table 5. Types of insects and spiders collected in the floating rice and the high yield rice at Vinh Phuoc Commune, Tri Ton, An Giang

Capacity group	**Floating rice**	**High yield rice**	**Repeated species**	**Total**
Beetles	6	5	5	6
Pests	27	25	23	29
Food eating	14	9	9	14
Spider	17	10	10	17
Flora eating	11	10	9	12
Others	8	4	4	8
Total	83	63	60	**86**

Biodiversity indicator Shannon-Wiener (H) and equality indicator (EH)

Biodiversity indicator (Shannon-Wiener (H)) is the most significant indicator used to reflect the biodiversity of a community, including the variety of species and the equality of species in a community. The equality indicator fluctuates from 0 – 1. Equality indicator is the highest while the species in a community or the variety of species remains the same.

Diversity indicator of natural insects in the high yield rice field (H=3.05) is lower than in the floating rice field (H=3.22). Relying on the research of the biodiversity in other regions in Vietnam, the indicator scale is H>6.0 which is a high diversity of a society in terms of biodiversity. H=5,0-6,0 indicates high diversity; H=4,0-4,9 is medium diversity; H<4,0 is low diversity. According to this scale, the diversity indicator of natural insects in both of the rice fields is still low (Figure 5). Equality indicator of natural insects in the floating rice field (EH=0.79) is higher than in the high yield rice field (EH=0,71). This revealed the diversity of natural insects in the ecosystem, which does not remain the same.

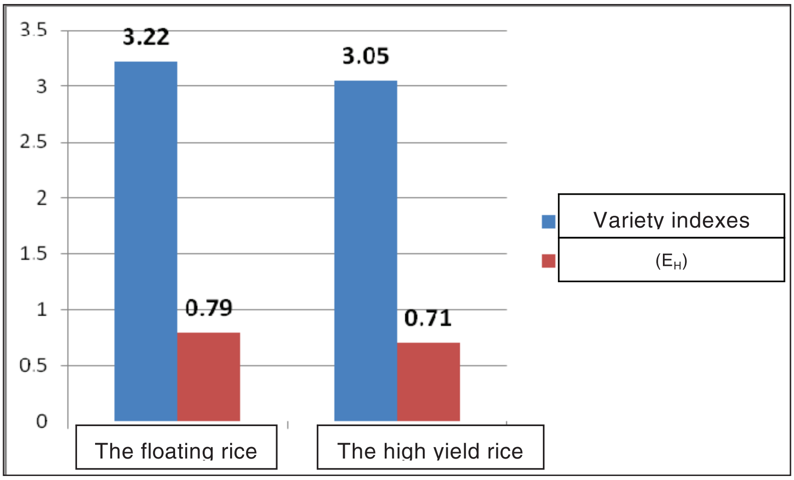

Figure 1. Biodiversity indicator and uniformity factor of natural insects was recorded in the floating rice and the high yield rice field at Vinh Phuoc Commune, Tri Ton District, An Giang in 2014 – 2015

The analysis result of biodiversity indicator (H) and the equality factor (EH) have shown that natural insects are higher than in the high yield rice field. However, the biodiversity indicator (H) of enemies of natural insects is medium in both types of fields.

Conclusion

The number of existing insects is high, including 86 species. There are 59 dangerous species (68.6%), 19 benefitial species (22.1%) as well as 9 unidentified species in the ecosystem (9,3%).

The number of insects existing in the floating rice field (3,213 individuals) is higher than in the high yield rice field (856 individuals). In addition, the number of insects and spiders in the floating rice field is higher than in the high yield rice field.

The natural insects (food eating and pests) and spiders are available much more than the dangerous species in both the floating rice and the high yield rice field.

Diversity indicator of natural insects in the high yield rice field (H=3,05) is lower than that in the floating rice field (H=3,22). The equality indicator in the floating rice field (EH=0,79) is higher than in the high yield rice field (EH=0,71). This indicates that the diversity of natural insects is the same in both types of fields.

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Coleoptera: *Micraspis* sp., *Paederus fuscipes*

Figure 2. Coleoptera : Micraspis sp., Paederus fuscipes

Figure 3. Araneae (Arachnida)

Figure 4. Hymenoptera: Braconidae 1, Ichneumonidae, Chalcididae, Braconidae 2

Experiment on growth and yield of some cassava (manihot esculenta) varieties in Vinh Phuoc Commune, Tri Ton District, An Giang province, Mekong Delta

Le Huu Phuoc

Abstract

The experiment was conducted at the experimental field of An Giang University, Dong Xuyen Ward, Long Xuyen City, An Giang Province from October 2014 to April 2015 in order to make collection, cultivation, research agronomic characteristics, growth time and yield of 16 varieties/lines of domestic and exotic sweet cassava. After that, selecting varieties / lines of high-yield, shorter growth period (comparing with present in Vinh Phuoc) serve to crop rotation with floating rice in Tri Ton, An Giang.

There were 8 varieties (V3, V5, V6, V8, V9, V10, V11 and V17) completed their growth cycle in 5 months, whileas 7 other (V2, V4, V7, V13, V14, V15, V16) completed it in 5.5 months and the control (V1) finished in 6 months.

The control variety had a yield of 22.8 tonne/ha, while 6 varieties (V8, V9, V10, V11, V14, V17) produced more than 40 tonne/ha. Ben Tre 2 variety (V8) had a yellowish root, similar to V16 (Dong Nai, originally from America) in stem shape, leaf, root and flowering characteristics.V10 variety, from Thailand, (5 months and 42.3 tonne/ha) with green petioles caught the attention of many farmers. Almost not having serious diseases or insects appeared, only whitefly (Bemisia tabaci) on leaf with low density.

Keywords: cassava, Manihot esculenta, cassava varieties.

Introduction

Sweet cassava (*Manihotes culenta*) has been cultivated by farmers for a long time in the floating rice area in Tri Ton district, An Giang province because of the suitability ofthe natural condition and farming practices of local farmers (Le 2015). In the floating rice area, the fields have been grown sweet cassava from January to June every year. After harvesting it, floating rice has immediately been planted to catch up with the flood. This floating rice – cassava farming systemwas confirmed by the community as the best crop rotation for meeting their economic needs, with fewer risks, availability of investments, availability of time for care, available of fertiliser, and without using pesticides (Le et al. 2013; Le et al. 2013).

At present, suitable variety source depends on a middle-men buying it in Cu Lao Dung District, Soc Trang province with 200 km from Tri Ton District. That is a sweet cassava variety suitable for eating, but the growing time is too long to rotate, lasting 6 months. If flood comes earlier, it will damage the roots, resulting in a sharp decrease in productivity and quality (Le 2015). For these reasons, farmers need to find cassava varieties with shorter growth time, higher productivity and quality in order to decline the effects of climate change.

Materials and Methods

Collecting varieties

Agronomic characteristics were collected fromkey farmers and local agricultural technicians to know about the field site, cultivation techniques, growth period, main pests and yields.

Table 1. The origin of the collected varieties

Number	Label	Cassva collected from
1.	V1	Vinh Phuoc Commune, Tri Ton District
2.	V2	Khanh Binh Commune, An Phu District
3.	V3	Vinh Phu Commune, Thoai Son District
4.	V4	Vinh Khanh Commune, Thoai Son District
5.	V5	My PhuocCommune, Long Xuyen District (variety 1)
6.	V6	My Phuoc Commune, Long Xuyen District (variety 2)
7.	V7	My Hoa Commune, Long Xuyen District
8.	V8	Giong Trom Commune, Ben Tre District
9.	V9	Cu Chi District (variety 1), Ho Chi Minh city
10.	V10	ChangMai, Thailand
11.	V11	Giong Trom Commune, Ben Tre District
12.	V12	Cu Chi District (variety 2), Ho Chi Minh city
13.	V13	Tam Nong District (variety 1)
14.	V14	Tam Nong (variety 2)
15.	V15	Hon DatDistrict, Kien Giang Province
16.	V16	Dinh Quan Commune, Dong Nai Province
17.	V17	Long Xuyen District (variety 3)

Cultivation techniques

Varieties for the trial were prepared by using 10cm sections of stem, cut from 1.5m above the roots, and any shoots or leaves removed before planting.

Varieties were buried 5cm below the surface at an angle of 300 within 40 x 60cm spaces (Le Huu Phuoc and Le Thanh Phong 2015).

Experimental design

The experiment was designed in completely randomized blockswith 16 treatments, corresponding to 16 varieties, labeled V1 (control) to V16 and repeated 3 times. Each plot had an area of 6 $m^{2.}$

- Basal fertilising (2 days before planting): 400kg super phosphate
- Dressing 1 (30 day after planting): 175kg ure + 130kg potash fertilizer
- Dressing 2 (60 day after planting): 175kg ure + 130kg potash fertilizer

Plants were harvestedthe almost top leaves fell off (left about) and the remaining 6-9 leaves turned from green to light yellow.

Statistical analysis

Analysis of variance to calculate significant difference of 5% of agronomic parameters, productivity of 16 cassava varietieswas carried out with Minitab 16.0 software, through Tukey test(Blair and Taylor 2007), with V1 as the control.

Results

Growth

The survival rate of cassava above 80% does not need to fill the gap, according many farmers in Vinh Phuoc commune. At 15 days after planting, this parameter was from 90% to 100% higherwith the control in the experiment except V2, V10, V11.

Table 2. Some growth parameters of Cassava varieties

N_0	Treatment names	Survival rate at 15 days	Height at 150 days (cm)	Stems per plant	Stem diameter (cm)
1	V1	92,47 b	121,1 c	1,6 b	1,7
2	V2	78,45 d	120,1 c	1,5 b	1,9
3	V3	94,67 ab	131,1 b	1,8 b	1,8
4	V4	91,12 c	138,3 b	1,7 b	1,9
5	V5	96,67 a	148,8 ab	1,6 b	2,2
6	V6	90,33 c	135,0 b	1,4 b	2,0
7	V7	92,87 b	119,1 d	1,5 b	1,6
8	V8	96,10 a	130,6 b	2,2 a	1,7
9	V9	100,00 a	113,7 d	2,3 a	1,8
10	V10	85,7 b	138,8 b	1,8 b	2,2

11	V11	86,2 b	138,0 b	1,7 b	2,1
12	V13	100 a	162,9 a	1,6 b	1,6
13	V14	100 a	153,7 a	1,0 d	1,8
14	V15	94,3 ab	178,5 a	1,6 b	1,9
15	V16	96,1 a	144,8 b	1,3 c	2,1
16	V17	99,4 a	185,2 a	1,0 d	2,2
	CV (%)	5,25	15,18	14,72	23,53
	P	*	*	*	*ns*

[1]*Stem diameter: measured at maximum diameter*

Plantheight, sterm per plant, stem diameter wereinfluenced by variety, soil and fertiliser (Hayford Sarfo, 2015). VarietiesV13, V14, V15, V17 with higher height compared with control ($P<0.05$) while stem diameters were not significantly difference at the harvest.

Cassava varieties were from 1-2 stems/clump, andstem diameter from 1.6-2.2 cm in average(Table 2). For root crops, leaf-stem biomass should not be too high because of nutrient accumulation on biomass than root weight (Institute of Agricultural Technology of the South 2014).

Yield and plant growth

Root size, yield and growth time are three most important factors that farmers most concerned with. In this collection, varieties with a growth time of 5.5 months were V2, V4, V7, V13, V14, V15, V16 and 5 months were V3, V5, V6, V8, V9, V0, V11 and V17 (Table 3). The harvesting timedepends on the variety fallen almost to the peak leaves (left about 6-9 leaves) and the leaves turned from green to light yellow (Tran 2003).

The size of the individual root cassavas were not too large, compatible with collectors (mostly the middle-man). They were sweet, suitable for eating or making cakes.

Table 3. Some parameters, plant growth and yield of Cassava varieties

N_0	Treatment names	Plant Biomass (tonne/ha)	Root length (cm)	Root Diameter (cm)	Yield (tonne/h)	Plant growth (months)
1.	V1, control	46,1 c	25,5 b	2,2 c	22,8 c	6.0
2.	V2	44,4 c	16,5 c	1,9 d	19,9 d	5.5
3.	V3	50,9 b	22, b	1,9 d	26,8 c	5.0

4.	V4	54,5 b	17,3 c	2,2 c	24,0 d	5.5
5.	V5	70,4 a	24,2 b	2,4 b	29,8 bc	5.0
6.	V6	48,8 b	22,7 b	2,5 b	34,3 b	5.0
7.	V7	34,1 d	19,3 bc	2,5 b	17,3 d	5.5
8.	V8	45,1 c	30,4 a	3,4 a	47,1 a	5.0
9.	V9	44,2 c	30,8 a	3,0 a	42,6 a	5.0
10.	V10	74,4 a	23,3	1,5 d	42,3 a	5.0
11.	V11	45,2 c	29,0 ab	2,2 c	41,6 a	5.0
12.	V13	49,9 bc	19,0 bc	4,1 a	32,7 b	5.5
13.	V14	33,3 d	20,8 b	2,4 b	40,8 a	5.5
14.	V15	39,1 c	32,0 a	2,3 c	31,9 b	5.5
15.	V16	32,4 d	22,6 b	2,3 c	32,7 b	5.5
16.	V17	55,7 b	32,0 a	3,3 a	49,9 a	5.0
	CV (%)	9,31	13,8	9,5	10,73	
	P	*	*	*	*	

1 tonne = 1,000 kg

Six varietiesin the survey recorded higher yields than the control, with significant difference (P <0.05), these were varieties V8, V9, V10, V11, V14, V17, which yielded from 41.6 t/h (V11) to 49.9 t/h (V17) compared to the 22.8 t/h yield by the control (V1) (table 3). All but one of these higher yielding varieties also completed their growth cycle in around 5 months, compared with 6 months for the control, except V14 (5.5 months).

V8 varieties have high yields, reaching 47.1 t / ha, which have 38% higher than Vinh Phuoc commune varieties. The cassava rootof V8 has bright yellow which has good taste.

The V10 variety (derived from Thailand) had a smaller root size, only 1.5cm width x 23cm long, but yielded 42.3 tons/ha. Variety V17 yielded 49.9 t/h, the highest productivity, the largest root size,with 32cm length x 3.3cm width, and having growth time of only 5 months.

Discussion

In fact, many vegetables other than, or in addition to, cassava could be rotated seasonally with floating rice farming system, depending on the market demands (Nguyen 2013). However, for many years, sweet cassava has proved to be technically and economically for many farmers who grow floating rice. For some time, pressure has been mounting to find a way to shorten the growing time for the cassava cropin order to create more flexibility around the time that rice needs to be sown and harvested. Success for the rice is dependent on the timing of the flood, this effects the photoperiodism of the flowering, as it only does so at the lunar December (Bui 1985). If the rice was planted too late, young rice may be sunk by floodwaters, especially inconditions of uncontrolled flood (Huynh et al. 2015) and flower too late to set seeds.

Floating rice requires 6 months from sowing to harvesting, though the timing of the start is dependent on when the floods start to rise, which varies from year to year. Therefore, choosing cassava variety with growing time of from 5.0 to 5.5 months gives farmers some leeway to bring cassava residue out of the field at the start and give the soil, and possiblyarest of 1-2 weeks. The next step was, or will be to multiply enough plants in order to conduct field trials with farmers in the flooding rice areaso that the community can assess their adaptability and productivity (Le and Le 2015).

V8 variety is a potential variety for farmers in Vinh Phuoc commune and also the market because of higher yield, “other color”. The V10 from Thailand has a plant growth of only 5 months, which yield is more than 30% higher than control. It also requires field trials on adaptability in field conditions in terms of yield, pests andmarket acceptability. High yielding and short growing time varieties should also be propagated and assayed some crops to be affirmed.

Conclusion

In this research, the growth time and yields of sixteen varieties of cassava (*Manihot esculenta*) from Vietnam and Thailand were compared with a control variety from a flooding rice area in Vinh Phuoc Commune, Tri Ton District, An Giang Province, Vietnam to find varieties with shorter growth times than 6 months. There could be suitable for trialing in with farmers, order to fit the crop into the shorter, and less predictable, time available between one flood season and the next. In the experiment, the control variety took 6 months to complete its cycle, while 8 varieties (V3, V5, V6, V8, V9, V10, V11 and V17) completed their growth cycle in 5 months, and another 7 (V2, V4, V7, V13, V14, V15 and V16) completed it in 5.5 months.

The control variety had a yield of 22.8 tonne/ha, while 6 varieties(V8, V9, V10, V11, V14, V17) produced more than 40 tonne/ha. The V8 variety (Ben Tre 2) had a yellowish root, similar to V16 (Dong Nai, originally from America) in stem shape, leaf, root and flowering characteristics. V10 variety, from Thailand (5 months and 42.3 tonne/ha) with green petiolescaught the attention of many farmers.

Future Work

Test the potential of 5 varieties V8, V9, V10, V11, and V17 for their adaptability, productivity and qualityin floating rice fields.

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Impacts of three microbial organic fertilizers on growth, yield and economic of leek (Alliums chinese G. Don) in Vinh Phuoc Commune, Tri Ton District, An Giang province, Mekong Delta

Le Huu Phuoc

Abstract

Leek has been cultivated in of Vinh Phuoc commuse, Tri Ton district, An Giang province because of high profit as a rotating with floating rice farming system. However, little is known about the effect of microbial organic fertiliser (MOF) in this farming to reduce the amount of chemical fertilizers in leek. The aim of this study was to use MOF to decrease the amount of NPK (Nitrogen, Phosphorus and Potassium) for leek with valuable benefit of the straw soil. The experiment was carried out with two factors, including 3 levels of microbial organic fertilisers Dien Bien Mekong, Ecofarm, Dasvila and 3 levels of NPK with 3 replications. The data were subjected to analyse of variance (ANOVA) using the Minitab 16.0 Software. Levels of significance were determined at 5% probability level. The results showed a significantly (P <0.05) higher yield between treatments using BinhDien Mekong, Dasvila comparing with farmer control. The yields were from 38.1 tons/ha to 43.8 tons/ha, while as the control was 32.5 ton/ha at all levels of the decreasing 75%, 50% and 25% amount of farmer NPK. Economic efficiency was also higher than that the control of farmers.

Keywords: leek, Alliums chinese, microbial organic fertilisers, Vinh Phuoc commune.

Introduction

Before 1975, the Mekong Delta had more than 0.5 million hectares of floating rice, of which about 50% was planted in An Giang (Vo Tong Xuan and Shideo Matsui 1998). However, the area of floating rice decreased dramatically by 80% between 1975 and 1994 due to the innovation policy (Karonen 2008). Particularly in 2012, the area of floating rice was only about 20 hectares in Luong An Tra commune and 41.2 hectares in Vinh Phuoc commune, Tri Ton district, An Giang Province.

The People's Committee of An Giang Province issued a document No. 69/ VPUBND-KT signed on March 6, 2012 to support the conservation and development of floating rice in Tri Ton district base on the submission No. 12 / TTr-UBND dated February 1, 2012 by the People's Committee of Tri Ton district. The People's Committee of An Giang province agreed to assign Tri Ton District

People's Committee to design and be responsible for the implementation of this season's conservation and development project. The Ministry of Agriculture and Rural Development has also agreed and requested supports to conserve and develop the remaining 100 ha of the floating rice area (Nguyen 2013).

The fact that, if the net-profit from the floating rice cultivation system is lower than that of high-yielding rice, the risk is that farmers will abandon floating rice. Net-profit of floating rice – leek system reached 37.3 million VND/1000 m^2, floating rice – cassava system developed 5.5 million VND/1000 m^2, while that of the rice – rice – rice system grewto only 3.7 million VND/1000 m^2 (Nguyen 2013).

Therefore, increasing the profit of the floating rice - vegetables cultivation system is an important issue. Alternating Allium chinese G. Don. with floating rice is a very effective way of cultivation that has been adapted by farmers in this area for a long time.

However, in this rotational cropping system, farmers should be gradually encouraged to use less chemical fertilizers and more bio pesticides when growing leek in order to produce safe products. Therefore, it is necessary to use microbial fertilizers to decompose straw to produce organic compounds useful for this vegetable, so the amount of chemical fertilizer can be reduced. The experiment was designed to select the lowest chemical fertilizer (NPK-Nitrogen, Phosphorus and Potassium) and the most appropriate microbial organic fertilizer (MOF) in 3 trade names: BinhDien Mekong, Ecofarm and Dasvila compared to the controlled farm (100% NPK).

Materials and Methods

Research site

Figure 1. Research site: leeks were planted in floating rice area, Vinh Phuoc commune, Tri Ton district

The leek had been perennially rotated on floating rice farming soil to utilize rice straw. Organic micro-organisms were added to decompose rice straw for producing organic compounds to reduce inorganic fertilizers.

Experimental layout

The trial was conducted in Vinh Phuoc commune, Tri Ton district, An Giang province and the experiments were designed in two factors, including 3 levels of MOF and 3 levels of NPK with 3 replications. Each unit of the experiment (plot) had an area of 20 m2, excluding the buffer between treatments.

Table 1. Experimental treatments and fertilizers applied

Treatments	Treatment names	Organic fertilizer + NPK applied
1	V1N1	BinhDien Mekong + 75%NPK
2	V1N2	BinhDien Mekong + 50%NPK
3	V1N3	BinhDien Mekong + 25%NPK
4	V2N1	Ecofarm + 75%NPK
5	V2N2	Ecofarm + 50%NPK
6	V2N3	Ecofarm + 25%NPK
7	V3N1	Dasvila + 75%NPK
8	V3N2	Dasvila + 50%NPK
9	V3N3	Dasvila + 25%NPK
10 (Farmer, control)		100%NPK

Noted: 100%NPK: dose of farmer fertilizer (180kg Ure + 240kg DAP + 300kg 20-20-15)
N1, N2, N3: 75%, 50%, 25% of farmer dose
V1, V2, V3: BinhDien Mekong, Ecofarm, Dasvila

Table 2. Microbialorganic fertilizer dose (kg/ha) at fertilizing times

Names of Fertilizer	V1- BinhDien Mekong	V2 - Ecofarm	V3 – Dasvila (diluted/irrigated ml/20m^2)	Days after planting (DAP)
Pre-planting	150	150	40	0
Top dressing 1	50	50	40	30
Top dressing 2	100	100	60	60
Top dressing 3	100	100	60	90
Total	400	400	200	

Analysis of variance with Minitab 16.0 to find differences between growth and productivity of treatment at 5% with Duncan's multiple range tests.

Results

Plant height

When applying MOF, it was possible to reduce 75% NPK without reducing the height. Data recorded in the experiment shown in Table 3 presented that the height of leek was not significantly different at the 5% level in four periods of 30 days, 60 days, 90 days and harvesting time (126 days) when applying microbial organic fertilizer BinhDien Mekong, Ecofarm and Dasvila and three levels of NPK 75%, 50%, 25% compared with farmer control.

Table 3. Height of leek at four points when applying three MOF with three different NPK doses, cited at Vinh Phuoc commune, Tri Ton district, 2014

Number	Treatments	Leek height (cm) at measured times			
		30 days	60 days	90 days	126 days (harvest)
1.	V1N1	4.6	47.5	47.7	42.3
2.	V1N2	5.4	48.2	47.4	41.5
3.	V1N3	4.7	47.7	47.5	38.9
4.	V2N1	5.0	46.4	47.1	40.6
5.	V2N2	4.8	47.3	47.3	38.9
6.	V2N3	4.3	47.5	47.1	39.7
7.	V3N1	4.9	47.9	47.5	38.3
8.	V3N2	5.4	48.1	46.7	39.1
9.	V3N3	5.2	47.4	48.3	39.8
	Control (not MOF, 100%NPK)	4.9	44.8	45.7	38.6
	CV (%)	4.8	2.4	2.7	6.3
	F (V)	*ns*	*ns*	*ns*	*ns*
	F (N)	*ns*	*ns*	*ns*	*ns*
	F (V*N)	*Ns*	*ns*	*ns*	*ns*

Noted: 100%NPK: dose of farmer fertilizer (180kg Ure + 240kg DAP + 300kg 20-20-15)
N1, N2, N3: 75%, 50%, 25% of farmer dose
V1, V2, V3: BinhDien Mekong, Ecofarm, Dasvila

Shoots/bush

The number of shoots/bush did not change significantly from 1 month to harvest. The treatments ranged from 4.5 shoots/bush to 5.6 shoots/bush and the treatments were not significantly different (Table 4).

Table 4. Number of shoots/bush at the four measurement points when applied to three MOF in combination with three different NPK doses, experimented at Vinh Phuoc commune, Tri Ton district, 2014

Number	Treatments	Shoots/bush average at measured times			
		30 days	60 days	90 days	126 days (harvested)
1.	V1N1	4.6	4.5	4.5	4.5
2.	V1N2	5.4	5.3	5.2	5.2
3.	V1N3	4.7	4.6	4.7	4.7
4.	V2N1	5.0	5.0	4.9	5.0
5.	V2N2	4.5	4.4	4.6	4.7
6.	V2N3	4.3	4.5	4.5	4.6
7.	V3N1	4.9	5.1	5.1	5.2
8.	V3N2	5.4	5.6	5.5	5.6
9.	V3N3	5.2	5.1	5.1	5.1
	Control (not MOF, 100%NPK)	4.4	4.5	4.5	4.6
	CV (%)	13.8	13.9	14.2	12.9
	F (V)	*ns*	*ns*	*ns*	*ns*
	F (N)	*ns*	*ns*	*ns*	*ns*
	F (V*N)	*ns*	*ns*	*ns*	*ns*

Noted: 100%NPK: dose of farmer fertilizer (180kg Ure + 240kg DAP + 300kg 20-20-15)
N1, N2, N3: 75%, 50%, 25% of farmer dose
V1, V2, V3: BinhDien Mekong, Ecofarm, Dasvila
ns: non-significant at 5%, Duncan's Multiple Range Test

Shoots above the ground should indicate the number of leek tubers. In other words, the number of shoots should be the same with the number of tubers. Reducing the amount of NPK fertilizer to 75% when applying one in three MOFs had not decrease the number of shoots/bush.

Leaves/m²

At 30 DAP, total leaves/m^2 data was not significantly different between all treatments, from 301.5 leaves/m^2 in V1N3 plot to 400.2 leaves/m^2 in V3N1 plot, while the controlled treatment reached 300.7 leaves/m^2 (Table 5). The period from 30 days to 60 days was the time when leeks concentrate to produce leaves, synthesize carbohydrates and other nutrients to grow tubers (tubers grow rapidly from about 45 DAP). Results in the experiment result showed that the number of leek leaves increased 3-4 times in 2 months compared to 1 month after planting.

Table 5. Total leaves/m² of the leek at the four measurement points when applied to three MOF in combination with three different NPK doses, experimented at Vinh Phuoc commune, Tri Ton district, 2014

Number	Treatments	Total leaves/m² average at measured times			
		30 days	60 days	90 days	126 days (harvested)
1.	V1N1	367.5	1385.3 a	1788.0 a	3502.8 b
2.	V1N2	337.8	1492.0 a	1536.0 ab	3587.8 b
3.	V1N3	301.5	1372.0 a	1678.7 ab	4050.6 a
4.	V2N1	357.9	1142.7 b	1800.0 a	3925.0 a
5.	V2N2	346.8	1216.0 ab	1653.3 ab	3273.9 cd
6.	V2N3	328.6	1376.0 a	1774.7 a	4188.9 a
7.	V3N1	400.2	1296.0 ab	1488.0 bc	3871.7 a
8.	V3N2	378.5	1158.7 b	1373.3 c	3636.1 c
9.	V3N3	367.4	1056.0 bc	1216.0 b-d	3786.7 b
	ĐC	300.7	1032.6 bc	1240.2 b-d	2989.8 d
	CV (%)	7.9	5.3	9.4	20.5
	F (V)	*ns*	*	*	*
	F (N)	*ns*	*	*ns*	*ns*
	F (V*N)	*ns*	*	*	*

Noted: 100%NPK: dose of farmer fertilizer (180kg Ure + 240kg DAP + 300kg 20-20-15)
N1, N2, N3: 75%, 50%, 25% of farmer dose
V1, V2, V3: BinhDien Mekong, Ecofarm, Dasvila
*ns and * non-significant and significant at 5%, Duncan's Multiple Range Test*

The treatments containing MOF did not differ fromthe number of shoots/bush, but the total number of leaves/m² was significantly different at 60 days to harvest. The treatments with microbial organic fertilizer in BinhDien Mekong, Ecofarm and Dasvila fertilizer were all higher than the controlled farm in many treatments at 60 and 90 DAP, especially at harvesting time. The total number of leaves/m² increased rapidly in growing periods until 1 month before harvest, and thenit declined. BinhDien Mekong MOF had an increased growing tendency and produced more leaves (Figure 2).

During the experiment, the MOFs plots had detected more shoots, so the tubers were divided into more pieces.

Insects and diseases

Insects

There are not many insects attacking leeks. However, army worms had damaged the leaves, occurring from 25 to 45 DAP, but in late growth it is no longer important. Some ants (Tapinoma sessile) and mole-crickets (belong to Gryllotalpidae family) had appeared, but with a low density. Rats usually move to floating rice fields to eat and reproduce. They stayed somewhere in soil banks but are not harmful for the leek.

Diseases

Diseases occurred from the early tuber stage to harvest time, creating leaf blight. The first lesions were usually in the middle of leaves spreading into broken leaf lines. The fungus penetrated and spread along the leaf stems to make oval, long black, light yellow marks on the grey background. Five to seven days later, the leaves were broken in the middle and dried if they were not treated in time. The fungus can attack welsh onion, make brown spotson tomatoes, and create leaf spotson spinach. If the leaves are healthy enough for photosynthesis, it will not reduce productivity.

Figure 2. The symptom of leek leaf blight in Vinh Phuoc in the field (1): control. (2) BinhDien Mekong MOF (V1N2)

Growth at harvest

The leaf weight, root length and tuber diameter were not statistically different between the experimental treatment and the controlled treatment. The leaf weight of 10 bushes ranged from 192.7 g (control) to 256.7 g (V1N1, using BinhDien Mekong + 75% NPK of control) (Table 6). Consequently, if the amount of NPKwas reduced, the weight of leaves at harvest might not differ significantly between two kinds of treatment. For leek plants or those in the onion families, the more NPK applied, the more leaves became greener, but the productivity had not increased. According to farmer experiences, when over-fertilized, the leaves will be greener, but have smaller tubers.

The root length ranged from 8.3 mm (V3N3) to 14.7 mm (V2N1) but was not significantly different, even with the controlled treatment. Application of BinhDien Mekong, Dasvila and Ecofarm fertilizers did not make roots longer than the farmers' control.

The tuber diameters were quite large, ranging from 12.3mm (V3N3) to 14.4mm (V1N1) but still did not show significant difference even in comparison to the controlled treatment with increased NPK.

The weight of 10 bushes collected at harvesting was significantly different among treatments. Three treatments of Dasvila displayed 10 bushes weighed lower than that of the BinhDien Mekong and Ecofarm treatments. When selling, the weight of 10 bushes of V3N1, V3N2 and V3N3 was 738.4g, 728.3 and 655.04g respectively. These weights arenot different from the controlledtreatment without using MOFs (reaching 676.7g).

The weight of 10 bushes at pre-harvest and selling time significantly differed in MOFs, but not in NPK factors and interactions between MOFs-NPK.

Table 6. Leaf weight of 10 bushes, root length, tuber diameter, 10 tubers weight and productivity, experiment in Vinh Phuoc commune, Tri Ton province

N	Treatment	Leaf weigh of 10 bushes (g)	Root length (cm)	Tuner diameter (mm)	10 bushes weight (g)	P (kg/ha)
1.	V1N1	256.7	10.16	14.4	900.0 a	43.8 a
2.	V1N2	230.0	9.3	13.1	848.4 a	37.3 a
3.	V1N3	243.3	9.8	13.5	835.1 a	36.3 a
4.	V2N1	255.0	9.6	14.7	825.1 a	43.1 a
5.	V2N2	235.0	9.5	13.6	791.8 a	38.7 a
6.	V2N3	226.7	9.2	13.9	778.4 a	38.1 a
7.	V3N1	230.0	9.4	13.4	738.4 b	32.0 b
8.	V3N2	240.0	9.1	13.7	728.3 b	29.1 b
9.	V3N3	208.3	9.2	12.3	655.0 b	29.3 b
10.	ĐC	192.7	8.3	12.9	676.7 b	32.5 b
	CV (%)	13.9	6.7	7.3	14.4	11.9
	ĐC	*ns*	*ns*	*ns*	*	*
	F (V)	*ns*	*ns*	*ns*	*ns*	*
	F (N)	*Ns*	*ns*	*ns*	*ns*	*

Noted: V1: BìnhĐiền Mekong, V2: Ecofarm KG TRICHO – VS, V3: Dasvila; N1, N2 N3: 75%, 50%, 25% NPK compared to the controlled treatment (100%NPK (180kg Ure + 240kg DAP + 300kg 20-20-15/ha)).

*ns: non-significant difference, *: 5% significant difference with Duncan's Multiple Tests.*

Through statistical data, we realized the leek productivity in this area was quite high. At sale time, productivity of farmers' treatment reached 32.5 tons/ha, it was not different from the three treatments using Dasvila MOF at all levels of NPK 75%, 50% and 25%.

Two treatments of BinhDien Mekong and Ecofarm MOFs gained higher yield than Dasvila and the controlled farm, even when reducing NPK. The highest yield achieved in V1N1 (BinhDien Mekong + 75% NPK) was 43.8 tons/ha. Productivity tended to slow down when NPK was reduced, but it was not significantly different. Therefore, it was possible to use BinhDien Mekong or Ecofarm plus 25% NPK of control (Table 6).

Economic efficiency

While costs of leek are for breeding, the cost of fertilizers is about 4-5% of the total expenses. The total cost of all treatments ranged from 159.79 (V2N3) to 164.67 million VND (V1N1).

Table 7. Economic efficiency of the leek using microbial organic fertilizers and reduction of NPK fertilizers

N0	Treatments	Fertilizers costs (million VND/ha)	Total expenditures (million VND/ha)	Productivity (tons/ha)	Prices (1.000 VND/kg)	Total revenues (million VND/ha)	Profits (million VND/ha)
1.	V1N1	9.72 a	164.67	43.77 a	11.5	503.35 a	338.68 a
2.	V1N2	7.28 b	162.23	37.30 a	11.5	428.95 b	266.71 b
3.	V1N3	4.84 c	159.79	36.33 a	11.5	417.79 b	258.00 b
4.	V2N1	9.08 a	164.03	43.10 a	11.5	495.65 b	331.61 a
5.	V2N2	7.28 b	162.23	38.70 a	11.5	445.05 b	282.81 b
6.	V2N3	4.84 c	159.79	38.13 a	11.5	438.49 b	278.70 b
7.	V3N1	7.72 b	162.67	32.00 b	11.5	368.00 c	205.32 b
8.	V3N2	7.28 b	162.23	29.07 b	11.5	334.30 c	172.07 c
9.	V3N3	4.84 c	159.79	29.30 b	11.5	336.95 c	177.15 c
10.	Control	9.76 a	164.71	32.45 b	11.5	373.17 c	208.46 b
	CV (%)	9.8	10.4	11.9	-	5.8	4.2
	F (V)	*	*ns*	*	*ns*	*	*
	F (N)	*	*ns*	*	*ns*	*	*
	F (V*N)	*	*ns*	*	*ns*	*	*

Note: The total expenses includes land preparation (4.13 M.VND/ha) + breeding (100.00/M.VND/ha) + labour planting (2.00 M. VND/ha) + hand weeding (2.20 M. VND/ha) + Fertilizer labour (0.76 M. VND/ha) + harvest (5.00 M. VND/ha) + bio pesticides (0.72 M. VND/ha) + control fertilizers (9.72 M. VND/ha) + irrigation water oil, self-labour (3,00 M. VND/ha).

Total revenue and profit were highest in V1N1 (338.68 million VND/ha), equivalent to V2N1 (331.61 million VND/ha). Two treatments BinhDien Mekong and Ecofarm with 75% compared to the controlled treatment. When NPK was lower in MOF treatments, the productivity would not show difference, but the profit showed a huge difference because of the different productivities. The experiment using BinhDien Mekong and Ecofarm was more effective for leek than for Dasvila under the same conditions of cultivation. The difference in total cost was not high, the difference in revenue was high due to the high price (11,500 VND/kg). Therefore, profit differences are clearly shown in V1N1 and V2N1 treatments using MOF BinhDien and Ecofarm + 75% NPK. Therefore, the reduction of costs due to the reduction of NPK did not make a difference in total revenue because the selling price was high for all treatments.

Conclusion

Binh Dien Mekong and Ecofarm KG TRICHO were suitable for leek plants in the trial site, which gained a higher profit than the controlled treatment of reducing 75% NPK.

The treatments of N1V1 and N2V1 had the highest profit, 338 and 331 million VND/ha. Fertilizer cost contributed to a small proportion of the total expenditure because most of the costs were for breeding. Yields of commercial leek were not significantly different when using Binh Dien Mekong MOFs or Ecofarm MOFs with a reduction of NPK from 50% to 75% compared to the controlled treatment.

Suggestion

Using MOFs for the leek brings more benefits in both profit and human health. In this experiment, BinhDien Mekong and Ecofarm MOF saved50-75% of NPK and reduced leaf blight on leek.

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The biodiversity of floating rice fields and intensive rice fields at Tri Ton and Cho Moi Districts of An Giang province, Mekong Delta

Trinh Hoai Vu & Le Cong Quyen

Abstract

The biodiversity of plant, fish and reptile species on the floating rice fields and the intensive rice fields was conducted in the floating season in 2015 and 2016. The survey results showed that there was a high level of varieties of plant, fish and reptile species on the floating rice fields than on the intensive rice fields at the survey time. There were 68 plant species (37 families), 20 fish species (8 families), 34 wild bird species, and 13 wild reptile species were identified on the floating rice fields in Vinh Phuoc commune, Tri Ton district compared with only 30 plant species (20 families), 5 fish species (4 families), 12 wild bird species, and 11 wild reptile species on the intensive rice fields in My An commune, Cho Moi district.

Keywords: floating rice, biodiversity, plant diversity, wild fish, wild reptile,

Research methods

Research sites

Research sites	Samples	Duration
Vinh Phuoc Commune, Tri Tôn District (floating rice)	Fishes, plants, reptiles and birds	From 9/2015 to 3/2016 (weekly data)
My An Commune, Cho Moi District (intensive rice systems protected by high dikes)	Fishes, plants, reptiles and birds	From 9/2015 to 3/2016 (weekly data)

Research methods

No	Species	Methods	Analysis methods
1	Fishes	Two samples per species	Truong and Tran (1993) and Rainboth (1996); Rainboth (1996)
2	Plants	Two samples per species	Pham (2000)

3	Reptiles	Interview local farmers and morphological identification in the field	Nguyen et al. (2009)
4	Birds	Interview local farmers and morphological identification in the field	Le (2012)

Materials and Methods

The plant biodiversity at flooding areas at Vinh Phuoc and My An communes

The survey result revealed a high level of biodiversity in terms of varieties of species in the floating rice fields at Vinh Phuoc Commune, Tri Ton, An Giang. There were 68 plant species collected in the floating rice fields and surrounding areas. These species were classified into 37 different families. The majority were herbaceous except melaleuca (*Melaleuca cajuputi*), which had existed before floating rice cultivation at this site. More than 50% of Poaceae, Cyperaceae, Fabaceae, Asteraceae, Capparaceae, Commelinaceae, Cucurbitaceae, Euphobiaceae were major species in floating rice fields.

Table 1. The total number of plant species in floating rice fields at Vinh Phuoc (Tri Ton district) and My An (Cho Moi district) communes, An Giang province, Viet Nam in 2015

No.	Families	Number of species		
		Vinh Phuoc	My An (outsidehigh dikes)	My An (insidehigh dikes)
1	Poaceae	9	14	3
2	Cyperaceae	5	4	5
3	Fabaceae	5	3	2
4	Asteraceae	6	7	3
5	Convolvulaceae	4	2	2
6	Commelinaceae	2	2	1
7	Cucurbitaceae	2	2	1
8	Euphorbiaceae	3	3	1
9	Others	32	19	12
	Total	68 (37 families)	56 (25 families)	30 (20 families)

However, only 56 species and 25 different families were found at My An Commune, indicating a lower level of diversity of plant species compared to Vinh Phuoc Commune. Most of the species were herbaceous. The majority of Poaceae, Cyperaceae, Fabaceae, Commelinaceae, Curcurbitaceae existed in the modern intensive rice fields located within high dikes. The research findings revealed that the density of wild plant species in floating rice fields in My An commune was lower than that in Vinh Phuoc commune.

Before the flooding season in 2015, billygoat-weed (*Ageratum conyzoides*), Indian heliotrope (*Heliotropium indicum*), Spider flowers (*Cleome chelidonii*), *Gymnopetalum integrifolium*, *Gymnopetalum cochinchinese*, dayflower (*Commelina* sp.), cetella (*Centella asiatica*), sessile joyweed (*Alternanthera sessilis*), *Mexican primrosewillow* (*Ludwigia octovalvis*) were the major species in the fields and surrounding areas of floating rice fields.

During the flooding season in 2015, Poaceae (*Echinochloa crus-galli*, *Leersia hexandra*, *Panicum repens*, *Digitaria* sp., *Oryza rufipogon*), Cyperaceae (*Eleocharis dulcis*, *Cyperus digitatus*, *Cyperus amabilis*), Fabaceae (*Sesbania javanica*, *Aeschynomene indica*), *Utricularia aurea*, *Myriophyllum spicatum*, *Nymphaea nouchali*, *Polygonum tomentosum* were only species that could adapt and survive in the floating rice fields.

A large number of plant species were affected by the flood level. In the flooding season, the number of species decreased. Some flood-adapted species survived in the fields. In addition, during the flooding season in 2015, the water level was lower than that of the previous years. Therefore, many species, such as climbing day flower (*Commelina diffusa*), water chestnut (*Eleocharis dulcis*), barnyardgrass (*Echinochloa crus-galli*), Mexican primrose willow (Ludwigia octovalvis), Ivy-leaved morning glory (*Ipomoea hederacea*), found on the floating rice fields. Nevertheless, a number of aquatic plants' density decreased inlower water level, such as *Utricularia aurea*, *Myriophyllum spicatum*, *Nymphaea nouchali*, *Nymphoides indica*. There was a significant relationship between flood and the biodiversity and density of aquatic plant species in the floating rice field.

Table 2. The list of plant species on floating rice fields at Vinh Phuoc and My An communes, An Giang Province, Viet Nam in 2015

No.	Families	Species	Vietnamese names	English names
1	Amaranthaceae	*Alternanthera sessilis* (VP, MA) (IR)	Rau dệu	Sessile joyweed
2	Apiaceae	*Centella asiatica* (VP)	Rau má	Centella
3	Araceae	*Colocasia esculenta* (VP)	Môn nước	Eddoe

4	Asteraceae	*Ageratum conyzoides* (VP) (IR)	Cỏ cứt heo	Billygoat-weed
		Blume alacera (VP, MA)	Cải trời	
		Ecliptapr ostrata (VP, MA) (IR)	Cỏ mực	False daisy
		Sphaeranthus indicus (VP, MA)	Cỏ chân vịt	East Indian Globe Thistle
		Chromolaena odorata (VP, MA)	Cỏ Lào, Yến bạch	Siam weed
		Vernonia cinerea (VP, MA) (IR)	Cỏ bạc đầu	
		Galinsoga parviflora (MA)	Cỏ thỏ	
		Spilanthes iabadicensis (MA)	Nút áo	
5	Boraginaceae	*Heliotropium indicum* (VP, MA) (IR)	Vòi voi	Indian heliotrope
6	Capparaceae	*Cleome chelidonii* (VP, MA) (IR)	Màng màng tím	Spider flowers
		Cleome viscosa (VP)	Màng màng vàng	Asian spiderflower
7	Commelinaceae	*Commelina diffusa* (VP, MA) (IR)	Rau trai thường	Climbing dayflower
		Commelina longifolia (VP, MA)	Rau trai lá dài	
8	Compositae	*Struchium sparganophorum* (VP, MA)	Cỏ lá xoài	
9	Convolvulaceae	*Aniseia martinicensis* (VP)	Bìm nước	
		Ipomoea hederacea (VP)	Bìm bìm	Ivy-leaved morning glory
		Merremia gemella (VP)(IR)	Bìm đôi	
		Operculina turpethum (MA)	Bìm nắp	
		Ipomoea aquatica (VP, MA) (IR)	Rau muống	Water spinach
10	Cucurbitaceae	*Gymnopetalum integrifolium* (VP)	Cứt quạ lá nguyên	
		Gymnopetalum cochinchinese (VP, MA) (IR)	Cứt quạ lá xẻ	
		Coccinia cordifolia (MA)	Bình bát dây	

11	Cyperaceae	*Eleocharis ochrostachys* (VP, MA)	Năng kim	
		Eleocharis dulcis (VP)	Năng ống	Water chestnut
		Cyperus digitatus (VP, MA) (IR)	Udutia	
		Cyperus amabilis (VP, MA)	Cú dễ thương	
		Fimbristylis miliacea (VP) (IR)	Cỏ chát	
		Cyperus difformis (IR)	Cỏ cháo	
		Cyperus elatus (IR)		
		Cyperus halpan (MA) (IR)		
12	Euphorbiaceae	*Manihot esculenta* (VP)	Khoai mì	Cassava
		Euphoria hirta (VP, MA) (IR)	Cỏ sữa	Asthma-plant
		Euphorbia thymifolia (MA)	Cỏ sữa lá nhỏ	
		Macaranga triloba (VP, MA)	Mã rạng ba thùy	
13	Eriocaulaceae	*Eriocaulon setaceum* (VP)	Cỏ dùi trống	
14	Fabaceae	*Sesbania javanica* (VP, MA) (IR)	Điên điển	Sesbania
		Aeschynomene indica (VP, MA)	Điền ma Ấn	
		Mimosa pigra (VP, MA)	Mai dương	Black mimosa
		Canavallia lineata (VP) (IR)	Đậu ma	
		Mimosa pudica (VP)	Mắc cỡ	
15	Pteridaceae	*Ceratopteris thalictroides* (VP)	Dương xỉ đất	
16	Haloragaceae	*Myriophyllum spicatum* (VP)	Rong đuôi chồn	Spiked Water-milfoil
17	Hydrocharitaceae	*Ottelia alismoides* (VP)	Mã đề nước	
18	Lamiaceae	*Leucas zeylanica* (VP)	Mè đất	
19	Lentibulariaceae	*Utricularia aurea* (VP)	Rong trứng	Bladderwort
20	Limnocharitaceae	*Limnocharis flava* (IR)	Tai tượng	
21	Linderniaceae	*Lindernia antipoda* (VP, MA)(IR)	Màn đất	

22	Lygodiaceae	*Lygodium microphyllum* (VP) (IR)	Bòng bong	Snake fern
23	Malvaceae	*Corchorus aestuans* (VP, MA)	Bố	
		Urena lobata (VP, MA) (IR)	Ké hoa đào	Caesarweed
		Hibiscus sagittifolius (MA)	Sâm bố chính	
24	Melastomataceae	*Melastoma affine* (VP)	Mua	
25	Menyanthaceae	*Nymphoides indica* (VP)	Thủy nữ Ấn	
26	Myrtaceae	*Melaleuca cajuputii* (VP)	Tràm	
27	Nymphaeaceae	*Nymphaea nouchali* (VP)	Bông súng ma	Blue star water lily
28	Onagraceae	*Ludwigia octovalvis* (VP, MA)(IR)	Rau mương đứng	Mexican primrose-willow
29	Parkeriaceae	*Ceratopteris siliquosa* (VP) (IR)	Ráng gạc nai	
30	Passifloraceae	*Passiflora foetida* (VP, MA) (IR)	Nhãn lồng	Bush passion fruit
31	Phyllanthaceae	*Phyllanthus urinaria* (VP, MA) (IR)	Diệp hạc hâu	
32	Plantaginaceae	*Scoparia dulcis* (MA)	Cam thảo đất	
33	Poaceae	*Oryza rufipogon* (VP, MA)	Lúa hoang	Wild rice
		Digitaria ciliaris (VP, MA)	Cỏ túc hình rìa	Southern crabgrass
		Eleusine indica (VP, MA)	Cỏ mần trầu	
		Panicum repens (VP, MA)	Cỏ ống	Torpedo grass
		Digitaria sp (VP, MA)	Cỏ túc	
		Echinochloa crus-galli (VP, MA)(IR)	Cỏ lồng vực	Barnyardgrass
		Cynodon dactylon (VP, MA)	Cỏ chỉ	Bermudagrass
		Leersia hexandra (VP, MA)	Cỏ bắc	Southern cut grass
		Hymenachne acutigluma (MA)	Cỏ mồm mỡ	
		Pennisetum purpureum (VP, MA)	Cỏ voi	

		Brachiaria mutica (MA)(IR)	Cỏ lông tây	
		Leptochloa chinensis (MA) (IR)	Cỏ đuôi phụng	
		Digitaria sanguialis (MA)	Cỏ chân nhện	
		Phragmites australis (MA)	Sậy	
34	Polygonaceae	*Polygonum tomentosum* (VP, MA)	Nghể	
35	Pontederiaceae	*Eichhornia crassipes* (VP, MA)	Lục bình	Water hyacinth
36	Portulacaceae	*Portulaca oleracea* (VP, MA)	Rau sam	Purslane
37	Rubiaceae	*Oldenlandia diffusa* (VP, MA) (IR)	Lưỡi đồng	
38	Solanaceae	*Physalis angulata* (VP, MA)	Thù lù	Cutleaf groundcherry
39	Urticaceae	*Pouzolzia zeylanica* (MA)	Thuốc dòi	
40	Vitaceae	*Cayratia trifolia* (VP, MA)	Giác	Bush grape

Notes: VP: Vinh Phuoc Commune, MA: My An Commune, IR: Intensive Rice

Plant diversity identification between the floating rice regions at Vinh Phuoc Commune and the modern intensive rice fields located within high dikes at My An Commune

There is more plant diversity in the floating rice fields at Vinh Phuoc than in the intensive rice fields at My An Commune. The findings in Table 1 showed that Poaceae, Cyperaceae and Asteraceae were the dominant families with 5, 3 and 3 species respectively in the intensive rice fields. In addition, the research results also revealed the plant diversity was significantly reduced, 30 species in 20 families in the intensive rice fields in My An compared with 68 species in 37 families in the floating rice fields at Vinh Phuoc Commune and 56 species in 25 families in the floating rice fields at My An commune. The dikes and herbicide practices of the local farmers have alleviated the plant diversity in the intensive rice fields at My An commune.

Eichhorni acrassipes

Commelina longifolia

Ipomoea aquatica

Scoparia dulcis

Vernonia cinerea

Sphaeranthus indicus

Merremia gemella

Heliotropium indicum

Canavallia lineata

Aeschynomene indica

Chromolaena odorata

Lygodium microphyllum

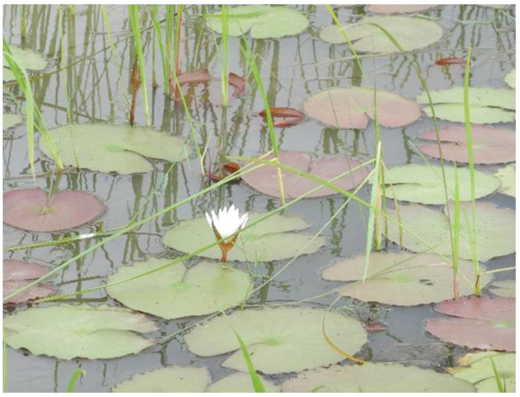
Nymphoides indica

Cyperus digitatus

Cleome chelidoni

Echinochloa crus-galli

Polygonum tomentosum



Nymphaea nouchali

Passiflora foetida

Oryza rufipogon

Composition of wild fish in floating rice fields in Tri Ton District and in intensive rice systems using high dikes in Cho Moi District

The research results identified 20 species and 08 families of wild fish in floating rice fields in Tri Ton District, compared to 5 species and 04 families found in intensive rice systems located in high dikes in Cho Moi District (Table 3 & Table 4).

Table 3. Composition of wild fish in floating rice in Vinh Phuoc and Luong An Tra communes, Tri Ton District, An Giang Province in the flooding season in 2015

No.	Local name	Scientific name	Frequencies
Family *Cyprinidae*			
1	Cá Linh ống	*Cirrhinus jullieni* (Sauvage, 1881)	+++
2	Cá Dảnh	*Puntioplites* (Bleeker, 1865)	++
3	Cá Mè vinh	Puntius *gonionotus* (Bleeker, 1850)	++
4	Cá He đỏ	*Barbonymus altus* (Bleeker, 1853)	++
5	Cá Rằm đất	*Puntius leiacanthus* (Bleeker, 1860)	+
6	Cá Lành canh	*Oxygaster oxygastroides* (Bleeker, 1852)	++
Family *Bagridae*			
7	Cá Chốt giấy	*Mystus cavasius* (Roberts, 1994)	++
8	Cá Chốt bông	*Pseudomystus siamensis* (Regan, 1913)	+
9	Cá Chốt sọc	*Mystus mysticetus* (Roberts, 1992)	+++

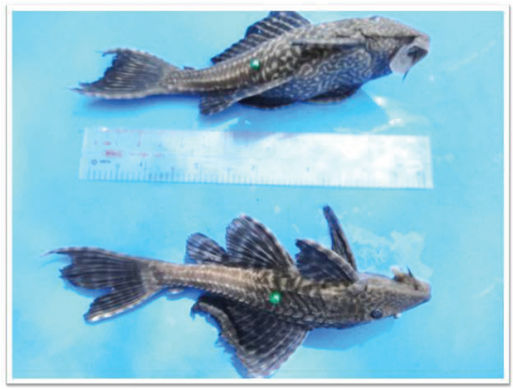
10	Cá Chốt chuột	*Leiocassis siamensis (*Regan, 1913)	+
Family *Siluridae*			
11	Cá Trèn răng	*Wallago dinema* (Bleeker, 1851)	+
12	Cá Trèn bầu	*Ompok bimaculatus* (Bloch, 1797)	+
Family *Clariidae*			
13	Cá Trê trắng	*Clarias bachachus* (Linnaeus, 1758)	+
14	Cá Trê vàng	*Clarias macrocephalus* (Günther, 1864)	+
15	Cá Sặc điệp	*Trichogaster microlepis* (Günther, 1861)	++
16	Cá Bãi trầu	*Trichopsis vittata* (Cuvier, 1831)	+
Family *Anabantidae*			
17	Cá Rô đồng	*Anabas testudineus (Bloch, 1792)*	+++
Family *Nandidae*			
18	Cá Rô biển	*Pristolepis fasciata* (Bleeker, 1851)	+
Family*Channidae*			
19	Cá Lóc đen	*Ophiocephalus striatus* (Bloch, 1793)	+++
Family *Loricariidae*			
20	Cá Lau kiếng	*Hypostomus plecostomus* (Linnaeus, 1758)	++

Table 4. Composition of wild fish in intensive rice systems using high dikes My An Commune, Cho Moi District, An Giang Province in 2015

No.	Local name	Scientific name	Frequencies
Family *Clariidae*			
1	Cá Trê vàng	*Clarias macrocephalus* (Günther, 1864)	+
2	Cá Săc điêp	*Trichogaster microlepis* (Günther, 1861)	+

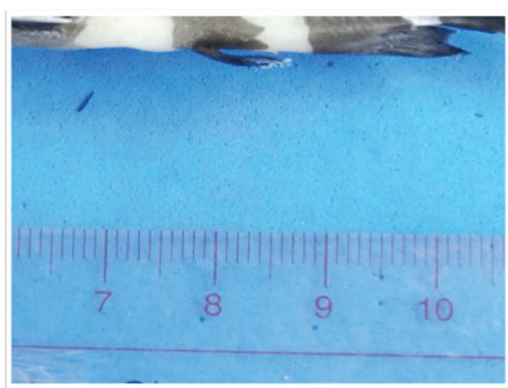
Family *Anabantidae*			
3	Cá Rô đồng	*Anabas testudineus (Bloch, 1792)*	+
Family *Cichlidae*			
4	Cá Rô phi vằn	*Oreochromis niloticu s*(Linnaeus, 1757)	++
Family*Channidae*			
5	Cá Lóc đen	*Ophiocephalus striatus* (Bloch, 1793)	+

Clarias macrocephalus



Hypostomus plecostomus

Pristolepis fasciata



Pseudomystus siamensis

Composition of wild birds in floating rice fields in Tri Ton District and in intensive rice systems using high dikes in Cho Moi District

The research findings identified 34 species of wild birds in floating rice fields in Tri Ton District and 12 species in intensive rice systems using high dikes in Cho Moi District (Table 5 & Table 6).

Table 5. Composition of wild birds in floating rice in Vinh Phuoc and Luong An Tra communes, Tri Ton District, An Giang Province in the flooding season in 2015

No.	Local name	Scientific name	Frequencies
1	Sẻ nhà	*Passer domesticus*	+
2	Sẻ tuố tlúa	*Passer montanus*	+++
3	Én nhà	*Delichon urbica*	+
4	Sâu	*Dicaeum cruentatum*	+
5	Cúm núm	*Gallicrex cinerea*	+++
6	Áo già	*Lonchura atricapilla*	+++
7	Lá rụng (sẻ đồng)	*Anthus rufulus*	+++
8	Cò lửa	*Ixobrychus sinensis*	+++
9	Cò trắng	*Egretta garzetta*	+++
10	Cò ma	*Bubulcus ibis*	+
11	Cò nâu	*Ixobrychus eurhythmus*	+++
12	Cò hương	*Ixobrychus flavicollis*	++
13	Giang sen	*Mycteria leucocephala*	++
14	Diệc xám	*Ardea cinerea*	++
15	Ốc cao	*Charadrius ruficapillus*	++
16	Chằng nghịt (gà nước vằn)	*Gallirallus striatus*	++
17	Vị tnước	*Anas poecilorhyncha*	+
18	Sếu đầu đỏ	*Grus antigone*	+
19	Trao trảo	*Pycnonotus spp*	+
20	Chìa vôi	*Dendronanthus indicus*	+
21	Khách	*Crypsirina temia*	++
22	Bìm bịp	*Centropus sinensis*	+++
23	Cu cườm	*Streptopelia chinensis*	+++
24	Cu ngói	*Streptopelia tranquebarica*	+++
25	Trích cồ	*Porphyrio porphyrio*	++
26	Điên điển	*Anhinga melanogaster*	+
27	Cu sen	*Streptopelia orientalis*	+

28	Cồng cộc	*Phalacrocorax niger*	+++
29	Vạt lùn	*Botaurus stellaris*	+++
30	Dòng dọc	*Ploceus philippinus*	++
31	Sa sả (bói cá)	*Ceryle rudis*	++
32	Cắt	*Falco columbarius*	+
33	Rẻ quạt	*Rhipidura hypoxantha*	++
34	Sáo sậu	*Gracupica nigricollis*	+

Table 6. Composition of wild fish in intensive rice systems using high dikes My An Commune, Cho Moi District, An Giang Province in 2015

No.	Local name	Scientific name	Frequencies
1	Sẻ	*Passer domesticus*	++
2	Énnhà	*Delichon urbica*	++
3	Sâu	*Dicaeum cruentatum*	+
4	Lá rụng (sẻ đồng)	*Anthus rufulus*	++
5	Cò trắng	*Egretta garzetta*	+++
6	Cò ma	*Bubulcus ibis*	+
7	Trao trảo	*Pycnonotus spp*	+
8	Chìa vôi	*Dendronanthus indicus*	+
9	Cu cườm	*Streptopelia chinensis*	+
10	Cu ngói	*Streptopelia tranquebarica*	+
11	Cồng cộc	*Phalacrocorax niger*	+
12	Rẻ quạt	*Rhipidura hypoxantha*	+
13	Sáo sậu	*Gracupica nigricollis*	+

Mycteria leucocephala (Giang sen)

Egretta garzetta (Cò trắng)

Rhipidura hypoxantha (Rẻ quạt)

Falco columbarius (Cắt)

Passer montanus (Sẻ tuốt lúa)

Streptopelia chinensis (Cu cườm)

Composition of wild reptiles in floating rice fields in Tri Ton District and in intensive rice systems protected by high dikes in Cho Moi District

The research identified 13 species of wild reptiles in floating rice fields in Tri Ton District and 11 species in intensive rice systems located inside dikes in Cho Moi District (Table 7 & Table 8).

Table 7. Composition of wild reptiles in floating rice in Vinh Phuoc and Luong An Tra communes, Tri Ton District, An Giang Province in the flooding season in 2015

No.	Local name	Scientific name	Frequencies
1	Tắc kè	*Gekko gecko*	+
2	Kỳ nhông	*Calote ssp*	+
3	Rắn mối	*Dasia olivase*	++
4	Trăn đất	*Python molurus*	+
5	Rắn hổ hành	*Xenopeltis unicolor*	++
6	Rắn roi thường	*Ahaetulla prasina*	+
7	Rắn leo cây	*Dendrelaphis pictus*	++
8	Rắn lục xanh	*Trimeresurus stejnegeri*	+
9	Rắn ri voi	*Enhydris bocourti*	+
10	Rắn nước	*Xenochrophis piscator*	++
11	Rắn hổ hèo	*Ptyas mucosus*	+
12	Rắn râu	*Erpeton tentaculatum*	+
13	Rắn bông súng	*Enhydris enhydris*	++

Table 8. Composition of wild reptiles in intensive rice systems using high dikes My An Commune, Cho Moi District, An Giang Province in 2015

No.	Local name	Scientific name	Frequencies
1	Tắc kè	*Gekko gecko*	+
2	Kỳ nhông	*Calotessp*	+
3	Rắn mối	*Dasia olivase*	++
4	Trăn đất	*Python molurus*	+
5	Rắn hổ hành	*Xenopeltis unicolor*	+
6	Rắn roi thường	*Ahaetulla prasina*	+

7	Rắn leo cây	*Dendrelaphis pictus*	++
8	Rắn lục xanh	*Trimeresurus stejnegeri*	+
9	Rắn ri voi	*Enhydris bocourti*	+
10	Rắn hổ hèo	*Ptyas mucosus*	+
11	Rắn lục đuôi đỏ	*Trimeresurus albolabris*	+

Calotes sp. (Kỳ nhông)

Xenochrophis piscator (Rắn nước)

Xenopeltis unicolor (Rắn hổ hành)

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Conclusions

Floating rice-based agroecological farming system research and development: a pathway for sustainable agriculture and food security

Nguyen Van Kien

It is clear that phase one research projects investigating floating rice-based agroecological farming systems have provided a reliable baseline of data that can be used to promote this resilient farming practice in the Mekong Delta and in the extended Mekong Region. Chapters within this book have presented important components influencing floating rice production. Importantly, specific farming activities have been outlined and the resulting effects on agrobiodiversity at the farm household and community level have been discussed. Floating rice cultivation has been reviewed in relation to the factors most likely to influence production such as: local knowledge, access to quality varietal rice seeds, sequential dry season vegetable crops, socio-economic issues, and farm product value chains. Notably this research has also investigated the linkage of science and agricultural policies to inform agriculture conservation. This research has been undertaken by an exceptional interdisciplinary team using qualitative and quantitative methods, informed by participatory action research. Research activities were conducted collaboratively involving research scientists, local decision makers, farmers, private sector partners and government agencies. Overall, the research demonstrates that floating rice-based agro ecological farming systems provided greater economic return for farmers compared with conventional intensive two to three crops of rice. Additionally, the ecosystem services of the floating rice-based farming systems contributed extensively to livelihoods and improved the well-being of households and communities. Agro biodiversity, fish stocks, and other aquatic animals were restored after the floating rice paddy fields were recovered. Farmers' livelihoods improved and were more dependable in floating rice-based farming systems.

The economic returns of floating rice and vegetable crops were much greater than double or triple high yield variety (HYV) rice crops. In floating rice systems, the rice yield was found to be lower than for conventional systems, yet the sale price of floating rice paddy was three-fold compared to the HYV rice. Additionally, farmers harvested wild fish and other aquatic plants and animals to supply quality nutritional food to rural families. Diets and livelihoods were also supplemented by profitable vegetable crops resulting from floating rice-based farming systems production. For example, farmers were able to catch fish for daily meals during the flood season and make fish sauce or fermented fish for all year-round use. This income source has not previously been measured in government statistics or poverty reports.

We found that the ecosystem services of the floating rice were totally restored when floating rice-based farming practices were re-instated. Wild fish stocks and aquatic animals increased in numbers and populated the flooded floating rice fields. There was a greater diversity of fauna and flora species in the floating rice fields compared with speciesfound infields with intensive three cropping systems. In addition, floating rice straw provided organic mulches to cover the dry season vegetable crops, reducing water use. Fertile sediments from annual flood event provided natural nutrients for floating rice systems, reducing the need for chemical fertilizers and pesticides. Floating rice systems are free of chemicals, and floodstend to naturally control pests. Further more, this rice production strategy provides an adaptation to climate change.

The interface of science and policy enhanced trust building among local university researchers, local decision makers, private sector partners and farmers. As a multi-disciplinary research project, social, economic, and ecological scientists were all part of this team. The co-design of the project facilitated collaboration between actors, so trust was built amongst actors. Floating-rice-based agroecological farming development efforts are continuing were farmers and local communities have benefited from this style of rice production. This impact is the key factor for the success of the project.

University researchers made a positive progress in extending the area of floating rice throughout the Mekong Delta. They shared scientific results to inform government policies. Local social scientists played a central role in liaising and collaborating with local, regional, and international experts and farmers. They made successful use of available funding and used resources in a sustainable, conscientious manner. Governments in neighbouring communes and districts adopted this framework to apply to floating rice conservation in their locality. Based on these results and impacts we recommend that this approach should be scaled up to a broader context with more rice farmers in more districts and provinces.

Overall and based on the advantages to the agroecology, our team proposeda continuing strategy to recover traditional floating rice-based systems in the Mekong region and in Myanmar. Local social scientists from the university played two key roles, firstly they supplied academic research and secondly, they developed an outreach program to continue agriculture conservation. Initially, local social scientists accessed international and national research and development grants to devise a long-term conservation program. This was followed by collaboration with international and local scientists to under take multidisciplinary research projects. Finally, we suggest that informed social scientist from the university sector can gather and present scientific data on which are the right persons to communicate with government agencies can develop agricultural policies in the rice sector.

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