International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

The Art and Science of Paddy Cultivation: A Comprehensive Overview

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ABSTRACT

This review article delves into the captivating world of paddy production, where age-old agricultural traditions harmoniously intersect with cutting-edge research, yielding one of humanity's most vital food sources. "The Art and Science of paddy Cultivation " offers an exploration of the intricate journey from a humble seed to the abundant harvest that graces our tables. Within these submerged fields, we uncover the amalgamation of soil chemistry, water management, and cultural practices that define the art and science of paddy farming. Delving into the origins of paddy, we investigate its remarkable journey from wild grass to the cornerstone of global agriculture. As we celebrate the International Year of Paddy, we recognize its profound significance, with over 60% of the world's population relying on it as a dietary staple. Moreover, we highlight the diverse applications of paddy beyond consumption, such as livestock feed and versatile byproducts. This review also emphasizes the adaptability of paddy cultivation, suitable for various soil types and climates. Whether in riverine alluvium or arid regions, paddy thrives, showcasing its resilience and versatility. Join us as we unravel the complexities of paddy production, where nature and innovation coalesce to nourish both body and soul, sustaining billions across the globe.

1. INTRODUCTION

Welcome to the amazing world of paddy production, where traditional farming methods converge with cutting-edge research to produce one of the most important food staples in the world: paddy. This review is a discussion of the complex procedures and methods involved in paddy production, highlighting how the seamless blending of tradition and innovation helps to ensure the survival of billions of people worldwide. For more than half of the world's population, paddy is an essential food source that has been grown for thousands of years. What was previously a labor-intensive and frequently unpredictable enterprise has transformed into an elaborate scientific method that makes the best use of resources, increases output, and has minimal negative effects on the environment. We will learn about the fascinating interactions between soil chemistry, water management, and cultural practices as we conduct this investigation to better understand how these factors jointly influence the art and science of paddy farming.

The journey uncovers the complicated system of issues that affect paddy production, from the small beginnings of a single seed to the plentiful yields that delight our feasts. We'll go into the nuances of seed preference, germination methods, and the function of nursery beds in raising strong seedlings. We will determine the ideal circumstances for transplanting these young seedlings into flooded fields, a recognizable sight in many paddy-growing regions, using the perspective of cutting-edge research and time-honored wisdom.

Explore the incredible procedure that transforms small seeds into a grain that can sustain life by studying The Art and Science of Paddy Cultivation . Let us as we investigate how nature and technology, along with tradition and innovation, can work together to satisfy the body and the soul. So let's explore the submerged fields where older knowledge and contemporary understanding collide to discover the mysteries of paddy, the most essential food for humanity.

2. Origin of paddy:

Despite not being a tropical plant "*Oryza sativa*" is thought to be connected with moist, humid climates. It is most likely originated from wild grass that was possibly cultivated in the highlands of the far Eastern Himalayas. According to another angle of considering, the paddy plant may have originated in southern India before moving north and eventually to China. Various species of paddy differ in their habits and distribution

Species	Habit	Distribution
Oryza sativa	Annual, cultivated	South and South-east Asia
O. nivara	Annual, wild	South and South-east Asia
O. rufipogon	Perennial, wild	Tropical Asia, Australia
O. glaberrima	Annual, cultivated	Trpical west Africa
O. barthii	Annual, wild	Sub-Saharan Africa
O. longistaminata	Perennial, wild	Tropical west Africa
O. glumaepatula	Parennial, wild	Tropical west Africa
O. meridionalis	Wild	Tropical Australia
O. officinalis	Perinnial, wild	South and South-east Asia
O. minuta	Perennial , wild	The Philippines
O. rhizomatis	Wild	Sri Lanka
O. eichingeri	Wild	Sri Lanka, Tropical Africa
O. punctata	Wild	Tropical Africa
O.latifolia	Wild	Central and South America
O. alta	Wild	Central and South America
O. grandiglumis	Wild	South America
O. australiensis	Wild	Tropical Australia

3. Importance of Paddy:

Millions of people's cultures, diets, and economies have been influenced by paddy. "Paddy is life" for more than half of humanity. The United Nations declared 2004 to be the "International Year of Paddy".

a. More than 60% of the world's population depends on paddy as a major food crop.

b. Over the past few years, there has been a minor rise in the consumption of paddy worldwide. Global paddy consumption increased from 437.18 million metric tons in the 2008/2009 crop year to around 520 million metric tons in

c. In addition to being used as cow fodder and to thatch roofs, paddy straw is also utilized in small-scale industries to make hats, mats, ropes, sound-absorbing materials, straw boards, and litter.

d. Apart from to being used as fuel, paddy husk is also used as food for livestock.

4. SOIL AND CLIMATE:

Any kind of soil can be used to cultivate paddy. Riverine alluvium, red-yellow, red loamy, hill and sub-montane, Terai, laterite, coastal alluvium, red sandy, mixed red and black, and medium and shallow black soils are the main soil types where paddy is grown. Paddy is adaptable in a wide range of soil responses from pH 5 to 9 and on soils with low permeability. The clay loamy soils are often the best for cultivating paddy.

Paddy grows well in areas with high temperatures, high humidity levels, continuous sunshine, and reliable water supplies. In India high paddy yield can be planned on if the maximum temperature is between 34 and 40, 33 and 35, while the minimum temperature is between 32 and 35°C.between 7-11, 6-10, and 10°C, with temperatures ranging between 23-28, 25-27, and 20°C.During the vegetative, blooming, and grain growth stages, respectively, 7–10 hours each day.

4.1. Critical temperature for the development of paddy plant at different growth stages

Growth stages	Critical temperature (^{0}C)		
	Low	High	Optimum
Germination	16-19	45	18-40
Seedling emergence	12	35	25-30
Rooting	16	35	25-28
Leaf elongation	7-12	45	31
Tillering	9-16	33	25-31
Initiation of panicle primordial	15	---	---
Panicle differentiation	15-20	30	---
Anthesis	22	35-36	30-33
Ripening	12-18	.>30	19-20

5.Agronomical practices:

5.1.Land preparation:

1) To reduce the amount of water needed for early soil preparation plough the surface during the summer.

2) Before planting flood the field and give it a few of days to absorb the water. Maintain a layer of water covering the field's surface.

3) When puddling keep the water depth to 2.5 cm.

For each hectare of soil add 12 to 15 tons of well-rotted farmyard manure or compost. To encourage weed germination, irrigate the land. After about a week, plough the field twice to kill weed seeds.

5.2.Selection of Seeds

The two main kinds of soil in India where paddy is cultivated are uplands and lowlands. The kind of soils irrigation systems, labor availability, labor intensity, and rainfall distribution all play a significant role in determining how paddy is grown in a particular area.

When growing paddy using high-quality seeds is a crucial part of increasing crop productivity. As a result, careful consideration must be given to choosing the highest-quality seeds. The quality of the seed plays a significant role in how successfully healthy seedlings are raised. The following criteria should be followed by seeds prepared for sowing:-

1. The seed must originate from a suitable variety that has been selected to be grown.

2. The seed must be transparent and free of visible seed combinations.

3. The seed should be scale, maturing, and well-developed.

4. The seed should not exhibit any explicitly aging or storage issues.

Fungicides should be applied to the seed just before sowing with the aim to protect it against soil-born fungus and to improve the growth of the seedlings.

The crop of paddy is grown with the following methods:-

(i) Dry or Semi-dry upland cultivation

(a) Broadcasting the seed

(b) Sowing the seed behind the plough or drilling.

(ii) Wet or lowland cultivation

(a) Transplanting in puddled fields.

(b) Broadcasting sprouted seeds in puddled fields

6. Methods of Nursery Rising:

There are three major methods of raising nursery:

- The area where dried seeds get planted in arid ground. When there is insufficient water to develop seedlings in wet nurseries, this method of cultivation is used.
- The soil in a wet nursery is used to sow growing seeds. When irrigation is present, wet nurseries are ideal.
- Also the "dapog" approach the nursery-raising technique was imported from the Philippines to India**.**

The "Dapog" method is widely used in the Philippines. This method's primary feature is to have a very thick stand of nursery seedlings that are not in contact with the soil at all. Typically, it takes 12 to 14 days for seedlings to be prepared for transplantation.

7. Seed Rate

In the nursery beds, 40 to 60 grams of seed per square meter should be planted. One hectare of land can be transplanted using a nursery with a size of about 500 square meters. The nursery area should be raised to 750–1000 square feet in cases of late seeding.

Before planting, treat the seed with Sprint 75 WS (carbendazim + mancozeb) by preparing a slurry of 3 g of the fungicide formulation in 10–12 ml of water for 1 kg of seed (or 24 g in 80–100 ml of water for 8 kg of seed).

8. Transplanting

In the production of paddy transplanting has a number of benefits over direct seeding. Transplanting seedlings improves greater root development and lowers vulnerability to pests and illnesses by giving them time to establish themselves before being planted in the main field. This method also makes it possible to grow a crop with constant plant spacing, resulting in a more effective use of resources like water and fertilizers.

Fields should be well puddled with bullock or tractor drawn puddlers before transplantation. In paddy transplants, puddling is a crucial process. The weeds are killed by puddles and are buried under them. Additionally, it prevents weeds from sprouting throughout the crop's succeeding growing season. In addition to producing desirable physical, biological, and chemical conditions, puddling maintains a more level soil surface and chemistry for the development of paddy plants. Transplanting should be done with proper age of seedlings.

8.1. Dates of Transplanting: One of the factors that has a significant impact on paddy output is the time of transplanting. Transplant paddy seedlings between June 20 and July 10 to achieve the highest production of paddy and to allow for the timely closure of the field for the planting of wheat and other crops. The transplantation of PR 126 is preferred in late-sown situations.

8.2. Age of Seedlings at Transplanting: Use seedlings that are 30–35 days old for medium-duration variety. However, seedlings of 25 to 30 days should be used for the short-duration variety (PR 126) instead. The yield and quality are reduced when seedlings that are too old are transplanted.

8.3. Uprooting of Seedlings: Before removing the nursery, irrigate it. To get mud off the seedlings, wash them in water.

8.4. Seedling Inoculation: 100 liters of water and a half kg packet of azospirillum biofertilizer should be combined. One acre's worth of nursery-grown paddy seedlings should be dipped in this solution for 45 minutes before being transplanted.

9. Spacing

The ideal spacing for cultivars

Like IR-8 should be around 20x10 cm for both kharif and rabi crops under excellent management and adequate nitrogen levels. The distance could be significantly broader with outstanding cultural customs, like 20x15 cm, but under abnormal circumstances, it should be slightly smaller, like 15x10 cm.

9.1. Depth of Planting and Directions of Rows

Planting Directions and Depth The depth of planting has become extremely important since the development of high producing cultivars. High tillering ability is a characteristic of the high yielding cultivars. However, shallow planting is the greatest way to show these cultivars' considerable tillering ability. In the case of shallow plantings, the tiller buds generated at the basal node are not repressed. As a result, the seedlings should be planted at a depth of 2 to 3 cm. Planting shallowly produces higher yields. In addition to delaying and inhibiting tillering, deeper planting causes the plants to grow tillering Rows

In general, crops planted with rows running north-south produce superior yields, especially during the rabi season. Since there is no additional cost associated with adopting this technique, it is worthwhile.

10. Weed Control

The two names used in weed science are weed management and weed control.

1) The technique of limiting weed plant infestation so that crops can be profitably cultivated is known as weed control.
2) Weed control measures include weed prevention, eradication, and control through controlled use, invasion restriction, growth suppression, seed prevention, and total elimination.

10.1. Cultural methods:

- To eliminate current weed growth, preliminary cultivation often incorporates weeds into the soil to a depth of 10 to 15 cm.
- Lowland paddy weed control benefits from flooding and vigorous puddling.
- The weed invasion is decreased by summer plowing and cultivation of irrigated dry crops in the aftermath of rain.

10.1.1. Manual weed control

Hand labor is used to pull and gather weeds from agriculture fields. The weeds that have been collected are stacked on bunds or, in the case of some weeds, brought home to feed animals. The most commonly used form of weed control in paddy is manual weeding, which is challenging, time-consuming, and frequently expensive.

10.2. Mechanical weed control

Mechanical methods of management include those that physically harm weeds in order to destroy or inhibit them. Pulling, digging, disking, plowing, and mowing are some examples of these techniques.

10.3. Chemical weed control

Chemical weed control refers to the use of substances, commonly known as herbicides, to eradicate weeds. The most efficient and effective way to manage weeds is by applying a herbicide.

10.3.1 Pre-emergence herbicides

Use pendimethalin 30% EC @ 4.5 kg/ha (1.5 kg ai/ha), butachlor 1.25 kg/ha or anilophos 0.4 kg/ha, thiobencarb 50% EC @ 2 kg/ha (1 kg ai/ha), and pendimethalin as a pre-emergence application. An alternative is to apply a pre-emergence herbicide mixture, such as Butachlor 0.6 kg + 2, 4 DEE 0.75 kg/ha or Anilophos + 2, 4 DEE'ready-mix' at 0.4 kg/ha. With one hand weeding on 30-35 DAT after that, a wide range of weeds can be controlled.

10.3.2.. Post – emergence herbicides

Apply 2,4-D sodium salt (Fernoxone 80% WP) 1.25 kg/ha dissolved in 625 liters of water with a large volume sprayer where broad-leaved weeds and sedges are prevalent three weeks after transplanting or when the weeds are in the 3–4 leaf stage.

10.3.3.Biological weed control

Biological control refers to the use of live organisms like as insects, pathogens, herbivorous fish, snails, or even competitive plants to control weeds.

Preventive methods

1. Use of weed free seeds.
2. Use of weed free seed bed.
3. Use clean tools and machinery.
4. Clean irrigation canals and bunds
5. Prevent entry of water-carried vegetative propagules of weeds that are perennial.

Management of Fertilizer and Mineral Nutrition

As early as 1918 researchers examined into how the rice plant absorbed nutrients at various growth phases. The mineral nutrition of the rice plant was subsequently carefully investigated by Gericke (1924) and Ishizuka (1932).

11. MINERAL NUTRITION

The delivery and assimilation of the chemical nutrients that an organism needs to survive is known as nutrition. The elements or straightforward inorganic compounds known as agricultural nutrients are necessary for the growth of crops but are not produced by the during the plant's typical metabolic processes**.** Paddy crop development and growth are highly dependent on mineral nutrition. Numerous physiological and biochemical processes that affect paddy crops' general health, productivity, and quality depend on a range of critical minerals. Macronutrients and micronutrients are the two main types of mineral nutrients needed by paddy crops.

Macronutrients:

1. **Nitrogen (N):** Chlorophyll which is essential for photosynthesis, is primarily composed of nitrogen. It encourages ferocious vegetative growth, accelerates tillering (side shoot production), and improves the general health and productivity of the plant.
2. **Phosphorus (P):** For the transfer and storage of energy within plants, phosphorus is essential. It promotes the creation of seeds, flowers, and roots. For optimum crop yield, phosphorus levels must be adequate.
3. **Potassium (K**): Potassium contributes to improved disease resistance, water uptake regulation, and overall plant strength. It is essential for grain filling, drought resistance, and overall grain quality**.**

Secondary Macronutrient:

- **Calcium (Ca**): Calcium is necessary for the development of roots, the formation of cell walls, and the defense against diseases like blossom-end rot.
- **Magnesium (Mg):** Magnesium is a central component of chlorophyll and is required for photosynthesis. It also plays a role in enzyme activation and energy transfer.
- **Sulfur (S):** Protein synthesis, enzyme activity, and overall plant health all depend on sulfur.

Micronutrients: such as Iron (Fe), Zinc (Zn) ,Manganese (Mn),Copper (Cu**) ,** Boron

Rice farming need organic manures just as much as it does chemical fertilizers. Applying compost or 10-15 tonnes of well-rotted farmyard manure to a one hectare area in upland fields should be done four to six weeks prior to sowing. Spreading equally should be done on organic manures the soil's upper surface and plowed into the ground to thoroughly mix it in. implementation of Chemical fertilizers mostly depend on (i) the field's fertility and (ii) the preceding crop. and the quantity of organic manure used. Soil must be considered when determining the fertilizer dose to be tested in order to determine the soil's levels of nitrogen, phosphate, and potassium. After Following a soil test, the fertilizer dose should be determined.

Fertilizer: Apply three equal applications of 130 kg of urea per acre at 4, 6, and 9 weeks following sowing. Only if a soil test reveals a lack of these nutrients, should phosphorus and potash be added. If the recommended dose of phosphorus was applied to the wheat crop before, do not apply it to the DSR.

12. Water Management

In comparison to other crops grown for a similar length of time, rice requires more water. The production of the crop is significantly impacted by the reliable and timely delivery of irrigation water. The initial water requirement for crop growth is typically very high. 30th-stage establishment of a seedling. Water should be permitted to stand in the area after the transplanting. until the seedlings are well-established, till the field at a depth of two to five cm. The following, the Tillering to flowering is the most crucial stage, and during this time the crop shouldn't be stress caused by soil moisture. Water should be drained from the field before harvesting to allow for uniform and speedy grain maturation**.**

13. Harvesting and Threshing

Rice and paddy must be harvested at the right stage of maturity for the greatest yield and best quality. Consequently, it is crucial to harvest the crop at the right time. Crop loss could occur if it is harvested before it is fully grown. contains grain of inferior grade. Grain may be lost if harvesting is postponed owing to damage from mice, birds, bugs, breaking, and lodging. Therefore, timely harvesting guarantees higher yield and high-quality grains, consumer acceptance, and milling results with less breakage. According to general consensus among non-specialists the ideal time to harvest is when panicles turn a golden yellow color and the grains have a moisture content of around 20%. When the rice grains' moisture content hits 16–17 percent in the standing crop in the fields suffers a significant loss as a result of breaking and damage by rodents and birds. The best time to harvest has been determined through careful study. In general, three factors are taken into account to designate the proper period of harvesting based on the findings of numerous research, namely (i) the moisture content of the grains, (ii) the number of days after planting or flowering, and (iii) the dry matter of the plant or seed. The two most popular and traditional techniques of threshing paddy are trampling by bullocks and raising the bundles and striking them on the wooden platform's high surface**.** Pedal threshers are now in use. Quick threshing is also accomplished using power-driven stationary threshers.

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