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Preface

Preface to the 4th International Conference Organic Rice Farming and Production Systems and the 21th International Symposium of the Integrated Field Science Center

Mizuhiko NISHIDA

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Since synthetic chemical fertilizers have been the main source of nutrients used in agriculture, the importance of organic farming has probably never been more emphasized. In the past, agricultural production depended on the recycling of resources within a region. However, the production of nitrogen fertilizer, based on the Haber-Bosch process, allowed almost unlimited application of nitrogen to farmland. In addition, the mining and trading of phosphate and potash ores made it possible to move large quantities of these nutrients over long distances. The heavy application of these nutrients to farmland has enabled high yields. We now live in a world based on high input nutrient agriculture. Indeed, a positive correlation has been observed between the amount of synthetic fertilizer applied to arable land and grain yields per unit area. Some countries in the world have continued to reap the benefits. However, the high-input, high-production system, which ignores resource recycling, has accelerated the degradation of agro-ecosystems. Humans are now suffering severe reactions from the environment they have degraded. So should we return to old agricultural practices? But it is clear that old-fashioned agriculture cannot feed the world's growing population. So what kind of agriculture is needed? The key may lie in technological innovations in organic farming. I am not an organic supremacist. I do not believe that organic farming is the only and best way of farming. However, it can point the way for agriculture to make the best use of resource recycling. How many people can local resource recycling agriculture feed without using synthetic fertilizers and pesticides? Are there enough nutrients in local resource recycling agriculture or not? If not, what should we do? We have to answer these questions scientifically. And I think that the process of finding these answers will eventually lead to innovations in organic farming. I hope that beyond the technological innovations in organic farming, we will see high productivity agriculture based on resource recycling.

This volume of the Journal of Integrated Field Science contains reports and abstracts from the forefront of research in organic rice production. I hope these reports will lead not only to future research on organic rice production, but also to the next generation of agriculture based on resource recycling.

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Symposium mini review

The Prevalence of Organic Rice Production in Japan

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Keywords
organic farming practice, rice production, census of agriculture and forestry

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Abstract

The importance of sustainable farming practices is increasing in consideration of the environment. Along with this background, the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF) has introduced a strategy for sustainable food systems; "MIDORI" strategy. In this strategy, by 2050, MAFF aims to increase the proportion of organic farming to arable land to 25% (equivalent to 1 million hectares). According to the 2020 Census of Agriculture and Forestry, 35,244 producers practiced organic farming in rice production. The proportion of organic producers is increasing as the area of paddy rice farmed increased up to 100 ha. Additionally, when we focus on the percentage of organic cultivation area (organic per total rice cultivation), we can get different findings. The percentage of organic cultivation area was mostly 100% of rice cultivation area up to about 10 hectares. On the other hand, the percentage of 100% organic farming decreased monotonically as the increase in cultivation area scale, and the majority of relatively large-scale producers practiced organic farming in a part of their field. These results suggest that it is necessary to consider both increasing the number of organic producers and increasing the area of organic farming for each producer.

Introduction

Background

The importance of sustainable farming practices is increasing from the perspective of the Sustainable Development Goals (SDGs) and in consideration of the environment. Organic agriculture contributes to the achievement of the SDGs by: (1) greatly enhancing the resource recycling function of agriculture, reducing the burden on the environment caused by agricultural production, and being highly effective in preserving biodiversity and preventing global warming (Sanders and Hess, 2019), and (2) providing a stable supply of domestically produced organic agricultural products to meet the growing demand for organic food both in Japan and abroad. Along with this background, the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF) has introduced a strategy for sustainable food systems, "MIDORI" strategy. In this MIDORI strategy, by 2050, MAFF aims to increase the proportion of organic farming to arable land to 25% (equivalent to 1 million hectares) (MAFF, 2023a).

Paddy rice is the staple food crop in Japan, accounting for 2.4 million ha of the total cultivated area of 4.3 million ha in 2020 (MAFF, 2024). Reducing the environmental impact of paddy rice can play an important role in reducing the environmental impact of agriculture as a whole.

Data availability

The area certified as Japanese Agricultural Standards (JAS) organic is internationally published as the areas of organic farmland in Japan (Willer et al., 2023). It is necessary to obtain JAS certification to sell agricultural products produced by organic farming practice with organic labelling in Japan. According to the data of JAS certification, the total organic farmland is expanding. However, in the paddy field, it remains constant at around 3,000 hectares. The main portion of the increase in JAS certified area has been in dry fields, especially temporary meadows, which has increased significantly since 2019 (**Table 1**). On the other hand, even if farmers follow the rules of organic management, products from organically managed areas are not always certified nor labeled (Argyropoulos et al., 2013). MAFF also collect the data of not-certified organic farmland. According to this data,

Table 1. Trend of JAS Certified Organic Farmland (ha)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total	8,506	9,084	9,401	9,529	9,889	9,937	10,043	9,956	10,366	10,800	11,002	12,027	14,137
Paddy Field	2,902	2,998	3,214	3,149	3,098	2,961	2,863	2,825	2,898	2,963	3,026	3,062	3,061
Upland Field	5,596	6,076	6,169	6,365	6,676	6,857	7,057	7,008	7,344	7,676	7,808	8,781	10,913
Ordinary	4,235	4,396	4,627	4,778	4,866	4,924	4,940	4,879	4,955	5,097	5,167	5,141	5,494
Permanent Crop	999	1,196	1,127	1,077	1,088	1,129	1,170	1,326	1,421	1,709	1,826	1,884	2,004
Tea	-	-	-	-	-	-	-	-	-	1,255	1,352	1,374	1,427
Temporary Meadows	362	483	416	510	722	804	948	803	968	870	815	1,756	3,415
Others	9	10	17	16	115	118	122	122	124	161	168	184	163

Note. Permanent crop includes tea.

Table 2. Trend of Organic Farmland (1,000 ha)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
JAS	9.4	9.5	9.9	9.9	10.0	10.0	10.4	10.8	11.0	12.0	14.1
non-JAS	7.3	9.9	10.6	10.5	11.6	12.1	12.7	12.7	12.7	11.8	11.1
Total	16.7	19.4	20.5	20.4	21.6	22.1	23.1	23.5	23.7	23.8	25.2

Note. 1) non-JAS is not certified organic farmland estimated by MAFF (2023b).
2) The date of JAS in MAFF (2023b) has one-year gap.

Table 3. Number of organic producer and their organic cultivation

	Num. of Producers	Prop. of OF (Num. of Producer)	Cultivated Area (ha)	Prop. of OF (Cultivated Area)
Num. of Producers	1,075,705	-	-	-
Cultivate Rice	713,792	-	1,285,654	-
Organic Rice	35,244	4.9%	60,624	4.7%
Cultivate Maize	49,731	-	132,084	-
Organic Maize	2,862	5.8%	5,122	3.9%
Cultivate Vagetables	282,543	-	264,734	-
Organic Vegetables	24,647	8.7%	18,435	7.0%
Cultivate Fruits	172,528	-	126,819	-
Organic Fruits	12,750	7.4%	9,630	7.6%
Others	-	-	-	-
Other Organic	6,598	-	21,458	-

Note. OF is organic farming

it is estimated 11,000 ha of not-certified organic farmland in 2021 (**Table 2**). However, it remains two questions. First, it is still unclear how much the organic farming is introduced. Second, it is not able to break down into micro-level. Along with this background, producer-level survey was conducted by the Census of Agriculture and Forestry in 2020.

Materials and Methods

This study is based on the producer-level microdata from the Census of Agriculture and Forestry in 2020. In this census survey, producers first answer whether they introduce organic farming practices, and if they introduce, they answer how much area they cultivate organically for each crop (rice, soybeans, vegetables, fruit trees, and others). Organic farming in the census survey includes organic farming that is not certified by JAS, but does not include organic farming that is not for sale.

Results and Discussion

Outline

The results of the census show that 69,309 producers practiced organic farming in 2020 (**Table 3**). By crop type, 35,244 of the producers practiced organic farming in rice production. Similarly, 2,862 producers practiced organic farming for soybeans, 24,647 for vegetables, and 12,750 for fruit trees, respectively. In terms of cultivated area, 115,269 hectares are cultivated organically (rice: 60,624 ha, soybeans: 5,122 ha; vegetables: 18,435 ha; fruits trees: 9,630 ha).

It was 10 times larger than the area certified by JAS. This may reflect that organic agriculture in the census can include "self-described" organic.

Organic rice producers

When we focus on rice production, 35,244 producers practiced organic farming in rice production (**Table 3**). **Fig. 1** shows that the proportion of organic producers increased

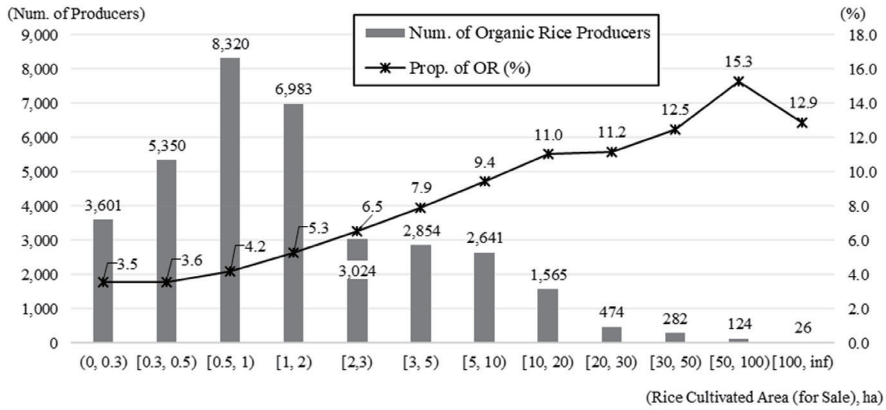

Fig. 1 Relationship between scales of rice cultivated area and organic rice (OR) producers

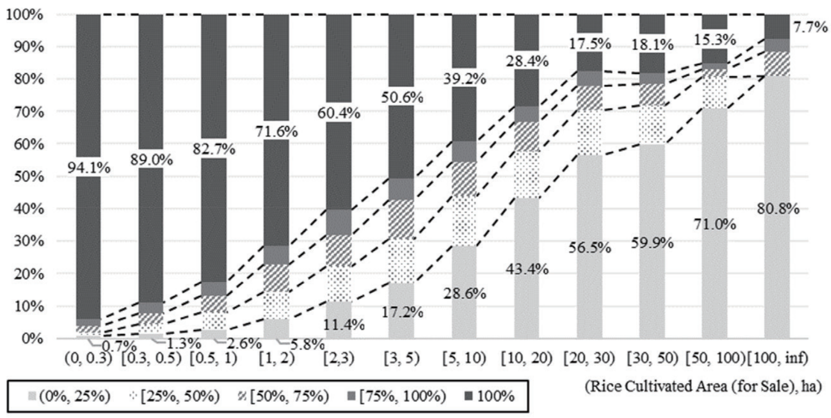

Fig. 2 Relationship between scales of rice cultivated area and the percentage of organic rice field

as the scale of rice cultivation increased up to 100 ha. This indicates that the larger the area cultivated, the more likely the producers to implement organic farming in rice production.

Next, **Fig. 2** shows the proportion of organic rice cultivated area out of the total rice cultivated area in the organic producers. The proportion of organic rice cultivated area was mostly 100% of rice cultivated area up to about 10 ha cultivated area scale. The proportion of 100% organic farming decreased monotonically as the increase in cultivated area scale. The majority of relatively large-scale producers practiced organic farming in a part of their cultivated rice fields. This may reflect the fact that it is appropriate for relatively small producers to practice organic farming in the entire field from the viewpoint of managing contamination from neighboring fields. In large-scale producers, their arable land is usually fractionated into several plots, and, in many cases, each plot is apart (e.g., Kawasaki 2010). Therefore, large-scale producers can practice organic farming in some of the plots while conventional farming in the rest of the plots.

Conclusion

According to the Census of Agriculture and Forestry in 2020, 115,269 hectares were cultivated by organic farming practices. It was 10 times larger than the area certified by JAS. This may reflect that organic agriculture in the census can include "self-described" organic which may not satisfy the standard of JAS certification. However, even if self-described organic is counted, there is still a large gap between the census organic farming area and the target in 2050.

Large-scale producers tend to practice organic farming in the part of their cultivated area. As a result, the expansion of organic cultivated areas continues to be limited.

Toward the achievement of the goal of organic farmland, the results of this paper suggest that it is necessary to consider not only increasing the number of organic producers but also expanding the area of organic farming for each producer.

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Symposium mini review

The Evaluation Management of Organic Rice Production by Farmers in Yasothon Province, Thailand

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Keywords
organic rice, the evaluation management, cost and return, supply chain, Yasothon Thailand

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Abstract

The objectives of this research were to: 1) study the general conditions of farm operations of certified organic rice producers; 2) study about cost and return of organic rice production. This research was collected by interviewing 328 samples of organic rice producers in Yasothon province, and data analysis by using simple statistics to find the frequency and percentage. The results showed that most organic rice producers were female, who graduated from primary school early, with a career in farming as their main occupation, most organic rice producers had family members between 3-4 persons. Furthermore, these people possibly had more experience in farming between 21-30 years for farmers of Thailand. As a result, with more than 7 years of experience in organic rice production, this group of farmers is certified under organic export standards. Besides, organic rice farmers had small farms between 0.96-1.6 ha for rice cultivation, generating sufficient income as their main source. The investment in that farm is mostly self-financed. When considering the production cost and return of organic rice farmers in Yasothon province, it was found that the average total cost for growing rice in 2017-2018 was 4,329.32 baht per ha. The average selling price was 14.77 baht per kilogram. Farmers had a total revenue of 29,716.94 baht per ha. Organic rice production had an average net profit of 25,387.62 baht per ha, with average net revenue of 26,929 baht per ha. Variable cash costs found that farmers who produce organic rice had net revenue above variable cash costs which was 643.81 baht per ha. In addition, the break-even point of organic rice farmers was an average break-even yield of about 293.12 kg per ha and a break-even price of about 2.15 baht per kg.

Introduction

The cultivation of organic rice in Thailand has been inherited since ancient times. Non-chemical-based (organic) rice production is currently in practice in many areas of the country which is specifically combined with meticulous production processes to meet standards of organic rice production systems. This explains why Thailand has won the confidence of rice consumers worldwide. Given the current and emerging trends of organic rice production, government agencies continue to facilitate farmers in fulfilling control and monitoring, based on international standards of organic agriculture such as the International Federation of Organic Agriculture Movements (IFOAM).

Despite Thailand being the world's 5th largest rice producer and largest exporter, rice production in Thailand is a result of expansion in area under production rather than an increase in yield per hectare (Thuithaisong *et al*., 2011). Since the last few years, the area under rice cultivation has decreased by 0.6% from 11.23 million hectares in 2007 to 11.10 million hectares in 2009 (OAE, 2009). Increasing yields per rai (1 rai= 0.16 ha), however, requires improved socio-economic conditions and efficient production management of rice-producing farms (Songsrirod, 2007). Production efficiency of farms means the acquisition of maximum production goals without any waste (Ajibefun and Daramola, 2003). Technical efficiency is the ability of a farmer to produce maximum output from given inputs (Elhendy and Alkahtani, 2013). The measurement of efficiency in agriculture is important because it provides a success indicator and performance assessment through which production units are evaluated. Previous studies have mentioned that the current production of rice at farms is below the ultimate output potential (Pochatarn, 2005), highlighting the need to increase production efficiency.

Growing concerns about environmental degradation caused by chemical-based crop cultivation and related issues have increased the demands for environmentally feasible organic foods (Basha *et al*., 2015; Hazra *et al*., 2018). The purchase of high-quality organic foods is directly linked with consumer's risk perception of chemical pesticides used in food production. Therefore, their health and biosafety are the main reasons which cause them to consume organic foods (Ueasangkomsate and Santiteerakul, 2016). Similarly, in Thailand, consumers are well aware of healthier products. Organic agriculture in Thailand expanded by 21% in 2017, with organic rice production increasing 28%, and other integrated farming experiencing a growth of 187% (Kerdsriserm *et al*., 2018).

According to the survey of positioning in 2019, the major markets were countries in Europe, where the demand for organic rice in the European market increased by 15-20% per year. Additionally, it is likely that Thai organic rice exporters will be able to penetrate more markets, namely the US, Japan, and Australia. For the organic rice market in Thailand, it accounts for about 4% of the total amount of organic rice produced. The organic rice sold in the country is divided into two markets: organic rice sold in modern trade channels and direct sales channels of which the price is quite high. But it adheres to the same standard as rice for export to the other markets and is the organic rice market sold by the farmer's communities. Such markets constitute communities that are the production units and shops for organic products, especially for which the price is lower than the first type of organic rice but still higher than normal rice prices.

Hence in Thailand, in 2017, the Department of Internal Trade Ministry of Commerce adopted the strategy to push 4 organic products with a vision. The main mission was that "Thailand is a regional leader in production, consumption, trade, products, and services of organic agriculture, aligning with sustainability and international recognition". This initiative was in line with the Twelfth National Economic and Social Development Plan in 2017-2021, (Strategy for Strengthening the Economy and Underpinning Sustainable Competitiveness Supporting Organic Agriculture). Its main content was to promote organic agriculture, expanding the farming area and supporting pilot areas such as Yasothon Province as a demonstration project. This involved strengthening existing farmers and extending knowledge networks of successful farmer groups in this area. Key implementing agencies involved are the Ministry of Agriculture and Cooperatives and relevant government agencies, such as the Ministry of Commerce, the Ministry of Interior, the private sector, and farmers' organizations. The operational time frame was set to 5 years by the Office of the National Economic and Social Development Board, and the Office of the Prime Minister in 2016. In 2017, the Agricultural Land Reform Office was assigned to promote sustainable organic farming in all 72 provinces of the land reform area in the country, focusing on the participatory learning process of farmers. This initiative was in line with the national organic development strategy 2017-2021 of the Ministry of Agriculture and Cooperatives.

Though the largest organic rice cultivations are conducted in the Northeast, this region is the poorest region of the country. The population of this region consists of seasonal rice growers, and subsistence-oriented families who sell a surplus of the foods for their livelihoods. Additionally, increasing the scarcity of farm labor afflicts this region (ADB, 2012). Yasothon province of the northeast region is a significant area mainly engaged in organic jasmine rice's unique fragrant characteristic scent. The efficiency of farmers producing organic rice is still very low and facing bio-physical (frequent floods, uneven rainfall, droughts, poor soil fertility, pest infestations), socio-economic (low income related to the high cost of production, unstable paddy prices, shortage of farm labor), and technological (low yielding conventional varieties) constraints (OAE, 2000). There exists a gap between the actual yields obtained at farmer fields and the maximum attainable yield of certain rice varieties that needs to be tackled for better and more efficient rice production on farms. Therefore, in order to gain related information, the supply chain characteristics of the organic rice production farms is an important aspect.

Supply chains of organic rice products were often considered as alternative supply chains, which was shorter, more locally oriented, and in which the producers and consumers were more tightly connected than those in the conventional rice supply chains. Despite this, the involvement of retailing groups into the certified organic rice supply chain has increased the market share of organic products in many European countries (Finfood, 2003; Hamm *et al*., 2002; Kottila, 2006). Therefore, increasing the size of the area of organic production by government policy affects the uncertainty of the number of certified organic rice producers of groups. These predicaments result in a belated delivery to purchase orders and the loss of opportunity in prospective markets. Consequently, supply chain management of organic rice production in Yasothon Province needs to be studied to create stable and sustainable production systems for the members. Finally, results from this study will be beneficial for organic agriculture supply chain management in the region of Thailand, providing insights to develop a sustainable supply chain management model, and establish a policy for other regions.

Moreover, regarding the importance of accelerating the expansion of the area and the amount of production of the organic system to enter the domestic and international markets, there remain some unanswered questions. For instance, how can we increase the certified organic rice production per ha using the same production factors on the farm. Additionally, can we get satisfactory results by applying the production model/Yasothon model to produce organic rice in other areas to be successful as a master model province? Therefore, the present study further attempts to quantify technical efficiency observed at farms producing certified organic rice in Yasothon province of Northeast Thailand to provide insights into the efficient utilization of farm input combinations under current rice farming practices and to evaluate the factors affecting technical inefficiency of certified organic rice growers in the region. Yasothon province is the chosen master province of organic farming as it constitutes the largest area under organic rice cultivation in Thailand. Furthermore, by studying the supply chain structure of organic rice in Yasothon province, we can answer on how to continue to expand the operations in other areas specifically by investigating the certified organic rice product supply chain of the export market.

Materials and Methods

Scope of study

The study area of our research was selected according to The Twelfth National Economic and Social Development Plan in 2017-2021 Thailand to promote organic agriculture city or Yasothon model as an organic farming province to world market targeted areas nationwide.

Sampling methodology

To achieve the goals of this study, a survey was conducted in 2017–2018 to collect farm-level data from certified organic rice-growing farmers in Yasothon Province of Thailand. Yasothon Province is the chosen major province of organic farming. A comparison of the proportion of cultivated area to rice yield revealed that province had a high yield per cultivated area and was ranked at the top in the country (Office of Agricultural Economics, 2018). Multistage cluster sampling was applied to collect the data (Yasothon Provincial Office, 2018). A well-structured questionnaire was prepared, and 328 farmers from a total of 1,811 were interviewed in seven districts, with a total area of 2,485.60 ha (Yamane, 1967). The sample size was estimated by the following formula given by Taro Yamane (1967). In order to know the demographic population, a 95% confidence level and (P-value = 0.5). The data were collected from 1 November 2017 to 30 March 2018 using questionnaires and interviews with the certified organic rice farmers. A total of 328 farmers practicing organic rice farming were selected by the purposive sampling technique. In-depth interviews were conducted in seven districts of Yasothon Province, located in the northeast of Thailand, namely, KutChum, MahaChanaChai, PaTio, KhoWang, LoengNokTha, SaiMun, and Muang Yasothon. This area was chosen for its immense significance in rice production. The participants in the study were mainly organic rice growers who cultivated certified organic rice. They were monitored and accredited by the Organic Agriculture Certification Thailand (ACT) standards. The standards were supervised by the International Federation of Organic Agriculture Movements (IFOAM), EU: TH-BID-121 Thailand Agriculture, and Canada Organic Regime (COR). Interviewed farmers originally accounted for approximately 18% of the population in each district.

Results

Basic socioeconomic

The general conditions of the farm operations of certified organic (jasmine) rice growers were collected by interviewing a sample of 328 organic rice producers in Yasothon Province, and the results were analyzed. Most of the organic rice producers were female rather than male, with females accounting for 57.93% of the sample. Most of them were aged between 51 and 60 years (33.23%), followed by 32.32% who were 41-50 years old, and 25.91% who were 61-70 years old. Further, 69.19% of organic rice growers had a primary school education, followed by 17.68% with junior high school/vocational training and 8.08% with secondary high school/vocational qualification. It is a worrying situation as low education is not conducive to mastering organic rice production technology. It was found that most (47.37%) organic rice producers had three to four family members, followed by 27.19% with one to two family members and 22.37% with five to seven family members. The results showed that 52.74% of organic rice growers had more than seven years of experience producing organic rice, followed by 19.51% with three to four years of experience and 19.21% with one to two years of experience. Most organic rice farmers (25.91%) had areas of 0.96–1.6 ha under organic rice production, followed by 20.43% with an organic rice production area of over 3.36 ha and 20.12% with a production area of 1.76–2.4 ha. Most organic rice farmers (97.87%) used regular labor to produce organic rice, and 55.49% used temporary labor. Most of the organic rice farmers (85.06%) infrequently received regular government assistance, while only 14.94% received it regularly (**Table 1**).

Costs and benefits of organic rice production

Cost and return ratio results of organic rice farmers in the Yasothon province are summarized in (**Table 2**). When considering the production cost and return of organic rice farmers in Yasothon province, it was found that farmers had total cost average equal to 692.69 baht per ha of growing organic rice in the 2017-2018. The average organic rice yield was 2,011.98 kg per ha. The average selling price was 14.77 baht per kilogram. Farmers had total revenue of 29,716.94 baht per ha. Organic rice production had an average net profit of 29,024.25 baht per ha, with an average net revenue of 29,270.87 baht per ha. Variable cash costs found that, farmers who produce organic rice had net revenue above variable cash cost that was 589.68 baht per ha. In addition, the break-even point of organic rice farmers were with an average break-even yield about 46.90 kg per ha and break-even price about 0.34 baht per kg.

Technical Efficiency

The technical efficiency data obtained from the output-oriented (modified) DEA method for a total of 328 farms indicate that about 55 farms (representing 16.77% of the total) were operating with constant returns to scale, whereas 249 farms, constituting the highest share (75.91%), were found to be operating under increasing returns to scale, and about 24 farms (7.32%) were operating under decreasing returns to scale (**Fig. 1**).

The supply chain on organic rice

The market can be divided into two groupings; Export market; It was found that most of the organic rice of Yasothon province for export to markets in the United States of America, Europe, and Singapore accounted for 70%. Additionally, it was found that the most exported organic rice was jasmine rice which accounted for 99% of total export. Domestic market; It was found that organic rice in the domestic market accounted for 30%, such as supermarkets, green markets, hotels, restaurants, schools, consumers in upcountry, and factories (**Fig. 2**).

Table 1. Basic socioeconomic variables of farmers (n = 328)

Variables		Frequency	Percentage
Gender	Male	138	42.07
	Female	190	57.93
Age	Less than 30 years	2	0.61
	31–40 years	13	3.96
	41–50 years	106	32.32
	51–60 years	109	33.23
	61–70 years	85	25.91
	More than 70 years old	13	3.96
Education level (n = 198)	Not studying	1	0.51
	Primary school	137	69.19
	Junior High School/Vocational	35	17.68
	High School/Vocational	16	8.08
	Bachelor	7	3.54
	Master's degree	2	1.01
Household size (n = 228)	1–2 persons	62	27.19
	3–4 persons	108	47.37
	5–7 people	51	22.37
	More than 7 persons	7	3.07
Experience in organic rice production	1–2 years	63	19.21
	3–4 years	64	19.51
	5–6 years	28	8.54
	More than 7 years	173	52.74
Farm size	0.16–0.8 ha	46	14.02
	0.96–1.6 ha	85	25.91
	1.76–2.4 ha	64	19.51
	2.56–3.2 ha	66	20.12
	3.36 ha or more	67	20.43
Family workers *	Regular workers	321	97.87
	Temporary workers	182	55.49
Receiving help from the government	Received regular help	49	14.94
	Was assisted infrequently	279	85.06

Note: * Farmers could choose more than one item.

Table 2. Cost and return from organic rice production (single) planting year 2017-2018

List	Amount of input
Yield (kg/ha)	2,011.98
Paddy Price (baht/kg)	14.77
Total Revenue (baht/ha)	29,716.94
Total Cost (baht/ha)	692.69
Variable Cost (baht/ha)	446.07
Variable Cash Cost (baht/ha)	103.01
Variable Non-Cash Cost (baht/ha)	363.06
Fixed Costs (baht/ha)	246.62
Fixed Cash Costs (baht/ha)	0.80
Fixed Non-Cash Costs (baht/ha)	245.82
Net Revenue (baht/ha)	29,270.87
Net Revenue Overhead Variable Cash Cost (baht/ha)	589.68
Net profit (baht/ha)	29,024.25
Break-even point; in unit (kg/ha)	46.90
Break-even price (baht/kg)	0.34

Discussion

Socio-economic characters of certified organic rice producers

The results showed that gender, age, and level of education are related to the production of organic rice. Most organic rice producers were female. The reason is that they are middle-aged women who graduated from primary school early. Residents outside the city often engage in agriculture, farmers have a career in farming as their main occupation and no extra occupation, which is similar to personal characteristics in other regions of Thailand as reported by (Kerdsriserm *et al*., 2016 and Kerdsriserm *et al*., 2018). As for household size, most organic rice producers had family members between 3-4 persons, supported by the findings of (Kallika *et al*., 2010). However, in rural areas, farmers in Kwara State, Nigeria, reported a larger household size with an average family size of 12 members (Ogunniyi *et al*., 2015), while in Nepalese,

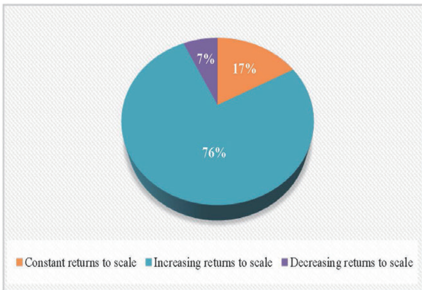

Fig. 1 The returns to scale of certified organic rice-producing farms

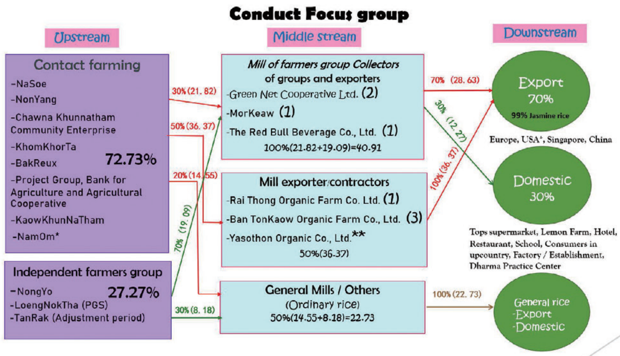

Fig. 2 An organic rice supply chain for Yasothon province

the reported average family size was 8 members (Dhungana *et al*., 2004). Hence, most of the family workers were regular workers for farms. Furthermore, these farmers have more experience in farming between 21-30 years like the research report of Kerdsriserm *et al*., 2018 and Kallika *et al*., 2010. Which is different from Ogunniyi *et al*., 2015, who reported farmers in Nigeria have experience in farming between 11-20 years. As a result, these farmers have more than 7 years of experience in organic rice production, causing this group of farmers to be certified organic export standards (Organic Agriculture Certification Thailand, 2018). In addition, organic rice farmers had small-sized farms between 0.96-1.60 ha for rice cultivation (Klinchan, 2014 and FAO, 2018). These farms serve as the main income, providing sufficient means to maintain a balance between income and expenditure. The investment in these farms is mostly self-financed. Farmers in the northeastern region have less rice-growing areas than those in the central region. However, most rice farmers in the central region have loans (Kallika *et al*., 2010 and Tonpanya, 2011). Similarly, it was found that those with organic rice growers are certified to international standards. Receiving agricultural knowledge news and assistance from government officials influence on the quality of rice cultivation in the organic system. This impact might be attributed to the increased knowledge, understanding, and received information gained about organic rice cultivation in the system (Kerdsriserm *et al*., 2016).

Technical Efficiency

In this study, the analysis of technical efficiency using the DEA method revealed that 17% of organic rice-producing farms were operating under constant returns to scale. About 7% were found to exhibit decreasing returns to scale, and 76% were within increasing returns to scale (Krasachat, 2004). Our results are supported by findings in the same northeast region in a similar (jasmine) rice-growing area in Chiang Mai Province of Thailand (Chauanphoonphon, Wibunphong and Sriboonjit, 2005).

The supply chain on organic rice

The results showed that these activities were linked together across the supply chain from upstream to downstream and may be divided into 3 sub-sectors. These findings are advocated in Chachoengsao Province of Thailand (Kerdsriseam and Suwanmaneepong, 2015). The organic jasmine rice commodity chain is based on the re-arrangement of the conventional rice commodity chain (Taotawin, 2011). The organic rice supply chain exhibits a shorter structure compared to the general supply chain (Kottila, Maijala, and Rönni, 2006). Furthermore, the results showed that 70% of organic rice produce of Yasothon province was exported to markets in the United States, Europe, and Singapore which corresponds to the previous study by (Yotkaew, 2017). Whereas the amount of organic rice sold in the domestic market remains at an average of 30%, which is consistent with the study of (Ruenglertpanyakul, 2016).

Conclusion

When considering the organic rice supply chain that has been certified for export, it was found that the characteristics of the organic rice supply chain in Yasothon are shorter than conventional rice. However, the obtained data revealed that the current situation of the supply chain in the focused area predicts the highest (70%) annual export of organic rice to the United States of America, Singapore, and European markets apart from the domestic market, which constitutes 30% of the total produce. Moreover, the cost and benefit ratio analysis revealed that when considering the production cost and return of organic rice farmers in Yasothon province, it was found that farmers had a total cost average equal to 4,329.32 baht per ha of growing organic rice in 2017-2018. The average selling price was 14.77 baht per kilogram. Farmers had a total revenue of 29,716.94 baht per ha. Organic rice production had an average net profit of 25,387.62 baht per ha, with an average net revenue of 26,929 baht per ha. Variable cash costs found that farmers who produce organic rice had net revenue above variable cash cost which was 643.81 baht per ha. In addition, the break-even point of organic rice farmers was an average break-even yield of about 293.12 kg per ha and a break-even price of about 2.15 baht per kg. From the result of this research, it can be concluded that Thai farmers have great potential to increase the yield of organic rice production, which can reach 72%-77% at maximum.

The research is expected to yield benefits such as information on organic rice production and export market system. This information can be presented to government and private sectors engaged in promoting the farmers to increase their production capacity and improve the standard of living of organic rice farmers. Furthermore, this study can provide critical information to farmers, agricultural planners, and the Thai government departments to determine strategies that are useful and practical in raising efficiency performance in each region and to help increase the trend of the rice productivity index in some areas of Thailand. Besides, increasing rice yield per ha under the present technology can be achieved by improving the socio-economic characteristics and production management of farmers. In other words, the technical efficiency of rice production can be increased by improvements in farmer conditions and farm characteristics levels.

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Symposium mini review

No Organic or Chemical Input Crop Production (NOChI-CP) and Activities of the NPO No Organic or Chemical Input Crop Production Research Group

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Abstract

There is a growing concern regarding the impact of agriculture on both human health and the environment, and a unique approach named here as "no organic or chemical input" (NOChI) crop production (NOChI-CP) has gained attention. NOChI-CP avoids the use of fertilizers, pesticides, and even organic materials. This is rooted in a philosophy that allows the soil to fully express its inherent capabilities. Research efforts have been dedicated to exploring the intricacies of NOChI-CP, which NPO *Muhiken* currently promotes. This review provides an overview of NOChI-CP and outlines the group's promotional activities. Several studies in rice have revealed that NOChI-CP exhibits a low, but stable and acceptable yield. Compared with conventional rice production, varieties with the "panicle weight" plant-type and late-maturing trait adapted better to NOChI conditions. It has been reported that some nutrient requirements are met by nutrients carried in irrigation water, but further study is required. NOChI rice is more resistant to blast diseases and brown planthoppers than conventionally fertilized rice. In a long-term survey of NOChI mulberry production, leaf yields had long been comparable to conventional practices. The leaves produced in NOChI-CP were significantly preferred by silkworm larvae over fertilized leaves, and silkworms raised on NOChI leaves showed higher resistance to carcinogenic substances. NPO *Muhiken*, No Organic or Chemical Input Crop Production Research Group, is active in four main areas: research, public relations, technical support, and certification. The research includes both practical and academic perspectives. The public relations include three major events (meetings, exhibitions, and excursions) and publish a periodic newsletter. Moreover, the staff periodically visits member farmers' fields across Japan for technical support and certification.

Introduction

Modern agricultural practices, once solely focused on productivity, are undergoing reevaluation. While the "Green Revolution" has significantly boosted crop yields, the adverse effects of chemical fertilizers and pesticides on the environment and human health have long been ignored. In recent years, there has been a growing emphasis on human health and environmental conservation, leading to extensive research on the effects of organic and other environmentally friendly agricultural practices on soil and human health, and their complex interactions (Reeve *et al*., 2016). However, some farmers choose to adopt alternative approaches, practicing crop production without resorting to chemical fertilizers or organic materials, a method referred to as no-organic or chemical input crop production (NOChI-CP).

Mr. Mokichi Okada, the pioneer of NOChI-CP, asserted that soil inherently possesses the capability to yield edible plants sufficient for sustaining human life, a quality he termed "natural power" (Okada, 1984). NOChI-CP is a cultivation method designed to allow the soil to fully harness this natural power. While Okada (1984) initially referred to these methods as "nature farming", we have opted to name it "NOChI-CP" to avoid confusion with the varied interpretations of "nature farming," which can include organic agriculture, no-tillage cultivation, and other practices (also, in Japanese, "nochi" translates to agricultural field).

Although the number of published reports on NOChI-CP is limited, the advantages of crops produced under this system have become progressively recognized. Despite not yet achieving large-scale implementation, we are advocating adoption of this unique cultivation method for the benefit of environmental conservation and food safety.

The objective of this review article is to present overview and the state of the knowledge of NOChI-CP as well as the promotional activities of NPO *Muhiken*.

No organic or chemical input crop production (NOChI-CP)

Experiments and field surveys were conducted to elucidate the nature of NOChI-CP, primarily in rice paddy fields. The yield of NOChI-CP rice ranged from 2 to 4 t ha^{-1} in nine fields (Tada *et al*., 2023). Notably, in the two of the nine fields located in Ritto, Shiga Prefecture, NOChI rice production was practiced from 1951 to 2006, consistently yielding approximately 4 t ha^{-1} of grain (Hasegawa *et al*., 1979). In a study comparing the growth of rice plants under NOChI and conventional fertilization, it was observed that the crop relative growth rate, especially in roots, decreased more slowly in the late grain filling stage in the NOChI field than that in the conventional field (Takeuchi *et al*., 1979a). Takeuchi *et al*. (1979a) concluded that the dry weight of the roots of NOChI plants in the late grain-filling stage exceeded that of fertilized plants, suggesting that the "autumn vigor" type phenomenon observed in NOChI paddy fields may be attributed to these differences. Further experiments examining the varietal difference in the growth of rice under NOChI-CP and conventional fertilization have revealed that panicle weight-type varieties adapt favorably under these conditions (Okumura *et al*., 1979). Additionally, the study suggested that late-maturing cultivars should be selected as planting varieties.

Few studies have been conducted to elucidate the mechanisms underlying sustained NOChI rice yields in terms of soil and water nutrition. Notably, the previous research by Hasegawa *et al*. (1979) and Takeuchi *et al*. (1979b) reported that a greater amount of irrigation caused a relatively high yield in the Ritto fields described above. In a quantitative analysis of nitrogen in the Ritto fields, Okumura (2002) demonstrated that 26%, 12%, and 62% of the nitrogen were supplied from irrigation water, biological fixation, and soil complex, respectively. Collectively, these contributions maintain stable grain production. However, Tatara *et al*. (2016) reported that nutrient supply with irrigation water was not always large. Further studies are required to comprehensively elucidate the mechanisms underlying the stable yields of NOChI rice.

NOChI rice is resistant to plant diseases and pests, which has been extensively investigated. Notably, differences have been observed in a study focusing on blast disease resistance in rice plants grown under NOChI-CP. The percentage of silicate-accumulating cells in the leaves per unit area was smaller at the early growing stage but larger at the late growing stage in NOChI rice than in rice cultivated with fertilizers and chemicals. The larger percentage leads to lower grades of invaded cells and decreases fungal appressoria formation. Collectively, these findings suggest that NOChI rice displays higher resistance to blast disease than conventional rice (Hirai and Kimura, 1979). Additionally, Sugimoto *et al*. (1984) compared the degree of damage caused by brown planthoppers in two adjacent rice fields, one a NOChI field and the other a conventional field. This study revealed that damage rarely occurred in NOChI fields. This can be attributed to the greater tolerance to feeding by brown planthoppers in rice plants grown in the former fields, owing to the high C/N ratio in rice stems and leaves, an increase in the number of silicate cells in the late growth stage, and greater predation by spiders living at higher densities in NOChI fields.

In addition to rice, mulberry grown under NOChI conditions was investigated for productivity and interaction with silkworms, focusing on attractiveness and worm health. In a comparative study spanning 19 years between NOChI and fertilized mulberry fields, the yearly yield of fresh leaves from NOChI field remained stable, ranging from 1800 g m^{-2} to 2000 g m^{-2}, which was almost equivalent to the level observed in the fertilized field (Kuwada *et al*., 2006). Annually, 17.5 g m^{-2} of nitrogen was estimated as the input to the NOChI field from the natural environment, with the majority presumed to originate from the nitrogen pool in subsoil layers, the adjacent environment, and/or atmospheric nitrogen fixation (Kuwada *et al*., 2006). Interestingly, the attractiveness of NOChI mulberry leaves to silkworm larvae was significantly higher than that of fertilized leaves, with nitrogen fertilizers demonstrating a tendency to decrease attractiveness (Kuwada and Horie, 2002). Furthermore, silkworm larvae raised on NOChI mulberry leaves exhibited approximately 10-fold stronger resistance to phloxine, a known carcinogenic substance, than those raised on fertilized leaves (Kuwada and Horie, 2004).

Although determining the direct effect of food on human health remains challenging, the significance of this task remains paramount. The Iwata Takeru Shoten store, which deals with NOChI products, has been receiving positive comments from the consumers. They underscore the importance of a scientific investigation on the potential health effects of NOChI products.

No Organic or Chemical Input Crop Production Research Group (NPO *Muhiken*)

NPO No Organic or Chemical Input Crop Production Research Group is called NPO *Muhiken* in Japanese. The group was established in 2000 with the primary objective of studying and disseminating NOChI-CPs (website [in Japanese]: https://muhiken.or.jp/). As of December 31, 2023, the group comprised 119 regular members and 35 supporting members. Its activities are centered on four main areas: research, public relations, technical support, and certification. Below, we provide a brief overview of each.

Research stands as the cornerstone of the group activities. The dedicated staffs of NPO *Muhiken* conduct experiments to establish effective cultivation methods for NOChI-CP. For example, they examined the impact of tillage treatments on rice and weed growth, as well as the effects of winter flooding and midseason drainage on rice growth in the unique production system. Collaborations with researchers from various fields, including Kyoto University, Kyoto Prefectural University, and Nara Institute of Science and Technology, contribute to the experiments, by providing diverse perspectives on the production system. Most of these experiments have been conducted in NOChI fields managed by the group (**Fig. 1**). The outcomes of these studies are presented annually and discussed at the meetings described below.

Public relations activities include research meetings, exhibitions, excursions, and the periodic publication of

Fig. 1. One of the no organic or chemical input (NOChI) paddy fields managed by our group (NPO *Muhiken*), located in Uji city, Kyoto.

Fig. 2. Our group's activities related to public relations: research meetings (a), exhibitions (b/c), reception after the meetings or the exhibitions (d), excursions (e), and newsletters "*Muhiken dayori*" (f).

newsletter, "*Muhiken dayori*." As a major event, an annual research meeting takes place in March where researchers, producers, distributors, and consumers discuss the outcomes of the year's research activities (**Fig. 2a**). Subsequently, a reception is held featuring a meal that showcased a variety of NOChI crops, fostering participant enjoyment and communication. Another significant event, the exhibition in November showcases crops and processed products from members across Japan (**Fig. 2b/c**), with participants enjoying lectures, panel discussions, and a tasting reception featuring a diverse array of NOChI products (**Fig. 2d**). Moreover, an annual excursion takes participants to various member fields, including rice paddies, tea plantations, and upland fields (**Fig. 2e**), offering firsthand experience and insights into different agricultural practices. The newsletter, "*Muhiken dayori*," is published several times a year, providing updates on the group activities, introducing new farmer members, and more (**Fig. 2f**).

The group places a significant emphasis on technical support and certification within the NOChI-CP framework. To extend the technical expertise, the group staff travels extensively across regions from Hokkaido to Kyushu and Okinawa, delivering lectures and providing training to farmers and their successors in NOChI-CP techniques (**Fig. 3a**). This hands-on approach helps farmers manage their production practices. Certification is a vital component of the group activities, in which the staff confirms whether fields of the member farmers are managed according to the principles of NOChI-CP. Products from certified NOChI fields or processed products made from such products are distinguished by special seals based on the duration of NOChI-CP continuity. Products with 10 years or over of NOChI-CP earn gold seals, those with three years or over receive silver seals, and those less than three years are marked with green seals (**Fig. 3b**). As of December 31, 2023, the area of fields registered as NOChI fields totaled 62.5 ha, distributed across various categories. This includes 28.8 ha of rice fields managed by 39 farmers, an upland field area of 28.3 ha managed by 26 farmers, a tea field area of 1.0 ha managed by four farmers, and an orchard area of 4.4 ha managed by eight farmers. This widespread adoption reflects the successful integration and management of NOChI-CP practices among member farmers.

Acknowledgments

We would like to thank our member farmers practicing NOChI-CP, and our regular and supporting members who cooperated with us. Special appreciation is extended to the many researchers and collaborators for their valuable comments and contributions. We would like to express our sincere thanks to Iwata Takeru Shoten for providing us with valuable consumer voices. We would like to thank Editage (www.editage.jp) for English language editing.

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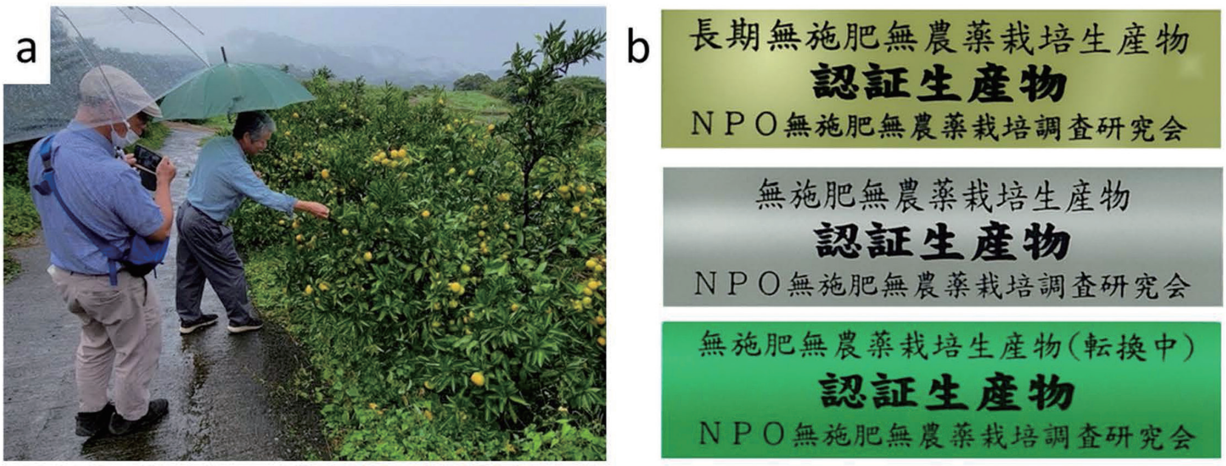

Fig. 3. Our staff travels across the region for technical support and certification (a). Products from the certified fields with 10 years or over of no organic or chemical input crop production (NOChI-CP) earn gold seals, those with three years or over receive silver seals, and those less than three years are marked with green seals (b).

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Symposium mini review

Reduction of Fe with Application of Saturated Soil Culture Technology and Biomass Ameliorant on Organic Rice Farming in Tidal Swamp

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Keywords
pyrite, saturated soil culture, organic rice farming, tidal swamp

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Abstract

The main constraint of rice cultivation in tidal swamps is pyrite (FeS2). Iron from pyrite reaction in the flooded (reductive) soil condition will be changed from Fe^{3+} to Fe2+, and Fe^{2+} is more absorbed than Fe3+ and causes poisoning in rice plants. Saturated soil culture (SSC) is a cultivation technology that gives continuous irrigation and maintains water depth constantly and makes the soil layer under root in a saturated condition. This technology is more appropriate to prevent pyrite over-reduction than conventional culture (flooded culture).

This research was conducted in Banyuasin District, South Sumatera Province; and in Tanjung Jabung Timur District, Jambi Province from 2009-2022. These objectives of this research are to study: 1) the rice adaptation mechanism to the soil with high Fe content, 2) the efficiency of production input of rice cultivation with biomass ameliorant, and 3) the farmer's response to the application of innovation. This research used field and greenhouse experimentation designs. This research consisted of 1) a study of the rice adaptation mechanism, 2) the response of rice varieties under SSC and Flooded Culture (FC), 3) the effect of biomass ameliorant on rice productivity, and 4) dissemination of technological innovation to the farmer.

The rice adaptation mechanism on SSC was begun with the increasing root ethylene content, aerenchyma formation, Fe deposit on the soil layer and Fe leaching on the ditch, and the decreasing of Fe in the leaf and bronzing percentage, and then the increase of productive tiller and grain dry weight per plant.

The highest productivity on sensitive until medium tolerance was obtained under SSC, but on tolerance genotype was obtained on flooded with drainage. Indragiri was grouped as tolerance, IRH108 as a medium, and IR64 as sensitive to the high Fe in tidal swamps.

Application of rice straw in the soil will improve soil fertility in tidal swamps, the straw will release humic acid, which will then chelate Fe and Al solubility. The application of rice straw will decrease NPK doses by 50 %.

The production input from local farmers was lower than that from transmigration farmers. High-yielding varieties were more responsive to the fertilizer than local varieties, thus, the transmigration farmer usually applied chemical fertilizer and pesticides, while the farmer local only used seed input. The productivity of rice on a local farmer is only 1.5-2.0 ton ha^{-1} and on a transmigration farmer 2.5-3.0 ton ha^{-1}. After we introduced our technology with SSC in combination with biomass ameliorant and NPK, the productivity increased to 5-6 tons ha^{-1}.

Introduction

Indonesia has tidal swamp areas about 20.1 million ha and 9.53 million ha suitable for agriculture. These areas were distributed at Sumatera, Kalimantan, Sulawesi, and Papua (Suwanda and Noor, 2014). The main constraint of rice cultivation in tidal swamps is pyrite (FeS_2) (Susilawati *et al*., 2017). Iron from pyrite reaction in the flooded (reductive) soil condition will be changed from Fe^{3+} to Fe^{2+}, and Fe^{2+} is more absorbed than Fe^{3+} and causes poisoning in rice plants. Saturated soil culture (SSC) is a cultivation technology that gives continuous irrigation and maintains water depth constantly and makes the soil layer under root in a saturated condition. This technology is more appropriate to prevent pyrite over-reduction than conventional culture (flooded culture). SSC was made with a wide bed, 4 m in width, along with ditches that were 30 cm wide and 10 cm deep under soil surface (Ghulamahdi *et al*., 2022).

Iron is absorbed by plants in the form of Fe^{2+} or Fe^{3+} ions, but the most absorbed is Fe^{2+} ions. Fe^{2+} ions which are absorbed by the roots then enter the roots starting from the epidermis, cortex, endodermis and vascular tissue (xylem) and then the Fe^{2+} ions are transported to the canopy via transpiration to the spaces between cells in the leaves. In the leaves, these ions act as catalyst for the formation of several types of reactive oxygen such as SOD, hydroxide radicals and H_2O_2 (Marschner, 2012). Ferri iron (Fe^{3+}) can also be absorbed by roots with the help of chelating agents. This chelating mechanism is more efficient than the reduction mechanism of Fe^{3+} to Fe^{2+} by reducing bacteria. Based on the research, Fe^{2+} ions are immobile in plant tissues, that is, the presence of these ions cannot be moved by being broken down from one tissue to another, especially from old tissue to young tissue, so that symptoms of Fe deficiency are more common in young leaves (Kim and Guerinot, 2007). Plants that experience Fe poisoning have different responses both morphologically and physiologically. This difference can be seen, among others, in differences in Fe accumulation in roots, stems and plant canopy (Audebert and Sahrawat, 2006).

Rice plants have strategies in dealing with Fe stress environments, namely: (1) excluder/avoidance: roots do not absorb Fe, retain Fe at the root level, do not absorb Fe^{2+} ions because they have the ability to oxidize Fe^{2+} to Fe^{3+} in the rhizosphere and also roots have ion selectivity root cell membrane by not absorbing Fe^{2+} ions. (2) includer/avoidance: Fe^{2+} ions are absorbed by roots but tissue damage can be avoided by compartmentation (immobilization of active Fe in disposal sites such as leaves that are no longer active in photosynthesis) or removing from symplast (immobilization in apoplast leaves), and (3) includer tolerant plants can tolerate increased Fe ions in leaf cells by means of enzymatic detoxification in the symplast. Fe detoxification (included/tolerant), that is, plants are able to withstand Fe poisoning in cells through an enzymatic detoxification mechanism in the symplast (Becker and Asch, 2005). Iron poisoning in plants is caused by the high uptake of Fe in plant tissues as a result of the high concentration of Fe^{2+} ions in the soil solution (Makarim *et al*., 1989). Excessive absorption of Fe results in increased polyphenol oxidase enzyme activity which will eventually increase the amount of oxidized polyphenols. This is thought to be the main cause of the formation of leaf rust (bronzing). Symptoms that can be seen in plants experiencing iron poisoning at the tips of the leaves are black spots that then spread to all parts of the leaf. Following this, the leaves turn brown and dry, and tiller formation and stem elongation are inhibited (Asch *et al*., 2005; Dobermann and Fairhurst, 2000).

Fe poisoning in tidal land is a major obstacle because the land has pyrite compounds. Under reduced conditions (flooding), the solubility of Fe^{2+} ions in the soil can be triggered and, the possibility of plant poisoning is very high. This iron poisoning can occur in the vegetative and generative phases. During the vegetative phase, poisoned plants are characterized by being dry and abnormally tall. The dry weight of the plants also decreased and the tillers were much reduced and the chlorophyll was low so that the appearance of the plants became ugly.

The objective of this research is to study: 1) the rice adaptation mechanism to the soil with high Fe content, 2) the efficiency of production input of rice cultivation with biomass ameliorant, and 3) the farmer's response to the application of innovation.

Material and Methods

This research was conducted in Banyuasin District, South Sumatera Province; and in Tanjung Jabung Timur District, Jambi Province from 2009-2022. This research used field and greenhouse experimentation designs.

This research consisted of 1) a study of the rice adaptation mechanism, 2) the response of rice varieties under Saturated Soil Culture (SSC) and Flooded Culture (FC), 3) the effect of biomass ameliorant on rice productivity, and 4) dissemination of technological innovation.

Result and Discussion

The rice growth under SSC was better than FC (**Fig. 1**), The rice adaptation mechanism on SSC was begun with the increasing root ethylene content, aerenchym formation, Fe deposit on the soil layer and Fe leaching on the ditch, and the decreasing of Fe in the leaf and bronzing percentage (**Fig. 2**), and then increasing of productive tiller and grain dry weight per plant (**Fig. 2**).

Shoot Fe content on SSC was lower than that on FC. The highest shoot Fe content and bronzing percentage were obtained on IR 64 with FC water management, and the lowest Fe content and bronzing percentage were obtained on

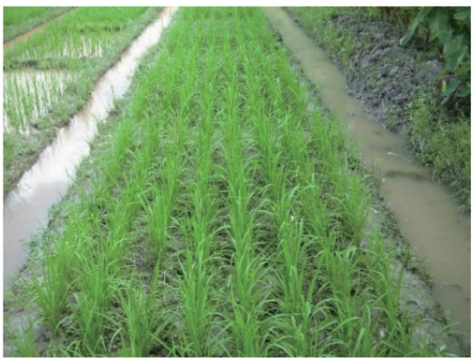

Fig. 1. Rice growth under Flooded Culture (FC-Left), and Saturated Soil Culture (SSC-Right)

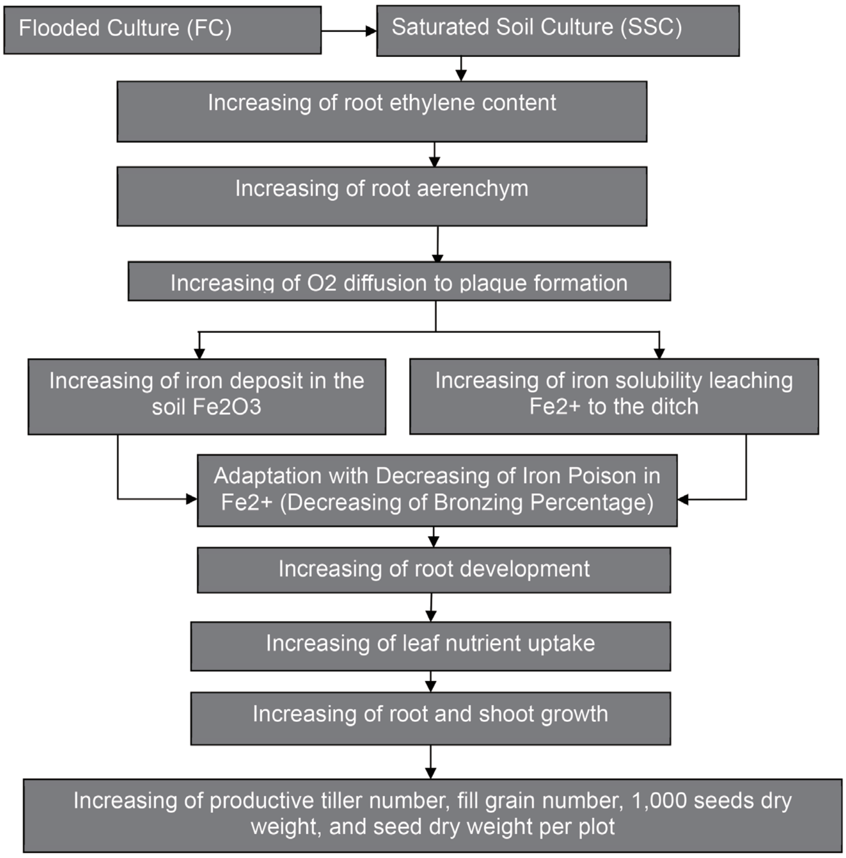

Fig. 2. Physiological change of rice from Flooded Culture to Saturated Soil Culture

Indragiri with SSC water management (**Fig. 3 and 4**). The tolerance mechanism from Indragiri was predicted by excluder and includer mechanism, but IR 64 by excluder mechanism. According researcher Becker and Ash (2005), stated that excluder type: Fe^{2+} was changed to plaque in Fe_2O_3 formation in rice root, but includer type: Fe^{2+} enter to the root and then to the leaf, in the leaf Fe^{2+} was neutralize by SOD enzyme (Super Oxide Dismutase), and result H_2O_2 was change to H_2O and triplet oxygen, so it is not poison to the rice plant.

The highest productivity on sensitive until medium tolerance was obtained under SSC, but on tolerance genotype was obtained on flooded with drainage. Indragiri was grouped as tolerance, IRH108 as a medium, and IR64 as sensitive to the high Fe in tidal swamps (**Table1**).

Application of rice straw in the soil (equivalent 7-10 tons ha^{-1}) will improve soil fertility in tidal swamps because, in the decomposition process, the straw will release humic acid (Toyip, 2020), which will then chelate Fe and Al solubility (**Table 2**). The application of rice straw will decrease NPK doses by 50 % (Sugiyanta, 2007).

In the other research, the application of peat humic acid increased rice productivity by as much as 30 kg ha^{-1}. The highest productivity was obtained on Inpara-2 with humic acid under SSC compared to FC without humic acid (Yartiwi, 2022). If we use high-tolerance rice under SSC on soil Fe content under 10,000 ppm, the rice productivity will increase

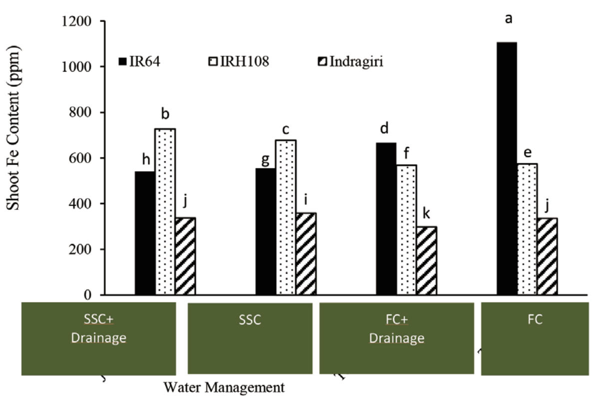

Fig. 3. Shoot Fe content of three varieties under FC and SSC

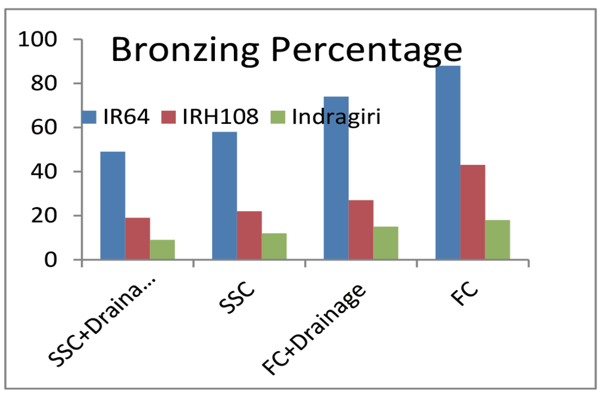

Fig. 4. Bronzing percentage of three varieties under FC and SSC

Table 1. Rice productivity of three varieties under FC and SSC on soil Fe content upper 20,000 ppm

Genotype	Water Management			
	SSC+Drainage	SSC without Drainage	FC + Drainage	FC Without Drainage
IR 64	4.41^{f}	4.56^{ef}	0.00^{h}	0.00^{h}
IRH108	5.46^{c}	4.81^{de}	3.80^{g}	0.00^{h}
Indragiri	6.23^{b}	5.96^{b}	6.83^{a}	5.13^{d}

Note: Numbers followed by the different letter are significant different with Duncan Multiple Range Test α 5 %

Table 2. The effect of straw biomass and ploughing to the soil chemical change (Toyip, 2020)

Soil Chemical	Soil Before Treatment	Straw Bimass without ploughing	Straw Biomass with 1 ploughing	Straw Biomass with 2 ploughing
pH	3.9	4.2	6.2	5.7
C (%)	4.01	3.69	10.83	11.08
N (%)	0.21	0.20	0.42	0.43
C/N	19	18	26	26
P_2O_5 Olsen	16.04	-21.33	51	37
K_2O	83	71	608	200
Ca (cmol(+) kg^{-1})	0.70	1.10	10.50	5.83
Mg (cmol(+) kg^{-1})	0.71	0.56	0.67	0.62
K (cmol(+) kg^{-1})	0.08	0.07	0.64	0.25
Na (cmol(+) kg^{-1})	0.15	0.12	0.16	0.22
CEC (cmol(+) kg^{-1})	8.39	7.91	17.65	15.31
Base Saturation(%)	20	23	67	45
Al (cmol(+) kg-1)	6.09	5.63	0	0
Fe (%)	2.80	2.77	1.98	1.47
S (%)	0.07	0.01	0.20	0.20
Pirit (%)	0.38	0.38	0.13	0.03
Humic acid %)	7.29	7.27	12.42	16.45

to 7-9 tons ha^{-1}. The productivity of Inpari16-Pasundan, Sertani, Inpara2, and IR64 on soil Fe content 3,000 ppm was obtained: 9.35, 8.35, 7.73, 6.55 ton ha^{-1}, and on soil Fe content 6,000 ppm was obtained: 7.66, 6.20. 5.90, and 4.51 ton ha^{-1} (Lestari *et al.*)

Local farmers usually use local varieties with a long age of about 180 days, but transmigration farmers (who move from Java to Sumatra) usually have high-yielding varieties with a shortage of about 115-120 days. The production input from local farmers was lower than that from transmigration farmers. High-yielding varieties were more responsive to the fertilizer than local varieties. Therefore, the transmigration farmer usually applied chemical fertilizer and pesticides, while the farmer local only used seed input. The productivity of rice on a local farmer is only 1.5-2.0 ton ha^{-1}. and on a transmigration farmer 2.5-3.0 ton ha^{-1}. After we introduced our technology with SSC in combination with biomass ameliorant and NPK, the productivity increased to 5-6 tons ha^{-1} (**Table 3**).

We are cooperating with a private company (FKS Multi Agro) to implement the SSC technology on farmer land in the tidal swamp. The private company gave production input (seed, ameliorant, and fertilizer) and the farmer conducted it with SOP (Standard Operational Procedure) of SSC technology. The farmer gets 75 % and the private company 25 % of the benefit. The farmer was responsive to following this project in Jambi Province.

The recommendations to implement organic rice farming in tidal swamps are: 1) to use high-yielding variety with high tolerance to high soil Fe content, 2) to prepare the land with minimum tillage, 3) to use SSC with a wide bed, 4 m in width, along with ditches that were 30 cm wide and 20 cm deep, 4) to use biomass ameliorant (straw biomass, soybean biomass, humic acid) combination with dung and bio-chart, 5) to use microorganism FMA (Fungy Micorrhyza Arbuscular) to increase P availability and 6) to use Azospirillum sp to increase N fixation. We have obtained FMA from the genus of Acaulospora and Glomus, and the next time, we will develop research to study of isolation and characterization of Azospirilum sp from tidal swamps.

Table 3. Cultivation technology in the different farmer type on tidal swamp

Description	Cultivation Technology			
	Local Farmer	Transmigration Farmer	Farmer with SSC Innovation	Farmer with SSC and Organic Farming (Next Time Planning)
Variety	Local (6 month)	High Yielding Variety (4 month)	High Yielding Variety (4 month)	High Yielding Variety (4 month)
Water Management	Flooded Culture	Flooded Culture	Saturated Soil Culture	Saturated Soil Culture
Ameliorant	Without	Without	Dolomit + Cow Dung + husk Ash	Straw Biomass or Soybean Biomass + Cow Dung
				+ Humic Acid
Fertilizer	Without	N, P, K	N, P, K	Biofertilizer (Azospirilum sp, Micorrhyza sp) + Guano
Pesticide	Without	Herbicide, Insecticide, Fungycide	Herbicide, Insecticide, Fungycide	Biopesticide (clove oil 5 ml/l water)
Rice Productivity (ton/ha)	1.5-2.0	2.5-3.0	5-7	Prediction: 5-7

Conclusions

1) The reduction of shoot Fe content on SSC was higher on sensitive rice variety than tolerant rice variety on FC.
2) The productivity of rice on SSC was higher than FC
3) Humic acid decreased of soil Fe and Al, and application of peat humic acid increased of rice productivity
4) The application of organic rice farming in tidal swamp can be done with: high yielding variety, SSC technology, ameliorant of rice biomass, peat humic acid, dung fertilizer, bio-fertilizer, and bio-pesticide
5) Collaboration with ABGC system will give beneficial to the Farmer and Private Company

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Field Science Center, Graduate School of Agricultural Science, Tohoku University

Symposium mini review

Cropping Pattern Rice-Shallot-Soybean under Saturated Soil Culture in Tidal Swamp

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Keywords
cropping system, saturated soil culture, rice-shallot-soybean, tidal swamp

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Abstract

The research was conducted on overflowing type B tidal fields, namely land that is only inundated during high tide in Mulya Sari Village, Tanjung Lago District, Banyuasin Regency, South Sumatra Province, Indonesia. This study aims to study: 1) observation of rice cultivation based on farmer interviews using adaptive varieties in tidal land, 2) Shallot cultivation with a water table depth of 20 cm water depth and shallot varieties that are tolerant to tidal land with water-saturated cultivation, 3) Soybean varieties that are tolerant to tidal land with water-saturated cultivation without fertilizer application. This research examines how the rice-shallot and soybean cropping systems take advantage of the residual effects of manure through water-saturated cultivation in tidal fields. The highest rice productivity was in the Inpari 42 variety, which produced 6-7 tons/ha, a tolerant variety in tidal areas. For the Ciherang variety, the initial growth was good, but after ear emergence, the panicle was attacked by Blast disease. And the sensitive variety in tidal land is IR64. This is based on interviews with tidal farmers that sensitive varieties experience Fe stress when the land is stagnant, causing Fe^{3+} to dissolve and oxidize pyrite quickly and decreasing soil pH.

Introduction

Indonesia has 20.1 million hectares of tidelands that could be used-land and for future agricultural development. The problem with tidal land is the presence of pyrite (FeS_2), which, if dry (oxidized), causes the pH to fall and poisons Rice-Shallot-Soybean crops. If the pyrite remains submerged (reduced), it will cause the appearance of iron (FeS_2), which can be toxic to plants (Ghulamahdi, *et al.,* 2019). The problem of tidal swamp development in tidal land is the presence of Fe and Al (Turhadi *et al.,* 2020). Technology using Saturated Soil Culture can stop pyrite oxidation, increase soil pH and prevent iron dissolving, thereby increasing the yield of soybeans and corn 2-3 times compared to conventional methods.

Saturated Soil Culture is appropriate for rice and nonrice (shallot and soybean) because this technology reduces over-reduction for rice and over-oxidation for shallot and soybean. Crop rotation between rice, shallot, and soybean is a wise alternative to maintaining soil fertility. Saturated soil culture is one of the water-saving techniques that can improve water productivity. However, it is either less implemented or adopted because it consumes more time and energy. Therefore, an experiment was conducted to determine the effective water depth that can keep soil moisture close to saturation for a commonly practiced irrigation interval, combined with a rainfall pattern for increasing water productivity (Kima *et al.,* 2014). Crop rotation is the practice of planting different types of crops in rotation on one piece of land. Crop rotation is a cropping pattern that is carried out in rotation in a certain time sequence. Crop rotation provides abundant above- and below-ground crop residues and root exudates, which are known to stimulate the growth of soil microorganisms. Adding plant residues and manure to the crop rotation system can be a source of nutrients because it can increase the organic matter content of the soil. Rice, shallots, and soybeans are important staple crops in tidal swamp areas. However, tidal swamps present unique challenges for crop cultivation due to saturated soil conditions. Optimizing cropping patterns and agronomic practices is key to obtaining good yields. This study evaluates cropping patterns and cultivation methods for rice, shallots, and soybeans under tidal swamp conditions.

Specifically, a cropping sequence of rice-shallot soybean will be tested using a saturated soil culture technique. Saturated soil culture involves maintaining soil moisture at or near saturation to mimic conditions in a tidal swamp. This is typically done by controlling water table levels through flooding, draining, or sub-irrigation. The benefits of saturated soil culture in tidal swamps include minimizing the negative impacts of flooding while enabling crops that are well-adapted to wet conditions to grow successfully. However, agronomic factors like planting dates, fertilizer management, and pest control may need adjustments under saturated culture. This study will provide valuable insights into the viability and management practices needed to grow key staple crops successfully in a sustainable triple cropping system under tidal swamp conditions. The findings will be relevant for improving food security and farmer livelihoods in tidal swamp regions.

Materials and Methods

The research was conducted on overflowing type B tidal fields, namely land that is only inundated during high tide in Mulyasari Village, Tanjung Lago District, Banyuasin Regency, South Sumatra Province, Indonesia. This study aims to study: 1) observation of rice cultivation based on farmer interviews using adaptive varieties in tidal land, 2) Shallot cultivation with a water table depth of 20 cm water depth and shallot varieties that are tolerant to tidal land with water-saturated cultivation, 3) Soybean varieties that are tolerant to tidal land with water-saturated cultivation without fertilizer application. This research examines how the rice-shallot and soybean cropping systems take advantage of the residual effects of manure through water-saturated cultivation in tidal fields. The rice varieties used are Ciherang, Inpari 42 and IR64. The shallot variety used in this research was Bima Brebes, while the soybean variety used was the Anjasmoro and Tanggamus variety. In this study, manure was used at a dose of 20 tons/ha through a rice-soybean and shallot crop rotation pattern.

Result and Disscusion

The Inpari 42 variety is the most popular variety planted by farmers in the tidal fields of Mulyasari village. They highlighted Inpari 42's high yield, large grain size, and tolerance to periodic flooding in tidal fields (**Fig. 1**). Most farmers on tidal land for the Inpari 42 variety produce 1 ton more rice per hectare than other varieties. Larger grains command higher market prices, increasing tide farmers' profitability. Most farmers plant the Ciherang and IR64 varieties along with Inpari 42. Ciherang is valued for its good food quality and aroma. However, concerns regarding adaptability and disease susceptibility arise, especially when periods of flooding are prolonged. As experienced by several Ciherang farmers, it tastes the best but is prone to pests. IR64 is considered reliable grain quality throughout the season but has a lower yield potential than Inpari 42. Some farmers obtain yields of only 4-5 tons per hectare from IR64 compared to 6-7 tons from Inpari 42. IR64 has rather low plants, making harvesting difficult because the panicles disappear below the cutting height. Overall, Inpari 42 is considered the most suitable for tidal areas, is resistant to Fe and Al stress, and is more tolerant of temporary inundation when high tides occur.

Fig. 1. Condition of rice plants in tidal fields with water-saturated cultivation for the Inpari 42 variety when entering panicle filling.

Tabel 1. Productivity Shallot (ton/ha) in saturated soil cultures of varying water depths

Water depth (cm)	Shallot Varieties					
	Bima Brebes	Bauji	Manjung	Tajuk	SS Sakato	Batu Ijo
10 cm	5.2 de	4.6 def	4.3 ef	4.6 def	4.1 f	4.3 ef
20 cm	6.2 bc	5.5 cd	5.2 de	5.0 def	5.0 def	4.6 def
30 cm	7.3 a	6.0 bc	6.5 b	6.3 b	5.2 de	4.8 def

Remarks: [a,b,c,d,e,f] It should be noted that values in rows and columns separated by different letters differ significantly (DMRT test, 5%).

Table 2. Soybean productivity

Treatment	Productivity
Variety	
Anjasmoro	2.09 b
Tanggamus	2.57 a
Fertilization Combination	
No Fertilizer	0.99 b
P	1.38 b
P+K	1.33 b
P+K+Ca	2.36 a
P+K+Ca+Chicken Manure	2.42 a
P+K+Ca+ Chicken Manure +Cu	2.62 a
P+K+Ca+ Chicken Manure +Zn	2.94 a
P+K+Ca+ Chicken Manure Cu+Zn	2.93 a

Remarks: [a,b,c,d,e,f] It should be noted that values in rows and columns separated by different letters differ significantly (DMRT test, 5%).

Fig. 2. Condition of Anjasmoro and Tanggamus varieties of soybean plants on tidal land with water-saturated cultivation.

One of the agricultural land developments can be achieved by using potential land. Tidal marshland is one of the ecosystems with great potential for developing shallot crops in the future. In the future, there will be climate change (Stahl et al. 2018), where suboptimal land will become an alternative in agricultural development. **Table 1** shows the shallot production on Saturated Soil Culture. The treatment of the Bima Brebes variety at a water depth of 30 cm is higher in yield than other shallot varieties. Statistically different markedly, the Bima Brebes variety, with a water depth of 30 cm, can reach 7.3 tons/ha. At the same time, the lowest productivity with water depth in the water-saturated cultivation system in tidal land is the SS Sakato variety, with a water depth of 10 cm.

The highest productivity of shallot crops with water-saturated cultivation is the Bima Brebes variety, with a water level height of 30 cm. This happens because water-saturated cultivation causes soil conditions at field capacity conditions. The stability of subsurface water at the beginning of growth until it enters the generative phase can meet the formation of shallot bulbs in water-saturated cultivation in tidal fields. The productivity of six varieties of shallots, namely Bima Brebes, Bauji, Manjung, Tajuk, SS Sakato, and Batu Ijo, at different groundwater table depth treatments, namely 10 cm, 20 cm, and 30 cm, in general, the increase in groundwater table depth is up to certain level tends to increase the productivity of the six shallot varieties. At a depth of 10 cm, the productivity of the Bima Brebes variety was the highest, namely 5.2 tons/ha, followed by the Bauji variety at 4.6 tons/ha. Meanwhile, at a depth of 20 cm, the highest productivity was achieved by Bima Brebes, namely 6.2 tons/ha and Bauji 5.5 tons/ha. Then, at a depth of 30 cm, Bima Brebes' productivity reached the highest at 7.3 tons/ha, followed by Bauji at 6 tons/ha (**Table 1**). The Manjung, Tajuk, SS Sakato, and Batu Ijo varieties also showed a similar pattern, even though their productivity values were lower. (Haitami *et al.,* 2024).

Productivity of 7.3 tons/ha in shallot varieties carried out with water-saturated cultivation technology means that the development of shallots with the SSC (*Saturated Soil Culture*) concept in tidal land is very promising for future development. Of course, it has also received assistance with mechanization technology in light tillage and the construction of irrigation ditches

The Tanggamus variety has higher productivity than Anjasmoro at 2.57 tons/ha. Soybean productivity on tidal fields is influenced by varietal differences (Bachtiar 2016). Tanggamus is the most adaptive variety in tidal land and is shown to have quite high productivity values using Water Saturated Cultivation technology (**Fig. 2**). With a combination of P, K, Ca, manure and Zn fertilizers gave the highest productivity of 2.94 tons/ha (**Table 2**). The amelioration process by lime takes place because lime/dolomite provides a supply of OH^- ions into the soil, which reacts with H^+ ions to become water and causes the H^+ levels to decrease so that the soil pH increases (Maftuah, 2013). Water-saturated cultivation techniques in tidal fields can press oxidized pyrite into a reductive form so that it does not come into direct contact with oxygen and does not cause plants to become poisoned. (Pujiwati *et al*. 2015).

Ca plays a role in increasing soil pH. An increase in soil pH causes nutrients to become available. The amelioration process by lime/dolomite supplies OH^- into the soil, which reacts with H+ to become water and causes H^+ ion levels to decrease so that soil pH increases. Water availability also influences the availability of elements available to be absorbed by plants and the response of plant genotypes shows genetic diversity in responding to nutrients (Pessarakli *et al.,* 2015).

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Symposium mini review

Inter-tillage Weeding in Organic Rice Farming

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Keywords
inter-tillage weeding, rice production, organic farming, agrochemical-free

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Abstract

The excessive application of chemical fertilizers and agrochemicals has caused many environmental problems. With the advancement of the Sustainable Development Goals (SDGs), organic cultivation area in Japan is increasing. Inter-tillage as a traditional mechanical weeding method, is widely conducted in organic rice cultivation. Previous research has indicated that multiple inter-tillage can improve rice yield and rice growth. However, the negative impact of inter-tillage weeding on soil microorganism abundance has also been indicated, but the specific effect on microorganism activity has not cleared yet. More research is needed to investigate the effects of inter-tillage weeding on soil nutrients and microorganisms depending on different climate and soil conditions.

Introduction

In Japan, the paddy field area was 2.37 million hectares, accounting for 54.5% of total arable field. (Japan Agricultural Administration Department, 2021). Due to the common irrigation and drainage practices in Japan, the fertilizers and chemicals application in paddy fields causes higher risk of ecological damages (Furihata *et al*., 2019). The excessive fertilizers application causes the eutrophication of fresh water (Cui *et al*., 2020; Kim *et al*., 2006; Yan *et al*., 2017) and exacerbates the emissions of greenhouse gas (Shcherbak *et al*., 2014; Zhang *et al*., 2016). The application of agrochemicals also has a negative impact on biological communities and biological abundances. (Chagnon *et al*., 2015; Dudley *et al*., 2017; Sánchez-Bayo & Wyckhuys, 2019).

From 2011 to 2021, the organic cultivation area increased from 19.4 thousand hectare to 26.6 thousand hectares. The increase rate was 37%, and the increase continues every year (Ministry of Agriculture, Forestry and Fisheries, 2021). However, the ratio of organic cultivation area to total arable field in Japan was just 0.6%, much lower than that 15.4% in Italy, 8.9% in Spain, and 8.2% in Germany (Ministry of Agriculture, Forestry and Fisheries, 2019). In Japan, because of the high ratio of paddy field to total arable field, the development of organic rice cultivation will play a significant role in the overall development of organic agriculture. In organic rice cultivation, the main problem is how to inhibit the weed growth, insect pests, and maintain sufficient nutrients supply for rice plants. Inter-tillage as a traditional mechanical method, can inhibit weed biomass effectively (Maimunah *et al*., 2021; Takayanagi, 2016; Zhou *et al*., 2023). In addition, the positive impact of mechanical weeding on rice growth and yield was indicated by former research (Liu *et al*., 2023; Zhou *et al*., 2023). Thus, inter-tillage was widely used in organic or natural rice cultivation (a type of organic farming, no fertilizers and agrochemicals application). Without agrochemicals and even fertilizer applications, Kasubuchi (2019) succeeded in getting high yield, and the yield increased with higher frequency of inter-tillage at the paddy field in Japan until around five times inter-tillage weeding were conducted before heading stage.

This mini review attempts to introduce the effects of inter-tillage on rice yield, rice growth, soil nutrients and soil microorganisms with former studies.

The effect of inter-tillage weeding on rice yield and rice growth

Inter-tillage weeding, as an effective weeding method without chemicals application, is widely used in organic or natural rice cultivation. Kasubuchi (2019) reported that the yield increased with the increase of inter-tillage frequency without fertilizers and chemicals application (natural cultivation) and the difference of yields was not observed when more than eight times inter-tillage were conducted before heading stage in Yamagata Prefecture in Japan (**Fig. 1**). After several years' fertilizer-free and agrochemical-

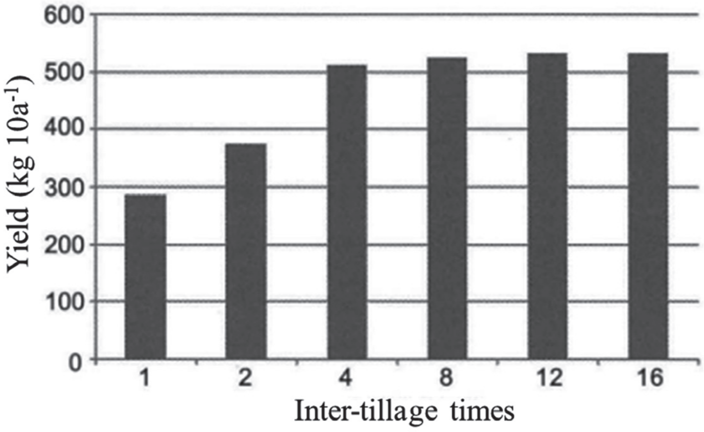

Fig.1. Inter-tillage time and yield. (Kasubuchi *et al.*, 2019)

free cultivation, the yield did not decrease. Also in Yamagata prefecture, Hiromi *et al.* (2001) reported that after conversion from conventional field to herbicide-free field (organic cultivation), the similar yield as one at conventional field was obtained in the first year just with one inter-tillage application. However, the yield decreased from the second year with the increase of weed biomass. When two times inter-tillage was conducted, the rice yield could reach more than 500 g/m^2 in organic cultivation when the average yield was 518 g/m^2 in Japan (Ministry of Agriculture, Forestry and Fisheries, 2002). Although the positive impact of inter-tillage on soil nutrients was observed, Zhu *et al.* (2023) showed that the yield was just 50% of conventional field in Hokkaido region three years after conversion from conventional to natural farming.

Even under inter-tillage the competition between weed and rice still exists, and it has been reported that the ratio of nitrogen absorbed by weed to the total nitrogen absorbed by rice plants and weed was 9.6% (Nakai, 2016). Thus, without the agrochemical application, several times inter-tillage are needed to keep the constant yield. Mikuni *et al.* (2010) indicated that four times inter-tillage were able to inhibit the weed biomass effectively since the second year after conversion from conventional field to agrochemical-free field. When inter-tillage times increase to more than four times, the yield will not increase continuously (Kasubuchi *et al.*, 2019). Therefore, around four times inter-tillage might be the best frequency to control weed biomass and ensure relatively higher yield.

The rice yield is closely related to the rice growth. It has been indicated that higher frequency of inter-tillage weeding can increase the nitrogen concentration in rice plants during growth period and N-uptake by inhibiting the competition between weeds and rice plants in organic rice cultivation (Maimunah *et al.*, 2021) and natural rice cultivation (Zhou *et al.*, 2023). The nitrogen absorption condition determined the rice physiological conditions. Liu *et al.* (2023) reported that the mechanical weeding significantly improved rice aboveground biomass during mid-tillering growth stage and increased the number of tillering and SPAD compared with herbicide application.

The effect of inter-tillage weeding on soil nutrients

As mentioned above, the positive impact of inter-tillage on rice yield was observed in former researches (Takayanagi, 2016; Hiromi Tokita *et al.*, 2001; Joe Nakai, 2011; Kasubuchi *et al.*, 2019), however, the specific mechanism was not clarified. Takayanagi (2016) concluded that the disturbance caused by inter-tillage could not improve the total nitrogen content in soil. However, some other hypothesis were proposed by other researchers. Arao (2015) reported that the total nitrogen content in surface soil (0-2mm) with sunlight was significantly higher than in lower layer soil because of stronger nitrogen fixation activity. After inter-tillage weeding, the surface soil with higher total nitrogen content would be introduced into lower layer, and the new surface layer would fix nitrogen again, then the total nitrogen in both surface layer and lower layer would increase (Kasubuchi *et al.*, 2019). Zhou *et al.* (2023) reported that in the first year after conversion from conventional field to fertilizer-free and chemical-free field, the average exchangeable ammonium concentrations during inter-tillage period in surface layer soil (0-1 cm) and lower layer (1-10 cm) were both significantly higher when more than 5 times of inter-tillage weeding was conducted. Although the significant difference was not observed in comparison with no inter-tillage weeding, the average concentrations of exchangeable ammonium nitrogen in the lower soil layer were 28.8% and 14.1% higher in the second year and third year, respectively when 5 times inter-tillage weeding was conducted. In addition, when inter-tillage was conducted, the ratios of organic nitrogen to total nitrogen in soil solution was lower than that of no inter-tillage, the inter-tillage might promote the organic matter decomposition in soil solution (Zhou *et al.*, 2023). Because the yields in previous research were quite different in regions, the specific effect of inter-tillage on soil nutrients should be also influenced by climate conditions or soil conditions.

The effect of inter-tillage weeding on microorganisms

Nitrogen fixation and organic matter decomposition were both closely related to the microorganism activities. An investigation was conducted on the impact of inter-tillage weeding on soil microbial abundance and community distributions by Lin *et al.* (2021). Their results showed that five times inter-tillage has significant negative impacts on bacterial abundances at the soil surface layer (0-1 cm), but no impact on the bacterial community structures was observed.

Because the specific nitrogen fixation amount by bacteria in paddy field can be influenced by other factors, such as nitrogen concentration in soil (Tanaka *et al*., 2006), only the results of bacteria abundance cannot indicate the effect of inter-tillage weeding on nitrogen fixation. The effect of inter-tillage weeding on microorganisms for organic matter decomposition was not fully investigated yet.

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Symposium mini review

The Challenges of Mechanical Weeding in Organic Rice Cultivation can be Mitigated by a Mechanical Inter-/Intra-Row Orthogonal Weeding Method

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Keywords
intra-row weeding, organic rice, orthogonal mechanical weeding, sparse planting, square transplanting

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Abstract

Reducing the labor required for weeding is an urgent issue in organic rice farming. Various types of weeding machines have been developed for paddy fields. However, they are good at inter-row weeding but inefficient with intra-row weeding. When transplanting rice, the distance between the hills is difficult to control. Hence, weeding machines can move only along the rows. Recently, a new transplanter that can precisely control the planting position has been developed, realizing mechanical square transplanting. Using this transplanter and a ride-on weeding machine, an examination of the organic rice cultivation system that combined square transplanting and orthogonal inter/intra-row weeding was initiated. This cultivation system is expected to drastically reduce the labor required for weeding, leading to the spread of organic rice farming.

Introduction

Organic agriculture is gaining importance daily from the perspective of reducing environmental impacts and sustainable food production. However, the area under organic agriculture in Japan is very low level, at approximately 0.6% of the total land area under cultivation (Ministry of Agriculture, Forestry and Fisheries, 2023). The most significant factor preventing the spread of organic agriculture is an increased labor requirement compared with conventional agriculture. Particularly in organic paddy rice, the labor required for weeding increases significantly, taking 50 h/hectare, which is about five-fold the time required for weed control in conventional cultivation and accounted for 21.1% of the total labor time (Yano Research Institute Ltd, 2023). Therefore, establishing more efficient weed control methods is an issue to be addressed urgently to promote the spread of organic agriculture. Various weed control methods for organic rice cultivation such as physical weeding, biological weeding with ducks and carp, paper mulch, and weed control using rice bran and other fresh organic matter, are available. Among these, mechanical weeding is adopted by many organic rice farmers because of its labor-saving and high effectiveness (The Nippon Agricultural Research Institute, 2007). However, sometimes a few weeds remain, resulting in a combination of other weed control methods (Azuma *et al*., 2007; Miura *et al*., 2015). Although a combination of various weed control methods is highly effective, it is challenging to select the appropriate combination based on the field conditions, weed type and growth, and whether it works depends on the farmer's experience. Therefore, a method that allows sufficient weed control with mechanical weeding alone is required. This paper attempts to discuss the problems of the commonly used weeding machines for rice paddy fields, efforts to improve these issues, and the possibility of realizing a new orthogonal weeding method with the advent of a precision rice transplanter.

Issues with the current weeding machines

Generally, rice is transplanted in rows, and weeding machines move along the rows. The distance between the rows is constant at 30-33 cm. On the other hand, the distance between the hills is narrower than that between the rows and varies significantly due to tire slip. Weeding machines include walking and riding, towed and engine-driven, roller, tooth, brush, chain types, etc. In any machine type, intra-row weeding must accommodate various hill spacing while not damaging rice plants, which is more difficult than inter-row weeding, resulting in lower weeding rates. A lot of efforts have been made to develop intra-row weeding machines to address this issue (Miyahara, 2007; Miki *et al*., 2012; Yoshida and

Mizukami, 2015; Lu *et al*., 2023). However, intra-row weeding requires maintaining the work speed while avoiding damage to the rice plants, and some challenges remain in realizing the same weeding effect in the intra-rows as in the inter-rows (Arakawa *et al*., 2007; Oomori *et al*., 2017; Tain *et al*., 2022). On the other hand, from the perspective of the weeding pattern, a method involving a combination of square transplanting and orthogonal weeding was considered, in which the weeding machine was applied in the horizontal direction, crossing the rows and in the vertical direction along the rows. This weeding method was often used when rice was transplanted manually. The weeding rate of orthogonal weeding is superior to the conventional along-rows-only weeding method (Oba *et al*., 2001). However, not to damage the rice plants during horizontal weeding, it is necessary to transplant rice seedlings in a precise square shape, which is difficult to realize using existing rice planters because of the marked variances in the distance of hills (Tasaka *et al*., 1997).

Square transplanting and orthogonal weeding with ride-on machines

Recently, a new type of rice transplanter has been developed that possesses an electric planting device separated from the running section (Yamada, 2014). By combining this rice transplanter with an RTK-GNSS positioning system, it is possible to precisely control planting positions, resulting in the realization of an organic cultivation system that combines square transplanting and orthogonal weeding with ride-on machines (Yamada, 2022). To demonstrate the practicability of this cultivation system, a field trial on a paddy field was initiated in 2022. The demonstration site was a 2.5-ha field in Ogata Village, Akita Prefecture, located in the cold region of Japan. It was a fertile field where a crop rotation of organic rice, green manure, and soybeans was practiced. The field was divided into two plots: an organic demonstration plot (11.1 hills m^{-2}, orthogonal weeding) and a conventional organic plot (18.2 hills m^{-2}, weeding along the rows only). The growth of rice plants and the amounts of remaining weeds were ascertained. The project is currently underway, and data is being collected. So far, rice yield in the demonstration plot exceeded that in the conventional organic plot and the surrounding herbicide-use fields (Imasu *et al*., 2023). In general, in sparse planting cultivation in cold regions, when combined with a delay in transplantation and shortening of the growing period or insufficient fertilizer, the number of panicles may be reduced, and yield may decrease (Hirano *et al*., 1997; Saito *et al*., 1997). In this experiment, the yield was maintained despite sparse planting. It was because the soil conditions were fertile after green manure and soybean cultivation, and transplanting was done at the appropriate time, which ensured a sufficient growing period.

Discussion and future perspectives

In this experiment, the initial number of tillers remained low in the demonstration plot due to sparse planting, causing a delay in field covering by rice, resulting in a more considerable number of weeds that grew after mechanical weeding compared to those in the conventional plot (Imasu *et al*., 2023). Similar issue was noted previously, which claimed that a delay in field covering by rice elongated the period required for weeding (Oba *et al*., 2001). However, in the case of using a ride-on weeding machine, the number of times the weeding operation could be conducted was limited. This was because when the weeding machine moved along the same lines many times, the tire tracks became deep, and the machine stuck. Besides, the weeding operation should be finished before the rice plants grow too high so as not to damage them. In this cultivation system, to obtain a sufficient weeding effect using a ride-on weeding machine alone, it is necessary to determine the optimal timing and frequency of weeding from the aspects of both rice and weed growth. If these issues are solved, an organic cultivation system of square transplanting and orthogonal weeding using ride-on machinery can be realized practically, even in cold regions, by combining cultivation management to ensure sufficient growth of paddy rice. This would reduce labor requirements, the most significant issue impeding organic rice cultivation, and is expected to contribute greatly to the spread of organic rice cultivation.

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Symposium mini review / Special Topic

Organic Food Consumption, a Step Forwards for More Sustainable and Healthy Habits: Key Findings of the French BioNutriNet Research Project

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Keywords
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Abstract

Until 2010's no large scientific studies have been conducted on organic food consumers while agro-ecological farming methods are increasingly acknowledged for their sustainability and health potential. We thus aimed to evaluate the characteristics of organic food-based diets, with acknowledged production standards and well-identified logos for consumers. This was made possible thanks to the large French nation-wide prospective NutriNet-Santé cohort of adult volunteers initiated in 2009. This short review article summarizes the data obtained and published on dietary patterns, food consumption and nutritional quality, pesticide exposure, impacts on human diseases and environmental indicators. Overall, beneficial impacts have been observed in most regular organic food consumers.

Introduction

In line with the FAO & United Nations (UN) definition of sustainable diets & food systems, there is an urgent need to face increasing challenges including food security, increased nutrition-related chronic diseases and ecological damages. Considering all these complementary aspects together for humankind and planetary health suggests the need for both sustainable food production, high food quality-safety and sustainable food consumption. This is the aim of the UN-supported concept "One Health" and the UN dedicated Sustainable development goals set by 2030.

In that line, agro-ecological methods of food production have been seen as potential alternatives for a more sustainable future, with organic agriculture at the front edge, with consistent standards and recognized logos. Limited but encouraging knowledge was available regarding the high nutritional value and safety of organic foods (see previous articles and reviews). But until 2010's no large scientific studies have been conducted on organic food consumers. Thus, we aimed to address this important multi-disciplinary question.

Methods

All data from our research studies as summarized herein are based on the French nation-wide prospective NutriNet-Santé cohort of adult volunteers initiated in 2009 by EREN and with 170,000 registered participants. It is a web-based prospective cohort study, based on a dedicated secure HTML interface for web-based questionnaires (www.etude-nutrinet-sante.fr). Repeated questionnaires were filled by participants regarding lifestyle, behaviors and motives, socio-economic characteristics, dietary pattern, physical activity, anthropometrics and all health outcomes (with further validation for some of them). Blood and urine sampling and clinical examination were made in a subsample of 20,000 subjects. This cohort follow-up has been ethically approved and financially supported by several public institutions and ministries.

A first observational cross-sectional study on 54,300 adults (77% women) was performed and published in 2013 (Kesse-Guyot *et al*., 2013). This pioneer large-scale investigation, based on repeated 24h food intake records (16 food groups) and a dedicated organic food questionnaire (never, occasionally, most of the time), allowed to observe that regular organic food consumers, compared to non-consumers, have a plant-based diet (much more intake of cereals and partly-refined/unrefined cereals, legumes, fruits, nuts, vegetables; less intake of meats, processed meat, diaries and cheeses; less fast foods) and a significantly lower probability of overweight and obesity (about – 50% in males and females).

To address more in depth all these issues, a consortium

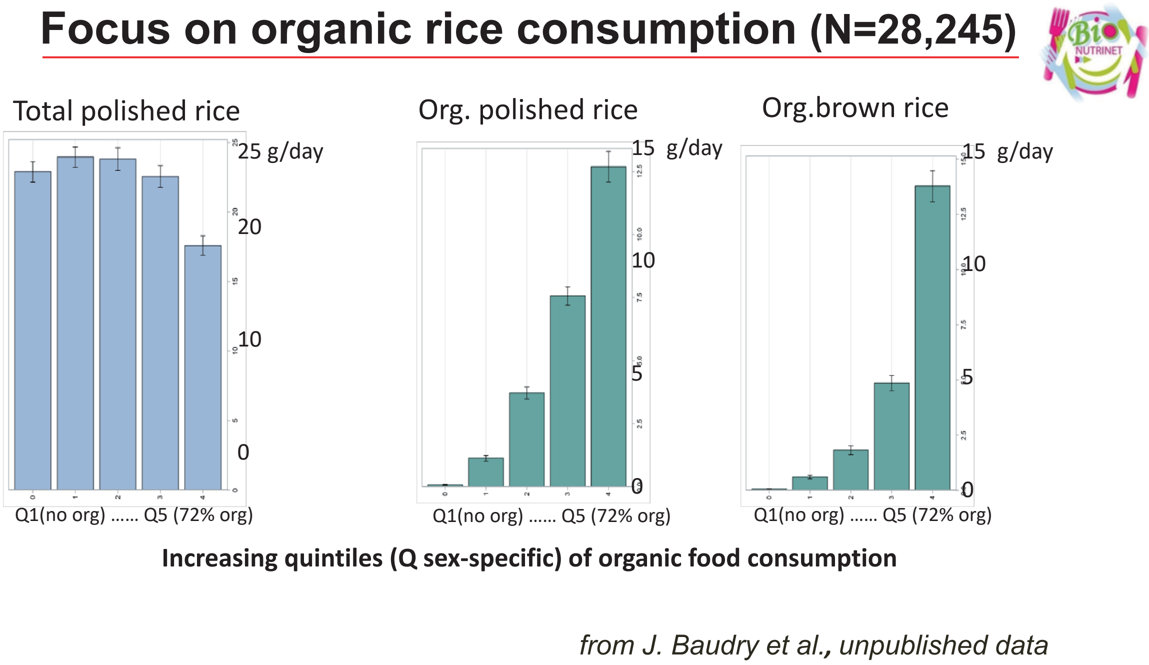

Fig.1. Total polished rice, organic polished and organic brown rice daily intakes in increasing quintiles (Q, sex-specific) of organic food consumption in French adults.

of French epidemiologists, nutritionists, economists, and toxicologists launched the prospective BioNutriNet project in 2013 (coordinated by E. Kesse-Guyot) that was funded by the French national research agency (ANR). In 2014, a FFQ (food frequency questionnaire) collected the usual organic and non-organic (defined as conventional) food consumption for 260 items with five levels (from never to always organic source) of approximately 35,000 NutriNet-Santé adult participants. Then, individual organic and conventional food intakes were merged with i) a food pesticide residue data set and ii) resource and environmental indicators (i.e. land use, energy demand, and greenhouse gas emissions for production of primary food products necessary for dietary patterns items, which distinguished between conventional and organic farming methods). Many studies were conducted and published to characterize organic consumers and organic food consumption, motives and impacts on health and the environment, as reviewed (Kesse-Guyot *et al*., 2021).

Results and Discussion

BioNutrinet project: dietary patterns

We observed that most regular organic food consumers (about 60% organic food) had daily diets that were richer in plant foods (legumes, nuts, grains and minimally refined grains, fruit, vegetables) accompanied by reduced amounts of animal foods (dairies, cheeses, red meat, poultry meat, processed meats and fast foods than non-organic consumers. This plant-based dietary pattern was associated with higher overall dietary and nutritional quality as well as higher adherence to dietary guidelines (as reflected by different validated scores). Increasing organic food consumption was associated with increasing plant/animal food ratio. (Baudry *et al*., 2016; Baudry *et al*., 2019).

For the purpose of the rice conference, we extracted data from our database regarding rice consumption in French adults. We found that total polished rice intake was about 24 g/d in most consumers while it fell down to approximately 17 g/d in regular organic consumers. As part of the increasing share of organic food in the diet, the intake of organic polished rice and organic brown rice markedly increased from about none up to about 15 g/d each in most regular organic food consumers, as illustrated in **Fig 1**. It is noteworthy that the nutritional content of brown rice versus polished rice is markedly higher for most nutrients (i.e. proteins, numerous minerals and vitamins, and dietary fiber). The above finding should be put in line with international scientific literature on the respective health impacts of rice consumption. Indeed, after previous individual studies and a meta-analysis, a recent meta-analysis evidenced that a substantial consumption of polished rice is associated with a noticeable increase in the risk of type 2 diabetes in adults (+ 16%) whereas intake of brown rice was associated with a lower risk (-19%) (Yu *et al*., 2022).

BioNutrinet project: exposure to food pesticide residues

In most regular organic food consumers vs no-organic food consumers, significantly reduced exposures to chemical pesticide residues were observed based on urine metabolite analyses (from synthetic organophosphates and pyrethroids, used in conventional agriculture only) (Baudry *et al*., 2018a). In addition, dietary exposures to 25 usual pesticide moieties were calculated based on a food pesticide residues database (Baudry *et al*., 2019). These findings are in line with those from other studies carried out in adults (4) and children (3) in various countries (Jiang *et al*., 2023).

BioNutrinet project: participant health outcomes

In 30 to 70,000 participants depending on studies, and after adjustments for potential confounders, regular consumption of organic food (about 60-70% share of organic food) was found prospectively associated with reduced risks of overweight (-23%) and obesity (-31%) (Kesse-Guyot *et al*., 2017), type 2 diabetes (-35%) (Kesse-Guyot *et al*., 2020a), postmenopausal breast cancer in women (-34%), and lymphomas (-86%) (Baudry *et al*., 2018b). A cross-sectional study showed a significant reduction (-31%) in the probability of having a metabolic syndrome (cardio-vascular risk) in regular organic food consumers (Baudry *et al*., 2018c). Recently, two prospective studies with the NutriNet-Santé cohort have demonstrated that a high exposure to a current mix of chemical pesticide residues provided essentially by conventional foods is associated with a significantly increased risk of having type 2 diabetes (+ 47%) (Rebouillat *et al*., 2022) or postmenopausal breast cancer in women (+ 73%), especially in overweight women (+ 413%) (Rebouillat *et al*., 2021), after adjustments for confounders. Some observations in line with ours have been made during other studies conducted in other countries i.e. Great-Britain (Bradbury *et al*., 2014), Germany (Eisinger-Watzl, 2015) and USA (Sun *et al*., 2018).

BioNutrinet project: impacts on natural resources and greenhouse gas emissions

Increasing the share of organic food in a plant-based diet up to 60-70% was associated with significantly reduced impacts for diet production on resources (-23% for agricultural land, - 25% for energy use) and greenhouse gas emissions (-37%) (Baudry *et al*., 2019).

In addition, a recent modeling study provided scenarios from present dietary patterns showing the feasibility of a full organic, plant-based diet with optimal nutritional intakes and markedly reduced negative impacts on natural resources and greenhouse gas emissions (up to about 90%) (Seconda *et al*., 2021).

French food-based dietary guidelines: 2019 sustainable update

The French food-based dietary guidelines for adults are published within the framework of the National Programme for Nutrition and Health (PNNS), started in 2001 and revised every 4 years. The more recent version of PNNS-4 was launched by the Ministry of health in January 2019. The key dietary guideline items are as follows:

- To increase all plant food: Fruits and vegetables (≥ 5 portions/day); unsalted nuts, (about 30g/d); legumes (≥ 2 portions/week); to prefer whole-grain and partly refined grains.
- To reduce all animal foods: dairies and cheeses (2 portions/d); red meat (≤ 500 g/w); processed meat (≤ 150 g/w); keep poultry meat (≤ 1 portion/d) and fish (2 portions/week).
- Added fats: to favor plant oils (olive, rapeseed, walnut); minimize sugared products, ultra-processed foods and salt.
- To favor organically produced plant food (fruits, vegetables, cereals, legumes).
- To prefer local and seasonal food, to practice culinary activities.

Modeled adherence to this recommended dietary pattern was found to improve several indicators of the multiple dimensions of diet sustainability (Kesse-Guyot *et al*., 2020b).

Conclusion

Overall, the main finding of the BioNutriNet project is that dietary shifts toward plant-based diets are feasible and could provide positive externalities on human health and the environment, while organic food consumption (i.e. above 60% organic food) allows to reduce pesticide exposure and make plant-based diets healthier by promoting better human health and planetary well-being thanks to avoidance of chemical fertilizers and pesticides.

The present higher diet purchase cost of an organic diet is mainly linked to the limited size of the organic food market, the minimal French government and European Union supports to organic agriculture and research, food processing and consumption, and the lack of consideration of the “true cost of food” due to negative externalities of the present agro-food system. This needs more sustainable political options with noticeably optimized support. Important progresses may still be expected in line with the recommendations of the European commission “Green deal”.

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Symposium mini review

Rice Diversity from Seed to Fork: a Living Lab for Organic Rice in Northern Italy

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Keywords
biodiversity, climate change, community biodiversity management, evolutionary population, living lab, organic farming, organic heterogenous material, participatory plant breeding

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Abstract

Organic Rice Systems require appropriate cultivars, adapted to the specific environments and farming managements used by organic growers. In Northern Italy, Europe's main rice producing area, a group of organic rice growers, in partnership with Italian NGO Rete Semi Rurali, developed three rice populations (short, medium, and long grain) starting from a collection of more than 200 rice germplasm accessions. The populations have shown promising preliminary results in terms of both agronomic value and consumers' appreciation. The European Organic Regulation (EU) 2018/848 which allows the marketing of seed from Organic Heterogenous Material, is paving the way for the development of diversity-based seed systems and value chains in the organic rice sector.

Introduction

Italy is the largest European rice producer, with 1,236,960 tons produced on 218,420 ha in 2022, representing 61% of the total European rice production area (EUROSTAT 2023). Organic rice production has been steadily increasing; in 2022, the area of organic rice was 15,559 hectares (SINAB 2023). However, rice varieties available to organic rice growers have been mostly developed by conventional breeding programmes and are not well adapted to Organic Rice Farming Systems (ORFS). Furthermore, there is virtually no certified-organic rice seed available on the market, forcing organic rice growers to either use their own seed, or resort to derogation for using non-organic untreated seed.

Materials and Methods

To address the lack of cultivars adapted to ORFS, Italian NGO Rete Semi Rurali (RSR) collected and multiplied rice germplasm from national gene banks and international research centres, thanks to the multilateral system of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). In 2019 and 2020, Multi Environmental Trials (MET) were conducted in four organic farms in the Lombardy and Piedmont regions, assessing 21 different cultivars – including a mixture – for agronomic traits and farmers' preferences (De Santis *et al*., 2021). Results showed strong Genotype by Farm Interactions for all entries, and indicated a good combination of yield, yield stability and disease resistance for the rice mixture, highlighting the opportunity for decentralised participatory selection in ORFS, in line with the findings of Ceccarelli *et al*. (2001) for crop improvement in marginal lands.

In 2019, a collection of 264 Italian rice varieties, including 214 accessions obtained from the International Rice Research Institute (IRRI) in the Philippines, was multiplied at "Una Garlanda" organic farm in Rovasenda (Vercelli, Piedmont, Italy). Based on the preference ranking by farmers, maturity time and grain size, three mixtures were assembled using an equal number of seeds per accession: a short grain (11 accessions), a medium grain (16 accessions), and a long grain (25 accessions) mixture. Between 2020 and 2022, the three mixtures were multiplied in four organic farms without artificial selection. They were managed as dynamic mixtures and therefore they became rice populations (RP) (Wolfe and Ceccarelli, 2020), given that the natural cross-pollination rate of *japonica* rice ranges between 0-0.6% and 3.9-4.3% (Oka

1988; Marathi and Jena 2015; OECD 2022). Meanwhile, dehulling and polishing tests were conducted on the RPs' paddy rice, showing processing yields comparable to those obtained with uniform varieties. Quantitative Descriptive Analysis (QDA) panel tests were conducted with the RP growers (2021) and with consumer group representatives (2022). Further panel tests involving citizens on the medium grain RP took place during two farm days in 2022, and through distribution of 400 packets (500 g) to consumer groups with an associated survey on the cooking and quality aspects of this RP.

The sensory evaluations conducted, including 63 replies to the survey, showed good appreciation by consumers. This prompted a group of organic rice growers belonging to the "Biodistretto del Riso Piemontese" (BRP) in Rovasenda, an organic network promoting green mulching and the preservation of endangered wetland species, to plant 1 ha of land with the medium grain RP in spring 2023 (**Fig. 1**). The preference for the medium grain RP, over the short and long grain RPs, is explained by its similarity to the medium grain variety "Rosa Marchetti", which is particularly well suited for green mulching cultivation and highly valued by consumers for its culinary qualities. The 1 ha field yielded 3.8 tons of grain, which is within the yield range obtained on the same organic farm in 2023 (2 t/ha for Carnaroli and 6 t/ha for Rosa Marchetti). The paddy rice was milled to semi-brown rice and placed on the market with the commercial name of "Riso Resiliente" (resilient rice) in November 2023 (**Fig. 2**).

Discussion and Conclusion

The Italian rice sector has been traditionally dominated by a high degree of uniformity: commercial rice seed needs to fulfil the European seed marketing requirement of Distinctiveness, Uniformity and Stability (DUS), whilst rice grain must fit in a strict classification grid (short, medium, long A and long B) before it reaches the market. As a consequence, 70% of the seed production is represented by only 20 varieties, and about 40% of the registered varieties have been bred with herbicide resistant technologies (Clearfield®, Provisia® and FullPage®) (Tamborini *et al*., 2021; 2023), to meet the wide reliance on chemical weed control of conventional rice production. On the backdrop of this reality, Italian ORFS represent a widely diverse range of target environments, mainly due to the variety of weed-control approaches adopted, which range from stale-bed sowing of dryland rice to green mulching, the latter relying on flooding, fermentation and allelopathic effects of *Lolium multiflorum* (Vitalini *et al*., 2020; Vaglia *et al*., 2022). The deployment of mixtures and populations in ORFS, can offer a concrete solution to the lack of suitable cultivars for organic conditions, however for its successful long-term implementations all the actors of the value chain need to be involved in the process. The BRP organic network includes organic rice growers, an organic rice seed company, a rice mill. It has developed a close connection with citizens and consumers through direct sale schemes to both private consumers and consumer groups, and through regularly hosting open farm days during the rice growing season. In this multi-actor context, RSR acts as an innovation broker, adopting a Living Lab (LL) approach. A LL can be defined as an open innovation ecosystem in real-life settings, in which user-driven innovation is the co-creation process for new services, products and societal infrastructures. Agroecology LLs adopt a transdisciplinary approach which involves farmers, researchers and other stakeholders in the co-design, monitoring and evaluation of agricultural practices and technologies in working landscapes (MACS 2019) and have become an instrument of the European Commission's Agricultural Knowledge and Innovation System (AKIS) to improve the effectiveness and early adoption of agricultural innovations. The experience of the Italian organic rice LL described in this article is part of a wider network of 17 LLs on organic seed and plant breeding of the European project LIVESEEDING (www.liveseeding.eu). After the successful implementation of the first medium grain RP value chain, its objective is to develop a second value chain with the long grain RP. Thanks to the European Organic Regulation (EU) 2018/848, which allows the marketing of seed from non-uniform cultivars

Fig. 1. The medium grain rice population grown in Rovasenda, Vercelli province, Italy.

Fig. 2. The product label of the "Riso Resiliente" (Resilient Rice) medium grain rice population.

as Organic Heterogeneous Material (OHM), it will also be possible to notify and market the RPs seed, making it available as organic certified seed to the wider community of Italian organic rice growers. Under this regulation, populations obtained from on-farm evolution of dynamic mixtures, can be notified as dynamic populations, to differentiate them from other types of OHM, such as composite cross populations (CCP) and heterogeneous landraces (Costanzo *et al*., 2019; Goldringer *et al*., 2019). The experience of the Italian organic rice LL has provided a proof of concept on the feasibility of population-based seed systems and value chains in the organic rice sector. Further work is needed to design and develop a wide range of rice populations to address the diverse needs of organic rice growers, millers, chefs and consumers, and scale the innovation up and out.

Acknowledgments

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Symposium mini review

Challenges to the Widespread Extension of Organic Rice Cultivation

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Keywords
fertile soil, puddled soil structure, reduction disorders, weed community ratio, support

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Abstract

The organic cultivation area and the ratio of organic farmers in Japan are as low as 0.5 percent. The probability of achieving weed control without the use of herbicides is considered to be extremely low. According to the research conducted by the International Nature Farming Research Center (INFRC, established in 1985), the reduction disorders in paddy rice growth due to improper rice straw and organic fertilization in low-fertility paddy fields alter the relative proportions of weeds and rice plants in the community, making it difficult to control weeds. In the case studies of some farmers, namely Yoichi Abe in Miyagi Prefecture, where we visited during a field trip in this symposium, Masaki Oikawa in Miyagi Prefecture, and Hiroshi Kataoka in Chiba Prefecture, they focus on cultivating fertile soil through appropriate tillage methods and puddling techniques in flooded conditions that suit the natural conditions of each region. Additionally, they enhance the health of rice plants through practices like using robust seedlings for transplanting and effective water management, resulting in reduction of weed infection. Successful organic rice farmers can control weeds by strategies such as adjusting soil moisture during cultivation to create paddy fields that do not induce reduction disorders, and tillage management. Our dissemination task and challenge are to share the understanding of fostering a healthy paddy ecosystem, and to encourage producers to develop integrated weed control methods. These methods aim to create a puddled soil structure that supports the early growth of rice plants, based on each climate condition.

Introduction

The implementation area of organic farming and the number of producers in Japan in 2017 were merely 0.5% (Ministry of Agriculture, Forestry and Fisheries of Japan, 2019). This can be expressed as a 0.5% probability that organic farming has been financially viable in the country. The main challenge in expanding organic rice production is the difficulty of weed control. The contribution of herbicides in integrated weed control system is more than 70%. Then, achieving integrated weed control without herbicides is considered unfeasible. This report is based on research results obtained by INFRC in the process of developing nature farming techniques since 1997, mainly conducted at agricultural research stations and on experimental farms. The research results were used to explain nature farming techniques in the extension fields, demonstrated under the various climatic conditions by the practitioners. At some sites, soil, weeds, and rice plants were collected, and the degrees of weed dominance were estimated. Subsequently, the collected data were organized and consolidated to establish the relationship with the characteristics of techniques and skills of the cultivation methods perceived by the local extension staff and farmers.

In paddy fields with less weed infestation and no need for weeding, rapid initial growth of rice plants after planting, slow weed emergence, and a fertile puddled soil structure called “Toro-tsuchi” were observed. At the same time, it was observed that the degree of weed dominance can significantly vary among farmers, even with similar cultivation methods. The methodology for creating paddy fields is different from that used by farmers with high weed dominance. The difference in the methodology was considered to have strong influence on the stability of weed control.

2. Understanding the reality and perspectives of organic rice cultivation system

2-1 Primary investigation methods for the amount of weed emergence and weed damage

Indicators of weed dominance in a community include the Weed Amount Ratio (WAR), which measures weed weight, and the Weed Flora Ratio (WFR), which estimates weed coverage percentage through visual assessment. After 40 to 55 days from planting, the ratio of dry matter weight or canopy-cover percentage of weeds was determined in the entire plant community including rice plants. To ensure objectivity, the WFR survey was conducted multiple times, adjusting the visually measured canopy-cover ratio and bare soil ratio become 100%.

2-2 The estimation of reduction disorders

To predict reduction disorders that increase weed emergence, INFRC collaborated with Niigata Prefecture, Niigata University, and ASUZAC to develop a diagnostic method (Agriculture, Forestry and Fisheries Research Council 2016). One of the diagnostic methods involves inserting a hydrogen sulfide detector (silver coated plate) into the paddy soils after the maximum tillering stage. The extent of discoloration on the surface of the plate is then observed to assess the level of hydrogen sulfide generation. This was introduced as a simple and immediate diagnostic method to promote better understanding for farmers.

2-3 Evaluate the growth and yield of rice plants

The width of the headland, the number of rows, the spacing between rice plants along the four sides of the paddy field, and the number of panicles of 20 rice hills were measured around the heading stage. Then, the number of panicles per m^2 were identified taking the lost rice plants by weeding and other causes into account. At the maturation stage, the approximate yield was estimated using either of the following methods: conducting harvest surveys at two locations in the field or estimating the yield from the number of hills per m^2 without collecting rice plants.

2-4 Comprehensive understanding and estimation of the situation through interviews

Interviews were conducted mainly on weed control techniques, such as the quantity of weeds and the work time required for weeding, and related rice farming management. At the end of weeding period, the weeded and unweeded fields were observed from all sides of the fields, and the relative ratios of weeds and rice plants were evaluated using the method described in 2-1 section.

WAR is an important indicator that can directly demonstrate the quantitative relationship between crops and weeds (Weed Science Society of Japan 2011).

In a mesocosm experiment conducted by INFRC in the Andisols paddy fields in Matsumoto City, Nagano Prefecture, located in central Japan, from 2003 to 2005, revealed a strong negative correlation between the WAR values and rice yield (**Fig. 1**). The WAR values were obtained at the end of the weeding period without weeding with variations in tillage and fertilizer application timings. Additionally, in 2008, a significant negative correlation was observed in the Koshinetsu region between the WAR values of surveyed rice plants at 40-55 days after transplanting where weeding was not carried out at, and the yield of surveyed plants at the maturity stage where farmers freely weeded (**Fig. 2**). In other words, while weed quantity varies greatly depending on the time of observation and weeding management, the relative proportion of weeds in the community around the maximum tillering stage changes mildly. This can be used as an indicator of weed damage, reflecting approximate weeding requirements and competition for nutrients and water with rice.

The weed community ratio is negatively correlated with the yield of unweeded paddy fields in terms of both weight and coverage. (WFR is approximately 50% higher in numerical value compared to WAR). However, by measuring the weed community ratio through weed coverage percentage, it is possible to make an immediate diagnosis of the level of weed emergence and weed damage in multiple paddy fields, surpassing the recognition of producers. Conducting interviews, the local extension staff selected periods with minimal burden on producers. In cases where on-site inspections at the weeding or harvesting seasons were

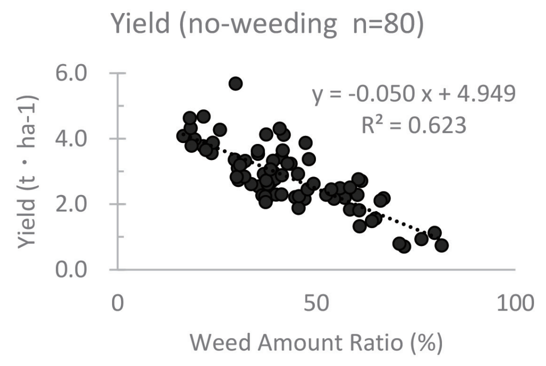

Fig.1. Strong Negative Correlation Between WAR Values and Rice Yield in Andisols Paddy Fields (2003-2005)

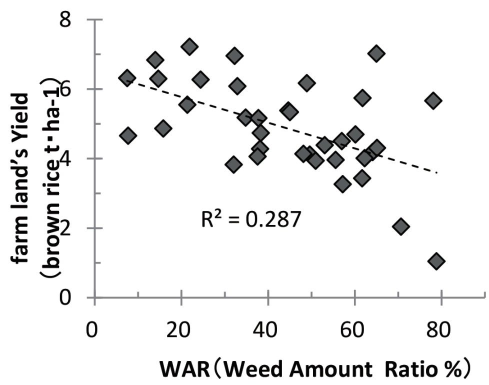

Fig.2. Weed Amount Ratio and farmer's rice yield farmer's 36 fields in Koshinetsu area in 2008

Negative Correlation: Weeding Impact on Rice Plant Growth and Yield in Koshinetsu Region necessary, the survey locations were determined in consultation with the farmers. The surveys were then conducted with the cooperation of local extension staff.

3. The characteristics of technological systems to eliminate the need for weeding in organic rice cultivation

3-1 The characteristics of cultivation in organic rice farming: A case study in Miyagi prefecture

Yoichi Abe in Misato Town maintains 90% of his 66.6 ha of organic JAS certified paddy fields weed-free, using only weeding machines and with the labor of three people. This achievement is attributed to his cultivation techniques that ensure the overall health of rice seedlings and unique soil management (Sakakibara 2018). To match the soil characteristics of epi-minerallic Low-moor Peat soil, tillage is conducted under a dry condition with borrow soil and subsurface drainage channels. A leveling machine is used for leveling operations to prepare a shallow, flat plow layer and fertile cultivated soil. The soil surface is repeatedly stirred with a riding-type weeding machine. Approximately 10% of the fields are dried by upland conversion. In most paddy fields, rice straw is removed to livestock shelters and composted. By creating a fine topsoil on the surface, a single puddling operation in flooded conditions is sufficient. In 2023, in approximately 50% of the paddy fields, a riding-type weeding machine called Q-hoe is used with its surface-stirring rake to refine the field surface, making it less conducive to weed growth and effectively suppressing weeds. In about 40% of the paddy fields, weeds are suppressed by running Orec, which performs inter-tilling and inter-plant weeding with high precision after running twice with Q-hoe. The remaining 10% is weeded by hand, but the total number of Q-hoe and Orec runs is 2 and 4, respectively, to reduce the burden of hand weeding as much as possible (**Fig. 3**).

Masaki Oikawa in Tome City, who cultivates the same soil type as Mr. Abe in the same prefecture, is trying to cultivate paddy fields by increasing the number of puddling with the aim of improving soil microbiology, and he planted 15 ha in 2023 by gradually increasing the area planted with organic management. Since the collaborative testing with the EM Laboratory (Effective Microorganisms Laboratory), which is in Shizuoka City, Shizuoka Prefecture, located in central Japan) in 2014, using the method of long-term flooding with the application of lactic acid bacteria and yeast solution, and multiple puddling times, a positive outcome has been observed. Subsequently, paddy fields covering more than 50% of the total cultivated area have consistently yielded crops without any weed growth, leading to successful harvests (**Fig. 4-1**). While weeds emerge in newly organic conversion rice fields and in those immediately after infrastructure improvement, such as subsurface drainage channels, characteristic soil structure development is observed on the ground surface in weed-free paddy fields (**Fig. 4-2**). This soil surface microstructure is repeatedly observed in organic paddy fields with few weeds, which we call "Toro-tsuchi". Mr. Oikawa adjusts his tillage and puddling methods based on the following structural changes observed in the puddled soil structure, 1) Foaming soil due to microbial fermentation, 2) Deposition of soil particles on the soil surface due to tillage and 3) Water-tolerant micro-cluster structure formed when soil passes through the gut of aquatic earthworms. Mr. Oikawa adjusts his tilling and puddling methods, taking into account changes in the structure of the plowed soil. Specifically, in order to equalize the thickness of "Toro-tsuchi" in the field, the period of inundation and the number of puddling are adjusted, and the tillage depth is made deeper in high areas and shallower in low areas before the water enters the field. According to Mr. Oikawa, if the plow layer can be leveled before puddling, the difference in elevation can be reduced, the thickness of "Toro-tsuchi" becomes uniform, and the paddy fields with less weed infestation can be produced at the third year. Peat soils release soil nitrogen during the ripening period, so cultivation is done with a reduced amount of fertilizer. Just under 10% of paddy fields are cultivated without fertilization and maintain a yield of 480 kg/10a or more. As of 2023, he manages 11.6 ha of organic JAS-certified land; 7 ha of which produces sun-dried rice after binder harvesting. The straw is taken out to make Japanese tatami mats.

3-2 The status of weed emergence in Isumi City, Chiba Prefecture, where all rice for school lunches is supplied as organic rice

In 2014, a collaborative effort between the private rice research institute in Tochigi Prefecture, Isumi Agricultural Office, JA Isumi, and Isumi City in Chiba Prefecture led to the initiation of a three-year demonstration project for organic

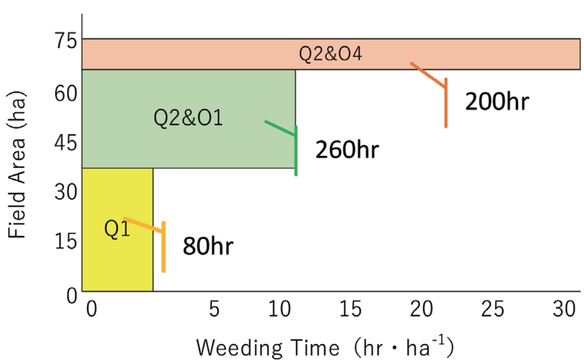

Fig.3. The total amount of time required to weed Abe's field
Q1; The total number of Q-hoe is one time
Q2&O1; The total number of Q-hoe is twice, and Orec is once
Q2&O4; The total number of Q-hoe is twice, and Orec is four times

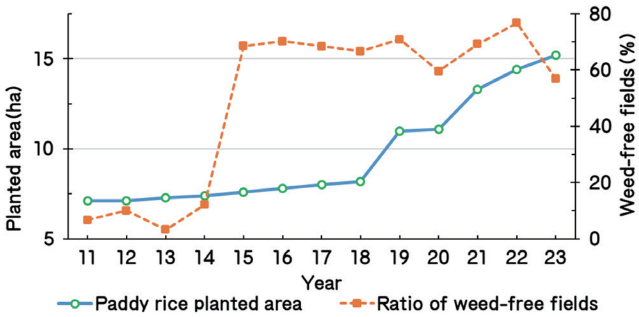

Fig. 4-1. Conversion of Mr. Oikawa's organic paddy fields in the cultivated area and the ratio of unweeded fields
Fig. 4-2. Condition of "Torotsuchi" layer after harvest (Oikawa2018)
Falling water tillage ensures uniform tillage depth, Long period flooding , multiple puddling times , and healty seedling.

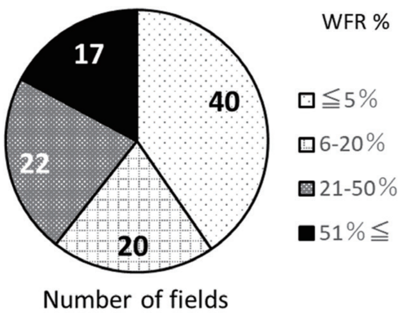

Fig.5. The status of weed emergence in Isumi City (2023)

paddy rice cultivation. In 2015, they began introducing 4 tons of organically grown rice into school lunch programs. In 2017, along with providing a total of 42 tons for school lunches, the process of acquiring organic JAS certification was initiated. INFRC began conducting workshops in Isumi City in 2019 They have actively engaged in skill development programs for organic rice cultivation through multiple on-site surveys and exchange of opinions since fiscal year 2022. In the fiscal year 2023, among the 719 rice cultivation entities in Isumi City with a total cultivation area of 1,797 ha, organic rice cultivation entities accounted for 2.4% in terms of the number and 1.7% in terms of cultivation area. One to two months after transplanting, weed emergence in paddy fields shows that approximately 60% of the total area has a WFR below 20%. In these fields, no weeding is needed, or simple weeding is sufficient to suppress weeds. Slightly more than 20% of the areas have a WFR between 21-50%, requiring multiple weeding. Under 20% have a WFR of 51% or more, leaving some weed damage even with meticulous weeding (**Fig. 5**).

In paddy fields with a WFR (Weed Flora Ratio) of 5% or less, the generation of hydrogen sulfide is minimal or negligible, and there are few occurrences of reduction disorders. In paddy fields with a WFR of 21% or more, reduction disorder by hydrogen sulfide occurs. Moreover, deep-water management was difficult due to the instability of surface soil elevation or water leakage from the fields. In paddy fields with a WFR of 21% or more, in addition to reduction disorders, there is a 10-20% decrease in rice plants due to damage from weeding and apple snails, resulting in insufficient planting density at 40 plants per square meter. Among the farmers in Isumi City, Mr. Hiroshi Kataoka manages 16 paddy fields covering 3.1 ha with a WFR of 5% or less. These fields had more than 330 panicles per square meter, where planting density of 50 plants per square meter, and the average yield was just under 540 kg/10a. 15 of his fields had no weeds and required no weeding. According to Mr. Kataoka, he observes the dryness of the paddy fields and conducts high-speed tillage multiple times. While maintaining a consistent plow layer depth, he

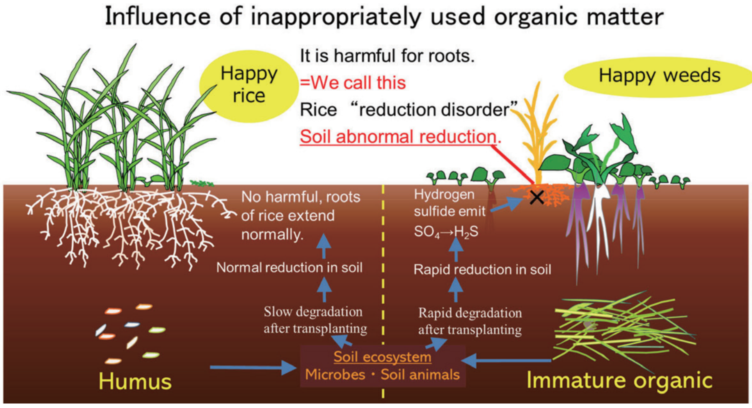

Fig. 6. Effects of unsuitable organic matter application methods

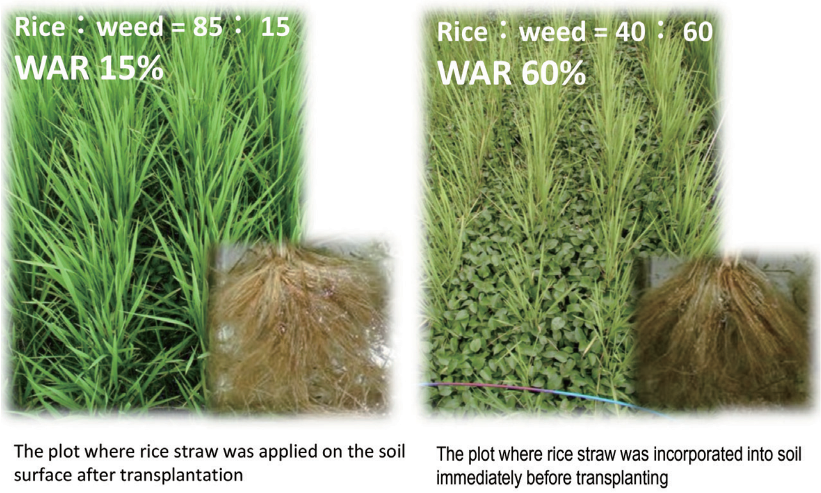

Fig. 7. Changes in Weed Amount Ratio (WAR) due to the experiment with varied rice straw application positions

performs puddling 2-3 times, adjusting the frequency of tillage while observing the soil condition. In his 6th year of organic conversion, based on the cultivation practices of colleagues and his own trial and error, he has gained confidence in creating organic paddy fields without weed infestation problems by refining the cultivation methods during water drainage and water management.

Change the way we think – changes what we see –Focusing on supporting living plants and ecosystems

In many countries, organic cultivation is practiced by direct sowing in dry paddy fields, but in Japan, where precipitation is abundant, transplanting is generally employed after puddling in flooded conditions. Because most weeds in paddy fields begin to emerge within a few days after puddling, soil moisture and fertilizer managements are factors that determine the timing of weed emergence. Reduction disorders and weed damage in paddy fields are mostly caused by the decomposition of organic matter such as rice straw, rice stubble, and roots immediately after rice planting, which consumes oxygen in the soil and causes rapid reduction (**Fig. 6**). In an experiment in which rice straw was taken out and the position of rice straw application was changed around rice planting, it was found that rice straw which decomposes rapidly at the position where rice plant roots grow, hinders root growth and suppresses rice plant growth, thereby increasing weeds (**Fig.7**). Organic fertilization, deep-water management, multiple times of puddling, and mechanical weeding deprive wet soils of oxygen and promote reduction disorders, helping aquatic weeds to grow.

To prevent such reduction disorders in paddy fields, farmers intentionally reduce the amount of rice straw returned to the paddy fields and increase the frequency of tilling before flooding the fields to suppress weed emergence. In other words, organic rice farmers, who have succeeded in weed control, commonly focus on growing healthy rice, and they devise cultivation and puddling methods to promote the decay of organic matter without causing reduction disorders. They also maintain a shallow plow layer and high bonding ridge to keep the paddy fields at a suitable water depth. Furthermore, the fertile soil, with its high water and nutrient availability, has been made over time as if it were treated like biological creatures. In organic rice cultivation in Japan, water management after healthy seedlings transplanting and fertile soil cultivation that does not require fertilizer application are combined to increase the health of rice plants and establish a holistic weed control system.

Integrated weed management without relying on weeding

Weed control in organic rice cultivation can be summarized by the following objectives and methods.

- The goal is to cultivate soils with high biological activity, richness and depth while avoiding reduction disorders.
- Simultaneously, constructing paddy fields with high ridges capable of maintaining a high water level and shallow plow pan is essential.
- In order to achieve the above, it is necessary to select cultivation methods that follow the laws of nature and climate.

These incorporate integrated technology aimed at fostering a paddy field ecosystem in which rice plants take a leading role.

Acknowledgments

This report could not have been described without the ingenuity and guidance of many farmers practicing nature farming. I deeply appreciate those who shared their experiences and information. In particular, I would like to express my gratitude to Mr. Yoichi Abe and his family, who generously provided the venue for the symposium visit as representatives of organic farmers. Additionally, I extend my thanks to the late Dr. Hiroshi Umemura, Dr. Hui-lian Xu, and Mr. Hidehiko Okubo for their dedicated efforts in the international dissemination of INFRC. I am also grateful to Mr. Susumu Nosaka (former Director of Extension), who contributed to the promotion of nature farming in this report. I express my gratitude to the seniors, colleagues, and staff who have worked since the establishment of INFRC as well as Mr. Tatsuo Kuroda, the current Chairman. And Mr. Yoshiaki Nagahama, with his profound knowledge of vegetable cultivation on the Chita Peninsula, for providing valuable insights for information sharing. Finally, I appreciate Dr. Mizuhiko Nishida and Ed. Chiho Nishiwaki of Tohoku University for their kind and thoughtful advice.

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A Statement of the 4th International Symposium on Organic Rice Production System held on 4th – 7th September 2023 in Sendai, Japan

ORP4 Scientific Committee

Following the World trends

In Asian, European, and American countries, rice is grown in various natural and socio-economic environments. Rice cultivation contributes to food production and provides multiple services such as flood control, soil conservation, wetland protection, water purification, landscapes and ecosystem conservation. However, inputs applied to rice fields, such as pesticides and chemical fertilizers directly impact the watershed.

Many countries have set policy goals to promote organic farming, including the recent implementation of the Strategy for Sustainable Food Systems in Japan and the Farm to Fork Strategy in the European Union (EU). Holistic approaches toward sustainable agrifood systems are now a global trend. Although the published targets for reducing the use of pesticides and chemical fertilizers and increasing the percentage of area under organic farming are ambitious, the proactive engagement and dedication of the agricultural sector, with the support of the entire nation, is required. Therefore, consumers' actions and public support are vital initiatives for change. Moreover, boosting efforts to promote and support rice farming, which accounts for most of the arable land, is crucial to significantly increasing Japan's organic cultivation area.

Regional presentations from abroad showed a significant increase in organically managed rice fields. This symposium became an important opportunity for researchers, producers, consumers, and other stakeholders to establish international collaborations.

Holistic management

Transplant cultivation is mainly practiced in East Asia, while direct seeding cultivation is a common practice in the rest of the world. However, the goal of cultivating healthy and robust rice crops through properly managing flooding, drainage, and water depth is similar worldwide. In organic rice cultivation, weed control is a common issue across the world's diverse organic rice cultivation systems. A variety of best practices are being developed around the world to improve the ecological health of rice fields.

Organic rice production is a system that combines a variety of techniques that producers acquire through trial and error under various economic conditions and production environments and a holistic management of the field ecosystem. Regular monitoring of the field condition and its environment, developing strategies for weed control and fertilization management, and taking countermeasures to respond to yearly changes in weather in accordance with the unique characteristics of the field and field environment are vital. Taking advantage of the functions of diverse living organisms, organic rice cultivation should not only be considered labor-intensive, but also represent a knowledge-intensive agricultural model.

Acquisition of situated knowledge

The key is not to spread technology and knowledge developed in experimentation centers and research institutions, as demonstrated in the successful example of technology dissemination during the Green Revolution, but to acquire situated knowledge and support how to obtain it. A new agroecological approach that allows producers, researchers, and various stakeholders to work together through diverse communication and networks, like participatory research and living labs that combine research and practice, is required.

Moreover, Information and Communication Technology (ICT) in agriculture is expected to contribute significantly to developing organic rice cultivation. ICT in organic rice cultivation will be a tool for understanding and dealing with the complex and diverse field ecosystem, unlike automation and standardization in agriculture in general.

One health and organic rice production system

According to cohort studies on the consumption of organic and non-organic foods and their respective effects on health and the environment, regular consumption of organic foods reduces the risk of lifestyle-related diseases and the environmental impact of food. An organic rice-based system that pursues the health of people and the health of livestock and soil through integrated crop-livestock farming systems enables the circulation of local resources and enhances the health of the rice paddy ecosystem.

Moreover, the relationship between agriculture and the region is extremely close. Thus, identifying common denominators among agricultural production, ecosystems, and human health and comparing efforts and best practices among countries and regions may solve local problems and eventually address global issues.

Thinking of scalability of organic rice production systems

To further expand the organic rice production system, the bottom-up approach with horizontal collaboration rooted in the region is more appropriate rather than a top-down approach led by the government. Moreover, there is a need to implement outscaling in which each production system based on the characteristics of the field and region is highly considered, rather than through upscaling, which involves updating production systems with newly developed technologies.

We learned about exemplary organic rice farming in the Camargue region in France, the Central Valley in California, the Po River basin in Italy, tidal wetlands in Kerala, India and Indonesia. These farms conserve wetlands that foster rich biodiversity. Meanwhile, family farms that cultivate organic rice from a few to tens of hectares are emerging in Japan. Suppose these developments in various regions eventually establish a vast complex of several hundred hectares of organic rice fields. In that case, we expect to see a rice field-wetland ecosystem that can coexist with a wide variety of creatures. Therefore, we should design a future for organic rice farming based on existing interdisciplinary scientific and practical knowledge while overcoming immediate challenges in production and business.

We wish to support the establishment of an organic rice network to foster technology and knowledge through interaction between producers, encourage participatory breeding of varieties suitable for organic cultivation, and engage in interdisciplinary research in agriculture, agroecology, social and human science, medicine, etc. on complex and cross-disciplinary issues surrounding organic rice production systems, including agroecosystems, quality of organic rice, human health, and consumption.

ORP4 Scientific Committee


TOHOKU
ホーム 発表資料 プログラム
English Presentation Program
4th International Conference Organic Rice Farming and Production Systems
The 21th International Symposium of the Integrated Field Science Center
Tohoku University Sendai - Japan
September 4 th – 7 th , 2023
This conference will be held at the conference room and online at the same time.
Language: Japanese and English.
Simultaneous or consecutive interpretation will be provided.
Participation fee: Free
Field trip and lunch fee separately

Time schedule

2023 March	Call for Abstracts for Oral and Poster Presentations
April	Start of Registration
May	Deadline of Abstract Submission
June	Notification of Abstract Status
July	Deadline of Paper Submission
September 4th (Mon.)	PM Session
5th (Tue.)	Field Trip
6th (Wed.)	AM/PM Session We will have a reception and we will enjoy dishes made with local organic ingredients from 18:00 on September 6th (3,000 yen per person)
7th (Thu.)	AM Session

The conference aims to stimulate and foster exchanges between scientists, rice growers and other stakeholders in the organic rice production and commercialization chain. These exchanges, focused on organic rice production in different regions throughout the world, will be organized to
1) collect and assess practical knowledge and functions of current organic rice production systems,
2) discover applied innovations and identify obstacles that hinder further development of the systems,
3) analyze the impact of different types of organic rice production on food quality, health, and the environment,
4) strengthen the international innovation network on sustainable rice production,
5) explore the issues, levels, and consequences of a scale shift toward the mainstreaming of organic agriculture throughout the agri-food chain.

Background of the International Symposium on Organic Rice Production Systems：
The 1st International Symposium on Organic Rice Production Systems was held in September 2012 by the Montpellier Center of the French National Agricultural Research Institute. Since 2000, the center has been conducting participatory research in collaboration with farmers, focusing on promoting organic rice in the Camargue region, which extends to the delta at the mouth of the Rhone River. With the shared recognition of its participants towards the importance of promoting and encouraging international comparisons of organic rice production systems based on collaborative research outputs, succeeding symposiums were held in various locations: 2nd International Symposium in Milan, Italy, in September 2015 in the framework of the International EXPO Feeding the Planet, Energy for Life; and 3rd International Symposium in Porto Alegre, Brazil, in March 2018.
The 4th International Symposium was initially scheduled for August-September 2021 but was eventually postponed due to the Covid 19 pandemic, and related travel restrictions for both local and international participants.

CALL FOR ABSTRACTS

Language
The 4th International Conference on Organic Rice Farming and Production Systems (ORP4) Scientific Committee welcomes abstract submissions for oral, poster and video presentations. All abstracts should be written in **English** or in **Japanese**.

Oral/Poster/Video Presentations
The conference will have plenary sessions only. An oral presentation in the plenary session is scheduled for 15 minutes. A video presentation should be recorded in advance within 15 minutes.

Reviewing and Acceptance
All submitted abstracts will be reviewed by the conference committee which will decide those that will be accepted, and of those, which will be for oral, poster or video presentation based on their overall quality, impact, and relevance to the conference.

Abstract
An abstract should be written in English within 2 pages according to the attached template below. Please send the abstract to conference email (orp2023@grp.tohoku.ac.jp) on or before 31 May 2023. If you have any inquiries, please contact us.

Publication
After the presentation, authors have the option to submit their extended abstract for publication in the Journal of Integrated Field Science of Tohoku University.

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4th International Conference Organic Rice Farming and Production Systems

The 21th International Symposium of the Integrated Field Science Center

Tohoku University Sendai - Japan

September 4 th – 7 th, 2023

Program

				Presenters	Original titles
4th SEP.	**Opening**	13:00	13:10	**Keiichi Ishii** (Organizer of ORP4)	
		13:10	13:15	**Shinichiro Ogura** (Director of Integrated Terrestrial Field Station, Tohoku University)	
		13:15	13:20	**Yoshimitsu Taniguchi (**President of the Japanese Society of Organic Agriculture Science)	
	Session 1	13:20	13:25	Chair: **Atsushi Tanaka** (Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries, Japan)	
	Trends in organic rice production - Japan, South Korea, Thailand and France	13:25	13:40	Takeru Kusudo (Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries, Japan), Atsushi Tanaka	The Prevalence of Organic Rice Production in Japan: An Overview from the Census of Agriculture and Forestry
		13:40	13:55	Jongin Kim KREI (Korea Rural Economic Institute) (online)	Environment-friendly rice production and consumption in Korea and future challenges
		13:55	14:10	Nalun Panpluem (SukhothaiThammathirat Open University), Changbin Yin	The Evaluation Management of Organic Rice Production by Farmers in Yasothon Province, Thailand
		14:10	14:25	Jean-Marc Barbier (French National Institute for Agriculture, Food and Environment), Jean Claude Mouret, Fanny Balma, Isabelle Michel, Laure Hossard, Sylvestre Delmotte, Santiago Lopez-Ridaura	Organic Rice Production in Camargue, France. A resilience glimpse in turbulent times
		14:25	14:50	Discussion	
			Break		
	Session 2-1	15:10	15:15	Chair: **Masakazu Komatsuzaki** (Ibaraki University, Japan)	
	Organic rice production: cropping and farming system	15:15	15:30	Hiroyuki Tateno (Tateno kaeru farm, Japan)	Organic production practice by using weeds
		15:30	15:45	Isabelle Michel (French National Institute for Agriculture, Food and Environment), Jean Claude Mouret, Laure Hossard, Marie-Jeanne Valony, Fanny Balma, Jean-Marc Barbier, Santiago Lopez-Ridaura, Charles-Henri Moulin	The role of alfalfa in the transition to organic rice production on farms in Camargue, France
		15:45	16:00	Terufumi Tada, Masayuki Kobayashi, Makoto Mori, Koki Homma, Tatsuhiko Shiraiwa	Variation in yield and harvest index in long-term non-fertilized and pesticide-free rice
		16:00	16:15	Luis Espino, Anders Lundberg, Bruce Linquist, Whitney Brim-DeForest (Video)	The Organic Rice Production System in California
		16:15	16:30	João Batista Amadeo Volkmann (Alimentos Volkmann, Brazil) (Video)	Perception of living forces in rice crops
		16:30	16:45	Yashbir Singh Shivay (Indian Agricultural Research Institute), Dinesh Kumar, K.S. Reddy	Effect of nutrient management options on productivity and nutritional quality of organically-grown Basmati rice under the long-term experiment (20 years) of basmati rice-wheat cropping system
		16:45	17:15	Discussion	
6th SEP.	**Session 2-2**	9:00	9:05	Chair: **Koki Honma** (Tohoku University, Japan)	
	Organic rice production: cropping and farming system	9:05	9:20	Takao Furuno (Aigamo duck Family Furuno Farm)	Weeding with duck and hawking in organic dry direct seeding field
		9:20	9:35	Mizuhiko Nishida (Tohoku University), Ayako Sasaki, Yoshiki Tokonami	Effects of introducing AigamoRobo to an organic paddy field
		9:35	9:50	Margi Asih Maimunah (Iwate University), Valensi Kautsar, Samuel M. Kimani, Nanami Sekishita, Yuka Hosogoe, Shinkichi Takami, Keitaro Tawaraya, Hideki Murayama, Weiguo Cheng	Improving rice competitive to weeds by frequencies of weeding in Japanese organic farming

		9:50	10:05	Kazuma Katahira (Katahira Farm)	Proposal for Organic Rice Cultivation Using the Fertilizing Effect of White Clover Green Manure and Irrigating According to the Growth Rate of Seedlings in Early Dry Fields
		10:05	10:20	Munif Ghulamahdi (IPB University)	The Application of Organic Rice Farming in Tidal Swamp
		10:20	10:45	Discussion	
			Break		
	Session 2-3	11:05	11:10	Chair: **Koichi Shoji** (Kobe University, Japan)	
	Organic rice production: cropping and farming system	11:10	11:25	Zhiduo Zhou (Hokkaido University), Yan Zhu, Munehide Ishiguro, Junichi Kashiwagi, Araki Hajime	The effect of inter-tillage weeding on rice yield, growth and nutrient dynamics without agricultural chemicals and fertilizers
		11:25	11:40	Hiromi Imasu (Tohoku Agricultural Research Center, NARO), Yoshiaki Kawana, Takuo Kokuryu, Kazuya Sasahara, Takahiro Inumaki, Yuichi Yamada	Organic rice cropping system combining wide square pattern rice transplantation and Inter-/Intra-row weeding
		11:40	11:55	Natsuko Tanaka, Kohei Okamura, Ami Hashimoto, Hiroshi Nogami	Automatic Steering System Challenges Multiple Times Tilling Weeding
		11:55	12:20	Discussion	
			Lunch		
	Poster session	12:30	14:50		
			Break		
	Special Topic	15:00	15:05	Chair: **Sanae Sawanobori** (Keisen University, Japan)	
		15:05	15:25	Denis Lairon (Aix Marseille University), Julia Baudry, Emmanuelle Kesse-Guyot (online)	Key findings of the French BIoNutriNet project on organic food-based diets and sustainability (diet, nutrition, health and environment)
		15:25	15:40	Discussion	
	Session 3	15:40	15:45	Chair: **Hiroyuki Yasue** (NARO, Japan), Nocon-Shimoguchi Nina (Tokyo University of Agriculture, Japan)	
	Practices and Participative research for development	15:45	16:00	Y.V. Singh (Indian Agricultural Research Institute)	Farmers’ participatory on-farm testing (FP-OFT) of organic and conventional systems on productivity, soil and grain quality of aromatic rice in India
		16:00	16:15	Matteo Petitti (Rete Semi Rurali), Giuseppe De Santis, Salvatore Ceccarelli, Rachele Stentella, Michele Salvan, Bettina Bussi, Riccardo Bocci, Daniela Ponzini	Rice Diversity from Seed to Fork: a Living Lab for Organic Rice in Northern Italy
		16:15	16:30	Stefano Bocchi (University of MIlan), Farmers group	Evolution of principles and practices of research on rice during the last 10 years - University of Milan as a Case Study
		16:30	16:45	Valentina Vaglia (University of MIlan), Jacopo Bacenetti, Francesca Orlando, Sumer Alali, Elena Pagliarino, Stefano Bocchi	Participatory approach for developing knowledge on organic rice farming in Italy
		16:45	17:15	Discussion	
7th SEP.	Session 4	9:00	9:05	Chair: **Takuya Mineta** (NARO, Japan)	
	Agro-ecosystem, biodiversity, landscape	9:05	9:35	Kazumasa Hidaka	Agrodiversity and biodiversity of rice cultivation - Agroecological design for sustainable food and agriculture
		9:35	9:55	Naoki Iiyama (Research Center for Management of Disaster and Environment, Tokushima Univ.)	Citizen participation in paddy field biodiversity survey - A case study in Tokushima prefecture-
		9:55	10:15	Weontai Jeon (National Institute of Crop Science, Rural Development Administration, Suwon, Gyeonggi, Republic of Korea)	Current status and prospects of weed management technology using green manure crops Hairy vetch and Golden Apple Snail in paddy soil in Korea
		10:15	10:20	Chairperson's Comment	
			Break		
	Session 5	10:40	10:45	Chair: **Joji Muramoto** (University of California Santa Cruz, USA)	
	Scale shift towards mainstream organic production	10:45	11:00	Stéphane Bellon (French National Institute for Agriculture, Food and Environment), Dominique Desclaux, Cécile Detang-Dessendre, Françoise Medale, Servane Penvern	Scalability of organic agriculture (OA): insights from Europe
		11:00	11:15	Shinji Iwaishi (International Nature Farming Research Center)	Challenges when spreading and expanding organic rice cultivation

	11:15	11:30	Madonna Casimero (International Rice Research Institute), Rizal G. Corales, Myrna Malabayabas, Johannes Mendoza	Palayamanan: a holistic approach for sustainable intensification and diversification of organic rice-based farming systems for smallholders in the Philippines
	11:30	12:10	Discussion	
Closing				
Workshop "How far can organic rice develop?"	13:30	14:30	Coordinators: Servane Penvern, Stéphane Belon, Jean-Marc Barbier	

Poster Sessions

Chair: **Mizuhiko Nishida** (Tohoku University)

	Presenters	Original titles
1	Yoshihiro Kobayashi, Hiroshi Tsuyuzaki, Yoshinobu Usumoto, Jung Ishwor Kunwar, Koji Nishikawa, Hidehiro Inagaki	The effects of multiple inter-tillage weeding on rice growth and yield
2	Nanami Sekishita (Yamagata University), Shinkichi Takami, Samuel M. Kimani, Yuka Hosogoe, Keitaro Tawaraya, Weiguo Cheng	Effect of surface soil disturbance by hand weeding on organic rice cultivation in a new constructed rice paddy during three consecutive growing seasons
3	Monrawee Fukuda (NARO), Rio Takama, Toshiyuki Imaizumi, Akira Koarai	Mechanical Inter-/Intra-Row Weeding Effect in Rice Transplanted in Wide Square Pattern
4	Manami Yabe, Misaki Kaneko, Hikaru Nakamura, Miki Hunada, Kazuma Kaneko, Nanami Sekisita, Yuka Hosogoe, Keitaro Tawaraya, Weiguo Cheng	Adaptability to Organic Cultivation and Weed Competitiveness among Rice Varieties Grown in the Shonai Region since the Meiji Era
5	Jean Yves Dukuzumuremyi (Yamagata University), Christian Nkurunziza, Margi Asih Maimunah, Yuka Sasaki, Murayama Hedeki, Weiguo Cheng	High-yielding cultivar “Takanari” shown over competition to “Koshihikari” on nitrogen absorption and biomass production under natural rice farming
6	Guglielmo Savoini (University of Milan), Valentina Vaglia, Fosco Vesely, Stefano Bocchi	Innovative and sustainable products for the organic rice production focusing on the use of biostimulants and allelopathic rice varieties
7	Geeta Singh (Indian Agricultural Research Institute), Manoj Menapadi	Microbiological basis of soil carbon sequestration in Organic rice production in India
8	Yoshinori Watanabe (Faculty of Food and Agricultural Sciences, Fukushima University), Nobuhiro Kaneko	Nitrogen nutrients and carbon accumulation in no-tillage grass-grown rice fields
9	Takumi Hasegawa (Tohoku University), Ryosuke Tajima, Mizuhiko Nishida	Root Dynamics in organic rice farming in comparison with conventional farming
10	Dinesh Kumar (Indian Agricultural Research Institute) and Y.S. Shivay	Long-term effects (20 years) of cropping systems and nutrient management practices on grain yield of organically-grown basmati rice and soil fertility
11	A.Haitami (Bogor Agriculture University), Munif Ghulamahdi, Anas Dinurrohman Susila, Didy Sopandie, Yulin Lestari	Cropping Pattern Rice-Red Onion-Soybean under Saturated Soil Culture in Tidal Swamp
12	Francesca Saitta (University of Milan), Andrea Bresciani, Valentina Vaglia, Francesca Saitta, Dimitrios Fessas, Maria Cristina Casiraghi, Daniela Erba, Maria Ambrogina Pagani, Stefano Bocchi, Alessandra Marti	Evaluation of differences in physical properties, cooking behaviour and starch digestibility of different rice varieties associated also to management strategies
13	Minyu Sun (Tohoku University), Hidetoshi Asai, Aung Zaw Oo, Toshiyuki Takai, Koki Homma	Effects of Salinity on Yield and Grain Antioxidant Contents of Black Rice
14	Sumer Alali (University of Brescia), Valentina Vaglia, Gianni Gilioli, Stefano Bocchi	How organic rice farming impacts the biodiversity: a case study of the rice paddies in north ITALY
15	Michele Salvan (University of Turin), Giuseppe Desantis, Matteo Petitti, Daniela Ponzini, Rachele Stentella, Riccardo Bocci, Irene Piccini, Simona Bonelli	Natural Biodiversity Promotion in Diversified Organic Rice Farming Systems in Northern Italy
16	Naomi Naomi, Takatoki Kaku, Koki Muto, Jun Sugai, Naoya Takashima, Masakazu Komatsuzaki	Organic rice cultivation technology utilizing paddy ecosystem benefits
17	Ryosuke Tajima (Tohoku University), Takumi Hasegawa, Naoto Nemoto, Fumihiko Sakurada, Kazunori Akita, Toru Uno, Kazumi Suzuki, Ito Toyoaki, Masanori Saito, Mizuhiko Nishida	Field experiment of organic rice farming in Field Science Center, Tohoku University over ten years
18	Jean-Marc Barbier (Reunion Rice Association)	The revival of sustainable (upland) rice cultivation in Reunion Island (France, Indian Ocean)
19	Vanaja Taliyil (Kerala Agricultural University)	Success story of equipping stake holders of naturally organic saline prone sea coastal wetland ecosystem of Kerala through research and development interventions

Session 1

Trends in organic rice production - Japan, South Korea, Thailand and France

Organic production is expanding worldwide. However, only a few countries experience the same growth and development due to differences in regional market size and national governments' set targets. In recent years, organic rice production has been growing in Europe, the U.S., and some Asian countries. For further promotion and expansion, it is necessary to determine and evaluate the growth and development triggers and disrupters in organic rice production and consumption and clarify reasons for the similarities and differences among countries and regions. In this session, we expect a wide range of reports and discussions on the international situation, national and local government policies and regulations, and the issues for further promotion of organic rice production and consumption. For the future of organic rice, we encourage networking and proactive discussions from the socio-economic and political perspectives.

Session 2

Organic rice production: cropping and farming system

Organic rice farming has been continuously growing in the last three decades and has discovered much scientific evidence and innovations regarding organic rice farming practices to improve the yield responses, material inputs, labor requirements, and environmental sustainability. This session will be discussing the recent cutting-edge of the development of organic rice production systems from the viewpoint of field scale approaches to maximize the agroecological intensifications and to create a smart organic system. This session also encourages the sharing of knowledge and experience between farmers and scientists.

Session 3

Practices and participative research for development

Organic rice does not use chemical fertilizers or pesticides; it is produced by preparing the soil and making good use of the roles of various ecosystems. What are the quality characteristics of organically-grown rice produced regarding nutritional content, safety, palatability, and other various functionalities? Furthermore, how can such quality characteristics be obtained? Moreover, what kind of processed products can be produced from organic rice by taking advantage of these quality characteristics?

This session aims to bring together various knowledge related to the quality of organic rice and leverage it for future practice and research.

Session 4

Agro-ecosystem, biodiversity, landscape

In rural areas, organic rice farming is gaining attention for improving biodiversity through conserving and regenerating rare species and controlling pests and diseases in rice cultivation.

Traditional rice farming in Japan strongly connects with satoyama, such as obtaining organic resources from surrounding grasslands and forests. Organic rice farming utilizes local resources that use the blessings (ecosystem services) from these satoyama areas, the regeneration of the accompanying rural culture, and the formation of traditional satoyama landscapes. Furthermore, resource-recycling and low-input organic rice farming on a regional basis are expected to reduce greenhouse gas emissions and contribute to the mitigation of climate change. In this session, we encourage presentations and discussions about exemplary organic rice-based rural ecosystems, the latest findings on invasive alien species that have become a threat in recent years, and participatory research by farmers and citizens. We expect that farmers, citizens, and other stakeholders will have a more profound and mutual understanding of the functions and impacts of organic rice farming on ecosystem conservation at the regional level.

Session 5

Scale shift towards mainstream organic production

Facing the demand for an agroecological transition and more healthy products in agriculture, the prospect that organic farming could become the major agricultural production system in the near future has been the subject of large discussions among various scientific communities and groups of stakeholders. Strong debates have emerged about the many consequences of such a possible situation, mainly with the concern of the capacity of such farming systems to really feed the worldwide population. To assess if such a future is even desirable, two main set of questions arise: (i) is it technically, economically and socially feasible? To which conditions? (ii) if yes, what would be the consequences? Are all the impacts compatible with a more sustainable agriculture?

Even if the recent international crisis (pandemic, war) has changed the pre-existing dynamics in terms of extension of the organic agricultural sector, it is still relevant, with the aim to anticipate plausible futures, to study, from a scientific point of view, what are the issues, the levers and the consequences of a change of scale of organic production throughout the whole agri-food chain.

Oral Session 1-1

The Prevalence of Organic Rice Production in Japan: An Overview from the Census of Agriculture and Forestry

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The importance of sustainable farming practices is increasing from the perspective of the SDGs and in consideration of the environment. Along with this background, the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF) has introduced a strategy for sustainable food systems, “MIDORI” strategy. In this MIDORI strategy, by 2050, MAFF aims to increase the percentage of organic farmland to total agricultural land to 25% (1 million hectares). In the 2020 Census of Agriculture and Forestry, a survey was conducted on whether or not organic farming is practiced and its scale at the agricultural entity (hereafter, producer) level. In this presentation, we present an overview of organic rice production in Japan based on this census data. The main findings are as follows. Among the whole rice producers (for sales), 35,244 producers practiced organic farming in rice production (**Table 1**). The proportion of organic producers is increasing as the scale of cultivated paddy rice field increased up to 100 ha (**Fig. 1**). Additionally, when we focus on the percentage of organic cultivation area in each scale (organic per total rice cultivated area), we can see different findings. The percentage of organic cultivation area was mostly 100% of rice cultivated area up to about 10 ha, i.e., the majority of the relatively small rice producers practiced organic farming in the entire rice cultivated area. However, the percentage of 100% organic farming decreased monotonically with the increase in the scale of rice cultivated area, and the majority of relatively large producers practiced organic farming in a part of the rice cultivated area (**Fig. 2**). This may reflect the fact that it is appropriate for relatively small producers to practice organic farming in the entire field from the viewpoint of managing contamination from neighboring fields. On the other hand, in large producers, their arable land is divided into several plots, and, in many cases, each plot is apart. Therefore, large producers can practice organic farming in some of the plots while conventional farming is practiced in the other plots. These results suggest that it is necessary to consider both increasing the number of organic producers and increasing the area of organic farming for each organic producer.

Table 1. Number of organic producer and their organic cultivation

	Num. of Producers	Prop. of OF (Num. of Producer)	Cultivated Area (ha)	Prop. of OF (Cultivated Area)
Num. of Producers	1,075,705	-	-	-
Cultivate Rice	713,792	-	1,285,654	-
Organic Rice	35,244	4.9%	60,624	4.7%
Cultivate Maize	49,731	-	132,084	-
Organic Maize	2,862	5.8%	5,122	3.9%
Cultivate Vagetables	282,543	-	264,734	-
Organic Vegetables	24,647	8.7%	18,435	7.0%
Cultivate Fruits	172,528	-	126,819	-
Organic Fruits	12,750	7.4%	9,630	7.6%
Others	-	-	-	-
Other Organic	6,598	-	21,458	-

Note. OF is organic farming.

Fig. 1. Relationship between scale of rice cultivated area organic rice (OR) producers

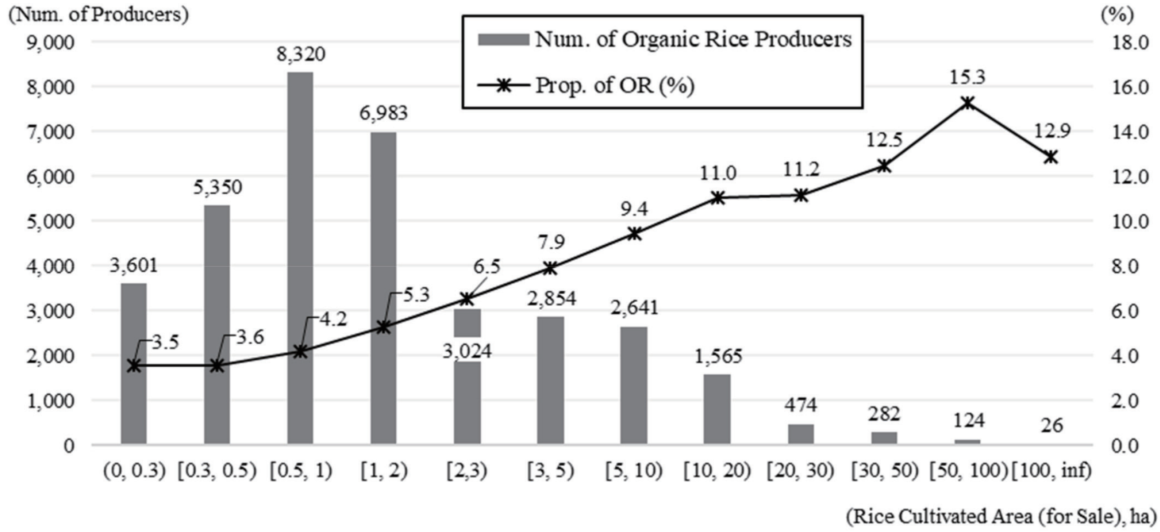
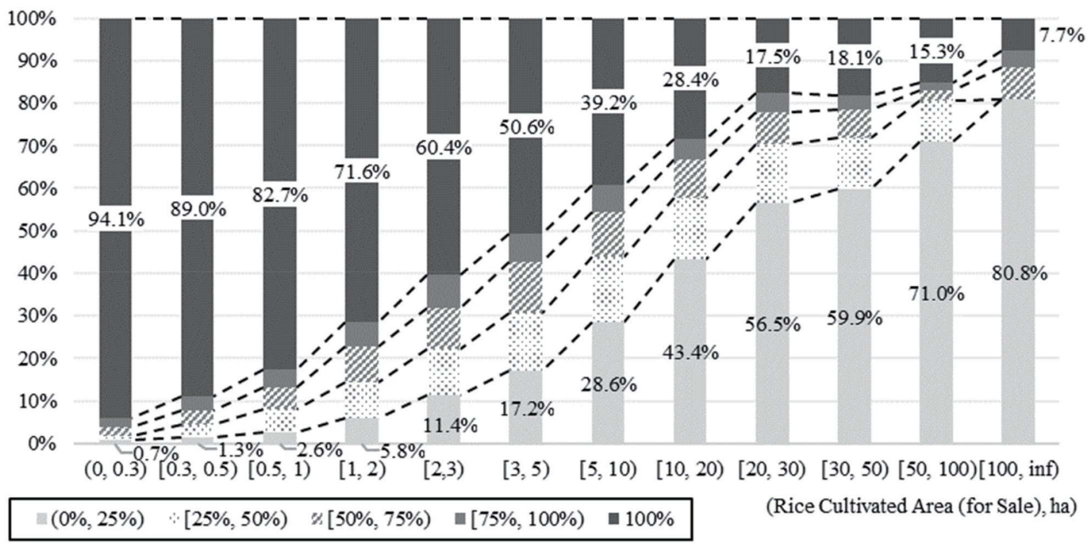


Fig. 2. Relationship between scale of cultivated area and the percentage of organic rice field



Keywords: census of agriculture and forestry, organic rice production, scale of cultivation, small producer, large producer

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Oral Session 1-2

Environment-friendly Rice Production and Consumption in Korea and Future Challenges

Jongin KIM

KREI (Korea Rural Economic Institute)

In Korea, the agricultural environment deteriorated due to high input farming methods for the purpose of increasing production, which acted as a threat to sustainable agricultural production. Although the government induced reductions in the amount of fertilization by developing and supplying low-concentration chemical fertilizers, the amount used per unit area did not significantly decrease due to the customary fertilization of farms. Accordingly, the government enacted the Eco-Friendly Agriculture Promotion Act in 2001 and promoted the spread of eco-friendly agriculture by implementing an eco-friendly agricultural product labeling system.

On the other hand, the certified area for eco-friendly agricultural products in Korea is showing a gradual decrease as the area for pesticide-free certification continues to decrease. On the other hand, certified organic area has increased significantly at an average annual rate of 12.6% over the past five years (2018-2022). This seems to be because Korean consumers are increasingly interested in health and eco-friendliness. For the stable production of eco-friendly agricultural products, technology development, certification system improvement, and eco-friendly agricultural material cost reduction are required. In order to expand the consumption of eco-friendly agricultural products, it is necessary to improve the certification system, lower prices, find new sources of demand, and seek exports. In particular, it is necessary to develop new markets, such as public catering, institutional and corporate catering, to discover new sources of demand. Public meal service needs to be expanded not only to school meals but also to soldiers and pregnant women.

Keywords: organic farming, eco-friendly rice, public food

Oral Session 1-3

The Evaluation Management of Organic Rice Production by Farmers in Yasothon Province, Thailand

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Sustainable agricultural production has been a major concern globally. In Thailand, self-sufficiency in rice production has been a key goal for the last decades. Nevertheless, high crop yields are often associated with conventional rice cropping system, but this system may also cause soil degradation, loss in biodiversity, environmental pollution, and chemical residues in foods. On the other hand, the organic food pursuing by consumers prompts local farmers to alter the conventional cropping system into a more sustainable way of organic farming. Rice production holds a significant position in the Thai economy. Although it is the world's largest rice exporter, Thailand's increase in rice production is the result of expansion in the cultivation area rather than an increase in yield per unit area. The cultivation of rice under organic farming in Thailand is facing certain biophysical, sociological, and economic challenges that hinder the efficiency of organic rice production.

Therefore, the present study was designed to estimate the management of organic rice production by farmers in Yasothon province, Thailand. The specific objectives of this work were to: (1) study the general conditions of farm operations of certified organic rice producers; (2) study about costs and return of organic rice production. The Yasothon province was chosen as this area, for it has been known as the largest organic rice production area in Thailand. To reach the goals of the study, the sampling group was employed consisting of 328 farmer groups sampled from 7 districts of the Yasothon province, located in the northeast of Thailand, namely, Kut Chum, Maha Chana Chai, PaTio, KhoWang, Loeng Nok Tha, SaiMun, and Muang Yasothon. For this purpose, data were collected from a sample of groups of certified organic rice growers in Thailand, entrepreneurs, and stakeholders. The research methodology used was a mixed method that covered the qualitative and quantitative aspects of the data. This included interviews with organic farming and key informants using questionnaires. These organic rice-producing farms have been monitored and accredited by the Organic Agriculture Certification Thailand (ACT) standards. The standards are supervised by the International Federation of Organic Agriculture Movements (IFOAM), EU: TH-BID-121 Thailand Agriculture, and Canada Organic Regime (COR).

The results showed that most organic rice producers were female. The reason is they are middle-aged women who graduated from primary school early. Residents outside the city often engage in agriculture, farmers have a career in farming as their main occupation. Moreover, they do not engage in any no extra occupations. As for household size, most organic rice producers have family members between 3-4 persons. Hence, most of the family workers are regular workers for farms. Furthermore, these people possibly have more experience in farming between 21-30 years for farmers of Thailand. As a result, with more than 7 years of experience in organic rice production, this group of farmers is certified under organic export standards. Besides, organic rice farmers had small farms between 0.96-1.6 ha for rice cultivation, generating sufficient income as their main source. The investment in that farm is mostly self-financed. When considering the production cost and return of organic rice farmers in Yasothon province, it was found that the average total cost for growing organic rice in 2017-2018 was 4,329.32 baht per ha. The average selling price was 14.77 baht per kilogram. Farmers had a total revenue of 29,716.94 baht per ha. Organic rice production had an average net profit of 25,387.62 baht per ha, with average net revenue of 26,929 baht per ha. Variable cash costs found that farmers who produce organic rice had net revenue above variable cash cost which was 643.81 baht per ha. In addition, the break-even point of organic rice farmers was an average break-even yield of about 293.12 kg per ha and a break-even price of about 2.15 baht per kg. From the result of this research, it can be concluded that Thai farmers have great potential to increase the yield of organic rice production, which can be reached 72%-77% at maximum. The market can be divided into two groupings; Export market; It was found that most of the organic rice of Yasothon province for export to markets in the United States of America, Europe and Singapore accounted for 70%. Additionally, it was found that the most exported organic rice was jasmine rice which accounted for 99% of total export. Domestic market; It was found that organic rice in the domestic market accounted for 30%, such as supermarkets, green markets, hotels, restaurants, schools, consumers in upcountry and factory. However, there were some production problems like uncertain weather conditions, production costs problems arise from high wages but don't have marketing problems, because organic products have a higher market price than conventional agricultural products. Also, information on the health and environmental impacts of farmers growing organic rice is given; farmers did not have problems with soil conditions, water resources problems (restriction) and illness caused by chemical allergies. Farmers cultivated rice by using chemicals to turn into organic systems by discontinuing the use of chemicals, causing no problems as mentioned above. Organic agriculture seems to contribute to maintaining an optimal health status and decreases the risk of developing chronic diseases. This may be due to the higher content of bioactive compounds and lower content of unhealthy substances such as cadmium and synthetic fertilizers and pesticides in organic foods of plant origin compared to conventional agricultural products. In terms of health advantages, organic diets have been convincingly demonstrated to expose consumers to fewer pesticides associated with human disease. Organic farming has demonstrated to have less environmental impact than conventional approaches.

The research is expected to receive benefits such as information on organic rice production and export market system, to be

presented to the government and private sectors engaged in promoting the farmers to increase their production capacity, and raise the standard of living of organic rice farmers. Furthermore, this study can provide critical information to farmers, agricultural planners, and the Thai government departments to determine strategies that are useful and practical in raising efficient performance in each region, and to help increase the trend of rice productivity index in some areas of Thailand. Besides, increasing rice yield per ha under the present technology could be achieved by improving the socio-economic characteristics and production management of farmers. In other words, the technical efficiency of rice production can be increased by improvements in farmer conditions and farm characteristics levels.

Keywords: organic rice, costs and return, Yasothon Thailand

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Oral Session 1-4

Organic Rice Production in Camargue, France. A Resilience Glimpse in Turbulent Times

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The Camargue, situated in the delta of the Rhône River, is France's most important region for rice production. The Rhône River, one of Western Europe's largest rivers, stretches from the Alps to the Mediterranean Sea in southern France. The Camargue delta is among Europe's largest wetlands, designated as a wetland of international importance under the Ramsar Convention. It is also classified as a UNESCO Biosphere Reserve and Regional Nature Reserve. In this unique and delicate environment, the Camargue is home to over 270 bird species and various other animals and plant species of interest (Pernollet, 2016).

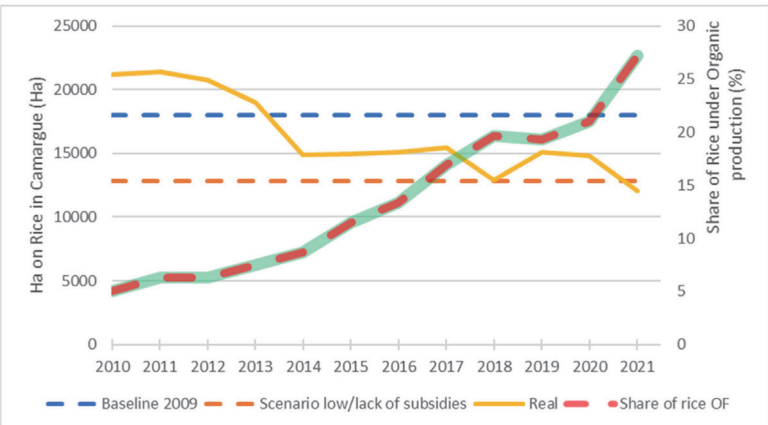
Rice, specifically the japonica type, plays a crucial role in agricultural production in the Camargue. It allows for the cultivation of other crops in this saline environment by desalinating the soil through flood irrigation with fresh water from the Rhône River. Additionally, rice production is economically attractive and serves as a central element for the livelihoods of approximately 200 farm households. Due to regulations on herbicide usage, rice cultivation needs to be rotated with dry crops, primarily wheat, to control weed infestations and achieve yields of approximately 5-7 tons per hectare after a 3 to 5-year rotation.

The Camargue has around 35,000 hectares of agriculturally suitable land, with rice being presently grown on 10,000 to 13,000 hectares annually. Approximately 3,300 hectares of rice in the Camargue are cultivated using organic management methods, involving around 90 farms. This represents approximately 25% of the total rice production in the region. However, this situation hasn't always been the case. In the past 10 to 15 years, overall rice production in the Camargue has halved, while the area under organic management and the number of farmers practicing organic rice production have tripled.

Over a decade ago, we conducted prospective studies, including quantitative and qualitative scenario analyses, to explore potential changes for organic rice production and agriculture in the Camargue (Delmotte et al., 2016; Delmotte et al., 2017). Through participatory approaches, we identified the main drivers and integrated possible, plausible, and probable future situations into a multi-scale and multi-criteria assessment framework. In 2023, we returned to the region and interviewed 15 different farmers and regional actors to understand the current situation, assess the evolution of organic rice production, and evaluate the accuracy of our past scenario assessments.

Our previous scenario assessments highlighted various future situations for agricultural development in the Camargue, including organic rice production. Our analyses identified the discontinuation of subsidies to rice production, as envisioned in the development of the European Common Agricultural Policy (CAP) since 2014, as one of the most significant threats to rice production in the Camargue. Additionally, we recognized a key driver related to the reduction of pesticide usage (including herbicides) in line with France's aim to decrease their use by 50% by 2025 (Plan ECOPHYTO II+, 2018). According to our models, organic agriculture could play a vital role in mitigating the effects of subsidy withdrawal and contribute to the pesticide reduction program. Mixed crop-livestock farmers were found to be in a favorable position to convert to or maintain organic rice production. Furthermore, the diversification of farming and cropping systems appeared inevitable to overcome the aforementioned challenges.

In 2023, we found that these scenario analyses had been relatively accurate. Coupled subsidies for rice had been suppressed, along with further constraints on farmers' use of pesticides. This saw the cultivated area reduced to around half of the 2009 reference value—as suggested by our scenario assessments—while mixed crop-livestock systems and further diversification of cropping and farming systems were observed throughout the 2014-2022 period.



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Keywords: ex-ante assessment, scenarios, retrospective analysis, systems approaches, participatory

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Oral Session 2-1-1

Organic Rice Cultivation Techniques by Utilizing Weeds

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Tateno kaeru farm, Japan

A challenge in organic paddy rice cultivation is weed control technology. Conventional weed control methods have focused on weeding after rice planting. However, organic rice cultivation without weeding after rice planting is possible through paddy field management techniques prior to rice planting. During seedling cultivation, relatively longer period for multiple puddling prior to rice planting can be secured by growing adult seedlings, and at the same time, deep-water cultivation that suppresses weed growth is possible. Increasing humus organic matter in paddy fields and promoting the formation of "Torotoro-layer" (soft, muddy layer on the soil surface) in the soil are effective for weed managements. It is important to increase the activity of soil microorganisms that humify organic matter in order to form this layer. Weeds in the fallow season are effective in supplying this organic matter. This is because weeds grow with rhizospheric microorganisms and have the effect of nurturing microorganisms. Multiple times of puddling during the flooded period prior to rice planting stirs up the paddy soil and promotes humification of organic matter. The water level in this puddling technique is about 5 cm deeper than that of conventional puddling. This deep-water puddling allows soil particles and humus to mix thoroughly and sink slowly in layers. In this process, the weed seeds in the surface layer also sink and a light, fine "Torotoro-layer" accumulates on the weed seeds to cover them. This burial effect of weed seeds and the change in the wavelength of light due to the deep muddy water inhibit germination of weed seeds. Such pre-planting paddy field management eliminates the need for weeding after rice planting, and at the same time, the nutrients from the weeds become organic fertilizer which are supplied to the rice plants. This effective use of weeds significantly reduces the cost of organic rice cultivation.

Keywords: organic farming, weed, seedling cultivation, deep-water plowing,

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Oral Session 2-1-2

The Role of Alfalfa in the Transition to Organic Rice Production on Farms in Camargue, France

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In Camargue (France), the area of rice under organic farming has increased rapidly during the last decade, with the transition of around 90 farms. We distinguish two steps in this notion of transition. The first step is the conversion to organic farming, requiring 3 years for the lands and 6 months for the herds. The second step concerns the evolution of cropping systems after the conversion. The purpose of this communication is to show the roles of forage crops in the transitions. We used a case study database comprising 42 farms, 24 of which switched to organic farming. We built this database from a training action with Master 2 level students between the years 2010 and 2023. We identified four types of transition. They differ according to farm type (cultivated area, location, soil types, degree of original rice specialization, presence or absence of livestock, farm history); to the degree of conversion to organic farming (on all plots or only part) and the organic cropping systems implemented. All conversion trajectories include alfalfa cultivation. The comparison of the types shows the agronomic benefits of alfalfa for the 3-year conversion period, and then for the construction of organic rotations including rice. We also show limitations of alfalfa, such as its incompatibility with the lowlands, floodable in winter and prone to salinization. Another constraint is the problem of harvesting and marketing alfalfa for farms without livestock. Growers build contractual agreements with livestock farmers to valorize their alfalfa or shorten the alfalfa's lifespan (1 to 2 years), and testing alfalfa/cereal combinations to boost gross margin per hectare. Some of them also rent plots to market gardeners to cultivate organic melon or tomatoes. In this case, new organic rotations with rice are possible without alfalfa. Mixed crop-livestock farmers use the alfalfa for their herd and realize forage intercropping, including grazed regrowth after watering, which further diversifies organic rice cropping systems. Some go so far as to use their equipment and know-how to provide alfalfa harvesting services to growers. Finally, farmers specializing in livestock tend to replace rice with irrigated grassland in the lowlands. In diversified trajectories with possible back-and-forth movements, farmers in Camargue use several levers to develop organic rice production, such as mixing organic and conventional, mixing crop and livestock or building agreements with other specialized farmers. Livestock played a key role in the development of organic rice in the last decade, but large-scale market gardeners looking for plots to rent for organic farming could alter this role in the future.

Keywords: livestock-crop interactions, cropping systems, farmers' trajectories, socio-economic drivers

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Oral Session 2-1-3

Rice Yield and Harvest Index of Long-term Unfertilized and No-chemical Production

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Background and Purpose

Modern agriculture uses large amounts of chemical fertilizers, pesticides, and even organic matter, and this high input agriculture is thought to have a negative impact on environmental pollution and human health. In reality, however, paddy rice production is practically sustainable with only natural supply from soil and water. In this study, we focused on a farming method that does not artificially apply pesticides as well as organic matter and fertilizers, including compost, without fertilizer (hereafter referred to as NF farming), and aimed to evaluate the productivity in terms of brown rice yield and harvest index (HI) in a long-term continuous NF farming field.

Materials and Methods

Brown rice yield and HI were investigated in nine paddy field plots continuously cultivated without fertilizer for a long period of time in the Kinki region in Japan. Yield was obtained from a few sampling points for the long-term continuous cultivation, and the yields from entire field were also investigated to evaluate their response. Note that no fertilizers, pesticides, nor organic matter were used in the nine plots, and the rice straw was taken out of the system at harvest. The duration of this study ranged from 15 to 56 years.

Results and Discussion

Brown rice yields decreased slightly during the first 10 years and then leveled off. Overall, yields averaged 2-4 t ha^{-1}, lower than the current average yield in Japan, but higher than that of the Edo and early Meiji periods. The stabilization of yields at a constant level can be attributed to the development of mechanization, efficient water management, and the crop's resistance to pests and diseases. Although many of the tested varieties were relatively old, their HI was 0.4-0.5, which may have contributed in part to the achievement of a constant level of yield.

Conclusion

Pesticide- and chemical-free cultivation does not mean a return to the past in agricultural productivity. Furthermore, improved management using current science and technology can be expected to have a positive effect on productivity. The data reported in this study may be useful in examining the sustainability of paddy rice production.

Keywords: long-term unfertilized and no-chemical farming, yield, HI, biomass

Reference: Kobayashi et al., in preparation.

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Oral Session 2-1-4

The Organic Rice Production System in California

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Rice is grown in 200,000 hectares annually in the Sacramento Valley of California. Of these, between 6,000 and 8,000 hectares are grown as certified organic, with acreage fluctuating according to market conditions. Productivity of organic rice is about half to three quarters of conventional, but the market price of organic rice can be more than double that of conventional.

In the organic rice system, fertilizer is applied before planting as dry manure, which supplies a large part of the nitrogen requirement of the crop. In some cases, a leguminous cover crop is grown during the off season and incorporated before planting to provide more nitrogen. At mid-season, a top-dress may be applied using an organic fertilizer to increase nitrogen availability.

The main pest problem of the California rice system is weeds. Conventional rice is typically grown from seeding to harvest under a 10 cm flood to limit the establishment of weeds; however, herbicides are necessary to reduce weed infestations that can severely limit yields. In the organic rice system, higher water depths of 20-30 cm are commonly used to suppress and control water grass for 18-22 days after planting. In addition, a mid-season dry down period of roughly 30 days is often applied to kill aquatic weed species. These methods are generally effective, but the dry down period extends the vegetative period of the crop and may have negative effects in productivity. On the positive side, the dry down period has also been shown to reduce methane emissions and reduce arsenic content in the grain. Management of other pests relies on cultural practices; the availability of organic insecticides or fungicides is limited.

After harvest, organic rice is dried, stored, and milled by processors that specialize in organic rice. Because chemical fumigants cannot be used to control stored grain pests in organic systems, food-grade CO_2 may be used to control insects.

Lundberg Family Farms is a family owned business in the northern part of the Sacramento Valley. Its founders grew their first crop of organic rice in the late 1960s.To this day, the company is the leading producer of organic rice in the U.S. Lundberg produces, processes, and markets organic rice and rice products under its own brand. The company has also pioneered many of the techniques and cultural practices used in California organic rice production. In addition to the commonly used practices, Lundberg has done extensive work in trying to improve California organic rice system productivity. This work includes variety development, development of new organic weed control techniques, and extensive work in sustainability. In 2022, Lundberg Family Farms was the first California rice brand to become Regenerative Organic Certified ®.

Oral Session 2-1-5

Perception of Living Forces in Rice Crops

João Batista Amadeo VOLKMANN

Alimentos Volkmann, Brazil

1. Introduction

This paper approaches life processes in the rice crop South of Brazil agricultural year. Those processes are understood according to the science that was practiced in Ancient Greece. The paper approaches the transformation phenomena in the soil, plant, fauna and landscape. With this knowledge the farmers can make similares experiences in their landscapes. In Ancient Greece, science was based on the perception and management of the four natural elements: Earth, Water, Air/Light and Fire. Bringing these concepts to the present, how in modern agriculture time can we find sense in them? May it be valuable? Could it contribute to soil management? In Ancient time, the agricultural calendar was read directly in the sky and the high priest, who knew astronomy, dictated the agricultural rhythms. In Astrology these concepts are connected to the Zodiac constellations. It may appear far from the actual reality, but during the agricultural year the phenomena due to these elements can be observed and, from these observations, it is possible to make decisions. It is not a recipe, but one exercise to discover and learn from this observation. Through the year, each of these four elements can be observed in relation to the soil fertility, temperature, plant development, insects presence, birds, and so on. In this paper, these elements will be brought using as example the rice crop.

2. The rice cultivation in the Capão Alto das Criúvas farm, South of Brazil

In the Western, rice cultivation was not some typical activity. Culturally, rice was domesticated in the east and adapted to western culture. In Europe, the first records about rice growth happened in the South of Portugal between the V and VII century. In South of France the records point to introduction by Templars in Camargue region at the Röne river delta in the XIV century. The goal with that introduction of rice was to turn the saline soils in arable land. Until now, rice helps in crop rotation. The environment where rice crops grow is of a very special peculiarity. It is ecosystems closely linked to water resources. Some areas are valleys where soils are made of solids coming from the mountains. We can say that rice crop soils are the most fertile soils in the world, with extremely vitality. The quiet observation of these aquatic environments leads us to a new way to study these environments full of vitality. In periods, seasons or depending on special weather conditions, we can contemplate the sunset and the eventide and see some dusk or some fog going to the valleys. We can say that the soil on the valleys receive both the depositions of the flooding and of the atmosphere. Like a mother that shelters a child. The valleys have a coagulation motif while the mountains and hills have a gesture of expansion, like a man. It is in this exact “coagulation” environment or spot that the rice finds its habitat where another kind of cereal cannot grow. Many adaptations in rice physiology and anatomy allow rice to grow in a flooded environment. Leaves can absorb nutrients in water solution in a gesture similar to a foliar fertilization. Rice also gets silicon support by the light and air relation. Because of this special relation with the silicon, rice gets success in generating grains in such conditions. Silicon brings light and structure to such a dark and wet environment. Also, it is interesting to observe the differences between the soil and water layers in rice fields. It is common to believe in the exclusivity of air absence or anaerobic condition of the soil in the irrigated rice grows, but, in fact, there is a thin superficial aerobic layer on soil surface, under the water. The oxygen dissolved in the water supports that aerobic activity in the first layer soil. Like in the bottom of the seas and lakes, this small thin layer is extremely important and poorly researched in the rice fields. Superficial roots develop in that layer promoting a closed relation with soil biota. The quantity of the oxygen dissolute in the water depends on some factors: water temperature and water layer height. It is very important that research be done in these transitions: water surface X atmosphere, atmosphere X water surface; water layer X soil surface, soil surface X water layer. Between the surfaces is where the gaseous exchange and in these surfaces also can be observed the interaction with the nitrogen. The rice aerenchyma system does not transport only oxygen, but also nitrogen, because the atmospheric air contains 78% of nitrogen. The cyanophytes bacteria present in the rice stalk can promote nitrogen fixation. Each rice variety has a particular relationship and ability to make different gaseous exchanges. We can ask ourselves which elements are needed in order to germinate a seed. We immediately recall warmth/light, air (O_2), water and soil itself, where plants are going to grow. Soils at the border of rivers are normally humid and they receive the benefits of floods. The water element is naturally present in these soils. When farmers cultivate the soil, they bring the air element to this environment. A vital impulse starts the germination process of the seeds of weeds already present in the soil. In a few days after turning the soil by plowing, the dark soil top becomes green, covered by new plants. Modifying the equilibrium of the four elements -soil, water, air, warmth- the farmer floods the paddock for 21 days (a solar day), all the seeds that started the germination process start to develop foliar area and seeds that did not germinate will start dormancy because of lack of O_2. Plants regarded as unwanted at the beginning (red rice, cockspur grass, zigzag jointvetch) will be biomass builders (green manure). In this flooding period of 21 days, several phenomena occur. Besides inducing seed dormancy, pH turns neutral because of saturation of bases. With pH neutralization, nutrients are available for plants, making the ideal environment for the rice seedlings. That biomass is incorporated into the inundated soil producing available amino acids for the new rice plants. That decomposition digestion process of biomass needs guidance and it is here that the spiritual knowledge of biodynamic agriculture can contribute in a beneficial way. At this moment we do not want putrefaction but humus formation (OBS: in this stage it is used compost heap biodynamic preparations). Keeping soil inundated along and after the biomass incorporation, other plants' sprout is controlled efficiently. Rice can be sown with seeds pre-germinated. In case of pregerminated rice seeds, it is important to clarify that rice can develop radicle when water has a concentration of O_2 above 4 ppm and develop epicotyl and leaves with levels of O_2 dissolved in water with values over 6 ppm. Because of this, pre-germinated rice follows its growing process on water. After sowing, the application of biodynamic preparation 500 (horn manure) is done to favor the link of the plant to the soil, promoting initial rooting. Also, the management of the water level can change the plant architecture. With a deeper level of water, the plant will grow higher, with a shallower water level, the plant grows lower and with more roots. Handling water layers during the cycle of rice, by drying and flooding, favors live nitrogen formation and reduces the methane (CH_4) emission. During the crop cycle we can still promote living nitrogen according to the management of water. Crop management works together with the vital rhythm and it can be perceived by the leaves coloration. At this initial foliar development, the application of biodynamic preparation 501 (horn silica) is done. In the first weeks, the young plants continue developing until a certain point that we notice a vigor loss and an apparent growing stagnation. Leaves lose the green intensity and when we examine roots, we notice that some pests are present in roots. In some points, the worm of Oryzophagus oryzae start to eat the new roots of rice, then, it is time to drain off the paddock, eliminating the water lay to inhibit the development of the insect. This drainage demands wisdom and patience from the farmer to watch calmly the plant suffering. The process of vitality loss is intensified due to the lack of water, and it is important to be patient and trust that it is the right decision. At this phase it can be sprayed again the biodynamic preparation of horn and manure – prep. 500 - to stimulate root renovation. When water is back, a vitality explosion takes the rice crop, an intense green is disseminated and the plant reacts with intensity. This sudden exchange from flooding to dry and contrariwise, strengthening not only worm control but also significantly reduces the emission of methane in the cropping system and stimulates the formation of life nitrogen. The drainage stimulates change in soil life, anaerobic microorganisms die and immediately a new aerobic life is installed in the soil. With a new flooding in the paddock, another change occurs: aerobic microorganisms are substituted by anaerobic ones. Life and death shifts create a rich soup of microorganisms decomposition with high levels of nitrogen that collaborate with rice growth. Plant growth comes to an end and starts a new stage where it prepares itself for flowering and in this stage, the water layer is elevated to protect the environment from temperature oscillations which are harmful for flowering. The elevation of the water layer also protects rice from the rice stink bug attack which needs a low water layer to suck the stem when panicles emerge. At the stage of grain growth, we can again promote drainage and floodings to favor the grain quality and the plant can receive again an application of preparation of horn silica – preparation 501 - which improves the grain taste and quality. Harvest is done preferably with dry soil.

3. Conclusions

In this text, the relationship between the four elements of Ancient Greek Science and the cycle of irrigated rice cultivation in southern Brazil was approached. The earth element can be directly observed in the seed before its germination, when it is static, immobile as a stone. When starting the germination process, we can already see a small movement with the flow of liquids, presenting a movement like the process of the water element. The process of the air/light element is expressed at the time of flowering where the plant as a whole demonstrates itself in a gesture tending to free itself from earthly matter. And, finally, the process of the fire element is present at the moment of maturation and ripening when in this period the caloric processes act by drying the plant, crystallizing, drying the rice grain until taking it back to the solid state as the earth element. By the way, we can observe the four elements happening in the soil itself. During the winter the ground is cold, and excessively wet, static like a stone. Here the earth and water elements are manifested. With drainage, the air element is invited to act, suppressing the water element. The entire soil biota reacts to changes. It is an invitation to vital processes to be activated. Human action (thinking and acting like the fire element) changes the balance of the elements bringing water. Water management provokes a sequence of action of all elements. When draining a plot, the air element starts its action and little by little the fire element prints colors to the soil, inducing a saline process on the soil surface. Otherwise, when it is flooding again, a solubilizing process begins. Human activity can be considered the performance of the fire element with its thinking capacity. The farmer's task is to contemplate the whole landscape, passing all the year by imaginative capacity, from which image is possible to decide the crop management and the farm organism. With those examples I want to show the possibility by which it is achievable to manage and lead a crop rice from the four elements of knowledge.

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Oral Session 2-1-6

Effect of Nutrient Management Options on Productivity and Nutritional Quality of Organically grown Basmati Rice under the Long-term Experiment (20 Years) of Basmati Rice-wheat Cropping System

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The world market for organically grown food is increasing at a very faster rate considering the ill effects of the excessive use of chemicals. Among many rice germplasm, *Basmati* is known to be the world's most precious rice strain (Shobha *et al.,* 2001). Farmers face diverse problems in rice production, especially the decline in factor productivity, erosion of mineral nutrients and soil organic carbon content, water-logging and soil salinization, and high level of nitrate concentration in well water (Prasad *et al.,* 2017). There is significant scope to expand the area of organic rice in India. Basmati rice is long-grain aromatic rice grown for many centuries in a specific geographical area, in the Himalayan foothills of the Indian sub-continent, blessed with characteristics of extra-long slender grains that elongate at least twice their original size with a characteristics soft and fluffy texture upon cooking, delicious taste, superior aroma, and distinct flavor. Basmati rice is unique among other aromatic long-grain rice varieties. The areas of *Basmati* rice production in India are the states of J&K, Himachal Pradesh, Punjab, Haryana, Delhi, Uttarakhand, and western Uttar Pradesh. India is the leading exporter of Basmati rice to the global market. India has exported 3.948 million tonnes of Basmati rice to the world for the worth of 3,540.4 million US$ during the year 2021-22. Major export destinations (2021-22) countries were Iran, Saudi Arabia, Iraq, UAE, USA & Yemen Republic, etc. (https://apeda.gov.in/apedawebsite/SubHead_Products/Basmati_Rice.htm). To increase production, *Basmati* rice needs a systematic approach, especially in respect of nutrient management. Therefore, a study was conducted on long-term (20 years) to increase the productivity of *Basmati* rice through organic nutrient management options.

A field experiment on *Basmati* rice with organic nutrient management options was initiated in 2003. The present study on the combined application of diversified sources of organic nutrients to Basmati rice was undertaken during 2022 at the research farm of ICAR-Indian Agricultural Research Institute (IARI), New Delhi, India. The experimental site is located in the semi-arid sub-tropics having soil belonging to *Typic Ustochrepts*. The climate of New Delhi is semi-arid with dry hot summers and cold winters with an average annual rainfall of 650 mm, 80% of which is received through the 'South–West Monsoon' from July-September and the rest is received from December-March. The soil of the experimental field was sandy clay loam in texture, having a *p*H of 7.35. The field experiment was conducted in randomized block design with 6 treatments viz. control, farmyard manure (FYM) @ 10 t/ha, sesbania green manuring (SGM), SGM + blue-green algae (BGA), SGM + FYM and SGM + FYM+ BGA and replicated thrice.

Among different organic nutrient sources, the highest grain (4.30 t/ha), straw yield (12.58 t/ha) and biological yields (16.90 t/ha) were recorded with the application SGM + FYM + BGA followed by SGM + FYM. The lowest grain (2.23 t/ha) straw yield (8.42 t/ha) and biological yields (10.65 t/ha) were recorded with control (Table 1). Application of SGM + FYM + BGA recorded 48.3%, 33.1% and 36.9% higher grain, straw and biological yields, respectively compared to the control. The highest harvest index (25.6%) was recorded with the application of SGM + FYM + BGA and the lowest with control (20.9%). Further, the application of SGM + FYM + BGA recorded the highest nitrogen content in the grain being 14.4% higher, similarly 20.9% higher zinc concentration in rice grain over the control (Figure 1). Application of SGM + FYM + BGA remained statistically on par with SGM + FYM for most of the attributes.

Based on the long-term study of organic nutrient management options in organically grown *Basmati* rice under the *Basmati* rice-wheat cropping system it can be concluded that the application of *Sesbania* green manuring (SGM) + FYM (10 t/ha) + BGA is one of the best options to achieve the highest productivity and nutritional quality of organically grown *Basmati* rice.

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Keywords: blue-green algae, basmati rice, farmyard manure, green manuring

Table 1. Effect of organic nutrient management options on the productivity of *Basmati* rice under the long-term experiment (20 years) at New Delhi, India

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
Control	2.23^{c}	8.42^{d}	10.65^{d}	20.9^{b}
FYM @ 10 t/ha	3.62^{b}	11.44^{bc}	15.07^{bc}	24.0^{ab}
Sesbania green manuring (SGM)	3.43^{b}	11.13^{c}	14.56^{c}	23.6^{ab}
SGM + Blue-green algae (BGA)	3.63^{b}	11.38^{bc}	15.01^{bc}	24.2^{ab}
SGM + FYM	4.16^{a}	12.35^{ab}	16.51^{ab}	25.2^{a}
SGM + FYM+ BGA	4.30^{a}	12.58^{a}	16.90^{a}	25.6^{a}
SEm (±)	0.097	0.206	0.348	0.725
LSD (P =0 .05)	0.310	0.658	1.118	2.315

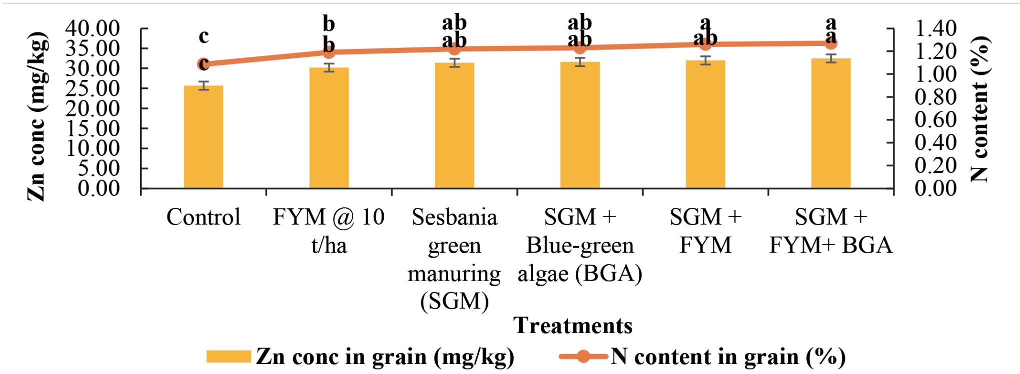
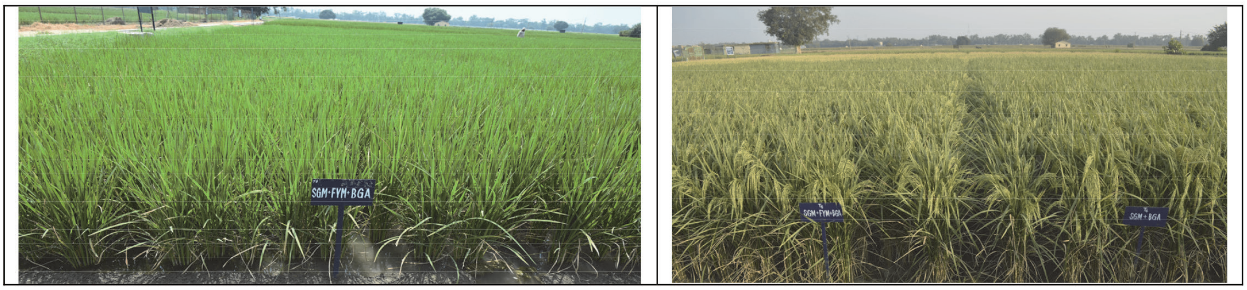


Fig. 1. Effect of nutrient management options on zinc and nitrogen content of organically-grown *Basmati* rice under long-term experiment (20 years) of basmati rice-wheat cropping system



Field experiment treatments photos

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Oral Session 2-2-1

Weeding in Organic Dry Field Direct Seeding Using Aigamo ducks and Hawking

Takao FURUNO

Aigamo duck Family Furuno Farm

I have been farming organically since 1978. It is organic farming with rice field rotation. Aigamo ducks and paddy rice are cultivated simultaneously in summer paddy fields integrating rice cultivation and animal husbandry creatively. After harvesting, wheat, potatoes, onions, and a wide variety of autumn, winter, and spring vegetables are grown in the rice fields. Simultaneous cropping and crop rotation enrich the rice fields. Since 2003, we have been trying Aigamo duck dry field direct sowing, which is a combination of Aigamo duck paddy rice cultivation and dry field direct sowing. However, I was unable to understand the principle of weeding between plants during the dry rice field period, and I was unsuccessful. I have realized from my long experience that weeding between plants (intra-row weeding) is the bottleneck in organic farming. Farmers around the world must be struggling with weeding between plants. In 2016, I handmade a selective weeding equipment made of wire of ubiquitous pine broom and named it Hawking after the Japanese word for broom pronounced “hoki” + ing). Another wire attached horizontally to the first and fifth rows of Hawking with five rows was created, and named Hitman.

Hawking and Hitman have given me hope. After repeated experiments, it was discovered that they are extremely effective weeders between the plants of most other crops, not just rice wheat.

1. How Hawking and Hitman work

Fig. 1 shows the state of a crop before its first true leaf. Compared to weeds and crops, weeds have short plants, weak and shallow roots, and uneven emergence. I focused on this difference. When Hawking attached with Hitman is towed, the tip A of the wire swings up and down, left and right, and back and forth in the soil at a depth of about 1 cm, pulling out small weeds, burying them, and disturbing them. On the other hand, the crops are tall and have somewhat deep and strong roots, so they will not be damaged. This is how Hawking and Hitman do selective weeding. They are not very powerful, so they cannot be used to remove weeds once they grow tall. When weeds grow and become large, they are difficult to deal with, but when they are small, they are easy to deal with. That’s time to attack the weeds. For a long time, I overlooked dealing with small grasses.

2. Weeding of Aigamo duck dry fields for direct sowing

The difficulty of weeding of dry fields for direct sowing is that weeding must be done continuously under the contradictory conditions of dry fields and flooded fields.

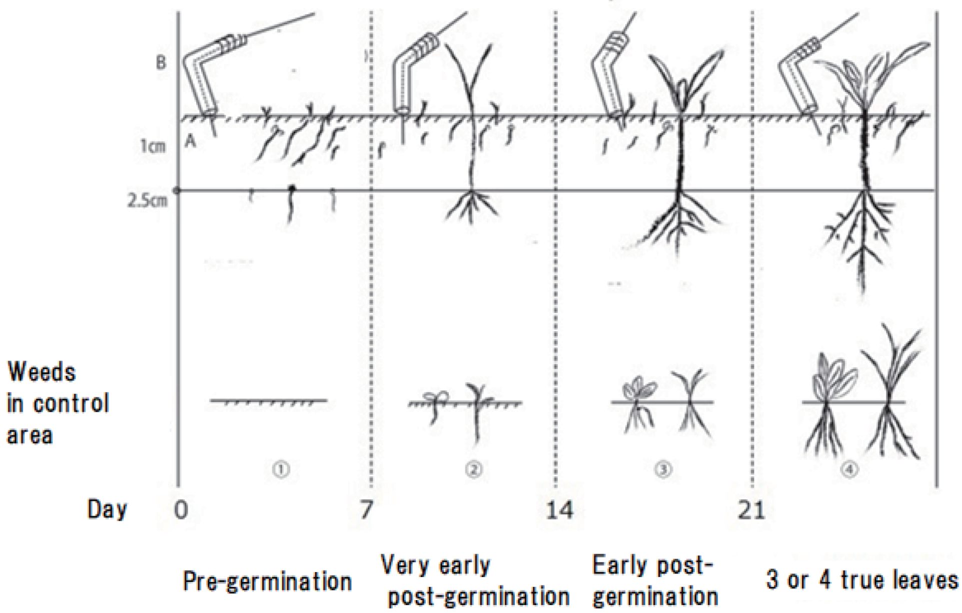

Fig 1. Pattern of diagram of Hawking

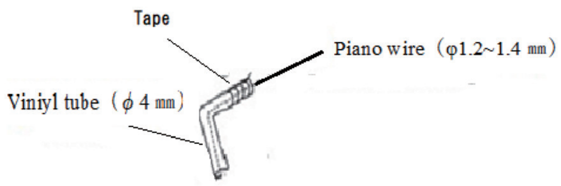

Fig 2. The tip of Hawking

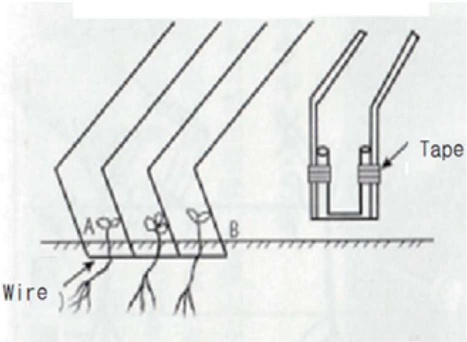

Fig 3. Mechanism of Hitman

2-1. Weeding during the dry field period

Various weeds grow in dry fields. In particular, an amphibious weed, *Echinochloa*, is a big problem. This is because it does not die even when flooded. First, the dry fields are plowed to dig trenches at 4-meter intervals using a subsoiler to allow the soil to dry out. The soil is shallowly tilled three times every other week to encourage the germination and the death of wild plants near the soil surface, and to reduce the density of wild plants in the soil. Two or three days after sowing, weed the seedlings before emergence twice with Hawking installed with Hitman (**Figs.1,2**). By pulling this twice before budding, weeds can be removed thoroughly. Hitman also moves forward in a shaking motion, pushing down, pulling out, and burying all the weeds fallen on the line of AB (**Fig. 3**). Before the crops emerge, the small "first grass" are weeded with Hawking and Hitman. As shown in fig. 1, the crops have not yet sprouted, so weeding can be done as many times as needed. Always performing pre-emergence weeding is a very effective method for all crops. In the case of rice, it germinates in 7 to 10 days, so weeding should be done with Hawking twice every other week after germination. Finally, just before flooding, when the rice is slightly damp, a roller is applied to level the field and prevent water from penetrating vertically. Rolling makes the soil clods smaller, and large clods are buried in the soil. Rice seedlings are completely fine. When you add water and release the Aigamo ducks, it immediately becomes cloudy.

2-2. Weeding during the flooding period

The field is flooded in less than a month after sowing the seeds. First, small wild *Echinochloa* weeds are submerged in deep water to soften and saturate them with water, and let the 14-day-old Aigamo ducks step on them. Let Aigamo ducks step on the soil surface and the fallen grass, which helps to retain water further. Then, gradually increase the depth of the water so that the Aigamo ducks can walk and swim. Let the Aigamo ducks swim in all directions until the rice ears emerge. Aigamo ducks have a variety of effects on rice, including weeding, insect control, nutrient supply, and contact stimulation. They also suppress methane generation.

3. Results

In 2022, wild grasses grew in the high places of rice fields due to drought. In 2023, there were very few *Echinochloa* weeds. Now the golden ears of rice are swaying in the wind.
(Search for Takao Furuno and Hawking on YouTube to see the video.)

Oral Session 2-2-2

Effects of Introducing AigamoRobo to an Organic Paddy Field

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Weeds are the biggest problem in organic rice cultivation. AigamoRobo is a unique robot that automatically navigates the paddy field according to a set track, agitates the paddy water and stirs up surface soil. The suspended soil makes the paddy water turbid, then sunlight hardly reaches the soil surface. The germination and growth of weeds can be suppressed due to insufficient sunlight on the soil surface. This robot is expected to suppress weeds in a labor-saving manner and ensure stable rice production in organic paddy fields. However, researches, which evaluated the effects of introducing this robot to organic paddy fields, are limited. Therefore, we conducted a preliminary study on effects of this robot on weeds, growth and yield of rice, and greenhouse gas emission in an organic paddy field located in the cool climate region of Japan.

In 2022, immediately after the transplanting of rice plants, an AigamoRobo was introduced to one of organic paddy fields in Kawatabi Field Science Center, Graduate School of Agricultural Science, Tohoku University. The area of this field was 0.12 ha. The robot worked in this field for three weeks. An adjacent organic paddy field was used as a control field, where weeding was carried out three times with a rotary weeder. In the field where the AigamoRobo was introduced as well, weeding was carried out twice with the rotary weeder. The plant height, number of tillers and SPAD value of rice plants were measured during the rice growth period. At the maturity stage, rice plants were harvested and the yield components were investigated. Weed samples were collected at the panicle initiation stage of rice, and the dry weight was measured. Gas samples were collected three times by closed chamber method, and the methane fluxes from the paddy fields were evaluated.

AigamoRobo is sensitive to the difference in the level of the soil surface, and frequently stopped by getting stuck at places with high surface level. This shortened the operation time of the AigamoRobo than expected. Even in the field where the AigamoRobo was introduced, a large amount of weeds was observed, and the dry weight of the weeds at the panicle initiation stage of rice plants was about 100 g m^{-2}. However, compared to the control field without the AigamoRobo, the amount of weeds was reduced by almost half, indicating this robot can suppress the emergence and/or growth of weeds. The plant heights and SPAD values (leaf color) of rice plants in the field where the AigamoRobo was introduced were similar to those in the control field. However, the numbers of tillers and spikelets in the field where the AigamoRobo was introduced were smaller than those in the control field. The cause of decreasing tillers and spikelets may be the physical impact by the AigamoRobo on rice plants. Methane emissions were lower in the field where the AigamoRobo was introduced than those in the control field. The reason for this is vague. However, the results suggest that agitation of the paddy surface for 3 weeks after rice transplanting has some effect on the soil and reduced methane emission.

Keywords: AigamoRobo, methane, weed

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Oral Session 2-2-3

Improving Rice Competitive to Weeds by Frequencies of Weeding in Japanese Organic Farming

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Mechanical weeding is one common weeding practice that has been applied by Japan organic farmer. Optimizing weeding practices is one significant key to supporting organic rice growth and reaching higher yield. Therefore, the study aimed to evaluate the competition between rice and weeds under different frequencies of mechanical weeding. A three-year field experiment was conducted in one organic rice plot located in Yamagata University Farm, Tsuruoka, Japan. The transplanting of Rice (cv.Sasanishiki) was done in the end of May and harvested in September 2019, 2020, and 2021. The treatment was different weeding frequencies (0, 2, 4, 6, and 8 weeding frequencies (WF)) from 0 to 56 DAT (days after transplanting). Rice and weeds were sampled at harvest time. Meanwhile the plant growth was investigated at rice panicle initiation, flowering, and ripening stage (harvest time) in each year. Our findings showed that 8 times of weeding reached highest total rice biomass at harvest time (1298.85 g.m^{-2}, 1032.81 g.m^{-2}, and 1145.73 g.m^{-2} in 2019, 2020 and 2021, respectively). The more weeding frequencies resulted in higher N concentration in both rice and weeds. However, rice N uptake increased whereas weed N uptake decreased. Total N uptake for both rice and weeds in 8WF was highest in 2021, with rice accounting for 90% (9.21 g N m^{-2}), 96% (6.85 g N m^{-2}) and 86% (7.17 g N m^{-2}) of total N uptake for both rice and weeds in 2019, 2020 and 2021, respectively (Fig.1). The most dominant weeds found were *Echinochloa crus-galli* (Hie), *Monochoria vaginalis* (Burm. f.) (Konagi), *Schoenoplectus juncoides* (Inoho) and *Eleocharis kuroguwai ohwi* (Kuroguwai). Hie dominated the field in 2019 before declining in subsequent years. Kuroguwai appeared swiftly in 2020 and rapidly grew its population in 2021, becoming the most dominant weed. However, each weed responded negatively to the frequencies of weeding in the density and N uptake. Among the weeds, konagi had the highest N intake among weeds, as well as a steady population over three years and was suspected of being the weed that most affected rice N uptake. These findings indicate that the 8WF treatment enhanced rice growth and strengthened its competitiveness to weeds, while weed development was severely hampered as 8WF was applied.

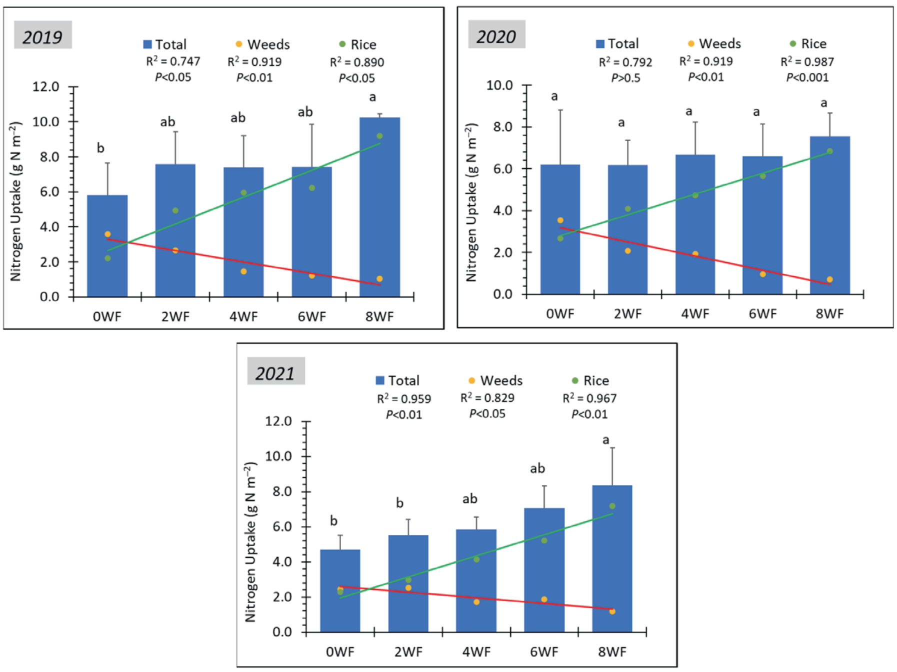

Fig. 1. Correlation between weeding frequencies and total nitrogen uptake (g N m^{-2}) of rice and weed or each nitrogen uptake of rice and weed in 2019, 2020, and 2021.

Keywords: nutrient competition, weeds density, mechanical weeding

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Oral Session 2-2-4

A Proposal for New Weeds Control in Organic Paddy Fields

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Katahira Farm

In the organic rice cultivation, weeds are troublesome problem because they inhibit/suppress **rice** growth.
New weeds control in organic paddy fields was studied to ease farmers' weeding works.
Table 1 shows the features of weeds control process in the old weeding (conventional) and the proposed new weeding.

The new weeding has been conducted by following 4 steps.

Step 1 Weed germination and then plowing are repeated three times in dry paddy fields to increase the weed suppression effect.

Step 2 Sowing germinated rice seeds and white clover seeds in the dry paddy fields.

Step 3 Intermittent irrigation is carried out by monitoring the dryness of dry paddy fields.
Water depth must be controlled to less than 5cm/per irrigation to support the rice growth (**Photo 1**).

Step 4 The sunlight and air (oxygen) are shut off on the water surface by the rotted white clovers and weeds. By applying deep-water management that maintains a water depth of around 20 cm, algae grow in the paddy fields (**Photo 2**).

In this way weeds suppression can be achieved by natural power.
The old weeding method required 22 days of manual weeding, while the new weeding takes only 6 days.
This contributes to efficient rice cultivation as a whole.

Table 1. Features of weeds control process in the old weeding (conventional) and the proposed new weeding.

Weeds control process	Old weeding	New weeding
How to prepare the paddy fields before planting rice seedlings	Twice weeding was done, the fields' floors are broken up and flattened by a tiller machine according to the growth of the weeds, and irrigated from time to time.	Plow the surface of dry paddy fields three times to facilitate weeding by a tiller machine
Weeding the paddy fields after the preparation	Human weeding (22 days)	Natural weeding (once) human weeding (6 days)

Photo 1

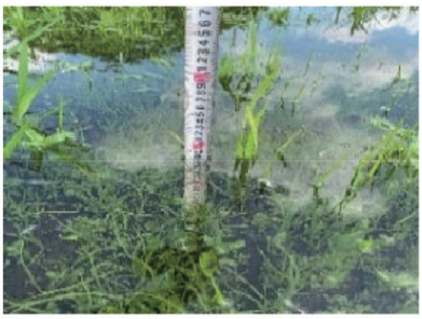

Photo 2

Keywords: weeds control, paddy fields, weeding by humans, weeding by nature

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Oral Session 2-2-5

Reduction of Fe with Application of Saturated Soil Culture Technology and Biomass Ameliorant on Organic Rice Farming in Tidal Swamp

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Indonesia has tidal swamp areas of about 20.1 million ha and 9.53 million ha suitable for agriculture. The main constraint of rice cultivation in tidal swamps is pyrite (FeS2). Iron from pyrite reaction in the flooded (reductive) soil condition will be changed from Fe^{3+} to $Fe^{2+,}$ and Fe^{2+} is more absorbed than Fe3+ and causes poisoning in rice plants. Saturated soil culture (SSC) is a cultivation technology that gives continuous irrigation and maintains water depth constantly and makes the soil layer under root in a saturated condition. This technology is more appropriate to prevent pyrite over-reduction than conventional culture (flooded culture).

This research was conducted in Banyuasin District, South Sumatera Province; and in Tanjung Jabung Timur District, Jambi Province from 2009-2022. These objectives of this research are to study: 1) the rice adaptation mechanism to the soil with high Fe content, 2) the efficiency of production input of rice cultivation with biomass ameliorant, and 3) the farmer's response to the application of innovation. This research used field and greenhouse experimentation designs. This research consisted of 1) a study of the rice adaptation mechanism, 2) the response of rice varieties under SSC and Flooded Culture (FC), 3) the effect of biomass ameliorant on rice productivity, and 4) dissemination of technological innovation to the farmer.

The rice adaptation mechanism on SSC (**Fig.1**) was begun with the increasing root ethylene content, aerenchyma formation, Fe deposit on the soil layer and Fe leaching on the ditch, and the decreasing of Fe in the leaf and bronzing percentage, and then the increase of productive tiller and grain dry weight per plant (**Fig. 2, 3**).The highest productivity on sensitive to medium tolerance was obtained under SSC, but that on tolerance genotype was obtained on flooded with drainage. Indragiri was grouped as tolerance, IRH108 as a medium, and IR64 as sensitive to the high Fe in tidal swamps (**Table 1**).

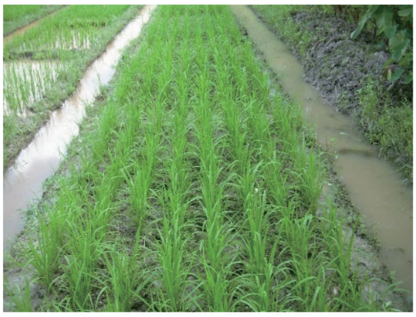

Fig.1. Rice growth. Left: FC. Right: SSC

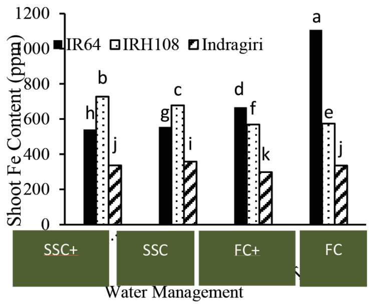

Fig.2. Shoot Fe content

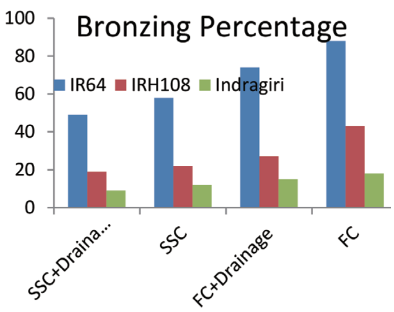

Fig.3. Bronzing percentage

Table 1. Rice productivity

Genotype	Water Management			
	SSC+ Drain age	SSC Without Drainage	FC+ Drain age	FC without Drainage
	Grain Dry Weight (ton ha^{-1})			
IR64	4.41^{f}	4.56^{ef}	0.00^{h}	0.00^{h}
IRH108	5.46^{c}	4.81^{de}	3.80^{g}	0.00^{h}
Indragiri	6.23^{b}	5.96^{b}	6.83^{a}	5.13^{d}

Application of rice straw in the soil (equivalent 7-10 tons ha-1) will improve soil fertility in tidal swamps because, in the decomposition process, the straw will release humic acid, which will then chelate Fe and Al solubility. The application of rice straw will decrease NPK doses by 50 %.

In the other research, the application of peat humic acid increased rice productivity by as much as 30 kg ha^{-1}. The highest productivity was obtained on Inpara-2 with humic acid under SSC compared to FC without humic acid. If we use high-tolerance rice under SSC on soil Fe content under 10,000 ppm, the rice productivity will increase to 7-9 tons ha-1. The productivity of Inpari16-Pasundan, Sertani, Inpara2, and IR64 on soil Fe content 3,000 ppm was obtained: 9.35, 8.35, 7.73, 6.55 ton ha^{-1}., and on soil Fe content 6,000 ppm was obtained: 7.66, 6.20. 5.90, and 4.51 ton ha^{-1}.

Local farmers usually use local varieties with a long age of about 180 days, but transmigration farmers (who move from Java to Sumatra) usually have high-yielding varieties with a shortage of about 115-120 days. The production input from local farmers was lower than that from transmigration farmers. High-yielding varieties were more responsive to the fertilizer than local varieties, thus, the transmigration farmer usually applied chemical fertilizer and pesticides, while the farmer local only used seed input. The productivity of rice on a local farmer was only 1.5-2.0 ton ha^{-1}. and on a transmigration farmer 2.5-3.0 ton ha^{-1}. After we introduced our technology with SSC in combination with biomass ameliorant and NPK, the productivity increased to 5-6 tons ha^{-1}.

We are cooperating with a private company (FKS Multi Agro) to implement the SSC technology on farmer land in the tidal swamp. The private company gave production input (seed, ameliorant, and fertilizer) and the farmer conducted it with SOP (Standard Operational Procedure) of SSC technology. The farmer got 75 % and the private company 25 % of the benefit. The farmers were responsive to following this project in Jambi Province.

The recommendations to implement organic rice farming in tidal swamps are: 1) to use of high-yielding variety with high tolerance to high soil Fe content, 2) to prepare the land with minimum tillage, 3) to use of SSC with a wide bed, 4 m in width, along with ditches that were 30 cm wide and 20 cm deep, 4) to use of biomass ameliorant (straw biomass, soybean biomass, humic acid) combination with dung and bio-chart, 5) to use of microorganism FMA (Fungy Micorrhyza Arbuscular) to increase P solubility, and 6) to use of *Azospirillum sp* to increase N fixation. We have obtained FMA from the genus of *Acaulospora* and *Glomus*, and the next time, we will develop research to study of isolation and characterization of *Azospirilum sp* from tidal swamps.

Keywords: pyrite, saturated soil culture, organic rice farming, tidal swamp

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Oral Session 2-3-1

Establishment of the Organic Rice Cultivation System through Square-transplanting and Mechanical Inter-/Intra-row Orthogonal Weeding

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In Japanese organic rice farming, weeding accounts for approximately 30% of labor hours related to direct work (Ministry of Agriculture, Forestry, and Fisheries, 2003), making it the biggest challenge for the spread of organic rice farming. Mechanical weeding is a major technique used by more than 70% of organic farmers because of its labor-saving and relatively stable effectiveness.

Rice transplanting is a common practice in Japan, in which rice seedlings are planted in rows using transplanters. Mechanical weeding can be done only along these rows. However, the mechanism for intra-rows is often less effective than that for inter-rows to avoid damage to rice seedlings. Consequently, manual weeding in intra row is frequently necessary, hindering the expansion of organic rice farming with mechanical weeding.

To address this challenge, we initiated a project in 2022 to develop and demonstrate an organic cultivation system that drastically reduces the need for manual weeding. This system employs orthogonal mechanical weeding in both vertical and horizontal directions. During this symposium, we report on some project experiments in this project, including tests for cultivation management and field demonstrations in a cold region of Japan.

Traditional rice transplanting using a standard rice transplanter makes it difficult to align the planting position with the adjacent row, because of shifts in the starting point and tire slippage.

However, a square-transplanting machine developed by the Institute of Agricultural Machinery, NARO (IAM/NARO) can precisely control the planting position using a satellite positioning system. This machine can transplant rice seedlings in a grid pattern with 30 cm spacing between rows and hills. We conducted experiments and field demonstrations using this square-transplanting technology to establish a new organic rice cultivation system with square-transplanting and inter-/intra-row orthogonal weeding.

1) Tests of inter-/intra-row orthogonal weeding variation using a weeding machine

In conventional mechanical weeding along rows, it is recommended to conduct the first weeding operation within 7 days after transplanting, followed by a total of three weedings at 7-10 day intervals (NARO 2021). However, in the inter-/intra-row orthogonal weeding system, although a high weeding effect can be expected, there is a concern that sparse planting may accelerate weed growth. To address this concern, we conducted research to determine the optimal timing for inter-/intra-row orthogonal weeding in the fields at the Tohoku Agricultural Research Center (TARC), Daisen City, Akita Prefecture. The results indicated that performing weeding three times at 7-9 day intervals after transplanting, with a orthogonal weedings in the order of vertical-horizontal-vertical direction, improved the weeding rate by approximately 30% compared with conventional inter-row weeding methods.

2) Tests of cultivation management for stable yield in organic sparse cultivation

In colder regions, sparse planting of 11 hills m^{-2} (30 cm x 30 cm) may lead to reduced yield due to an insufficient number of panicles. To address this issue, we conducted experiments using the rice variety "*Akitakomachi*" in the TARC fields. By increasing the number of seedlings per hill from four to eight, it was possible to maintain the initial growth and yield at the same level as that achieved with a denser planting of 22 hills m^{-2}. When it comes to cultivation after soybean, it is common to grow without fertilizer. However, organic sparse planting without fertilizer can result in inadequate growth and decreased yield. Therefore, we investigated the impact of organic basal fertilizer on the yield of organically sparse planted rice following soybeans. We transplanted the rice variety "*Akitakomachi*" with four seedlings per hill. The result revealed that when transplanted at the conventional density of 22 hills m^{-2}, the amount of basal fertilizer did not significantly affect the yield. However, when transplanted with sparse planting at a rate of 11 hills m^{-2}, the yield declined as fertilizer application decreased. To maintain the yield at the same level as that of 22 hills m^{-2}, 8 kg N m^{-2} of organic fertilizer was necessary.

3) On-farm demonstration in Ogata Village, Akita Prefecture

In 2023, we initiated an on-farm experiment in Ogata village to showcase an organic rice cultivation system that combines square transplanting with mechanical inter-/intra-row orthogonal weeding. Ogata village is a prominent hub for organic rice cultivation in Japan, with 48 producers tending to organic rice on 243 ha in 2022. However, the area dedicated to organic rice farming has been declining because of a shortage of manual weeding labor. Establishing a mechanical weeding system that reduces manual weeding labor is an urgent priority.

In this experiment, we introduced a new organic rice cultivation system (NS) in a farmer's paddy field, where organic crop rotation between soybeans and rice was practiced. The rice variety used in this experiment was "*Akitakomachi.*" Our goal was to achieve a rice yield of 90% compared to general cultivation and to reduce manual weeding time by 30% compared to conventional organic cultivation systems (CS) that rely on walking weeders.

In the CS plot, rice seedlings were transplanted at a density of 18 hills m^{-2}, with 7.5 seedlings per hill, using a standard transplanter. Weeding was performed twice at 7-10 day intervals after transplanting using a walking weeder. In the NS plot, rice seedlings were transplanted at a density of 11 hills m^{-2}, with 6.5 seedlings per hill, using a square-transplanting machine. Orthogonal weeding was conducted three times at 7-10 day intervals after transplanting, following an inter-intra-inter-row pattern, using a riding weeder.

Transplanting in both plots was performed on May 21, 2023. Notably, in the NS plots, the transplanting time was reduced by approximately 25%, and the required number of seedling boxes decreased by approximately 40%, showcasing the labor-saving benefits of sparse planting. Following mechanical weeding, manual weeding was carried out, and the time needed for manual weeding in each plot was compared while assessing its impact on rice growth and yield.

The new organic rice cultivation system can potentially be implemented with various weeding machine, although the timing and frequency of weeding may require adjustment for each machine. Further research is required to determine the suitability of field size, soil type, target weed species and other factors for application of this organic cultivation system. To ensure stable and high yields, the introduction of automatic steering technology to minimize damage to rice seedlings and a thorough understanding of the variety characteristics and seedling quality suitable for organic sparse cultivation may prove beneficial. The integration of the new organic rice cultivation system, which combines square transplanting with mechanical inter-/intra-row orthogonal weeding, offers labor saving benefits while stabilizing yields. This has the potential to reduce production costs and enable expansion of production scale. Such a labor-saving approach to organic rice cultivation is expected to significantly contribute to the growth of organic rice production.

We acknowledge the support of the development and improvement program of strategic smart agricultural technology grants from the Project of the Bio-oriented Technology Research Advancement Institution (BRAIN) for this research.

Keywords: organic rice, square-transplanting, orthogonal mechanical weeding, intra-row weeding, sparse planting

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Oral Session 2-3-2

Automatic Steering System Challenges Multiple Times Tilling Weeding

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While the safety and security of agricultural products is attracting attention, the problem of aging farmers is becoming more prominent. Therefore, we examined a farming method that is easy for new entrants even if they have little agricultural experience.

In the Edo period, the multi-plowing weeding method was practiced increasing yields by repeatedly medium-tillage (Japan Agricultural Books, Vol. 29). In order to make this farming method smart agriculture, we investigated what kind of effect can be expected on rice growth and yield without chemical fertilizers and pesticides by using an automatic steering system on a ride-type medium-tillage weeder to cultivate paddy rice.

On June 22, 2023, we transplanted grown-up "Kinumusume" seedlings (seedling variety encouraged by Okayama Pre.) using passenger rice transplanter for adult seedlings (4--row planting manufactured by Minoru Sangyo) installed with an automatic steering system (manufactured by CHCNAV; **Fig. 1**), with a space of 19cm between plants and 33cm between the rows. The automatic steering system was attached to the passenger medium-tillage weeder (4-row manufactured by Minoru Sangyo; **Fig. 2**) to record the running data from the rice transplanter. It ran on the same track as the wheels of the rice transplanter and carried out medium-tillage weeding work without stepping on the rice. The first medium plowing work started on June 29, one week after the rice was planted, and finished on July 22.

Fig. 1. Automatic steering system

Fig. 2. Medium tillage weeder

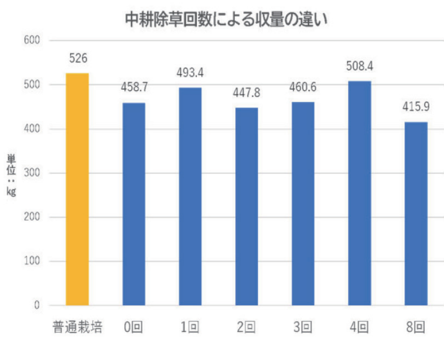

Fig. 3. Difference in yield depending on the number of medium-tillage

6 plots were set up with 0 to 4 and 8 times of medium plowing, and growth and yield surveys were conducted. The plant height was suppressed lower immediately after the medium plowing work, but there was no difference in subsequent growth as the number of medium plowing times increased. Although the yield was not clearly different, it tended to increase as the number of medium plowing times increased to 2 to 4. The yield was the highest when plowed 4 times, 508.4 kg per 10 a, decreased slightly compared to the yield average of Okayama Prefecture for conventional cultivation (**Fig. 3**). In terms of quality, it was ranked 1st class in grade inspection, it was a good result compared to "nikomaru" (2nd class) and "Asahi" (3rd class) which are conventionally grown at our school.

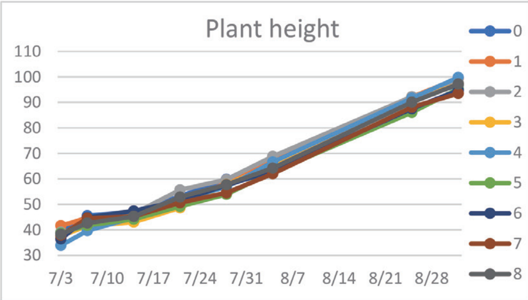

Fig. 4. Plant height

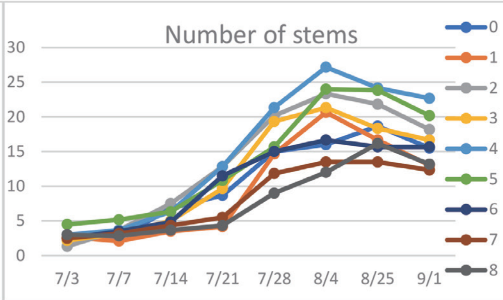

Fig. 5. Number of stems

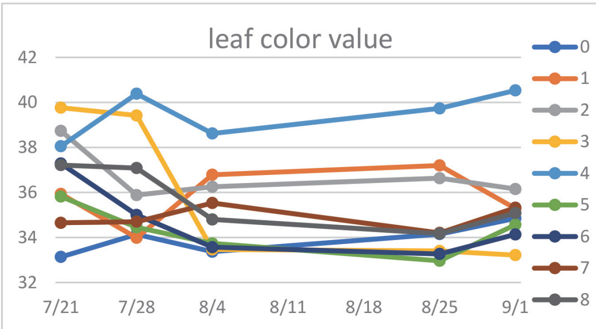

Fig. 6. leaf color value

Organic rice cultivation requires a lot of effort such as weeding, and yield declines generally occur in cultivation that does not use chemical fertilizers.

By using an automatic steering system, even first-year high school students with little farming experience could easily perform medium tillage work. Labor and cost of applying fertilizers, using herbicides, and spraying fungicides and insecticides were reduced. There was almost no weed growth, and there was no effect on rice growth.

On June 23, 2023, we set up 9 plots with 0 to 8 times of medium plowing and transplanted grown-up “Kinumusume” seedlings using passenger rice transplanter for adult seedlings (4-row planting manufactured by Minoru Sangyo) installed with an automatic steering system (manufactured by Hitachi Zosen), with a space of 21cm between plants and 33cm between the rows. Medium-tillage weeding was performed manually using a riding medium-tillage weeder. Plant height tended to be higher in plots with few medium plows and lower in those with a large number of medium plows. (**Fig. 4**) The number of stems increased in the 4 to 5 times plots and decreased in the 7 to 8 times ones (**Fig. 5**). The leaf color value was also the highest in the 4 times plot (**Fig. 6**).

Based on the results of the growth survey, it is considered that it is appropriate to plow about 4 or 5 times, rather than plowing a lot. The results of the last year’s surveys also suggest that four times would be the best.

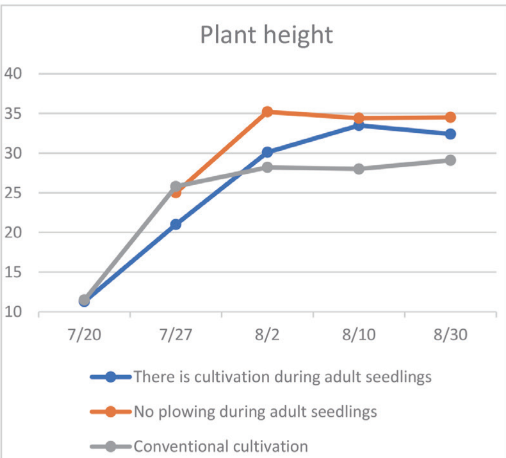

Fig. 7. Plant height

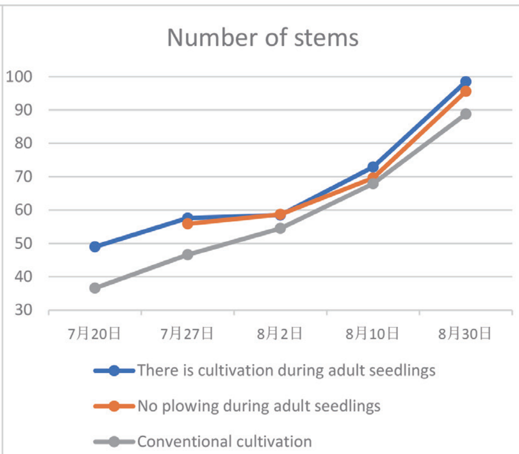

Fig. 8. Number of stems

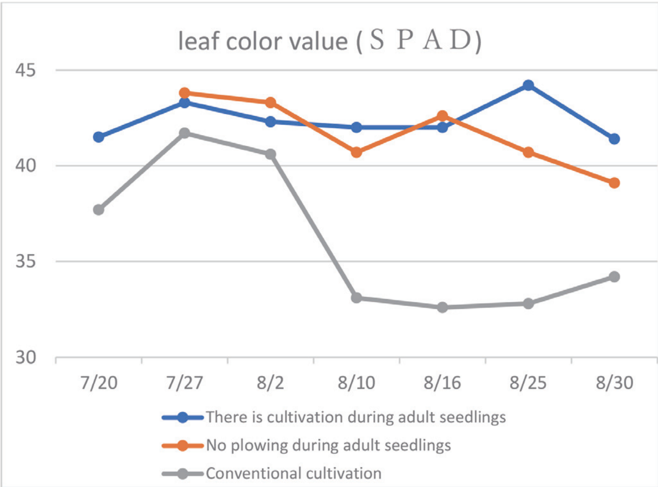

Fig. 9. leaf color value

Fig. 10. Comparison with root-medium tillage

From left to right:
・With adult seedlings rooted
・No root-cutting of adult seedlings
・Seedling practice cultivation

New Attempts

It is assumed that one of the reasons for the increase in yield was that fine roots were cut off before ear emergence in the medium-tillage weeding, to allow new vigorous roots to emerge, just like the mid-drying work.

Therefore, we produced a claw specially designed for root-cutting weeding that can plow deeper with a large claw, and on July 20, medium-tillage weeding was carried out in Tottori Prefecture for the purpose of root-cutting. The results showed no significant difference in plant height, but the number of stems gradually increased to the ear emergence (**Figs. 7,8**). While most of the rice with root-cutting and weeding had many solid and thick stems, conventionally cultivated rice had lighter leaves and thinner stems (**Figs. 9,10**).

Keywords: multiple times tillage weeding, automatic steering system, organic rice cultivation

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Oral Session Special Topic

Key Findings of the French BIoNutriNet Project on Organic Food-based Diets and Sustainability (Diet, Nutrition, Health and Environment)

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Few studies have investigated the relationships between organic food consumption, dietary patterns, monetary diet cost, health, and the environment. A first study on 54,300 adults (77% women) belonging to the French nation-wide prospective NutriNet-Santé adult cohort was performed and published in 2013. This pioneer large-scale investigation, based on 24h food intake record and a dedicated organic food questionnaire, allowed to observe that regular organic food consumers, compared to non-consumers, have a plant-based diet and a significantly lower probability of overweight and obesity (about – 50 %). To address more in depth all these issues, a consortium of French epidemiologists, nutritionists, economists, and toxicologists launched the prospective BioNutriNet project in 2013 that was financially supported by the French national research agency. In 2014, an FFQ (food frequency questionnaire) collected the usual organic and non-organic (conventional/industrial) food consumption for 260 items with five levels (from never to always organic source) of approximately 35,000 NutriNet-Santé adult participants. Then, individual organic and conventional food intakes were merged with retailed price, environmental, and pesticide residue data sets, which distinguished between conventional and organic farming methods. Many studies were conducted and published to characterize organic consumers and their organic food consumption motives and impacts on health as well as environmental impacts (i.e., greenhouse gas emissions, energy demand, and land use).

We observed that organic consumers had diets that were richer in plant-based food than nonorganic consumers and overall more nutritive and healthier. Their diets were associated with somewhat higher monetary costs (up to + 26%) and reduced exposure to chemical pesticide residues as calculated from food pesticide residues levels and measured in participant urine samples. In 30 to 70,000 participants and after adjustments for confounders, regular consumption of organic food (about 60-70% share of organic food) was found prospectively associated with reduced risks of overweight (-23%) and obesity (-31%), type 2 diabetes (-35%), postmenopausal breast cancer in women (-34%), and lymphoma (-80%). Recently, two prospective studies with the NutriNet-Santé cohort have demonstrated that a high exposure to a mix of chemical pesticide residues provided by foods is associated with a significantly increased risk of having type 2 diabetes (+ 47%) or postmenopausal breast cancer in women (+ 73 %) after adjustments for confounders. Some observations have been confirmed by several other studies conducted in other countries. Finally, increasing the share of organic food in a plant-based diet diet up to 60-70% is associated with significantly reduced impacts for diet production on resources (– 23% for agricultural land, - 25% for energy use) and GHG emissions (-37%). A recent modelisation study showed the feasibility of an organic, plant-based diet with high nutrition value and markedly reduced negative impacts. Overall, the main finding of the BioNutriNet project is that dietary shifts toward plant-based diets can provide positive externalities on human health and the environment, while organic foods should base plant-based diets to allow for better planetary and human health.

Review article : Kesse-Guyot, E., Lairon, D., Allès, B., Seconda, L., Rebouillat, P., Brunin, J., Vidal, R., Taupier-Letage, B., Galan, P., Amiot, M.J., Péneau, S., Touvier, M., Boizot-Santai, C., Ducros, V., Soler, L.G., Cravedi, J.P., Debrauwer, L., Hercberg, S., Langevin, B., Pointereau, P. and Baudry, J. (2022) Key Findings of the French BioNutriNet Project on Organic Food–Based Diets: Description, Determinants, and Relationships to Health and the Environment. *Adv. Nutr.*, 2021;00:1–17. DOI: 10.1093/advances/nmab105

Keywords: dietary pattern, prospective cohort, adults,

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Oral Session 3-1

Farmers' Participatory On-farm Testing (FP-OFT) of Organic and Conventional Systems on Productivity, Soil and Grain Quality of Aromatic Rice in India

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Since last few years organic cultivation of aromatic (Basmati) rice has taken a momentum in India because of higher premium price and preference in international market.Basmati rice is the leading aromatic fine quality rice of the world trade and it fetches good export price in the international markets. Basmati rice has characteristic like long-grain, subtle aroma and delicious taste and is one of the major agricultural commodities the country exports every year to earn foreign exchange. India is the largest producer and exporter of Basmati rice in the world, around 2/3rd is exported and remaining is consumed, within the country. Due to favorable geographical conditions available exclusively in northern India, Basmati rice grown in this region has got geographical indicator (GI) tag also. With this background, afarmers' participatory researchwas conducted to study the productivity, soil and grain quality and carbon dynamics in organic farming (OF) *via-a-vis* integrated nutrient management (INM) and mineral fertilized (MF) production system.

A farmers' participatory on-farm testing (FP-OFT) was conducted in two villages of Uttar Pradesh (UP), India during 2020-2022 involving 8 farmers. Farmers of the study group were fallowing basmati rice-vegetable cropping system. Three crop nutrient practices *viz.* organic, integrated nutrient management (INM) and chemical fertilization were taken in rice as well as vegetable crops. In organic crop nutrition four organic inputs *viz*. Blue Green Algae (BGA), *Azolla*, Vermicompost and farmyard manure (FYM) were applied in rice. In integrated nutrient management (INM), FYM was supplemented with urea, di-ammonium phosphate (DAP) and muriate of potash (MOP) in 25: 75 ratiowhereas in mineral fertilized (MF) system mineral fertilizers like urea, di-ammonium phosphate (DAP) and muriate of potash (MOP) were used to provide recommended dose of nutrients ($N_{120}P_{60}K_{60}$). For crop protection farmers applied FYM enriched with *Trichoderma* @ 2 kg ha^{-1}. Besides, need based spraying of Sudocel (*Pseudomonas* formulation) and Trichoel (*Trichoderma* formulation) both at 2% along with Neem oil (3000 ppm) was done @ 2%. Application of Biotercel (consortium of entomopathogenic fungi) and soil augmentation with neem cake at 125 kg ha^{-1} was also done for plant protection.Egg parasitoid *Trichogrammachilonis*@1, 20,000 ha^{-1} (1 card= 20,000 eggs) were released. Fixing of spider net and pheromone traps with lure @ 5 ha^{-1} was done to control yellow stem borer and leaf folder. In conventional method farmers' managed insect pest and disease of rice through chemical pesticides. For protection from bacterial leaf blight (BLB) farmers applied hexaconazole @ 300 ml ha^{-1}and tricyclazole @ 120 gm ha^{-1}. Carbendazim (50 WP) was applied for control of sheath blight @ 1.35 kg a.i ha^{-1}and for control of stem borer and leaf folder pesticides like Chlorpyriphos @1.0 L a.i ha^{-1}, Cartap hydrochloride@ 5-7.5 kg a.i ha^{-1}, Imidachlorprid @100 ml a.i ha^{-1} and Fipronil @ 5 kg a.i ha^{-1} were applied as and when needed and in majority of the cases rate of application of pesticides was higher than the recommended doses. For data on productivity, grain yield data were taken from a net plot area of 100 m^2. For estimation of grain quality and soil health parameters standard protocols were followed.

FP-OFT results showed that the rice grain yield under organic farming *i.e.* application of four organic inoculants (BGA, *Azolla*, Vermicompost and FYM) was the highest in all the farmers' fields followed by the yield under INM and mineral fertilization. Organic system proved to be beneficial for farmers as it gave higher net return than the conventional system. Farmers growing organic rice got around 25% higher price than conventional rice so they could get higher revenue of their produce. The net return under OF varied between INR 107550 to 145655 ha^{-1} (1 US Dollar = 80 INR) while in conventional farming it ranged between INR 50458 to 85674 ha^{-1}. The same trend was observed in cost benefit ratio. Singh *et al.* (2007) also found higher net returns of rice under OF than inorganic fertilization. Ramesh *etal*. (2010) revealed that under organic farming, inspite of the reduction in crop productivity by 9.2%, net profit to farmers was higher by 22.0% compared to conventional farming. Higher returns under OF was mainly due to the availability of premium price (20–40%) for the certified organic produce and reduction in the cost of cultivation by 11.7%.

Micronutrients (Fe, Zn, Mn) concentrations in rice grain enhanced significantly due to OF over INM and MF. Physical properties of soil *viz.* field capacity, available water content and water retention capacity of soil improved with organic management. Higher amount of soil organic carbon (SOC) was observed in organic treatment as compared to inorganic treatment. Microbial biomass carbon was highest under organic treatment followed by INM and MF. SOC content of soil improved in organically fertilized soil compared to INF and MF. OF practices affected grain elongation and length: breadth ratio. Mean values of KL: KB increased from 3.94 (before cooking) to 6.19 (after cooking) in organic fields whereas this increment was from 3.71 to 5.82 in case of MF. Grain elongation was higher in organic fields (191.5%) over the MF fields (191.2%). OF enhanced grain elongation, kernel length, kernel breadth and their ratio compared to INM and MF practice. OF enhanced grain amylose content and slickness but reduced crude protein content compared to INM and MF. Organic cultivation exhibited higher amylose content (25.3%) as compared to 21.7 % in conventional fields. Tripathi and Verma (2008) also found same type of results. However, Elaine *et al.* (2007) found no difference in apparent amylose and mineral contents due to organic cultivation. Total nitrogen and crude protein content was considerably higher under inorganic (1.57% total N, 9.87% crude protein) compared to organic cultivation (1.38% total N and 8.6% crude protein).

Considerable reduction in incidence of key insect pests and diseases due to use of microbial and botanical pesticides were observed. Population of individual natural enemies like spiders, crickets (egg predators), damselflies, ants, bettles, wasps and mermithids were noticed predating on larval stages of insect pests. Comparison of plant protection practices showed that conventional farmers group by and large were not risk evasive and go for spray of chemical pesticides for managing weeds, insects and plant diseases as per recommended schedule or sometimes even before that. However, in organic fields the crop was managed by alternative eco-friendly pest management method, which mainly relied on cultural, microbial and bio-rational approaches. These results are in line with the description of Reganold (2006). Natural enemies play an important role in regulating pests, pest outbreaks often occur in intensive agricultural practice due to imbalance between pests and natural enemies by the use of indiscriminate use of pesticides (Heong and Schoenly, 1998).

Thus, grain yield, profitability and quality of aromatic rice with organic nutrient management was significantly better compared to INM and mineral fertilization. There was improvement in chemical, physical and microbiological quality of soil also in organic farming.

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Keywords: Organic farming, Basmati rice, grain quality, micronutrient uptake, soil health

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Oral Session 3-2

Rice Diversity from Seed to Fork: A Living Lab for Organic Rice in Northern Italy

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Italy is the largest European rice producer, with 1,459,310 tons produced on 227,040 ha[1] in 2021. Organic rice production has been steadily growing: in 2021, the area of organic rice was estimated at over 15 thousand hectares[2]. However, rice varieties used in organic farming have been mostly developed by conventional breeding programmes, and are not well adapted to Organic Rice Farming Systems (ORFS). Furthermore, there is virtually no certified-organic rice seed available on the market, forcing all organic rice growers to either use their own seed, or resort to derogation for using of non-organic untreated seed.

To address the lack of cultivars adapted to ORFS, Italian NGO Rete Semi Rurali collected and multiplied rice germplasm from national gene banks and international research centres, thanks to the multilateral system of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). In 2019 and 2020, Multi Environmental Trials (MET) were conducted in four organic farms in Lombardy and Piedmont regions, assessing 21 different cultivars – including a mixture – for agronomic traits and farmers' preferences (De Santis et al., 2021). Results showed strong Genotype by Environment Interactions (GEI) for all entries, and indicated a good combination of yield, yield stability and disease resistance for the rice mixture, highlighting the need for decentralised participatory selection in ORFS. In 2019, a collection of 264 Italian rice varieties, including 214 accessions obtained from the International Rice Research Institute (IRRI) in the Philippines, was multiplied on an organic farm. Based on the preference ranking by farmers, maturity time and grain size three mixtures were assembled: a short grain (11 varieties), a medium grain (16 varieties), and a long grain (25 varieties). Between 2020 and 2022, the three rice mixtures were multiplied in four organic farms, becoming Dynamic Populations (DP) (Costanzo et al., 2019). Meanwhile, dehulling and polishing tests were conducted on the DPs' paddy rice, showing processing yields comparable to those obtained by uniform varieties. Quantitative Descriptive Analysis (QDA) panel tests were conducted with the DPs' rice growers (2021) and with consumer group representatives (2022). Further panel tests involving citizens on the medium grain rice DP took place during a farm day in 2022, where a professional chef prepared a risotto, and through distribution of 500 g packets to consumer groups with associated survey on the cooking and qualitative aspects of the medium grain rice DP. All these tests showed good appreciation by consumers.

During this process, a group of farmers, an organic rice seed company and rice processors started a close collaboration, becoming effectively a Living Lab, with the innovations being the rice DPs.

The current objective is to start certified seed production for the rice DPs, thanks to the European Organic Regulation (EU 2018/848), which allows the marketing of seed of non-uniform cultivar as Organic Heterogeneous Material. This would offer to organic rice growers, citizens and consumer a new product, which is beneficial for the ORFS, biodiversity and the organic rice value chain.

Fig. 1. Medium grain dynamic population growing at Una Garlanda, Rovasenda (VC), Italy 2022

Fig. 2. Medium grain dynamic population rice packet distributed to consumer groups in Italy in 2022/2023. The label explains how the DP was constituted and includes a link for the evaluation.

Keywords: organic rice systems, dynamic populations, climate change, participatory plant breeding

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Oral Session 3-3

Participatory Approach for Developing Knowledge on Organic Rice Farming in Italy

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There is a lack of knowledge concerning the organic rice performance and management, probably due to the limits encountered by the reductionist approach in studying complex systems such as an organic paddy. The study proposes a knowledge-intensive and qualitative research methodology based on researcher-farmer participatory approach, with the aim to improve the state of knowledge on organic rice, explore the yield potential and variability, and identify the successful agronomic practices.

A wide range of cropping systems placed in North Italy were monitored and analyzed during three years by a multi-actor network. Knowledge was generated from collected data and information, integrating the scientific and empirical knowledge on the basis of the DIKW hierarchy and through mutual learning and knowledge sharing tools. The organic rice field proved to be a complex and difficult system to predict, which evolves over the time, under the on-going pressure of the bottom-up innovations, and whose performance depends on many interacting elements.

The results highlighted three main knowledge-intensive management strategies, not involving universal recipes but a range of agroecological principles and flexible solutions that the farmers adapt to the time- and space- variability through an active adaptive management. Yield showed a wide variability (0–7 t/ha) and normal distribution (median 4 t/ha). The lower, middle and upper quartiles of yield showed a mean of about 2, 4 and 6 t/ha, respectively, with high variance associated with upper and lower quartiles. The variability sources related to the management and effectiveness in weed control have mainly determined the productivity gap, "Know-how" (suitability of the chosen management plan), "optimization" (timely and accuracy of interventions) and "seed bank" (previous operations and land uses affecting the weeds dynamics) were responsible of the low yield in 77%, 54% and 31% of the cases, respectively, drowning out the impact of climate, soil and variety. Results are useful to drive further scientific inquiries and evaluations consistently with the reality faced by the farmers and suggest that improvements in the farmer' know-how and skills can lead to further yield increase and variability reduction.

The participatory research, adopted to explore complex systems, has worked in this direction, fostering the co-creation of knowledge and innovation and the social cohesion. However, the methodology showed constraints mainly related to the time-consuming surveys and its nature affected by human component.

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Oral Session 4-1

Future Prospects from a Citizen Participatory Paddy Field Biodiversity Survey in Tokushima Prefecture - Toward a More Local Bottom-up Agrobiodiversity Monitoring Infrastructure

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We know that some of the citizens who are paying attention to the excessive using of agrochemicals are willing to participate in biodiversity surveys. And their attention is important considering the linkage with ethical certification of agricultural products. Our group including diverse stakeholders has been conducting a trial-and-error survey with citizen participation for six years, using the "Manual for Survey and Assessment of Biodiversity to Understand Bird Friendly Paddy Fields" (NRI 2018). **Fig. 1** illustrates the demographic composition of the participants involved in our survey. The research has been conducted in diverse paddy field ecosystems in different agro-geographical conditions. We consider this survey will induce them such proactive participation. We are tuning this survey manual to fit for Tokushima area, situated in Shikoku region, to the east of the main island of Japan, in terms of regional adaptation and modification of methods and evaluation, and aiming for a bottom-up process in customizing of the manual by Tokushima-original approach. We recognize that the original manual examined a lot of fields data in the preparation process but there are few data from Shikoku area.

So far, results including the following new findings have been obtained so far: 1) Survey methods for participatory action research in organic and conventional farmers' rice paddy agroecosystems should be tailored to local conditions. This is because the environmental conditions of rice paddies can vary depending on the region. For example, a study of 33 rice paddies in six regions of Tokushima Prefecture found that visual checkup on plants was a more effective method of assessing biodiversity than sweeping for insects. Spider species, on the other hand, were not good indicators of biodiversity. 2) The globally invasive alien apple snail (*Pomacea canaliculata*) was a major inhibiting factor in the biodiversity assessment BD score. In addition, it was clear that not only were there fewer plants, including paddy weeds, and a clear decline in biomass in the areas invaded by apple snail, but also that it affected productivity and biodiversity in the rice paddies by causing rice plant deficiencies. 3) Regarding birds, the evaluation BD score in the paddy fields where Oriental white storks (*Ciconia boyciana*) fly over was not as high as others, and invasive alien species red swamp crawfish (*Procambarus clarkii*) and apple snail were more frequent (**Table 1**). It was suggested that the study may help determine the cause of this situation, as it has been difficult to establish a breeding base in Tokushima Prefecture except for the adult pairs in Naruto.

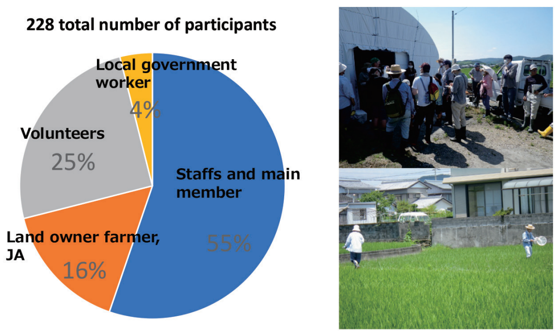

Fig. 1. Participatory action research and stakeholders.

	Total number of data	*Pomacea canaliculata*	*Procambarus clarkii*
	258	Apple snail	Red swamp crayfish
Aratano	39	−	−
Kushibuchi	5	+++	+++
Taura	125	++	++
Awacho	54	++	++
Minocho	9	−	−
Higashimiyosi	26	−	−

	Apple snail invasion	no invasion
BD. score underwater scooping	1.30	1.85
Total number of data	93	41

	Red swamp crayfish invasion	no invasion
BD. score underwater scooping	0.56	1.54
Total number of data	9	125

Table 1. Invader species and Biodiversity score.

As described above, various new scientific findings are being obtained from participatory action research, and the customizing of the manual is becoming an effective tool for citizen participation gradually. In many cases, citizens who participated in the project were surprised to see the biodiversity of the rice paddies. As part of the results, it has become clear that a bottom-up approach and organization rooted in the local community are necessary for this activity. For citizen-participatory surveys, especially in rice paddies, and for understanding agrobiodiversity in organic agriculture, a reasonable social infrastructure will be necessary. Since it is difficult to conduct biological classification and ecological surveys without the participation of various specialists, a local private research infrastructure with a parataxonomist training function is needed in familiar areas.

A social infrastructure that integrates local knowledge and has the awareness to monitor and conserve diverse local resources, will be a model for future agricultural biodiversity enhancement, responsible for organizing locally initiated research methods and research systems. Citizen participatory action research will continue in the future.

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Keywords: citizen participation, social infrastructure, apple snail,

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Oral Session 4-2

Current Status and Prospects of Weed Management Technology using Green Manure Crop Hairy Vetch and Golden Apple Snail in Paddy Soil in Korea

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The most urgent task in organic farming is environmentally friendly weed management. Weed management can be divided into chemical methods using herbicides in conventional farming methods, biological methods using plants (green manure crops) and animals (golden apple snails, ducks, etc.), and physical methods such as tillage or top dressing. The purpose of this study was to investigate weed management methods and changes in the ecosystem when using green manure crops hairy vetch and golden apple snail in Korea.

When the green manure crop hairy vetch was introduced, there was no significant change in the species of weeds. The density of weeds tended to increase, but there was no significant difference in chemical control compared to conventional fertilization. In particular, there were no problems with controlling barnyard millet, which is the most problematic weed in rice fields. As the number of years of hairy vetch input increased, the diversity of inhabiting animals increased, the physical properties of the soil (bulk density, water-stable aggregates) improved, and in particular, the glomalin content increased significantly. In particular, the increase in the number of inhabiting animals and the content of glomalin were evident at organic farming sites.

The golden apple snail, which was introduced from Japan for food, is highly effective in controlling weeds, so many organic and conventional farms in Korea also use it for weed control. However, due to recent concerns about ecosystem disturbance, it must be managed in accordance with the management guidelines of the Ministry of Agriculture, Food and Rural Affairs. In particular, it should be done by raising the initial paddy field, and collecting and disposing of it after spillage and harvest. In addition, control technology was developed using snail biology, eco-friendly methods, and pesticides.

Hairy vetch, a green manure crop, is ecologically excellent, but is insufficient to be used for weed management in rice fields. Although the golden apple snail has an excellent weed control effect, it still has ecological problems. Therefore, for eco-friendly weed management, it is expected that technology combining physical methods with technologies such as green manure crop hairy vetch, and robots to manage photogerminative weeds that exist in abundance in rice fields will be used continuously by organic farmers.

Keywords: rice, weed management, hairy vetch, golden apple snail, Korea

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Oral Session 5-1

Scalability of Organic Agriculture (OA): Insights from Europe

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This introductory presentation addresses recent dynamics of the organic sector in Europe, with special reference to the French situation. In a first section, we relate trajectories that led to the current situation of organics, characterised in France by an exceptional growth during the past ten years and a recent slowdown. Secondly, we report on research initiatives at French and European level. Finally, we draw perspectives framed both by European Union (EU) targets and research contributions regarding the scalability of organics.

From niche to plateau or further extension: dynamics of OA in EU

Mid-term development trajectories of organics have already been addressed, displaying different sequences of key stages as well as discrepancies between western European and western Balkan countries. In six western European countries, the following stages were identified: establishment of an organic community, political recognition (and regulations), financial support to value chains, acceptance by general farming community, established organic food market, institutional setting underway (Michelsen, 2001). While OA has become institutionalised through standards and certification, forms of collective commitment have also emerged, contributing to the development of organics (Allaire, 2016).

The organic sector has been strongly extending during the recent years, with the growing interest of farmers, economic organisations, public agencies, consumers (Willer et al., 2022). This entails greater diversity of organic models and arrangements at different scales. As a result, some countries or regions in Europe made organic shift out of what was previously considered as a “niche” regime. Conversely, such an extension is also questioned by various agents and institutions who consider that a “plateau” is achieved in terms of organics growth, whereas others consider that there is still room for development. A third movement can be considered, by which organic agriculture would be widespread or likely to inspire significantly other forms of agricultural regimes. Beyond quantitative objectives, the issue of organic development patterns is still at stake. New targets are set at EU level, in particular with the Green Deal and CAP, including quantitative ambitious objectives (EC, 2019; EC, 2020) while acknowledging differences between EU member states that can define their national plans (PSN-MASA, 2022). Such framing widely determines the future of organic food and farming.

Research contributions and agendas

In France, INRAE’s formal commitment to organic farming began in 1999, based on three premises: interdisciplinarity, partnership, and system approaches (Bellon et al., 2000). This programme enabled various activities and specific support to research projects. In 2020 INRAE launched a new metaprogram (Metabio) “Moving to predominant organic agriculture”. It aims to explore the hypothesis that the domestic supply of organic products becomes predominant, which would entail a radical change in the entire value chains within the context of a strong demand and wider agroecological transition. Its objectives are to develop proposals, scientifically substantiated, to anticipate the consequences of and support the development of organic agri-food systems. Accordingly, four topics were prioritized: (i) Conditions for a large scale transition and its support measures, (ii) Resources to be mobilised for sufficient and sustainable production, (iii) Processing, storage, and product qualities, (iv) Coexistence of production systems. The first outcomes of this metaprogram are available (www.inrae.fr/metabio). And INRAE was subsequently in 2022 the leader organisation in terms of publications on OA.

In Europe, the ERA-NET CORE Organic (CO for ‘Coordination of European Transnational Research in Organic Food and Farming Systems’) was established in 2004. In 2020 it included 27 ministries and research councils from 19 countries and regions whose main purpose is to fund and support transnational organic research. These partners have been working together to increase innovation potential, knowledge accessibility, alignment of national research and international outreach. By joining forces, the network sustains focused and coordinated research and innovation efforts, covering the most important challenges at every link of the organic value chains. All together more than 50 projects were funded during the entire period, with an average contribution of 1M€/project (Grando et al., 2020). The network continues as CO Pleiades (https://projects.au.dk/coreorganicpleiades/about) and a possible integration in the uprising European agroecology and food systems partnerships. As a new approach under Horizon Europe, partnerships aim to deliver on global challenges and industrial modernisation through concerted research and innovation efforts, alongside EU and associated countries, the private sector, foundations and other stakeholders.

European challenges in R&D: contribution of foresight exercises

The EU's Farm to Fork Strategy target of a 25% organic share of agricultural land by 2030 is ambitious given that organically farmed land was just under 10% in 2020. With an amplification of OA in view, both knowledge syntheses and foresight exercises are used to assess possible benefits if the 25% target can be achieved (Sautereau et al., 2016; Lampkin & Padel, 2022).

Foresight exercises such as Ten Years For Agroecology (TYFA) in Europe is an on-going project which started in 2014. A quantitative model simulating the agricultural functioning of the European food system was designed in order to develop an agroecological scenario for Europe in 2050 (Poux & Aubert, 2018). Due to the lack of data in agroecology, references from the organic sector were used to explore pesticide-free farming and extensification of crop production. Other hypotheses explored in this exercise refer to: fertility management at a territorial level; redeployment of permanent grassland; livestock extensification (phase-out of industrial modes); healthy and sustainable diets; food first, then feed, then biodiversity, then non-food use. Other on-going projects also use scenarios. The CLINORG flagship project (as part of Metabio programme) aims at exploring to what extent organic farming expansion in Europe, combined with changes in food and feed consumption, may affect land use worldwide and related GHG emission, based upon the combination of two spatially-explicit models. In the OT4EU project (EC funded) the EU targets are taken for granted (backcasting) and the focus is on development pathways and knowledge systems enabling their achievement.

As a whole, we stress (i) the importance of both demand for organic products and public supports, (ii) the need to modify diets to address the food security debate (balance between animal and vegetal protein sources), (iii) the necessary links between various agricultural models (synergy and trade-off)

Keywords: research program, development, trajectories, foresight, scaling

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Oral Session 5-2

Palayamanan: A Holistic Approach for Sustainable Intensification and Diversification of Organic Rice-based Farming Systems for Smallholders in the Philippines

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The emergence of organic movement in the Philippines was a result of resistance to the Masagana 99, national rice program of the government in the 1970s which introduced Green Revolution technologies such as short maturing and high yielding rice varieties, high fertilizer input, and pesticides to control pests and diseases. This bundle of technology was promoted with loan facilities to buy the chemical inputs and farm machinery. The Masagana 99 program resulted in a rice production boom but it was also associated with increasing debts, poverty and food insecurity of smallholder farmers. This gave birth to the first organic movement, initiated by critical farmers, scientists and civil society groups, called Magsasaka at Siyentipiko para sa Pag-unlad ng Pagsasaka (MASIPAG). The first project was to retrieve traditional rice varieties that performed well without application of synthetic inputs. The private sector and non-government organizations came into play in the 1990s with the aim of reducing poverty among smallholder farmers by capitalizing on consumers' interest in healthy and sustainable food from local producers.

In 2015, the country had 234,000 hectares of organic production area tilled by about 166,000 farmers and catering to the export market. In 2017, the Philippines ranked fifth in the number of organic producers with some 166,000 farmers growing various crops. Organic crop production remains anchored on a single crop (rice, banana, coffee, sugarcane, vegetables, coconut). There is a bigger opportunity for farmers to improve their livelihoods by taking advantage of the growing market for organically produced products by diversifiying their organic produce and by adopting a farming systems approach.

Palayamanan, coined from two Filipino words "*palayan*" and "*kayamanan*" which mean rice field and prosperity, respectively, is a development project initiated by the Philippines Rice Research Institute in 2000 that aimed to maximize utilization of resources, reduce farming risks, enhance farm productivity and sustainability, ensure household food security and economic stability of smallholder rice-based farmers. The *Palayamanan* embraces maximum utilization of on-farm biomass residues as nutrient source and animal feed with the help of microbial technology, as raw material for mushroom production and other value-adding products such as biodegradable seedling trays and pots. Sustainable intensification is implemented by diversifying the crops planted, with rice as the base crop, and integrated with fish and livestock to provide most of the food requirement and to stabilize the income of the farm family. The farm is divided into sections to accommodate the farm house, vegetable garden, and animal shed (0.05 ha); production area for rice-upland crop rotation, high value vegetables, rice-fish/rice-duck (0.75 ha) and the small farm reservoir (0.20 ha). The crop production practices include effective micro-organism (EM) technology, controlled irrigation, mulching, nutrient cycling of on-farm biomass and biological and/or natural pest control. For the livestock, raw or fermented feed supplement of on-farm biomass, mulch bedding, and automatic feeders/waterers are used. The net income derived from the *Palayamanan* farm is about 2 to 3 times more than conventional rice monocrop which is currently at USD 1,000/yr. The *Palayamanan* principles and approach towards sustainable intensification and diversification fits well in an organic food production system in response to consumers' demand for diverse, healthy and safe food and the opportunity for smallholder farmers to capture a higher profit margin due to the premium price of organically produced foods.

The Philippine government sees organic agriculture as a high value business niche complementing the conventional agriculture sector. It has established enabling mechanisms to support organic crop production through the enactment of the Organic Agriculture Act of 2010 (Republic Act 10068). The Department of Agriculture (DA) established the National Organic Agriculture Program (NOAP) that outlines concrete strategies to develop the organic sector and the Organic Agriculture Production Standards for Crops that guide farmers on Good Agriculture Practices (GAP). In December 2020, the law was amended by Republic Act 11511, which included provisions on establishing an educational and awareness campaign to promote organic food, adopting the "Participatory Guarantee System" for certifications, and ensuring proper market access to producers to ensure decent prices. Also, there is an increasing involvement of the private sector in the organic food value chain, especially in helping smallholders access the export market. However, the organic crop subsector is still challenged by the cost of third party certification.

The time is right to bring *Palayamanan* to scale. Capacity development needs to be done with the current *Palayamanan* farmers as well as other farmers that have not embraced diversified farming as a system for organic crop production. Advocacy is required so that more farmers will adopt the organic *Palayamanan*.

Fig. 1. Crop and animal components in the *Palayamanan* farm at the Philippines Rice Research Institute, Munoz, Nueva Ecija, Philippines.

Keywords: *Palayamanan*, sustainable intensification, diversification, rice-based farming systems

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Poster Session 1

Evaluating the Effect of Multiple Intertillage Weeding on Rice Growth and Yield

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According to old agricultural literature, “It is better to weed by intertillage, even if there are no weeds.” This emphasizes that intertillage weeding may offer advantages that extend beyond the removal of weeds. We previously showed that multiple intertillage weeding improved the uniformity of rice plant growth as well as crop yield. However, the underlying mechanisms responsible for these effects remain unknown. The results from previous studies on intertillage weeding might have been influenced by an abundance of paddy weeds, making it challenging to isolate the true impact of intertillage weeding. Consequently, we plan to conduct an experiment to eliminate the confounding effect of paddy weeds. Although intertillage weeding is labor-intensive, research on weeding robots is advancing rapidly. If the impact of multiple intertillage weeding on crops is clarified, it could emerge as an innovative technology for organic rice cultivation.

Keywords: organic rice cultivation, multiple intertillage weeding, mechanical weed control, weeding robot

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Poster Session 2

Effect of Surface Soil Disturbance by Hand Weeding on Organic Rice Cultivation in a New Constructed Rice Paddy During Three Consecutive Growing Seasons

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Weeding is an essential and important managemental practice of organic rice cultivation. Unlike conventional rice cultivation, where herbicides are applied, soil surface of the paddy field is disturbed by the weeding practices, which changed the surface physical, chemical and biological conditions. It was said that disturbance of paddy surface by weeding would promote nitrogen fixation in soil surface and improve rice growth. Therefore, in order to investigate the effect of soil surface disturbance by weeding on organic rice cultivation, we carried out a three consecutive years (2019-2021) experiment in a new constructed rice paddy located on Tsuruoka campus, Yamagata University, Japan.

Rice cultivar, Haenuki, was transplanted to both weeding and no-weeding plots in early June and harvested in late September every year. In the weeding plots, manual weeding with soil surface disturbing was carried out 5~7 times weekly from the middle of June to the end of July. Rice growth parameters such as shoot height, maximum tiller numbers, and leaf greenness were investigated weekly, rice and weeds biomass, N uptake were measured at and during the heading and grain-filling stages, rice yield and its components were measured after harvest (Fig. 1).

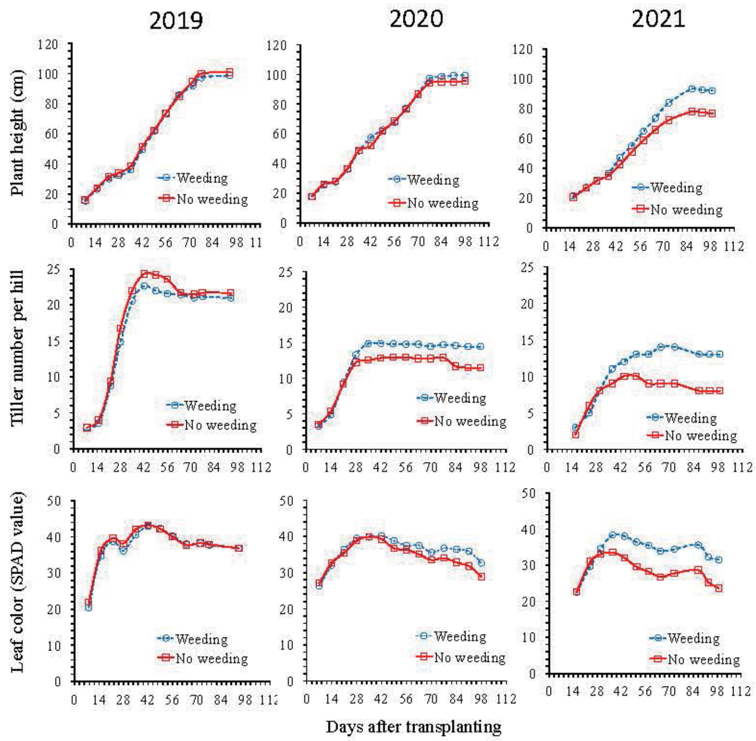

Fig. 1. Comparisons of plant height (above), tiller number (middle), and leaf color measured in SPAD values (bottom) of rice plants between weeding and no-weeding for 3 years.

The results showed that there were no significant differences in rice growth parameters, N uptake and rice yield between weeding (soil surface disturbing) and no-weeding treatments in the first year since there was no paddy weed appearance in the new constructed field. From the second year, large amount of weed of *Monochoria vaginalis* (Burm. f.) was observed in the no-weeding plots, rice growth and yields were significant differences between weeding (soil surface disturbing) and no-weeding treatments. The yields were decreased largely in the third year in no-weeding plots. The weeds biomass of no-weeding plots in 2021 was higher than that in 2020 (Fig. 2). The 3-year results suggest that it is very important for organic rice cultivation to remove weeds that compete with rice for nutrient absorption. Disturbing the soil surface only did not affect rice growth and maintaining soil fertility in continuous rice cultivation is necessary.

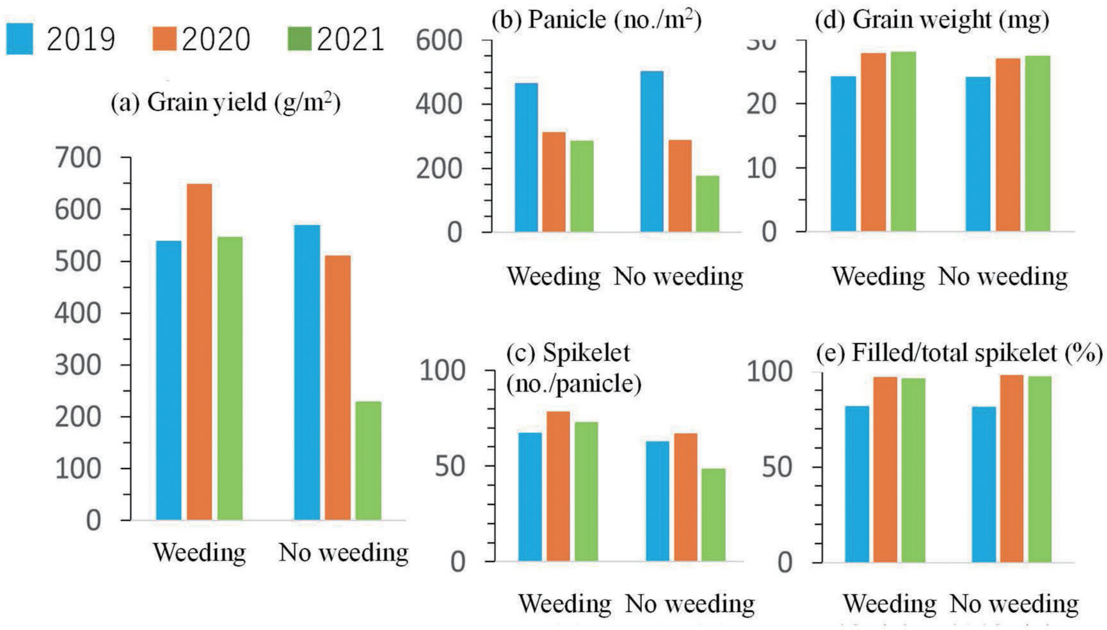

Fig. 2. Grain yield (a) and its components: panicles per m^2 (b), spikelet per panicle (c), individual grain weight (d) and percentage of filled spikelet (e) between weeding and no-weeding treatments for 3 years.

Keywords: hand weeding, organic farming, rice, soil surface disturbance, yield components.

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Poster Session 3

Mechanical Inter-/Intra-Row Weeding Effect in Rice Transplanted in a Wide Square Pattern

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Mechanical weeding is a labor-saving weed control method and a part of an integrated weed management system that allows farmers to reduce the use of herbicides including organic rice farming. Inter-row weeds can be easily controlled, while intra-row weeds are the challenge of mechanical weeding so hand weeding is used to control intra-row weeds. Reducing intra-row weeds and weeding costs are the main objectives for most organic rice production. Currently, mechanical inter-/intra-row weeding technology has been successfully developed. While widened intra-row can provide adequate space to improve mechanical weed control but the weeding period may be longer due to favorable conditions for weed growth. Little is known in this regard. Therefore, this study aimed to evaluate the weeding effect of mechanical inter-/intra-row weeding in wide square planting to provide suitable timing of weeding and weeding events for rice.

The experiment was carried out in the field (11a). The crop calendar for rice, soil puddling, fertilization, seedling, water, and mechanical weeding was managed under the organic farming scheme, while others (*i.e.* field ridge, autumn plowing) were under conventional management. Rice (*Oryza sativa* cv. Koshihikari) seedlings were transplanted in June 2022 and received 6 kg N $10a^{-1}$ of organic fertilizer (Yuuki-Aguretto 666) as a split application. Treatments consisted of (1) narrow planting (30 cm x 18 cm) + mechanical weeding equipped with the intra-row weeding tooth (The 1st, 2nd, and 3rd weeding; Inter-row weeding direction) and (2) wide square planting (30 cm x 30 cm) + mechanical weeding without the intra-row weeding tooth (The 1st weeding; Inter-row, the 2nd weeding; Intra-row, and the 3rd weeding; Inter-row and Intra-row weeding directions). The rice weeding machine had rotors and teeth as devices for inter-row and intra-row weeding respectively. The timing of weeding was 1, 2, and 3 weeks after transplanting (WAT) for the 1st, 2nd, and 3rd weeding, respectively. Treatments were laid in randomized complete block design with 3 replications. The experimental plot size was 99 m^2. Six sample quadrats were designated in each plot to investigate weeds (*Monochoria vaginalis* and *Schoenoplectiella juncoides*). Each quadrat covered 0.108 m^2 (for narrow planting) and 0.18 m^2 (for wide square planting) or equaled the space in between 6 rice plants. At 11 WAT, the number and the dry weight of weeds growing in the inter-row and intra-row were investigated as illustrated in Fig. 1.

The results showed that the dry weight of weeds that remained after weeding was significantly low in the inter-row of narrow and wide square plantings (data not shown). The number of weeds in inter-row and intra-row was 84 and 300 m^{-2} for narrow planting and 115 and 290 m^{-2} for wide square planting, respectively. It implies that weeding was effective in inter-row. It appeared that weeding 2 times in wide square planting (B- and C-area), 3 times in narrow planting (A-area), and 4 times in wide square planting (A-area) largely reduced weeds with insignificant differences among these weeding events. Unremoved weeds largely remained around the base of the rice plants (wide square planting, D-area) because the area was not disturbed by weeding rotors (Fig. 2). This suggests that weeding at least 2 times could effectively control weeds (Fig. 2). Among 2-time-weeding events, the dry weight of weeds was lower in C-area than B-area, indicating a 2-consecutive-weeding at 2 and 3 WATs was relatively more effective than a 2-time-weeding at 1 and 3 WATs. In addition, the delay of the first weeding up to 2 weeks after rice transplanting may not negatively affect weed control if it is followed by a 2-consecutive-time of weeding.

Based on our data gathered so far, mechanical weeding was an effective method for weed control in wide square rice planting through 2 times of weeding. The timing of these 2 times weeding can be the important key to improving weeding efficiency. The first weeding employed 2 weeks after rice transplanting may not adversely affect weed control if it is followed by weeding 2 times continuously. Further study should concentrate on the suitable timing for weeding and a tool to remove weeds growing in the areas where mechanical weeding is not applicable.

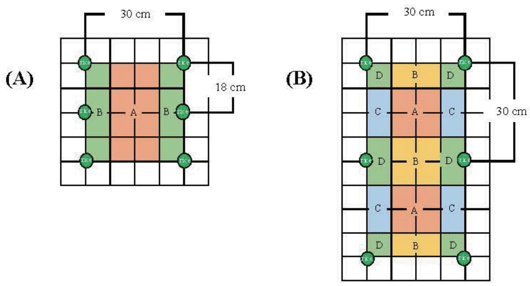

Fig. 1. Weed observing quadrats in narrow planting (**A**); A, Inter-row (3-time-weeded by rotor) and B, Intra-row (3-time-weeded by tooth), and wide square planting (**B**); A, Inter-row (4-time-weeded by rotor), B, Inter-row (2-time-weeded by rotor at 1 and 3 WATs), C, Intra-row (2-time-weeded by rotor at 2 and 3 WATs), and D, Intra-row/Base (unweeded by rotor and tooth), respectively.

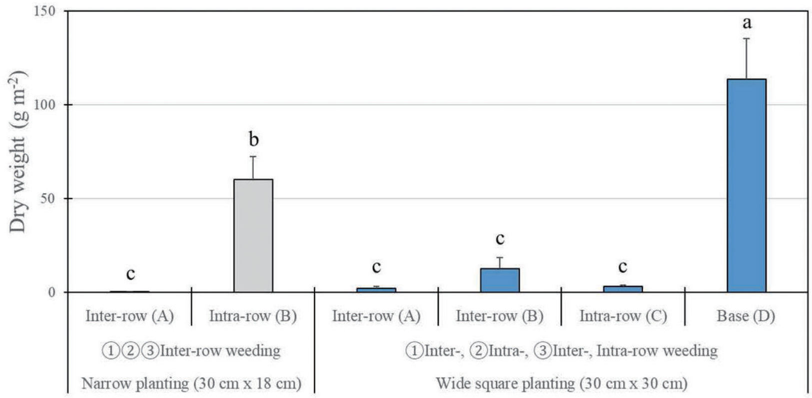

Fig. 2. Dry weight per unit area of weeds growing in different planting techniques in combination with mechanical weeding. Means with different letters are significant differences ($p < 0.05$, Tukey's HSD).

Keywords: high-efficiency rice weeding machine, inter-row weeding rotor, *Oryza sativa* cv. Koshihikari, weeding effect, weeding event

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Poster Session 4

Adaptability to Organic Cultivation and Weed Competitiveness among Rice Varieties Grown in the Shonai Region since the Meiji Era

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With the depletion of fertilizer resources and the increase of drug-resistant pests, there is a need to promote sustainable agriculture. Organic agriculture requires that no chemically synthesized fertilizers or pesticides be used, and it is hoped that the environmental benefits, such as the prevention of water pollution through reduced use of chemical fertilizers and pesticides, will lead to better health and welfare for people from the perspective of the SDGs. In organic cultivation of paddy fields, weeding is time-consuming and labor-intensive, and varieties that are highly competitive with paddy weeds are in high demand. On the other hand, about 120 years ago, Japanese rice cultivation was traditionally organic, without the use of chemical fertilizers and pesticides. Older varieties cultivated in the past are considered to be more adaptable to fertilizer-free cultivation and more competitive with paddy field weeds. In this study, five rice varieties cultivated in the Shonai area at different generations were grown in the same field, and their growth and yield, weed production, and nitrogen uptake were investigated to determine the differences in applicability to organic cultivation and weed competitiveness among the rice varieties.

In the summer of 2022, four repetitive weeding and no weeding zones were established in a paddy field (Photo 1) on the grounds of the Faculty of Agriculture, Yamagata University, and the five varieties listed in Table 1 were transplanted on May 31. Five manual weeding operations were conducted in the weeding area during the first semester of rice growth. During the entire growth period, weekly surveys of rice growth (grass height, number of tiller, and leaf color values) were conducted in each treatment area. Just prior to harvest, rice and weed biomass surveys were also conducted to determine nitrogen uptake by the rice and weeds. At harvest time (September 22), nine plants were harvested, and rice yield and its components were subsequently investigated.

Table 1. Varieties used in this study

Variety name (abbreviation)	Year of variety registration
Kamenoo (Ka)	1896
Rikuu 132 (Ri)	1921
Sasanishiki (Sa)	1963
Haenuki (Ha)	1993
Tsuyahime (Tu)	2009

The results showed that the relatively newer varieties produced more rice paddy yield in the weeding area than the older varieties with 458, 392, 538, 487, and 472 g/m² for Kamenoo, Rikuu 132, Sasanishiki, Haenuki and Tsuyahime, respectively (Fig. 1). Weed biomass in the no weeding plots was 200, 273, 329, 313, and 428 g/m², respectively, in the same order of oldness as above, with the older variety treatments producing more weeds. The percentage yield loss without weeding, calculated from the no weeding and weeding rice yields, was 38, 55, 68, 66, and 70%, respectively, in the same order of oldest to youngest, with the newer varieties having a higher yield loss rate (Fig.2). These results suggest that older varieties are more competitive with weeds than newer varieties and can be applied to organic rice cultivation.

Fig. 1. Rice yield of rice varieties of different ages in weeding and no weeding areas

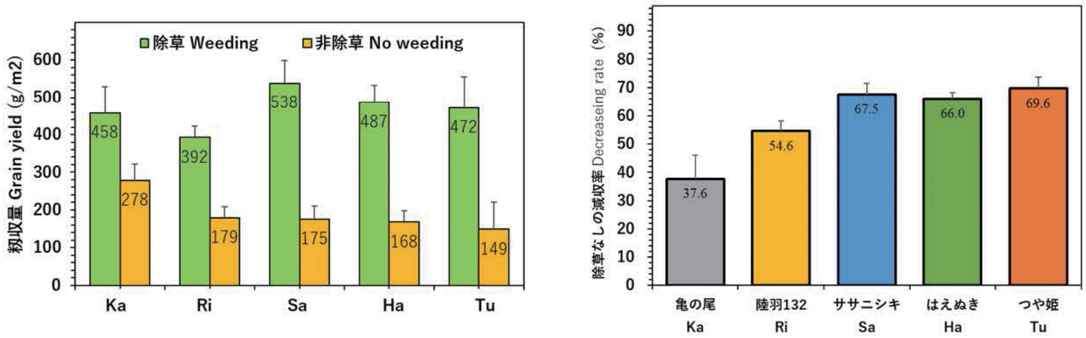

Fig. 2. Yield reductions for rice varieties of various ages

Keywords: organic rice cultivation, weed competitiveness, variety, Shonai area

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Poster Session 5

High-yielding Cultivar "Takanari" Shown over Competition to "Koshihikari" on Nitrogen Absorption and Biomass Production under Natural Rice Farming

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Rice yield and whole biomass production are strongly related to the rice cultivar's nitrogen (N) uptake ability and various meteorological conditions and managemental practices. Previous studies showed that Takanari as a high-yielding Indica rice cultivar has higher N uptake ability compared to regular japonica cultivar, such as Koshihikari under low nitrogen supply even if the atmospheric CO_2 concentration was increased. However, it is still unclear that the N uptake competition between Takanari and Koshihikari under natural rice farming without any manure and fertilizer application. For this reason, we conducted a pot experiment at Tsuruoka, Yamagata, Japan in the 2022 rice growing season.

Both Takanari (Tak) and Koshihikari (Kos) were transplanted into individual pots and interplanting pots (Tak+Kos) with main treatments of weeding and unweeding. The sub-treatments were individual cultivation (Tak, Kos) and interplanting cultivation (Tak+Kos). The pots were filled with 8.0 kg air-drying alluvial soil which was taken from an organic rice farming field in Yamagata University Farming. Rice seedlings of both varieties were transplanted on 28th May and Harvested on 19th September 2022; then rice plants were divided into the ear, leaf+ stem, and root to be assessed for biomass and N content.

As a result, plant biomass and nitrogen content were significantly different among all treatments. Comparing Takanari to Koshihikari, Takanari accumulated a higher amount of biomass and nitrogen content for ear, root, and whole rice plants in both treatments (weeding and unweeding); whereas Koshihikari accumulated a higher amount of biomass and nitrogen content for leaf+stem in both treatments (weeding and unweeding). The Takanari-Koshihikari ratios of total dry weight biomass were 1.20 and 1.34, when each cultivar is grown individually in the pot for weeding and unweeding treatments, respectively. Whereas they were 1.36 and 1.56 when two rice cultivars were grown in the same pot as interplanting cultivation ($P<0.001$). Then, the Takanari-Koshihikari ratio of the total N uptakes was 1.33 and 1.32, when each cultivar was grown individually in the pot for weeding and unweeding treatments, respectively; Whereas they were 1.62 and 1.48 when two rice cultivars grown in the same pot for weeding and unweeding treatments, respectively ($P<0.001$). The results indicated that Takanari expanded competition on N absorption and biomass production to Koshihikari when two rice cultivars were grown in the same pot as interplanting cultivation.

Keywords: planting system, organic farming; rice variety; weeding

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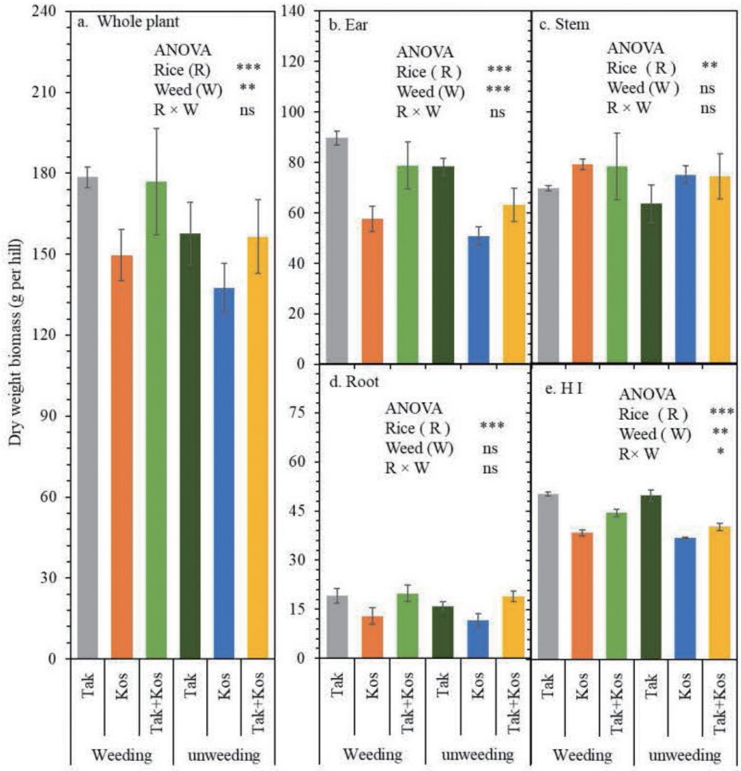

Fig. 1. Dry weight of whole rice plant (a), ear (b), leaf +stem (c), root (d), and harvest index (HI) (e) at harvest of rice cultivar plant grown individually in the pot (Tak, Kos) and interplanting (Tak + Kos). Bar indicates standard deviation (n=3). ANOVA results are inset. ns: not significant; *: $P < 0.05$; **: $P < 0.01$ and ***: $P < 0.001$.

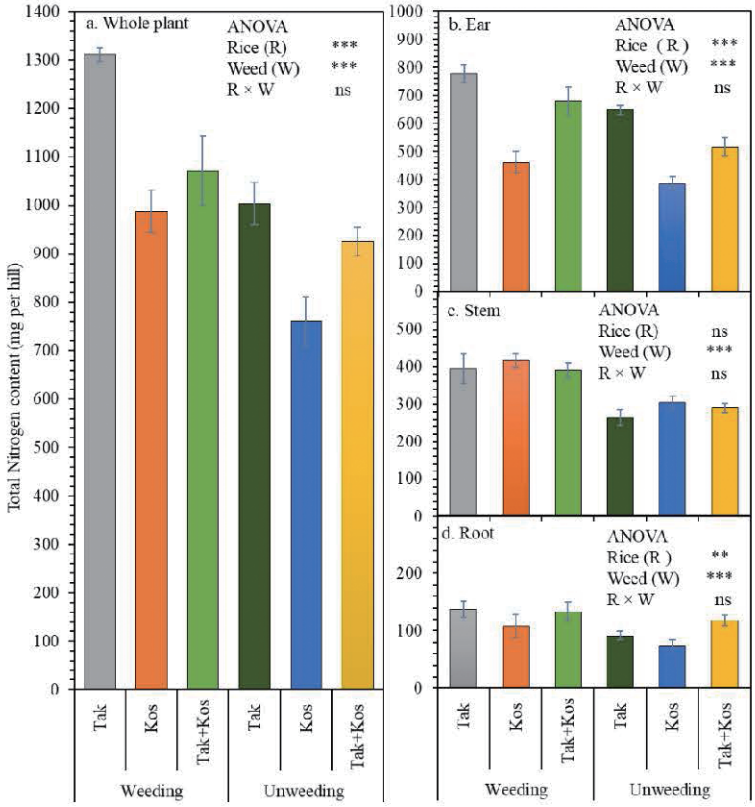

Fig. 2. Nitrogen uptake in (mg per Hill) of whole (a) rice plant, ear (b), stem (c), and root (d) at harvest of one rice cultivar plant grown individually in pot and interplanting (Tak+Kos). Bar indicates standard deviation (n=3). ANOVA results are inset. ns: not significant; *: $P < 0.05$; **: $P < 0.01$ and ***: $P < 0.001$

Poster Session 6

Innovation of Products and Varieties for Organic Rice Production: a Ph.D. project

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Introduction

Nowadays Agriculture is among the human activities that affect the rise in global warming because despite studies and single country effort, inefficient cultivation methods practiced all over the world waste the limited natural resources. The alternative methods proposed to avoid the errors provided by the "Green Revolution" model are still little studied/used. Considering this, a PhD project started at the University of Milan, Italy in the October 2021 funded by a private company (Terrepadane) with the purpose of studying sustainable fertilizers for organic farming and evaluating innovative and new methods for sustainable organic farming (e.g., allelopathic rice varieties), and it will end in September 2024.

Materials and Methods:

In the first year a review was initiated at global scale on methodologies / practices / choices for the mitigation of the impacts of agriculture in terms of lowering the main practices that are responsible for increasing global warming. This literature study focuses on understanding the best practices to support sustainable organic farming for rice cultivation.

This research was followed by field trials for the application of biostimulants for organic rice production and a preliminary study on allelopathic rice varieties.

During summer 2022, seeds were ordered from gene banks, of 18 rice accessions that were found allelopathic from literature review.

In the first year a foliar organic fertilizer was tested: AMINOENNE (Terrepadane), Fluid hydrolysed animal epithelium (N 8%) was used to assess the application of biostimulants for organic rice production. At Rovasenda (VC), piedmont in Italy, an experimental design parcel was started in 2 different fields, on 2 rice varieties (Carnaroli and Rosa Marchetti) with green mulching as field management*.

Data on N content and LAI measures were taken in replicates during the rice physiological stages: 2°-3°leaf; tillering, elongation, flag leaf, flowering and at the harvest time. The tools used for data collection were as follows: Dualex®** /Pocket N- Pocket LAI***/ elemental analyser for Nitrogen content. In the second year (nowadays) a biostimulant composed of the following components were evaluated in rice fields: *Azobacter chroococcum, Azospirillum brasiliense, Bacillus velezensis*, with foliar fertilizer of fermented sugar cane. The experimental designs consider 3 different fields of 2 rice varieties (Carnaroli and Rosa Marchetti) with green mulching as field management*. Data collection on N content and LAI measures were taken in replicates during the rice physiological stages: tillering, elongation, flag leaf and at the harvest time. The tools used for data collection were Pocket LAI***/ elemental analyser for Nitrogen content/ Samples of biomass.

Results and Discussion:

The study is ongoing, for that reason we don't have to show significant results but I'm presenting my PhD work that will end in October 2024. The graphs (Fig.1) below represent the trend of the Leaf Area Index (LAI) 2023 values in relation to the treatment performed (i.e., application of the biostimulant during the rice tillering phase) on rice varieties C: Carnaroli rice; R: Rosa Marchetti rice.

Conclusions:

During the last year the aim was to evaluate the sustainability of the innovative input introduced in different farming systems using a systemic tool like SAFA (FAO, 2014). The SAFA framework provides a common language for sustainability that can be adapted to suit different users' needs. The pillars of sustainability considered are social, economic, environmental and governance.

Data information will derive from surveys to farmers following SAFA protocol. The data will also be used for LCA (Life Cycle Assessment). To deepen the environmental information surveys on spontaneous flora were done in 2022 and will continue in 2024. The use of LCA as an evaluation tool for companies is widespread. For the farmers, that tool, could be used to assess the environmental impact of the process for rice production. The limit of LCA is that it doesn't consider the ecosystem services provided by the system under analyses. For that reason, this study wants to combine biodiversity indicator connected to spontaneous flora and LCA with the use of SAFA.

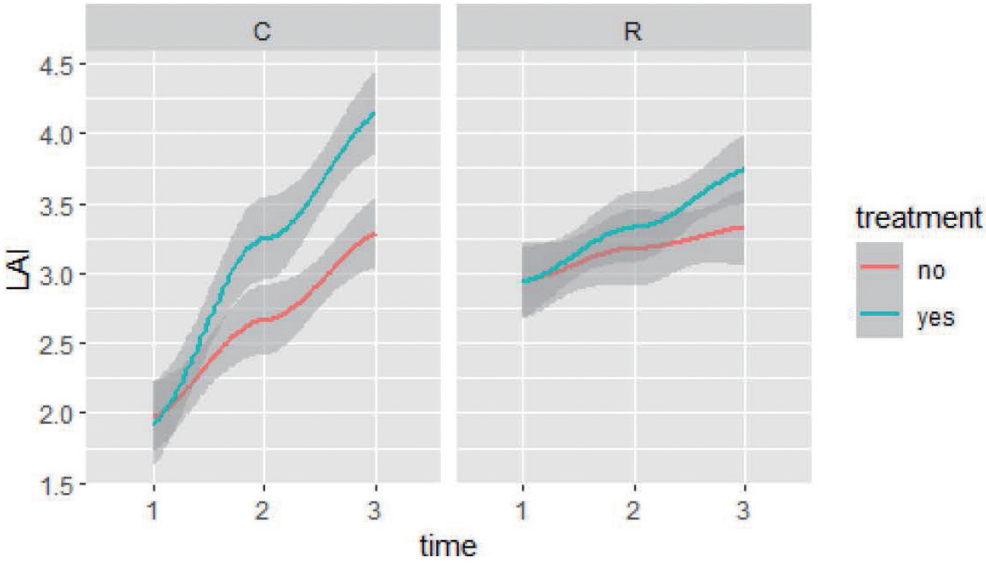

Fig. 1. The trend of the Leaf Area Index (LAI) values in relation to the treatment performed (i.e., application of the biostimulant during the rice tillering phase) on rice varieties C: Carnaroli rice; R: Rosa Marchetti rice. Legend: treatment: yes, or not treated with the biostimulants; LAI data was taken in different phenological states i.e., time: 1 BBCH 29-30, 2 BBCH 34-36, 3 BBCH 45.

Notes:

* The green mulching field management is described in Orlando et al 2019 and Vaglia et al 2022: A cover crop mixture (i.e. graminaceous, such as Lolium multiflorum Lam., and leguminous, such as Vicia sativa L.) sown before rice, and the weed control based on complex dynamics that involve the cover crop competition, the green mulching effect, the allelopathic relationships between weeds and the sowed species (Vitalini et al.,2020a; Vitalini et al.,2020b), and the toxic effects of the organic acids developed as a consequence of the cover crop biomass fermentation. The broad cast sowing of rice is on dryland and the standing cover crop. Immediately after, the field is flooded activating the fermentation processes of the cover crop. This flooding lasts on average five days and follows a dry period (on average 12 days).

** DUALEX® measures the chlorophyll content of leaf thanks to a transmittance ratio at two different wavelengths. One is in the far-red absorbed by chlorophyll and the other is in the near infrared as reference.

*** PocketLAI is the first mobile app for the estimation of leaf area index (LAI). PocketN is a smart app for the estimation of nitrogen content in plant tissues. These mobile apps are currently available as a paid application for the ANDROID platform ONLY, licensed and distributed by Cassandra Tech S.r.l.; Product Manager: Prof. Roberto Confalonieri, University of Milan

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Keywords: organic rice, biostimulants, allelopathic rice

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Poster Session 7

Microbiological Basis of Soil Carbon Sequestration in Organic Rice Production in India

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Soil microorganisms are key agents determining the fate of soil C and aid in its sequestration. The assessment of the impact of agri-management on the microbial activities related to C sequestration was undertaken using long term organic agricultural management in the rice-wheat rotation. The organic management included input of a combination of nutrient sources farmyard manure (FYM), vermicompost (VC) and biofertilizers (BF) in the rice-wheat rotation.

The treatment VC+CR+BF had significantly higher ergosterol, peroxidase, phenol oxidase, FDA hydrolase activity, β-glucosidase activity & Xylanase activity implying higher fungal populations that are active in the mineralization and subsequent loss of the soil C. while FYM+CR+BF had significantly higher, water-soluble phenolic content, SMBC, Melanin & Chitin content at 0-30 cm soil depth. A high degree of homology of these microbial metabolites with the SOM indicates superiority of this treatment with its potential to increase the soil labile C fraction.

Keywords: carbon sequestration, FYM, rice, soil organic carbon, vermicompost

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Poster Session 8

Nitrogen Situation and Carbon Accumulation in No-tillage with Weed Mulch Paddy Field

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【Introduction】

Natural farming with weeds (no-tillage with weed mulch management: NWM) in paddy is based on no tillage, without any pesticides, nor chemical fertilizer, and only rice bran or oil cake is applied at the time of planting. It uses weeds for mulching after slashing the aboveground weeds, thus a specific organic layer is formed on the soil surface. This management has been practiced throughout Japan. The rice production in NWM is sustained without fertilization. Interviewed in Nara prefecture, yields of 480 kg/10a (brown rice) were obtained. We hypothesized that the supply of nitrogen to rice from weeds and rice straw residues would maintain a certain level of rice yield even without chemical fertilizer. The objective of this study was as follows: (1) to examine nitrogen supply by weeds and rice straw in NWM paddy fields; and (2) to evaluate carbon accumulation in the organic layer and soil in NWM.

【Materials and Methods】

The survey was conducted in 2012 and 2022. The study sites were NWM and conventional paddy field in Nara (2012 and 2022) and, in Tokushima, Hyogo, and Okayama (2022 only). Those study sites are managed that rice straw, husk and bran are returned to the field, and mowed weed and covered the soil surface. Rice straw and winter weed were collected in each site. We collected soil samples at depth of 0-30 cm in 2012, 0-5 cm in 2022. Total C and N, and natural abundances of ^{13}C and ^{15}N in the soils were analyzed.

【Results and Discussion】

Winter weeds were less present in the conventional fields, while winter weeds thrived in NWM. The average above-ground biomass of rice straw and winter weeds in NWM were 281.2 g/m^2 and 787.5 g/m^2, respectively. The average nitrogen concentrations at depth of 0-5 cm of soil in the conventional and NWM fields were 3.19 g/kg and 3.01 g/kg, respectively. In Nara, the $\delta^{15}N$ at depth of 0-5 cm of soil in the conventional and NWM fields were 0.390 ‰ and 1.192 ‰, higher in NWM fields. The $\delta^{15}N$ of chemical fertilizers is close to zero. The NWM fields received no chemical fertilizer, and the $\delta^{15}N$ of rice straw and winter weeds were higher than zero, Therefore the internal cycle of nitrogen was considered to be higher in the NWM than in the conventional fields. It assumed that the nitrogen absorbed by weeds during the winter can be used by rice plants during the summer, and the nitrogen from the rice straw decomposition is used by weeds during the winter, resulting in an increase in isotope ratios. We considered that nitrogen supply by winter weeds contributed to the maintenance of rice yield.

The O layer was 5 -10 cm thick and its carbon concentration was 148.4 g/kg in NWM field. Soil carbon at depth of 0-5 cm in the conventional and NWM fields was 23.07 g/kg and 24.57 g/kg, respectively. Soil carbon accumulation at 0-30 cm with the O layer, the conventional and NWM were 5.38 kg/m^2 and 5.46 kg/m^2, respectively. Which were not significantly different. The O layer accounted for about 26 % of the soil carbon accumulation in the NWM field. The straw of NWM was higher than that of the O-layer and lower than soil, indicating that nitrogen recycle is limited in the O-layer in NWM management.

Keywords: conservation agriculture, nitrogen stable isotope ratios, internal dynamics

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Poster Session 9

Root Dynamics in Organic Rice Farming in Comparison with Conventional Farming

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Organic farming has been known as a sustainable farming method due to not using chemical pesticides, herbicides, and chemical fertilizers. Its market has been growing in the world. In organic farming, organic fertilizers are commonly used. The nutrients of organic fertilizers are absorbed by plants after they are decomposed by microorganisms. Therefore, it is difficult to control the efficacy of organic fertilizers affected by various environmental conditions; this is one of the causes of low yields in organic farming. In this situation, the root system is expected to play an important role, but few field studies exist about root dynamics in organic farming. In this study, we compared the rice root system dynamics, including root production and decomposition, with the rice growth and yield under conventional farming (CF) and organic farming (OF) in paddy fields in Kawatabi Field Center, Tohoku University in 2022.

The root dynamics were investigated by quantifying root production and decomposition using the ingrowth core method. Standing roots are quantified using the core sampling method. In CF, standing root biomass reached a maximum during the heading stage, and new roots declined after the heading stage. In contrast, the roots tended to be produced after the heading stage in OF. The root length density showed similar dynamics with root biomass. The rice yields were 518 g/m^2 and 379 g/m^2 in CF and OF, respectively. These results suggest that root production becomes more active after the heading stage for supplementing significant root decomposition in OF, which may affect the low yield because photosynthates may be allocated to belowground biomass. In the future, we will conduct more detailed surveys around the heading stage and research the paddy fields of several organic rice farmers.

Keywords: rice, root production, root decomposition

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Poster Session 10

Long-term Effects (20 years) of Cropping Systems and Nutrient Management Practices on Grain Yield of Organic-grown Basmati Rice and Soil Fertility

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The soil fertility is rapidly declining in India, particularly the organic matter decline has become a serious issue. The conventional farming has also reduced the biodiversity and farmers' income besides polluting the air, soil, and water. Rice crop has the largest cultivated area (43.5 million hectares) in India among all the crops, being grown mostly by conventional methods. The conventional rice production system has become unsustainable, and thus replacing it partly by organic production may sustain the production and soil fertility. In view of the above, this study evaluated the effect of including mungbean (*Vigna radiata* L.) and later *Sesbania* (*Sesbania aculeata*) green manuring in the rice-wheat cropping system and nutrient management practices on soil health and productivity of rice crop.

The long-term field experiment (20 years) on organic farming of rice-based cropping systems was started in year 2003 and has been continued till 2023 at the ICAR-Indian Agricultural Research Institute, New Delhi, India (Table 1). The experiment was laid out in a strip plot design with three replications. Treatments during first 10 years (2006-07 to 2015-16) consisted of 2 rice-based cropping systems (rice-wheat and rice-wheat- mungbean), six combinations of different organic materials and biofertilizers [farmyard manure equivalent to 60 kg N ha^{-1} (FYM), vermicompost equivalent to 60 kg N ha^{-1} (VC), FYM + crop residue (CR) of preceding crop @ 3 t ha^{-1} for each rice, wheat and mungbean, VC + CR, FYM + CR + biofertilizers and VC + CR + biofertilizers] and control (no manure applied). For biofertilizers, the blue green algae (BGA), phosphate solubilizing bacteria (PSB) and cellulolytic culture were used in rice, *Azotobacter*, phosphate solubilizing bacteria (PSB) and cellulolytic culture in wheat and *Rhizobium* + PSB in mungbean. Subsequently, during the years 2019-20 to 2022-23 (4 years), the rice based cropping systems were rice-wheat-mungbean and rice-wheat-*Sesbania* green manuring (SGM), but the nutrient management options were the same as during the previous years (2006-07 to 2015-16) in the fixed plots. All the cultural and management practices were followed as recommended by the Government of India for organic crop production. The insect-pests and diseases were managed through organic methods.

Table 1. History of the long-term organic farming experiment (2001 – 2023) at the New Delhi, India

Year	*Kharif* (rainy season)	*Rabi* (winter season)	*Zaid* (summer season)	Remarks
2001-03	Basmati Rice	Wheat	-	Conventional farming
2003–04 to 2004-05	Basmati Rice	Wheat	-	Transitional period
2004–05 to 2005-06	Basmati Rice	Wheat	-	Transitional period
2005–06	Basmati Rice Basmati Rice	Wheat Wheat	- Mungbean	Transitional period
2006–07 to 2015-16	Basmati Rice Basmati Rice	Wheat Wheat	- Mungbean	*OF: 10 cycles completed
2016-17 to 2017-18	Soybean Soybean	Wheat Wheat	Mungbean SGM**	*OF: 2 Cycles completed
2018-19	Maize Maize	Wheat	Mungbean SGM**	*OF:1 Cycle completed
2019-20 to 2022-23	Rice Rice	Wheat Wheat	Mungbean SGM**	*OF:4 Cycles completed

*Organic farming, **SGM: *Sesbania* green manuring

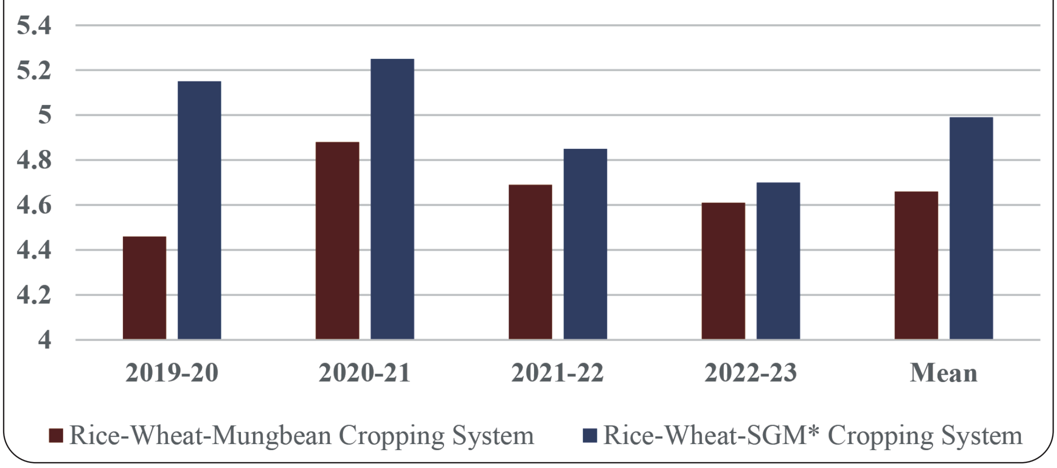
Averaged across the 10 years (2006-07 to 2015-16), the rice-wheat-mungbean cropping system (RWMCS) produced about 13.0 % higher grain yields of rice over the rice-wheat cropping system (RWCS) (Table 2). Levels of organic carbon, total N, available N, P, K and micronutrients increased significantly by inclusion of the mungbean in RWCS. RWMCS was more profitable over the RWCS. Increase in grain yields of rice and wheat crops was the most when biofertilizers and crop residues were combined either with farmyard manure (FYM) or vermicompost (VC). Application of vermicompost + crop residue + biofertilizers (BGA + cellulolytic culture + PSB in rice, *Azotobactor* + cellulolytic culture + PSB in wheat, *Rhizobium* + PSB in mungbean) was most productive and FYM + crop residue + biofertilizers was most profitable. Both these combinations also resulted in a significant improvement in the soil chemical and biological properties. Levels of organic carbon increased significantly due to the inclusion of mungbean in the RWCS. Simultaneously, the soil microbiological properties, viz., microbial biomass carbon, microbial biomass nitrogen and enzymatic (alkaline phosphatase, acid phosphatase, dehydrogenase, glucosidase, FDA hydrolysis, etc.) activities were also significantly higher in soils of RWMCS than in RWCS. All the nutrient management practices increased the SOM contents substantially over the control.

Table 2. Mean grain yield of organic-grown basmati rice (t/ha) across the nutrient management options in two different cropping systems

Year / cropping system	Rice-Wheat Cropping System (RWCS)	Rice-Wheat-Mungbean Cropping System (RWMCS)
2006-07	4.26	4.55
2007-08	4.51	4.91
2008-09	4.30	4.60
2009-10	3.94	5.10
2010-11	4.49	5.18
2011-12	3.71	4.08
2012-13	3.88	4.33
2013-14	4.11	4.59
2014-15	3.89	4.62
2015-16	3.93	4.81
Mean	4.10	4.68

The mean grain yield of organic rice during the last 4 years (2019-20 to 2020-21) were significantly higher (Fig.1) in the rice-wheat-*Sesbania* green manuring cropping system (RWSCS) over the rice-wheat-mungbean cropping system (RWMCS).

Fig.1 Mean grain yield (t/ha) of organically-grown basmati rice across the nutrient management options in two different cropping systems



*SGM: *Sesbania* green manuring

Thus, the cropping systems have important role in influencing the productivity of the component crops. Overall, the organic production of basmati can be sustained by diversifying the cropping systems and adopting the efficient nutrient management practices. Such practices also enhance and sustain the soil fertility and profitability as well.

Keywords: basmati rice, farmyard manure, green manuring, organic production, vermicompost

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Poster Session 11

Cropping Pattern Rice-Shallot-Soybean under Saturated Soil Culture in Tidal Swamp

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Indonesia has 20.1 million hectares of tidelands that could be used-land and for future agricultural development. The problem with tidal land is the presence of pyrite (FeS_2), which, if dry (oxidized), causes the pH to fall and poisons Rice-Red Onion-Soybean crops. If the pyrite remains submerged (reduced), it will cause the appearance of iron (FeS_2), which can be toxic to plants. Technology using Saturated Soil Culture can stop pyrite oxidation., increase soil pH and prevent iron dissolving, thereby increasing the yield of soybeans and corn 2-3 times compared to conventional methods.

Saturated Soil Culture is appropriate for rice and nonrice (red onion and soybean) because this technology reduces over-reduction for rice and over-oxidation for red onion and soybean. Crop rotation between rice, red onion, and soybean is a wise alternative to maintaining soil fertility. Crop rotation is the practice of planting different types of crops in rotation on one piece of land. Crop rotation is a cropping pattern that is carried out in rotation in a certain time sequence. Crop rotation provides abundant above- and below-ground crop residues and root exudates, which are known to stimulate the growth of soil microorganisms. Adding plant residues and manure to the crop rotation system can be a source of nutrients because it can increase the organic matter content of the soil.

The research was conducted on overflowing type B tidal fields, namely land that is only inundated during high tide in Mulya Sari Village, Tanjung Lago District, Banyuasin Regency, South Sumatra Province, Indonesia. This study aims to study: 1) observation of rice cultivation based on farmer interviews using adaptive varieties in tidal land, 2) Shallot cultivation with a water table depth of 20 cm water depth and shallot varieties that are tolerant to tidal land with water-saturated cultivation, 3) Soybean varieties that are tolerant to tidal land with water-saturated cultivation without fertilizer application. This research examines how the rice-shallot and soybean cropping systems take advantage of the residual effects of manure through water-saturated cultivation in tidal fields.

The highest rice productivity was in the Inpari 42 variety, which produced 4.2 - 4.5 ha^{-1}, a tolerant variety in tidal areas. For the Ciherang variety, the initial growth was good, but after ear emergence, the panicle was attacked by Blast disease. And the sensitive variety in tidal land is IR64. This is based on interviews with tidal farmers that sensitive varieties experience Fe stress when the land is stagnant, causing Fe^{3+} to dissolve and oxidize pyrite quickly and decreasing soil pH.

Table 1 shows the shallot production on Saturated Soil Culture. The treatment of the Bima Brebes variety at a water depth of 30 cm is higher in yield than other shallot varieties. Statistically different markedly, the Bima Brebes variety, with a water depth of 30 cm, can reach 7.3 tons/ha. At the same time, the lowest productivity with water depth in the water-saturated cultivation system in tidal land is the SS Sakato variety, with a water depth of 10 cm. The productivity of shallot crops with water-saturated cultivation is the Bima Brebes variety, with a water level height of 30 cm. This happens because water-saturated cultivation causes soil conditions at field capacity conditions. The stability of subsurface water at the beginning of growth until it enters the generative phase can meet the formation of onion bulbs in water-saturated cultivation in tidal fields.

Table 1. Productivity Shallot (ton/ha) in saturated soil cultures of varying water depths

Water depth (cm)	Shallot Varieties					
	Bima Brebes	Bauji	Manjung	Tajuk	SS Sakato	Batu Ijo
10 cm	5,2 de	4,6 def	4,3 ef	4,6 def	4,1 f	4,3 ef
20 cm	6,2 bc	5,5 cd	5,2 de	5,0 def	5,0 def	4,6 def
30 cm	7,3 a	6,0 bc	6,5 b	6,3 b	5,2 de	4,8 def

Remarks: [a,b,c,d,e,f] It should be noted that values in rows and columns separated by different letters differ significantly (DMRT test, 5%).

Productivity of 7.3 tons/ha in shallot varieties carried out with water-saturated cultivation technology means that the development of shallots with the BJA concept in tidal land is very promising for future development. Of course, it has also received assistance with mechanization technology in light tillage and the construction of irrigation ditches.

Table 2. Soybean productivity

Treatment	Productivity
Variety	
Anjasmoro	2,09 b
Tanggamus	2,57 a
Fertilization Combination	
No Fertilizer	0,99 b
P	1,38 b
P+K	1,33 b
P+K+Ca	2,36 a
P+K+Ca+Chicken Manure	2,42 a
P+K+Ca+ Chicken Manure +Cu	2,62 a
P+K+Ca+ Chicken Manure +Zn	2,94 a
P+K+Ca+ Chicken Manure Cu+Zn	2,93 a

Remarks: [a,b,c,d,e,f] It should be noted that values in rows and columns separated by different letters differ significantly (DMRT test, 5%).

Ca plays a role in increasing soil pH. An increase in soil pH causes nutrients to become available. The amelioration process by lime/dolomite supplies OH^- into the soil, which reacts with H+ to become water and causes H^+ ion levels to decrease so that soil pH increases.

Keywords: cropping system, saturated soil culture, rice-shallot-soybean, tidal swamp

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Poster Session 12

Evaluation of Differences in Physical Properties, Cooking Behaviour and Starch Digestibility of Different Rice Varieties Associated Also to Management Strategies

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Introduction:

To deal with climate change and environmental degradation, Europe is proposing a new model of sustainable growth, recognizing the inseparable link between the health of people, societies and the planet. The Farm to Fork strategy aims to make the European agri-food system a model of sustainability for all countries in the world. In this context, agriculture plays a key role in making the food system robust and resilient, able to meet the challenges of the future. Italian rice cultivation, being a very important sector for Europe, requires a sustainability assessment that considers all aspects: environmental, economic, social, governance and quality of the final product since these affect all the actors in the supply chain, from producer to consumer.

About rice as a final product of cultivation, since 2018 several studies have been carried out to compare physical properties, cooking behavior and starch digestibility at the University of Milan.

A first experiment took place thanks to the international project funded by the National Institute of Crop Science, Rural Development Administration (RDA) of Korea launched in 2018 and concluded in 2021 involving the University of Milan stimulated the interest to evaluate a comparison of physical properties, cooking behavior and starch digestibility considering five Tongil-type and six Japonica-type varieties (Experiment 1).

Since 2020, the interest has emerged in comparing varieties of Italian rice grown with Organic and Conventional methods (Experiment 2).

Materials and Methods:

Experiment 1. The Department of Southern Area Crop Science, National Institute of Crop Science, RDA (Korea) provided milled rice from eleven rice varieties: five Tongil type Indica rice (‘Geumgang1’, ‘Milyang354’, ‘Saegyejinmi’, ‘Saemimyeon’, ‘Shingil’) and six Japonica type (‘Dodamssal’, ‘Irumi’, ‘Milyang343’, ‘Milyang344’, ‘Saegoami’, ‘Yeongjin’). The samples were compared with a commercial sample of the Italian rice variety ‘Carnaroli’.

Experiment 2. The Italian rice variety were bought at supermarkets or directly from farmers. The varieties used for comparing organic vs conventional milled rice are: ‘Arborio’,’ Baldo’, ‘Carnaroli’ and ‘Rosa Marchetti’.

Analysis regarding kernel characterization, cooking behavior, pasting and thermal properties, in vitro starch digestibility was carried out following Bresciani et al. (2022).

Results and Discussion:

RDA is developing new rice varieties suitable for producing Western rice-based foods, such as risotto, a well-known Italian-style product.

The physicochemical traits of the Korean varieties extended over a vast range; the amylose content stood out (from 13.0 to 41.7%), influencing the hardness and stickiness of cooked samples and their starch digestibility. Although none of the Korean varieties seemed to guarantee cooking performances for risotto like the ‘Carnaroli’ one, ‘Saemimyeon’ and ‘Shingil’ cvs were judged the best for this purpose.

Results from experiment 2 related to Italian rice variety used for comparing organic vs conventional milled rice (‘Arborio’,’ Baldo’, ‘Carnaroli’ and ‘Rosa Marchetti’) are still preliminary, and in some cases, the differences among the same variety are more evident comparing the same variety in the same management strategy such as in the organic farming case. That could be possible because organic farming strategies could differ in each farming system, as Orlando et al. (2019) explained.

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Keywords: rice, amylose, physicochemical properties, risotto, tarch digestibility

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Poster Session 13

Effects of Salinity on Yield and Grain Antioxidant Contents of Black Rice

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【Background】 Rice with a black-colored pericarp (black rice) is famous for its abundant antioxidants. The antioxidant contents are expected to increase under unfavorable conditions as a part of tolerance-defense responses to abiotic stress. This study conducted a field experiment to evaluate the effects of salinity on black rice production.

【Materials and methods】 The experiment was conducted at the Aobayama experimental field for plants in Tohoku University, Sendai, Japan in 2021 and 2022. A black rice variety “Asamurasaki” and a common rice variety “Hitomebore” were tested in this study. Salt treatment and control plots were prepared, and the salt treatment was applied with irrigation of salt solution. Electric conductivity (EC) in soil solution ranged 0 to 3 dS/m and 5 to 10 dS/m in 2021 and 2022, respectively. Leaf area index (LAI), relative chlorophyll content of leaf (SPAD), tiller number, and plant height were measured every week. Yield components were determined at the harvest. Grain phenolics and flavonoid contents were measured as antioxidant components.

【Results and discussion】 The salt treatment adversely affected rice growth except for SPAD both in 2021 and 2022. SPAD increased by salt treatment, presumable due to a decrease in LAI. The adverse effect on rice growth caused yield reduction. The reduction rate was 9% and 26% in 2021 and 2022, respectively, being caused by the difference in soil solution EC. The reduction rate was not significantly different between Asamurasaki and Hitomebore. The grain phenolics and flavonoid contents tended to increase by salt treatment. The increase was more obvious under higher EC conditions in 2022. The results suggest a tradeoff relation between yield and antioxidant contents, requiring optimization of salt treatment level to obtain higher phenolics and flavonoids yield. Black rice will be an alternative variety to increase profitability in salt-affected areas. The results also imply the applicability of black rice to organic farming because a similar phenomenon is expected under biotic stresses.

Keywords: black rice; grain yield; salinity; flavonoid; phenolics

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Poster Session 14

How Organic Rice Farming Impacts the Biodiversity: A Case Study of the Rice Paddies in North Italy

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Introduction:

Despite the continuous growth in organically farmed areas worldwide, the assumption about whether organic farming reduces negative impacts on biodiversity is still debated, particularly in complex cropping systems such as rice paddies. Since the dynamics of the rice cycle are different from other crops, it is more difficult to assess biodiversity using the traditional indices. Moreover, most works focus on the compression between organic and conventional rice management on the direct reduction of the above-ground arthropod diversity in organic farming systems and weed control efficiency, which are the major challenges for organic systems productivity. Interestingly, the main target of agriculture impacts is expected to be the soil biota, these groups are not considered enough in the studies due to the difficulties in classification and the correct sample collection.

Thus, a simplified eco-morphological index that does not require the classification of organisms to species level, allows a broader application of these methodologies such as the QBS-ar (Soil's Biological quality index).

This work aimed to apply the QBS-ar in rice paddies, to highlight the differences between organic and conventional management systems targeting the soil microarthropod communities. Also, the field margins were considered to better understand the biodiversity dynamics in this agroecosystem. In addition, the flora diversity was assessed in the selected sites.

Materials and Methods:

- The study area was the North Italian rice cultivation district, the research considered a total of 5 rice paddies. The fields belonged to three organic farms (RB) and two conventional farms (RC) in the crucial Italian rice province Pavia (Lombardy region), in each rice paddy, almost at the end of the rice cycle and before the harvest, two sampling points were selected: in the middle of the field (c) and on the margin (m). In addition, three points in the nearby forest were sampled as a natural control (F).
- QBS-ar application phases are (1) sampling, (2) microarthropods' extraction, (3) preserving the collected specimens, (4) determination of biological forms, (5) calculation of QBS-ar index based on the EMIs (Ecomorphological Indices).
- The flora characterization followed the Braun-Blanquet methodology, through two steps: (1) species recognition, tabulation and determination of the percentage of area covered by each species; (2) assigning the abundance percentage of each species based on how the plants grow, whether alone or in groups assigning.

Results and Discussion:

The QBS-ar values for the rice paddies ranged between 29 and 108, which are generally low to moderate values while the forest samples ranged between 129 and 171, indicating a low biological quality of the sampled soil in both cases (organic and conventional).

The analysis showed no significant differences between organic and conventional rice paddies in QBS-ar values (p_vlue > 0.05), with values recorded in average as: organic filed centre (QBR-ar = 40), organic margin (QBR-ar = 54.7), conventional filed centre (QBR-ar = 38), conventional margin (QBR-ar = 69).

Results suggest that organic farming may affect the soil's microarthropod structure, not the composition. In other terms, the community of microarthropods was similar between the organic and conventional in general (Fig. 1), but the differences were evident when considering the field centre and the margins, and the percentages of the different groups of microarthropods adapted to the soil life. In this aspect, results highlighted that the organic field centre was dominated by epiedaphic groups (average 47.7%), while the organic margins were dominated by hemiedapgic groups (average 58.7%); the centre of the conventional field was dominated by hemiedaphic groups (average 46%) and the conventional margins were dominated by euedaphic groups (average 45%) (Fig. 2).

Results of the flora biodiversity were as expected, a low number of weed species in the conventional field compared to the organic one due to the chemical control application. Regarding the organic fields, fourteen species were found that may affect the yield (i.e. *Echinochloa* spp., Cyperaceae family; high-risky group), eleven species were classified as medium-risky, two as low-risky, and ten as null-risky, having only an ecological value, such as *Marsilea quadrifolia*, a species included in the European list of rare species due to the degradation of the habitat (Directive 92/43/EEC).

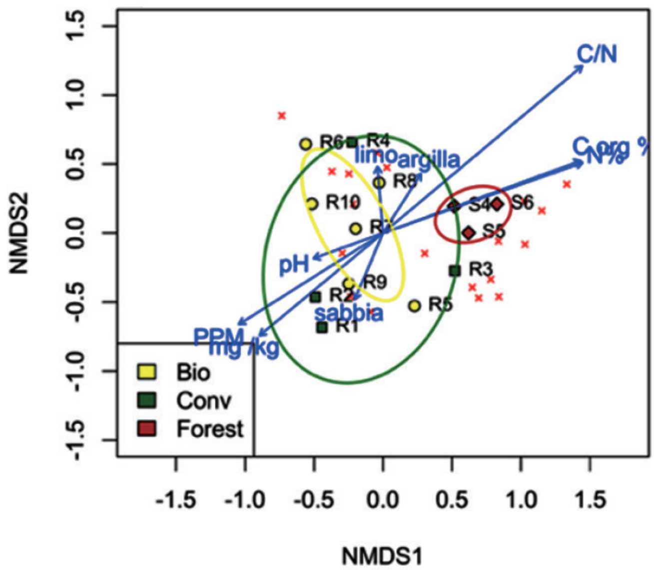

Fig. 1. Biplot of the two dimensional NMDS representing correlations between the microarthropods communities and factors (Organic=Bio vs Conventional=Conv, soil physical and chemical parameters the soil), standard error ellipses representing the 95% confidence area around the mean factores levels.

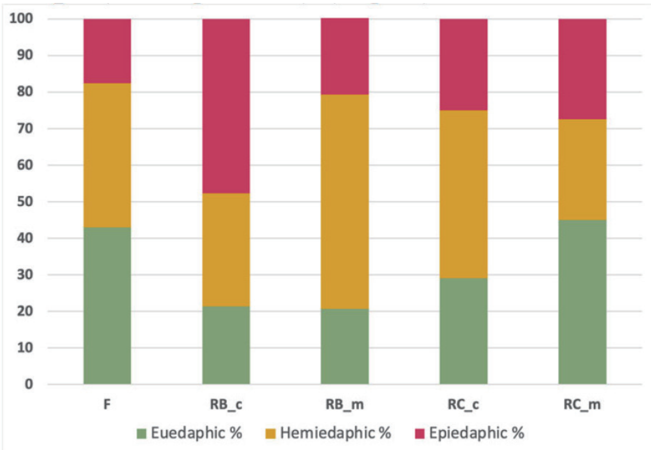

Fig. 2. Average percentages of microarthropod groups categorized based on their levels of adaptation to soil life (RC_m= Conventional margin; RC_c= conventional centre; RB_m; organic margin; RB_c= organic centre; F= forest)

Conclusions:

- Soil microarthropods appear to be consistent and potentially a good indicator for assessing the impact of organic farming on soil quality, but the impacts may need many years of application, to make significant changes in the soil characteristics, the soil microbial communities and microarthropods.
- The role of the margin of the field as a reservoir is increased in the conventional fields compared to the organic ones, which was higher in euedaphic microarthropods.
- Long-term research is required to fully understand the dynamics of soil fauna on organic rice paddies.
- The positive externalities of flora biodiversity in terms of ecosystem services should be quantified and integrated into the environmental assessment to obtain a comprehensive evaluation of the impacts and benefits of the organic rice field, in the different productive scenarios.

Keywords: organic rice, biodiversity, edaphic microarthropods, QBS-ar

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Natural Biodiversity Promotion in Diversified Organic Rice Farming Systems in Northern Italy

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Reconciling natural biodiversity conservation with agro-ecosystems is a current challenge for sustainable food systems.

Organic rice production is increasing in Italy, promoting biodiversity, both in terms of rice genetic resources and at ecosystem level. Rice fields can be considered as wetland areas substitutes, crucial as biodiversity hotspot, and thus representing natural or semi-natural habitats within intensively farmed districts. Their ecological role and value increases when combined with agro-ecological farming practices, including cultivar diversification through rice mixtures and dynamic populations.

To assess natural biodiversity in rice farming contexts, we developed a pool of entomological and botanical indicators, focusing on pollinators' ecosystems services, biodiversity stock and wetlands preservation. Insects can be targeted as environmental indicators, since they are relatively easy to monitor and provide an accurate picture of the health of the environment throughout the rice cultivation cycle.

Lepidoptera and Odonata Orders in particular were used as main natural biodiversity and ecosystem services proxy in rice farming systems. Species richness and individuals' abundance per species were correlated with environmentally-related variables, such as natural habitats proximity, water quality and farm management practices, both under organic and conventional conditions.

Rice fields' role as wetland areas substitutes has been studied and evaluated according to farming practices sustainability, within and around rice fields.

We argue, that entomological monitoring can be integrated in organic farming appraisal, to quantify crop and natural diversification. This data, correlated with biodiversity-friendly practices on a scalable field, farm or district/landscape level, could become a useful tool to weigh the measured benefits of biodiversity-friendly rice management practices and related ecosystem services, such as pollination, against the extra economic costs that these entail.

Agro-ecological rice farming system, paired with increased cultivated diversity – including rotations, rice cultivar diversification and rice mixtures – can improve food systems' resilience against abiotic and biotic stresses caused by climate change and enhance natural biodiversity and resilience at both farm and landscape scale.

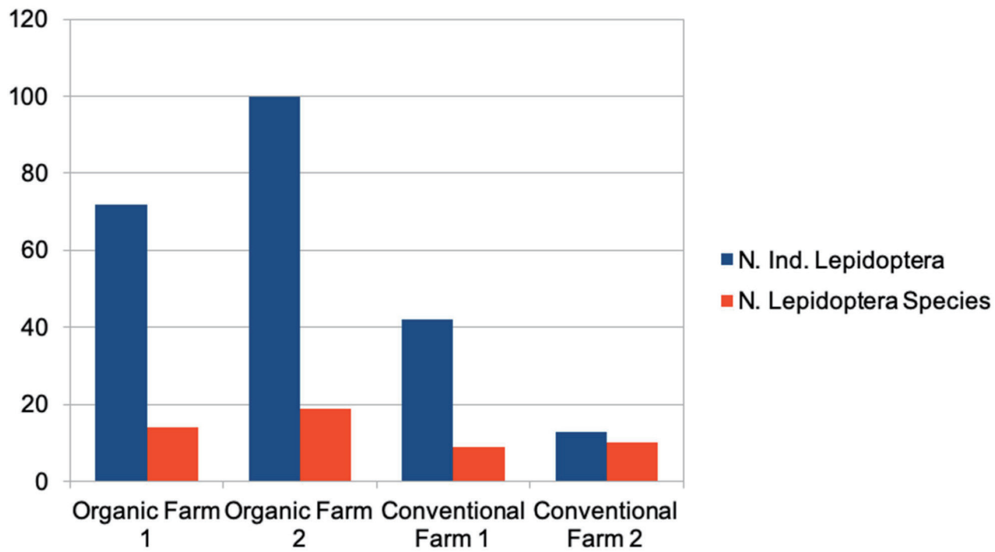

Fig. 1. Lepidoptera abundance and species richness in neighbouring organic and conventional farms. Organic farms contain decidedly more Lepidoptera's individuals compared to control conventional farms. Species richness however is more influenced by surrounding environmental context compared to Lepidoptera's Abundance.

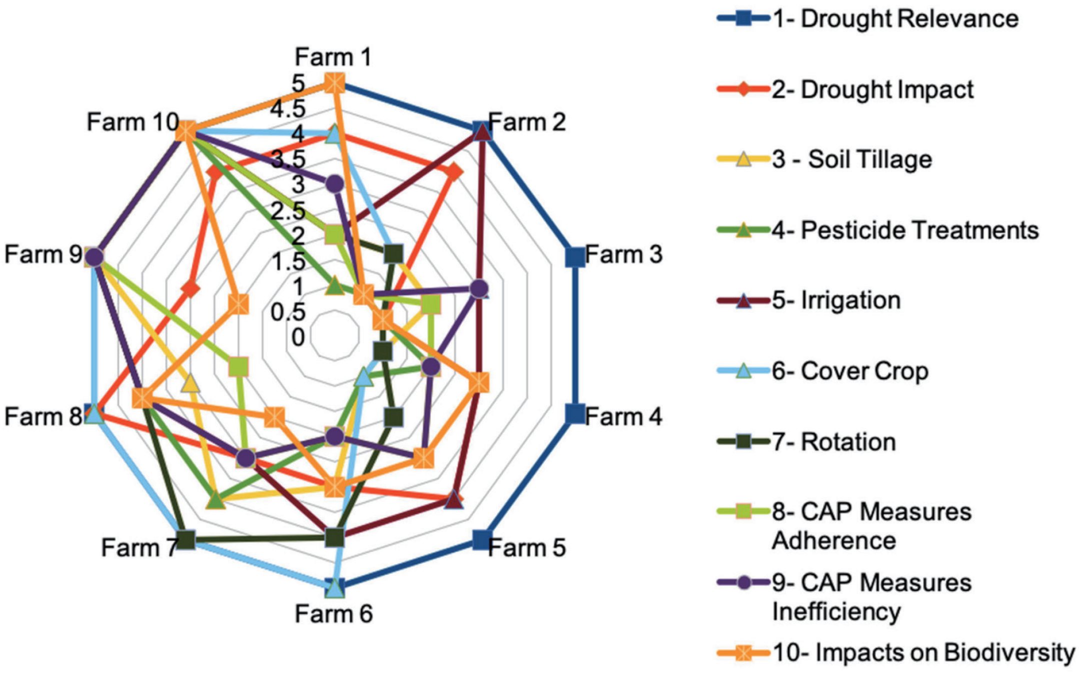

Fig. 2. Environmental impacts radar chart of organic (1-5) and conventional farms (6-10).

Organic farms (left part of the chart) show clearly inferior environmental impacts compared to their conventional counterparts (right part of the chart).

Keywords: organic rice farming, organic heterogeneous materials, rice mixtures, wetlands, natural biodiversity, environmental indicators, climate change.

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Poster Session 16

Development of Organic Rice Paddy Cultivation Techniques Using Paddy Field Ecosystems

— Effects of Cover Crop and Puddling on Weeds and Paddy Rice —

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As global warming and other changes in the environment become more apparent, it is desirable to establish organic farming techniques without chemical fertilizers or pesticides to contribute to the reduction of greenhouse gas emissions. To reduce the application of chemical fertilizers and pesticides, it is necessary to understand their ecological characteristics by observing rice and weed in organic paddy field. Therefore, we conducted an organic paddy field experiment using Italian ryegrass as a cover crop to evaluate the effects of cover crop and weeder use on weed and rice growth (the field experiment), and to determine the effects of cover crop and puddling on weed establishment (the pot experiment).

Field experiment: We have conducted field experiment in the organic paddy field in Center for International Field Agriculture Research & Education, Ibaraki University (36.032342, 140.211115, field area: 50 m×72 m) since 2019. Two treatments were established, treatment with cover crop (CC), and treatment without cover crop, fallow (FA). Italian ryegrass (sown in November and harvested in April) as cover crop was used. Puddling was conducted 3 times before transplanting paddy rice. Rice, Koshihikari was transplanted in late May to early June. The number of weeds, their dry weight and rice yield were measured. Pot experiment: Pots (1/10000a) were filled with CC and FA soil, respectively. For puddling, soil and water in the pots were mixed with a spatula after flooding. To investigate the effects of CC application and puddling (1 to 3 times) on weed development, the number of weeds and their dry weight were measured.

In the field experiment in 2020, weeds had lower grass height and smaller leaf blades in organic paddy fields than in conventional paddy fields. In both 2021 and 2022, weeds tended to be suppressed in the CC treatment, compared to the FA in organic paddy field. Even without a weeder, rice yield was similar to those obtained with a weeder. In the pot experiment, the number of weeds decreased as the number of puddling times increased. The reduction rate of weed number was particularly higher in the CC treatment.

From these findings, the combination of cover crop and multiple puddling has the potential to suppress weed development even when weeders are not used. In the future, it is necessary to clarify the details of the factors that suppress weed development. Detailed observation and investigation of weeds and rice growth under organic cultivation management are expected to be important roles in establishing a new organic cultivation system.

Keywords: cover crop, puddling, weed

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Poster Session 17

Field Experiment of Organic Rice Farming in Field Science Center, Tohoku University over Ten Years

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Organic rice farming has been known as one of conservation rice farming methods, and it has the potential that the area will expand rapidly in near future. However, few studies have investigated the characteristics of organic rice farming on the field scale, especially in comparison with conventional rice farming over a long period. We, Field Science Center of Tohoku University, set up the organic paddy fields in 2008 and have conducted many studies in the field until now. In the field experiments, several paddy fields were divided into conventional and organic rice farming to conduct statically valid trials. Therefore, we could statistically compare organic rice farming with conventional rice farming. In addition, the field experiments have been ongoing for over ten years. In this presentation, we will introduce the research conducted in these paddy fields.

Keywords: organic rice farming, conventional farming field experiment

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The Revival of Sustainable (Upland) Rice Cultivation in Reunion Island (France, Indian Ocean)

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Reunion Island is a small semi-tropical volcanic island (2512 km2, 860 000 inhabitants) situated in the west of the Indian ocean, in the south hemisphere (latitude 55°30 east, longitude 21° south). The neighboring countries are Mauritius (170 km) and Madagascar (680 km). It is a French overseas territory. The island is very mountainous and very sharply sloped. The major part of the population is concentrated in the coastal fringe accounting for approximately one third of the total island surface area; consequently population density is very high. Agriculture is an important economic sector. Agricultural land covers 20% (40 000 ha) of the island surface area and agricultural products constitute the first exportation item. Sugar cane (for exportation of sugar) is the main crop, covering about two-thirds of the cultivated area. The production of tropical fruits, aromatic and medicinal plants (mango, pineapple, vanilla…) and vegetables (temperate and tropical types) is a very dynamic sector oriented towards the domestic trade and it is the most concerned by organic agriculture development. Livestock farming is the third important sector (cattle, pigs, poultry, beekeeping). Organic agriculture is constantly increasing since the beginning of the century; nowadays it amounts to 400 farms and 1900 ha (about 5% of the total cultivated land).

The cultivation of cereals is very sparse in Reunion Island (small quantity of maize). Tubers (potato, sweet potato, yam, taro, cassava…) are much more grown. Yet, rice and bread are staple foodstuffs. Rice is almost consumed every day and it is unmissable in the local gastronomy. On average, rice consumption in Reunion island approximates 65 kg/inhabitant/year. As a consequence, rice is dramatically imported, from India, China, Thailand and Madagascar (Reunion Island imports 43 000 t of rice per year). Reunion Island is highly dependent on outside for a lot of goods (including energy) and services (and strongly linked to the European community for a lot of regulation policies and subsidies). Today, due to recent crisis (Covid, Ukraine-Russia war), people from Reunion faced numerous problems of supply of provisions. This new situation drove them to raise awareness of the island self-sufficiency, especially for food.

Looking in the past, one may observe that rice had been planted since the early colonial settlement establishments (end of the 17th century). During the slavery period (18th-19th century), besides working in the commercial plantations (firstly coffee, cotton, spices and tinctorial plants and later on sugar cane), slaves (coming from west and east Africa, Madagascar and India) also managed fields of cereals and tubers and raised animals to (i) contribute to the food supply of the numerous people living in the plantation and (ii) resupply the boats making stopovers at Reunion island. If maize and cassava were the main planted species, upland rice was also cultivated. This organization disappeared with the generalization of the sugar cane agrarian system in the middle of the 19th century, the abolition of slavery and the economic modernization of the island in the middle of the twentieth century. Rice disappeared completely. Nonetheless, in the 1980s, a group of farmers (around 50) intended to revive rice cultivation throughout the island. Rice fields were created, and machines were imported in order to be able to husk the paddy. The main motivation was to gain more independence in the agricultural sector. This experience failed because of various technical, commercial and political problems.

In 2019, an association of farmers (RRA: Reunion Rice Association) initiated a new revival project. Its ambition was to develop small scale sustainable (without chemicals) upland rice cropping systems, targeting local distribution networks for selling. For the promoters, it was essential that the nourishment of the population, even if it would be in small proportion, not be based only on imported food: "the landscape must reflect the content of the dishes". The project has three main objectives: (i) to recover the knowledge and the know-how to master upland rice cultivation and transformation under the Reunion island conditions, (ii) to set up agro-ecological management practices (no chemicals), ensuring no impact on the environment and a safe product for consumers (iii) to reconnect people with the plant they consume the most, the population being ignorant of what rice is. In case of an acute food crisis, Reunion island should be able to spread out rice seeds and know-how to grow it.

The starting point was the re-discovering of the rice variety planted during the 1980s ("early Dourado", originated from Brazil) and known to be adapted to Reunion ecological condition. Starting with a handful of seeds, RRA undertook a seed multiplication program. The next year (2020) started the experimental phase aiming at defining the best management practices (soil preparation, dates, density and mode of sowing, fertilization, hand weeding, irrigation, struggle against birds, straw management, crop rotations…). Very rapidly neighboring farmers were encouraged to join the project, cultivating for their own and with the help of the RRA association, a rice field inside their farm. At the same time, the RRA association took advantage of local public and private funds; they allowed: (i) to run the association, to boost the participation of farmers, to train them and to organize experiences exchange between them, (ii) to buy equipment for the transformation of the paddy rice, (iii) to realize educational actions oriented towards the general public and the young schoolchild and (iv) to promote the product and its origin on the whole island through different events (marketplaces, trade fairs…).

The poster will present the main field crop management practices: small fields of 250 m^2 protected against birds with nets (birds eat the seeds after sowing and the grain after flowering), dry seeding in rows, irrigation with sprinklers, organic fertilization, hand-weeding and hand-harvesting. At that point, rice is considered as an alternative cereal specie to enrich crop rotations of market gardeners. Besides of the birds, the main constraints are storms and cyclones (rice is grown in summer during the wet season) that make rice plants to lodge and call for the use of short straw varieties.

In 2023, six farmers and several private individuals (non-farmers) have cultivated rice on their land; nearly 800 kg of paddy rice are expected, sold at a unit price of 15 €/kg (they are sold in small packets of 350g corresponding to the rice needed for one dish for 4 persons). At that time, there is a high demand for locally produced rice and the market is very far to be saturated. The “Dourado” variety is expected to yield 3 tons/ha in favorable conditions. 31 farmers have been trained in 2022-23 and are waiting for the next season to sow rice.

First results, obtained in very few years are very promising. Nonetheless, a lot of challenges remain: (i) to train more farmers (ii) to extend the field size and to develop an adapted mechanization (iii) to continue the search for better management practices (seeding, organic fertilization, straw use and inter-cropping) (iv) to convince restaurant chef to cook and promote the Reunion rice and make individuals use it at least once a month.

Keywords: upland rice, small scale farming, self-sufficiency, empowerment, collective action.

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Poster Session 19

Success Story of Equipping Stake Holders of Naturally Organic Saline Prone Sea Coastal Wetland Ecosystem of Kerala Through Research and Development Interventions

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Coastal wetlands of North Kerala, which is popularly known as *Kaipad*, has peculiar ecosystem with respect to soil fertility, biodiversity, biotic and abiotic stress tolerance systems. It is a saline prone and naturally organic rice production tract falling in Kozhikode, Kannur and Kasaragod districts of Kerala state in 3808 hectors. The *Kaipad* system is critical to smallholder farmers in the highly populated coastal region of North Kerala where traditional methods of agriculture and fishery are prevalent. The *Kaipad* system of rice cultivation is an integrated organic farming system in which rice cultivation and aquaculture go together in coastal brackish water marshes which is rich in organic matter. The network of backwaters and estuaries serves as an inlet of sea water and causes salinity in the area. This ecosystem is rich in biodiversity with respect to flora and fauna. Mangroves which are seen on the fringes of back waters and estuaries are characteristic feature of *Kaipad* tracts. Mangroves provide breeding sites for fishes and prawn, and bind toxic chemicals and pollutants. Mangrove forests are valued for fish, shellfish, livestock fodder, fuel and building materials, local medicine, honey and bees wax, chemicals or tanning leather, timber and wood.

Rice farming is unique in the *Kaipad* paddy tracks because the lands are regularly flooded by sea water. Single-crop of rice is cultivated by small farmers in the low to medium saline phase of the monsoon based production cycle. During March and April each year, farmers prepare small mounds of 2-3 feet high in the field. Paddy is sown when the early monsoon showers of May wash away some of the salt in the top layers of the soil. After sufficient growth of seedlings, the mounds are dismantled and seedlings in clefts are dispersed around the flattened mounds when the southwest monsoon is active. Farming in the *Kaipad* system is purely in a natural way relying only on the monsoon and the sea tides. Neither chemical fertilizers nor plant protection chemicals are used. After planting the rice seedlings, there is no need of any cultural operations until harvest.

Out of more than 3808 hectors of total *Kaipad* fields at present available, 70-80% of the traditional *Kaipad* fields are left fallow without cultivation. Once a field becomes fallow, the mangroves confined on fringes of *Kaipad* intrude in rice tract and make it permanently unfit for cultivation. If the menace of keeping *Kaipad* fallow continues, it will result in the tragedy of loss of a precious ecosystem, which should not be allowed at any cost. The rice produce obtained from *Kaipad* is purely organic. Hence there is great potential for marketing organic rice in the domestic market as well as in the international market. As the farmers of this area are small and marginal farmers, there was limitation in exploiting the potential of this naturally blessed tract.

Due to sustained intervention of Kerala Agricultural University of India through various research and development projects for a period of 22 years, this tract is now having five saline tolerant high yielding organic varieties christened as 'Ezhome -1', 'Ezhome -2', 'Ezhome -3', 'Ezhome -4', and 'Mithila' which are the first of its kind. Stake holders' society was formed in 2010 and named 'Malabar Kaipad Farmers' Society' with a jurisdiction over three districts where Kaipad exists, namely Kannur, Kasaragod and Kozhikode. Thereafter, in 2014, Geographical Indication tag for the unique nutritionally rich Kaipad rice was approved. Later, the stake holders' society was strengthened with the establishment of Kaipad agency, KADS at the government level and restructuring the society with a strong network system of four independent regional societies in each district and 52 panchayath level samithies. Non mechanization of this marshy tract was another menace which was achieved partially. Kaipad rice production, processing and marketing centre was established to standardize four value-added products from GI tagged Kaipad rice and start domestic and export marketing through the stakeholders' society. Marketing through Amazon has also been materialised recently. The stake holders' society has recently become a farmer producer company. A research and development centre for organic wetland ecosystem is in the pipeline.

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