Organic Farming in the Tropics and Subtropics

Exemplary Description of 20 Crops

Rice

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Naturland would like mention the following authors and thank them for their contributions:

Franz Augstburger, Jörn Berger, Udo Censkowsky, Petra Heid,
Joachim Milz, Christine Streit, Vitoon Panyakul, Koen den Braber.

The cultivation guidelines are available in English, Spanish and German for the following crops:

banana, brazil nut, cashew nut, cocoa, coconut, coffee,
cotton, hibiscus, macadamia, mango, papaya, peanut,
pepper, pineapple, sugar cane, sesame, tea, vanilla.

The cultivation guidelines for Bananas, Mangoes, Pineapples and Pepper were revised in 2001 for the United Nations Conference on Trade and Development (UNCTAD) by Udo Censkowsky and Friederike Höngen.

In 2002 two more guidelines, for rice and date palms, were published in English.

All the authors emphasize, that the cultivation recommendations at hand can just provide general information. They do not substitute technical assistance to the farmers with regard to the location.

All indications, data and results of this cultivation guidelines have been compiled and cross-checked most carefully by the authors. Yet mistakes with regard to the contents cannot be precluded. The indicated legal regulations are based on the state of the year 1999 and are subject to alterations in future. Consequently all information has to be given in exclusion of any obligation or guarantee by Naturland e.V. or the authors. Both Naturland e.V. and authors therefore do not accept any responsibility or liability.

Furthermore the authors kindly call upon for critical remarks, additions and other important information to be forwarded to the address below. The cultivation guidelines will be updated regularly by Naturland e.V.

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Organic Cultivation of Rice

1. Introduction

Rice is the main staple food crop in the world and the crop is closely associated with the culture of billions of people around the world, particularly in Asia and Africa. Archeological data show that rice was already grown 6,000 – 7,000 years ago in countries such as China and Thailand. It is believed that the construction of irrigation systems for rice cultivation formed one of the cornerstones for the development of some of the major civilizations in South-East Asia, such as Angkor Wat.
Because the rice plant is highly adaptable to local environment and because human has succeeded in modifying local agro-ecosystem, rice can now be grown in many different locations and under a variety of climates. Rice farming can be found in all continents of the world as far north as the Northeastern China at latitude 53°N down south to many regions on the equator and down to New South Wales in Australia at latitude 35°S. In most cultivation areas, rice is grown at or near sea level, but it can also be found at high elevation such as those in Nepal where rice is cultivated at 2,000 meter above sea level. Rice is normally grown under moderately submerged conditions but can be grown also under upland conditions or in 1 – 1.5 m deep water.

1.1. Botany

Rice is a typical representative of the family *Gramineae* (grasses) but it belongs to the genus of *Oryza*. There are some 25 species of rice in the genus *Oryza*. The dominant rice species is *Oryza sativa*, which is believed to have originated somewhere in South-East Asia. Today, it is cultivated in Asia, Africa, Europe, Oceania and the Americas. In Africa *Oryza sativa* has now almost fully replaced the local species *O. glaberrima*, which was grown as a main staple crop in Western Africa before.
Other members of the *Oryza* genus are in general not cultivated but some indigenous peoples collect them in times of food scarcity. The "red" or "black" rice also has some popularity in the Western countries where they are sold as specialties. Some wild rice is important weed in the cultivation of *Oryza sativa* and some of them are also used in the breeding programs for *O. sativa*.
Within *Oryza sativa*, three sub-species are known: "japonica", "indica" and "javanica". "Japonica" varieties have a short grain, are more or less glutinous and originate in colder climates (Japan, Korea, North China). "Indica" varieties have a long grain, are not glutinous and belong to the warm, tropical regions. "Javanica" varieties have a medium long grain, are glutinous and are only grown in Indonesia.

1.2. Varieties and countries of origin

There are many ways to distinguish rice varieties. The most common one is based on the length. The main groups of varieties are thus long-grained and short-grained varieties. The short-grained varieties are more adapted to colder climates and are therefore commonly grown in Japan and Korea and in Europe. The long-grained varieties are common to warmer climates. Some experts further classify varieties based on the ratio between their length and their width. In this system the shortest rice is almost round (the Spanish "bomba") and the longest one is the Basmati.
Because rice is such an ancient crop, farmers have over the centuries developed many local varieties. "Modern" rice breeding started with the establishment of IRRI (the International Rice Research Institute) in the early 1960s. Nowadays, most national rice breeding programs, particularly in Asia, depend on IRRI for new materials which are then crossed with local varieties in order to create varieties that are well adapted to local agro-ecological conditions and consumption preferences.

1.3. Uses and contents

The rice grain is mostly consumed boiled (or fried) as main staple but it is also widely used for snacks, appetizers, rice soups (congee) and desserts. Rice is also used as flour, for making rice wine and as ingredient for beer and liquor. The rice bran is sometimes processed and sold as food supplement. However, most of the bran and other remains from the milling are used as animal feed. Rice straw, husks, bran, etc. are also a valuable source to fertilize the rice field and for composting.
Rice is harvested from the field in form of grain, often referred to as "paddy". Each grain consists of many layers. The outermost layer is called husk. Husk consists mostly of silica and cellulose. The inner layers are called bran layers, the most nutritious part of rice. Each layer consists of a very thin bran film. Bran is mainly fiber, vitamin B, protein and fat. At the base of each grain is the embryo which will grow into the new plant. The innermost part of the grain is the rice kernel, consisting mainly of starch. Two main compositions of rice starch are amylose and amylopactin. The ratio between these two determines the cooking texture of rice. Rice does not contain gluten. Glutinous rice is therefore a very misleading term because the stickiness of rice is not caused by gluten but by a high level of amylopactin.
During rice processing, i.e. milling and polishing, the husk, bran layers and embryo are normally removed. The result is called white rice. For the socalled wholegrain rice, the bran layers are still (partly) intact and this kind of rice therefore has a higher nutritional value than the white rice. However, wholegrain rice cannot be stored as long as white rice. In order to obtain a white rice but with a nutritional value more similar to brown rice, the process of parboiling has been developed. Before polishing, the rice is soaked, then steamed and finally dried. During this process some of the nutrients from the bran is absorbed by the rice kernel so that they are maintained during the following processing.

Rice seed (paddy) contains 6.7-8.3% protein, 2.1-2.7% of crude fat, 8.4-12.1% crude fiber, 62% starch and 19.1% dietary fiber.

2. Aspects of Plant Cultivation

Rice farming system has remains more or less unchanged since the immemorial time. The major technological change occurred in early 1970s with the invent of "Green Revolution" marked by the introduction of high yielding varieties (HYVs). Farmers adopted green revolution package are encouraged to use HYV seeds, artificial fertilizers and pesticides. With the use of artificial highly soluble fertilizer, the HYVs are often vulnerable to pest and diseases. The application of pesticide upsets agro-ecological system and destroys pest-natural enemy balance, causing further pest infestation. As rice is largest cultivated crop in Asia, the total amount of agrochemicals used in rice are also highest.
Beside substituting agrochemcials with natural organic fertilizers and mechanization of land preparation and harvesting, the method of rice cultivation has more or less remained unchanged from traditional rice farm thousand years ago.

2.1. Site requirements

From historical evidence dated around 2000 – 1500 B.C., rice was originally grown in a broad belt of Asia, from central India in the far west to Southern China in the far east. Later on rice cultivation was spread southward to Indonesia and the Philippines and to the east of Korea and Japan. With colonial trade, rice was then introduced to North and South America and Europe. This indicates that climatic condition for rice cultivation is very diverse, ranging from tropical, sub-tropical or even temperate zones.
Most people associate rice farming with flooded lowland plain areas. But in fact rice can be grown in almost all different geographical conditions provided that appropriate rice varieties is chosen and appropriate farming system is adopted. Upland farming is the oldest method of rice cultivation and has undergone evolution to a system presently known as shifting cultivation. Shifting cultivation is a very sustainable way of farming provided that it is practiced with long fallow period. But shifting cultivation is eroding fast due to government conservation policies prohibiting farming in forest areas. Lowland farming is now the most popular way for rice cultivation. Table below compares different rice farming system appropriate from particular geographical conditions.

Dry upland	Shifting cultivation where rice field is not leveled nor bunding. Rice seed is broadcasted and rice plant relies on rainfall only.	Traditional varieties with medium tall (130-150 cm) and yield around 1 tons/ha.
Rainfed lowland	Field is leveled and bunded. Rice seed can be broadcasted or transplanting of seedling.	Traditional or improved varieties with medium tall (130-150 cm). Yield is around 2 tons/ha.
Irrigated lowland	Similar to rainfed lowland but water source comes from irrigation. Water is sufficient and can be regulated, allowing rice to be grown more than one crop a year.	HYVs with semidwarf to medium tall (100-130 cm). Yield is around 3-3.5 tons/ha.
Floating and deepwater	Rice fields are flowed with water from a depth of 30 cm and deeper (can be as deep as 6 meter). Rice can be broadcasted or transplanting.	Traditional variety with very tall plant (above 150 cm) or floating with water level. Yield is around 1.5 tons/ha.

It should be noted that rice has a special characteristic that it can withstand water-logging condition. Farmers utilize this special character by growing rice in semi-aquatic conditions so that weeds can be more easily controlled. A new farming method known as System of Rice Intensification (SRI) encouraging rice farming in non water-logging conditions shows the possibility to increase rice yield by 2-3 times.

2.2. Seeds

Rice is an annual grass plant. Propagation can only done by seeding. Rice is self-pollinated plant and therefore seed can be kept for following crop. But seed selection is highly recommended because mixing of different varieties can reduce rice quality when it is sold.
Seed preparation is normally done to encourage fast germination. But direct broadcasting can be done without any preparation. Seed preparation starts with washing and sorting dirt and immature grain. Then seed is soaked in water for 12 hours. After that soaked seed is packed into bag to incubate the seed, encouraging seed germination. The incubation lasts for 1-2 days and the temperature should be maintained at around 30 degree Celsius. During incubation, rice bag should be turn at least once a day to allow air flow and prevent over heating.
For one hectare of rice transplanting, around 70-80 kg of rice seed is needed. For direct broadcasting, around 90-100 kg of seed is needed.

2.3. Planting methods

As there are diverse systems of rice farming, it is not possible to describe all systems in satisfactory details. The following description limits only to lowland annual rice cropping system. Lowland annual rice crop begins soon after the first rainfall. Rice fields are ploughed to get rid of weed and left over rice stalks. Weed and stalk residues are incorporated into the soil and the fields are left for the organic matters to decompose. After the decomposition, the second plowing is done to loosen the topsoil and to flatten the field in order to make it easier to regulate water level. Traditionally, animal is used for all the land preparation. However, increasingly a small plowing machine is used. Rice seedlings are prepared during the land preparation and transplanted into the field 1-2 months after land preparation (seedling is around 30 days old).

Depending on variety, around 55-85 days after germination, rice will start to produce tiller. During early tillering stage, rice plant needs high nitrogen fertilization in order to encourage maximum tillers. Too much nitrogen fertilization, however, will lead to over vegetative growth and cause the plant to collapse. After tillering, rice will start to initiate panicle. Again, fertilization may be needed at this stage to encourage panicle development. After this stage, there is little need for farm management for rice crop, beside weeding and regulating water level in the field.

Rice plant takes around 90-150 days to mature and ready for harvesting. During vegetative and flowering stages, rice fields must be kept moisture otherwise the rice growth and yield can be severely affected.

2.4. Diversification strategies

It is rather difficult to do intercropping with rice if rice farming is done on semi-aquatic condition. Upland rice farming can be intercropped with several annual field crops, such as bean and vegetables. Crop rotation is also quite difficult unless water is available during dry season. Perennial trees that can withstand drought and waterlogging can be grown in rice fields and around the bunds. Small shrub can also be grown in field bunds. Tree planting is highly recommended as it helps to improve farm bio-diversity.

If sufficient water is available during dry season, rotation with leguminous crops should be encouraged. Legumes can serve as cover crop to protect soil surface, to increase soil fertility through nitrogen fixation, and to produce organic matters. Also, harvested bean can be sold to increase farm income. High nitrogen-demanding crop (e.g. corn, leafy vegetable) should be avoided because soil fertility may be severely depleted when such rotation is repeated continuously.

2.5. Nutrients and organic fertilization management

Beside general organic soil management, (e.g. cover soil surface, incorporating organic residue back to soil, improving soil structure with compost) organic rice farming requires specific fertilization and nutrient management. As mention earlier, there are at least two growth stages that require careful intervention, one during early tillering and another during panicle initiation.

First let consider overall nutrient and fertilization strategy. With organic farming, it is better to provide nutrient to soil and let soil feed the rice crop. Generally, green manure is preferred to other organic fertilizer because green manure is easier to handle and more effective in supplying nutrients. There are several varieties of leguminous crops that can be used but each has its own special characters. Selection of leguminous crop must take into account water, soil and labour conditions. The following are suggested list of popular leguminous crop used in organic rice farming:

- green gram (*Vigna radiata L.*) broadcasting (at the same time as the rice)
- sesbania crop (*Sesbania rostrata*) sown early in the rainy season
- sword bean (*Canavalia ensiformis*) sown early in the rainy season or after the rice harvest as rotation crop
- various bluegreen algae and azolla in flooded rice field

Compost of rice straw and animal manure should also be encouraged if straw is removed from rice fields. Rice husk and bran should be added to the compost pile in order to recycle nutrient back. Compost should be applied by spreading in the field before first plowing so that it can be thoroughly incorporated into the soil.

For specific nutrient management of rice farming, animal manure is recommended. Aged animal manure is used, e.g. non-battery chicken, pig or cow dung. Rice plant should be monitored before applying animal manure because over fertilization may cause pest infestation or excessive vegetative growth.

2.6. Biological methods of plant protection

Although one may think differently from the experience of the Green Revolution, under normal conditions rice is a crop which rarely suffers from main yield losses through pests and diseases. Main reasons for this are the crop's high capacity to compensate for damage to leaves or tillers, the high level of naturally occurring predators and parasites of most pests, and the fact that rice in many areas is cultivated only once a year (with a long dry period in between crops).

To control pests, diseases and weeds, several biological methods are being used. Cultivation methods for fertilization and water management are very important because of their direct effect on crop health and because of their effect on the growing conditions of the pest, disease or weed. Plant variety selection is also very important and many local varieties have very good characteristics in terms of disease resistance.

And apart from these preventative measures, pests and diseases can also be directly controlled by applying botanical pesticides or bacterial and virus preparations.

2.6.1. Diseases

The main diseases in rice are rice blast and sheath blight. However, a large number of other diseases (fungi, bacteria, nematodes and virus) occur in the rice field which could from time to time cause problems locally.
Disease management largely depends on variety selection and good management. A good fertilizer management is important. For example, rice blast develops better when nitrogen application is high. Plant spacing is also important to reduce the spread of diseases. Some virus diseases such as tungro, can be transmitted by insects (leafhoppers). For this disease vector management is therefore important, mainly by stimulating the natural enemies of these insects or the application of botanical pesticides.
An interesting method to prevent disease infestation is the simultaneously planting of several rice varieties in one field.

2.6.2. Pests

Rice has a whole range of pests in all stages of its cultivation period. During the seedling stage, rice gall midge and thrips are important, while in the tillering stage a whole range of pests feed on the leafs and tillers. Important leaf feeding pests are leaf-folders and case-worm, while stem-borers feed in the tillers. Sucking insects such as leafhoppers, plant-hoppers and black bugs are also important during this stage. During the ripening stage of the crop, rats and paddy bugs are the most important pests. Birds can also cause problems in the ripening crop. Snails and crabs are important in the younger stages of the rice crop.
Most rice pests have a large range of natural enemies and rarely cause significant yield loss despite sometimes they may cause heavy damage to the plant. However, as rice can recover itself very well and in spite of heavy damage on rice plant, the rice plant can still deliver more or less the same yield as non-damaged crop. The
in rice there is no direct relation between damage and yield loss as trials with farmers in many IPM (Integrated Pest Management) training programs have demonstrated. These trials show that up to 30-40% of damage to leaves and 10-20% of damage to tillers will not result in any yield loss because the rice plant is able to compensate for lost leaves and tillers.
Insect pest management is rarely needed as explained above, but when farmers need to intervene they can use botanical pesticides or bacterial and virus preparations. They could also try to increase the number of natural enemies in their fields by planting flowering plants on the bunds or leaves some straw in the field after harvesting. Resistant varieties can also be useful in some cases.

For the management of rats and snails many biological methods can be used, such as trapping, hand picking, release of predators, etc. but there success is mostly determined by the existence of good cooperation between farmers in a large area. For these pests control measures should also be applied even when populations are low and may not seem very important.

2.7. Crop monitoring and maintenance

Crop monitoring in rice should be based on observing crop health and the balance between pests and natural enemies. Healthy plants will be better able to resist an attack by an insect pest or an infestation by a disease. Most field observations by farmers are directly related to this condition, for example when checking the water level.

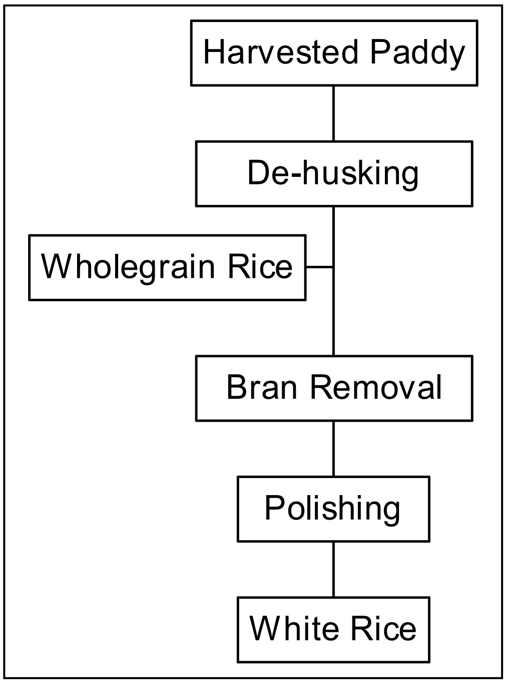
2.8. Harvesting and post harvest treatment

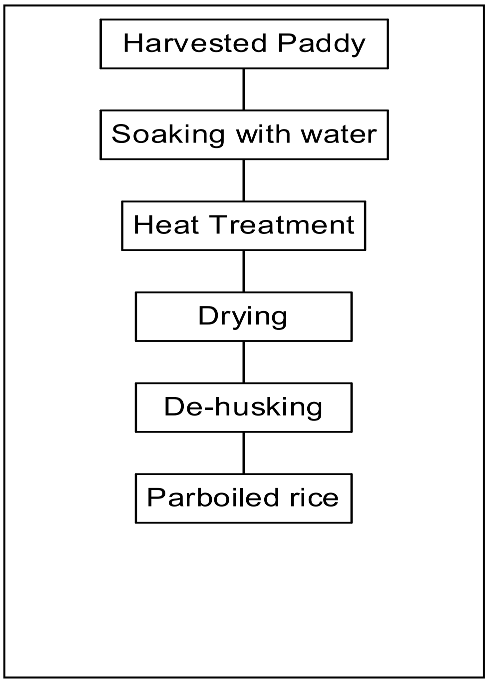
When rice grain in the field turns yellow, it is time for harvesting. If there is still water in the field, it should be drained out and let the field dried for at 7 days. Rice grain is harvested and left to dry in the field before threshing.
Traditionally, rice is harvested manually by hand using simple tools like sickle and threshing is also performed manually. However, combine harvest machine or threshing machine is replacing traditional method. In such cases, the risk of organic grain mixing with conventional grain arises, so it is highly recommended that the machine is properly cleaned before switching to handling organic crop.
If grain can not be dried in the field, other drying method is needed to bring moisture content in the grain down. This can be done by spreading grain on the ground under the sun or dried in silo with drying machine. Rice grain should have less than 15% moisture before storage.
Dried grain then can be stored in jute or polyethylene bag.

3. Product Specification and Quality Standards

3.1. Wholegrain and white rice

Wholegrain rice is also known as husked rice, cargo rice or brown rice. It is the rice grain that the husk has been removed. White rice is the rice grain that has its husk and bran removed. Another method of processing paddy is parboiling where paddy is pre-cooked before milling. Rice is normally sold either as wholegrain, white or parboiled rice.
The following is a processing steps involved in different paddy processing.





3.2. Quality requirements

The following is the list of quality characteristics for wholegrain and white rice required by importers. Different minimum and maximum values is subjected to negotiation among importers and exporters but they must comply with national regulations governing food and hygiene standards.

Quality characteristics	**Minimum or Maximum values**	
Physical	**Brown**	**White**
Foreign Bodies - organic - inorganic	 1.5% 0.5%	 0.5% 0.5%
Paddy	2.5%	0.3%
Damaged kernels	4.0%	3.0%
Immature kernels	12.0%	2.0%
Chalky kernels	11.0%	11.0%
Red kernels	12.0%	4.0%
Water content	15% max	
Residues		
Pesticides	Not measurable	
Mycotonins		
Afaltoxin B1, B2, G1, G2	< 0.2 µg/kg	
Salmonella	Not measurable	
Staphylococcus aureus	< 100 CFU/g	
Escherichia coli	< 5 CFU/g	
Clostridium prefringens	< 10 CFU/g	
Bacillus cereus	< 10 CFU/g	
Micro-organisms		
Total Germ Count	100,000 CFU/g	
Enterobactericeae	< 100 CFU/g	
Yeast	< 100 CFU/g	
Moulds	< 100 CFU/g	

3.3. Packaging and storage

Packaging

Rice export-import normally requires fumigation treatment to control grain insects. Conventional treatment either applies methyl bromide or aluminium phosphine. With organic rice trade, two alternative treatments are currently available, vacuumed treatment or carbon dioxide fumigation. The two methods then requires different packaging materials as vacuumed treatment need non air-exchange bag while fumigation need air-exchange bag.

Information printed on packaging during transport depends on whether the rice is shipped in bulk on consumer package. Shipping in bulk, the rice package should contain product name with specification that the rice is organic quality, name of exporter or trader, country of origin, weight, and batch number. For consumer package, the expiry date must be added.

Storage

Rice quality can be affected by temperature and air moisture. Different processed rice (i.e. wholegrain, white or parboiled, required different storage conditions. Parboiled rice should can be stored up to one year if keep at lower than 22 degree Celsius and airtight storage. For wholegrain, the maximum storage is two years with airtight storage and temperature is kept between 10-35 degree Celsius while white rice can be stored up to three years.