02.,0.3. RICE - ORIGIN - GEOGRAPHIC DISTRIBUTION - ECONOMIC IMPORTANCE – VARIETIES - SOIL AND CLIMATIC REQUIREMENT - CULTURAL PRACTICES – YIELD - ECONOMIC BENEFITS - SPECIAL TYPE OF RICE CULTIVATION – SYSTEM OF RICE INTENSIFICATION, TRANSGENIC RICE - HYBRID RICE

ORIGIN

Rice cultivation probably dates back to the antiquity and has probably been the staple food and the first cultivated crop in Asia. In India, rice has been cultivated since ancient times. This supported by archaeological evidences and by the numerous references made to rice in ancient Hindu scriptures and literature. Carbonised paddy grains were found in the excavation at Hasthinapur (Uttar Pradesh) at a site dated between 1000-750 B.C. This is the oldest rice specimen yet known in the world. From the study of Sanskrit and of other different languages in **South-Eastern Asia**, many investigators have come to the conclusion that rice was known in India before the present era.

De candolle (1886) and Watt (1892) thought that South India was the place where cultivated rice originated. Vavilov (1926) suggested that **India** and **Burma** should be regarded as the centre of origin of cultivated rice.

GEOGRAPHICAL DISTRIBUTION

Rice is the world's leading food crop, cultivated over an area of about 155 million hectares with a production of about 596 million tonnes (paddy). In terms of area and production it is second to wheat. It provides about 22 per cent of the world's supply of calories and 17% of the proteins. Maximum area under rice is in Asia. Among the rice growing countries, India has the largest area (44.8 million hectares) followed by China and Indonesia. In respect of production, India ranks second with 131 million tonnes of paddy next to China (200 million tonnes of paddy). In regard to average yield per hectare, Egypt ranks first followed by USA. Average rice yield of India is only 2929 kg per hectare.

The leading countries producing rice crop are Japan, Brazil, China, India, Indonesia, Bangladesh, Vietnam, Thailand, Myanmar and Philippines.

In India, rice is grown in almost all the states. Andhra Pradesh, Bihar, Uttar Pradesh, Madhya Pradesh and West Bengal lead in the area. West Bengal and Uttar Pradesh have the highest rice production. The average yield per hectare is highest in Punjab (3346 kg/ha).

ECONOMIC IMPORTANCE

Rice farming is the largest single use of land for food. Rice production totaled 600 million tonnes. 90% rice is produced in Asia alone. Only 6-7% of production is exported from area of production. Rice field covers 11% of arable land. It is the most important economic activity of earth. Rice eaters and growers form the bulk of the worlds' poor. Single most important activity of rural people in the world. Rice is grown in 250 million Asian farms. Rice farming is 10,000 years old. Once basis of social order and occupied major place in religions and customs. Rice is used pay debts, wages, and rent. Staple food for largest number of humanity in the world. It is single largest source of energy for poor. Rice is synonym with food throughout Asia.

CLIMATIC REQUIREMENTS

In India, rice is grown under widely varying conditions of altitude and climate. Rice cultivation in India extends from 8 to 35^0N latitude and from sea level to as high as 3000 metres. Rice crop needs a hot and humid climate. It is best suited to regions which have high humidity, prolonged sunshine and an assured supply of water. The average temperature required throughout the life period of the crop ranges from 21 to 37^0C. At the time of tillering the crop requires a higher temperature than for growth. Temperature requirement for blooming is in the range of 26.5 to 29.5^0C. At the time of ripening, the temperature should be between 20-25^0C. Photo-periodically, rice is a short-day plant. However, there are varieties which are non-sensitive to photoperiodic conditions.

SOIL REQUIREMENT

In India, rice is grown under so diverse soil conditions that it can be said that there is hardly any type of soil in which it cannot be grown, including alkaline and acidic soils. Soils having good water retention capacity with good amount of clay and organic matter are ideal for rice cultivation. Clay or clay loams are most suited for rice cultivation, such soils are capable of holding water for long and sustain crop. Rice being a semi-aquatic crop grows best under submerged conditions. A major part of rice crop in India is grown under 'lowland' conditions. Rice plant is able to tolerate a wide range of soil reaction, but, it does have a preference for acidic soils. It grows well in soils having a pH range between 5.5 and 6.5. It can be grown on alkali soils also, after treating them with gypsum or pyrite.

Rice Seasons

Month of sowing	Season	Duration (Days)	Districts
Dec-Jan	Navarai	< 120	Tiruvallur, Vellore, Tiruvannamalai, Cuddalore, Villupuram, Tiruchirapalli, Perambalur, Karur, Nagapattinam, Madurai, Theni, Salem, Namakkal, Dindigul, Dharmapuri, Coimbatore,Erode and Pudukkottai.
Apr-May	Sornavari	<120	Tiruvallur, Vellore, Tiruvannamalai, Cuddalore, Villupuram, Namakkal, Dharmapuri
Apr-May & May-June	Early Kar Kar	<120	Tirunelveli, Kanyakumari, Thoothukudi, Erode, Coimbatore, Madurai, Theni, Dindigul, Salem, Namakkal, Dharmapuri.
June-July	Kuruvai	<120	Tiruchirapalli, Perambalur, Karur, Thanjavur, Nagapattinam, Tiruvarur, Pudukottai, Erode
July-Aug.	Early Samba	130 to 135	Tiruvallur, Vellore, Tiruvannamalai, Salem, Namakkal, Cuddalore, Villupuram, Madurai, Theni, Ramanathapuram, Dharmapuri, Coimbatore, Erode, Pudukkottai, The Nilgiris
August	Samba	130-135 and >150	All districts
Sep-Oct	Late Samba Thaladi/ Pishanam	130-135	Tiruvallur, Madurai, Theni, Coimbatore, Erode
Sep-Oct	Late Pishanam	130-135	Madurai, Theni, Dindigul, Kanyakumari, Tirunelveli , Thoothukudi
Oct-Nov	Late Thaladi	115-120	Thanjavur, Nagapattinam, Tiruvarur, Tiruchirapalli,

			Perambalur, Karur
Sep-Oct	Late Samba Thaladi/ Pishanam	130-135	Tiruvallur, Madurai, Theni, Coimbatore, Erode

Seasons and Varieties

Navarai (Dec -Jan)	ADT 36, ADT 37, ASD 16, IR 64, ASD 18, ADT 42, ADT 43, MDU 5, ASD 20, IR 20, ADT 39, CO 43, CO 47, ASD 20, TRY (R)2*
Sornavari (April - May)	ADT 36, IR 36, IR 50, ADT 37, ASD 16, ASD 17, IR 64, ASD 18, ADT 42, MDU 5, ASD 20, ADT 43, CO 47, TRY (R)2*, ADT (R) 45, ADTRH 1, ADT (R) 47, ADT (R) 47
Early Kar (Apr - May)	IR 50, ADT 36, IR 64, ADT 42, ADT 43, ADT 45, CO 47, ADT (R) 47
Kar (May - Jun)	IR 50, ADT 36, ASD 16, ASD 17, IR 64, ASD 18, ADT 42, MDU 5, ASD 20, ADT 43, CO 47, ADT (R) 45, TRY (R)2*, ADTRH 1, ADT (R) 47, IR 36, ADT 37, Bhavani, IR 20, White Ponni, CO 43, MDU 4, ASD 19, Paiyur 1
Kuruvai (Jun -Jul)	ADT 36, IR 50, IR 64, ASD 16, ADT 37, ASD 18, ADT 42, MDU 5, ADT 43, CO 47, ADT (R) 45,TRY (R)2*, ADTRH 1, ADT (R) 47, ADT (R) 48
Samba (Aug)	Ponmani, IR 20, White Ponni, CO 43, ADT 40, Paiyur 1, PY 4, ADT 39, TRY 1, ASD 19, ADT(R) 44, CORH 2, CO 45, ASD 19, ADT 38, ADT (R) 46, CO 42, ADT 40, ADT 38, MDU 3, MDU 4, Bhavani
Late Samba (Sep - Oct)	IR 20, White Ponni, ADT 38, ADT 39, CO 43, CO 46, TRY 1, ADT (R)46, CORH 2, Ponmani, ASD 19, ADT (R)46, TPS 2, TPS 3, ASD 18, ASD 19, MDU 5,
Pishanam/Late Pishanam (Sep-Oct.)	ASD 18, ASD 16, ASD 19, CO 43, TRY 1, ADT (R)46
Dry (July - Aug)	ADT 36, PMK 2, TKM 11, PMK (R) 3, TKM 10, TKM (R) 12
Semi-dry (Jul – Aug)	ADT 36, IR 36, ADT 39, ASD 17, PMK 2, TKM (R) 12, PMK (R) 3, MDU 5,

Ruling Varieties in Tamil Nadu

Short duration: ADT 48 (95-100 days), ADT 43 (110 days), ADT 37 (105 days), ADT 36 (115 days), CO 47 (110-115 days), ASD 20 (110 days), ADS 17 (101 days), ADS 16 (110 days), IR 64 (115-120 days).

Latest varieties: RMD (R) 1 (100-105 days), TPS (R)4 (95 days), PMK (R)4 (100-105 days),

Medium duration (120 –145 days): IR 20, Bhavani, CO 43, CO 46, IR 36, MDU 3, MDU 4, ADT 38, ADT 39, ADT 44, ADT 46, TPS 2 , TPS 3, ASD 19, TRY 1.

Latest varieties: CO(R) 48, CO(R) 49, CO(R) 50, TRY ® 3.

Long duration (>150 days): Ponmani (CR 1009) /Savithri, White Ponni, BPT 5204 (Samba Masourie), PY 4 (Jawahar)

Hybrids: CORH 1, ADTRH 1, CORH 2, ADTRH 2, CORH 3.

Varieties famous in India: Ratna, Jaya, Rasi, Triveni, Mandya, Swarnapraba, Red Annapoorna, Aishwarya, Basmati.

TYPES OF RICE CULTIVATION

I. TRANSPLANTED PUDDLED LOWLAND RICE

A. NURSERY MANAGEMENT

i. WET NURSERY

Nursery area: Select 20 cents (800 m^2) of land area near to water source for raising seedlings for one hectare.

Seed rate: 30 kg for long duration; 40 kg for medium duration; 60 kg for short duration varieties and 20 kg for hybrids.

Seed treatment

- Treat the seeds with Carbendazim or Pyroquilon or Tricyclozole solution @ 2 g/l of water for 1 kg of seeds.
- This wet seed treatment gives protection to the seedlings up to 40 days from disease such as blast and this method is better than dry seed treatment.
- If the seeds are required for sowing immediately, keep the soaked seed in gunny in dark and cover with extra gunnies and leave for 24hrs for sprouting.
- **Seed treatment with *Pseudomonas fluorescens***: Treat the seeds with talc based formulation of *Pseudomonas fluorescens* 10g/kg of seed and soak in 1.0 lit of water overnight. Decant the excess water and allow the seeds to sprout for 24hrs and then sow.
- **Seed treatment with *Azospirillum***: Treat with three packets (600 g/ha) of *Azospirillum* and 3 packets (600g/ha) of Phosphobacteria or 6 packets (1200g/ha) of *Azophos*. In bio-inoculants mixed with sufficient water wherein the seeds are soaked overnight before sowing in the nursery bed (The bacterial suspension after decanting may be poured over the nursery area itself).
- Bio-control agents are compatible with bio-fertilizers
- Bio-fertilizers and bio-control agents can be mixed together for seed soaking
- Fungicides and bio-control agents are incompatible.

Forming seedbeds

- Mark plots of 1.5 to 2.0m breadth with channels of 30cm wide all around the seedbeds.
- Length of the seed bed may vary from 8 to 10m according to soil and slope of the land.
- Collect the puddled soil from the channel and spread on the seedbeds or drag a heavy stone along the channel to lower it, so that the seed bed is at a higher level. Level the surface of the seedbed, so that the water drains into the channel.

Sowing

Sow the sprouted seeds uniformly on the seedbed, having sufficient water in the nursery.

Water management

- Drain the water 18 to 24hrs after sowing.
- Care must be taken to avoid stagnation of water in any part of the seedbed.

- Allow enough water to saturate the soil from 3rd to 5th day. From 5th day onwards, increase the water level from 1.5cm depending on the height of the seedlings. Thereafter maintain 2.5cm depth of water.

Weed management

- Apply pre-emergence herbicides *viz.,* Pretilachlor + safener @ 0.3kg/ha, on 3rd or 4th day after sowing to control weeds in the lowland nursery. Keep a thin film of water and allow it to disappear. Avoid drainage of water. This will control germinating weeds.

Nutrient management

- Apply 1.0 tonne of fully decomposed FYM or compost to 20 cents nursery and spread the manure uniformly on dry soil.
- Basal application of DAP is recommended when the seedlings are to be pulled out in 20-25 days after sowing in less fertile nursery soils. For that situation, before the last puddling, apply 40kg of DAP and if not readily available, apply straight fertilizers 16kg of urea and 120kg of super phosphate.
- If seedlings are to be pulled out after 25 days, application of DAP is to be done 10 days prior to pulling out.
- For clayey soils where root snapping is a problem, 4kg of gypsum and 1kg of DAP/cent of area can be applied at 10 days after sowing.

ii. DRY NURSERY

- Dry ploughed field with fine tilth is required.
- Nursery area of 20 cents with sand and loamy soil status is more suitable for this type of nursery.
- Plots of 1 to 1.5m width of beds and channels to be formed. Length is according to the slope and soil. Raised beds are more ideal if the soil is clayey in nature.
- Seed rate and seed treatment as that of wet nursery.
- Sowing is dry seeding. Seeds are covered with sand and finely powdered well decomposed farm yard manure.
- Irrigation to be done to wet the soil to saturation.
- Optimum age for transplanting – 4th leaf stage.
- This type of nursery is handy in times of delayed receipt of canal water.

B. MAIN FIELD MANAGEMENT

Land preparation

- Plough the land during summer to economize the water requirement for initial preparation of land.
- Flood the field 1 or 2 days before ploughing and allow water to soak in. Keep the surface of the field covered with water.
- Keep water to a depth of 2.5cm at the time of puddling.

Problem soil management

a). Fluffy paddy soils: Compact the soil by passing 400kg stone roller or oil-drum with stones inside, eight times at proper moisture level (moisture level at friable condition of soil which is approximately 13 to18%) once in three years, to prevent the sinking of draught animals and workers during puddling.

b). Sodic soils with pH values of more than 8.5, plough at optimum moisture regime, apply gypsum at 50% gypsum requirement uniformly, impound water, provide drainage for leaching out soluble salts and apply green leaf manure at 5 t/ha, 10 to 15 days before transplanting. Mix 37.5kg of Zinc sulphate/ha with sand to make a total quantity of 75kg and spread the mixture uniformly on the leveled field. Do not incorporate the mixture in the soil. Rice under sodic soil responds well to these practices.

c). Saline soils with EC values of more than 4 dS/m, provide lateral and main drainage channels (60cm deep and 45cm wide), apply green leaf manure at 5 t/ha at 10 to 15 days before transplanting and 25% extra dose of nitrogen in addition to recommended P and K and $ZnSO_4$ at 37.5 kg/ha at planting.

d). Acid soils: Apply lime based on the soil analysis for obtaining normal rice yields. Lime is applied 2.5t/ha before last ploughing. Apply lime at this rate to each crop up to the 5^{th} crop.

Optimum age of seedlings

- Optimum age of the seedlings is 18-22 days for short, 25-30 days for medium and 35-40 days for long duration varieties.

Pulling out the seedlings: Pull out the seedlings at the appropriate time (4^{th} leaf stage).

Root dipping

- Prepare the slurry with 5 packets (1000 g)/ha of *Azospirillum* and 5 packets (1000g/ha) of Phosphobacteria or 10 packets of (2000g/ha) of *Azophos* inoculant in 40 litres of water and dip the root portion of the seedlings for 15-30 minutes in bacterial suspension and transplant.

Planting seedlings in the main field

Soil	**Medium and low fertility**			**High fertility**		
Duration	Short	Medium	Long	Short	Medium	Long
Spacing (cm)	15x10	20x10	20x15	20x10	20x15	20x20
Hills / m^2	66	50	33	50	33	25

- Transplant 2-3 seedlings/hill for short duration and 2 seedlings/hill for medium and long duration varieties
- Shallow planting (3 cm) ensures quick establishment and more tillers. Deeper planting (> 5cm) leads to delayed establishment and reduced tillers.
- Line planting permits rotary weeding and its associated benefits. Allow a minimum row spacing of 20 cm to use rotary weeder.
- Fill up the gaps between 7 and 10 DAT.

Management of aged seedlings

Follow the spacing recommended to medium and low fertility soil

- Plant one or two seedlings/hill
- Avoid cluster planting of aged seedlings, which are hindering the formation of new tillers.
- New tillers alone are capable of producing normal harvestable panicle. Weak panicle may appear in the mother culm within three weeks after transplanting and vanishes well before harvest.

- To encourage the tiller production, enhance the basal N application by 50% from the recommended and thereafter follow the normal schedule recommended for other stages.

Nutrient management

Application of organic manures

- Apply 12.5 t of FYM or compost; or green leaf manure @ 6.25 t/ha.
- If green manure is raised @ 20 kg /ha, *in-situ,* incorporate it to a depth of 15 cm using a green manure trampler or tractor.
- In the place of green manure, press-mud / composted coir-pith can also be used.

Stubble incorporation

- Apply 22 kg urea/ha at the time of first puddling while incorporating the stubbles of previous crop to compensate immobilization of N by the stubbles.
- This may be done at least 10 days prior to planting of subsequent crop. This recommendation is more suitable for double crop wetlands, wherein, the second crop is transplanted in succession with short turn-around period.

Bio-fertilizer application

- Broadcast 10 kg of soil based powdered Blue Green Algae (BGA) flakes at 10 DAT for the dry season crop. Maintain a thin film of water for multiplication.
- Raise *Azolla* as a dual crop by inoculating 250 kg/ha 3 to 5 DAT and then incorporate during weeding for the wet season crop.
- Mix 10 packets (2000 g)/ha of *Azospirillum* and 10 packets (2000g/ha) of Phosphobacteria or 20 packets (4000g/ha) of *Azophos* inoculants with 25 kg FYM and 25 kg of soil and broadcast the mixture uniformly in the main field before transplanting and *Pseudomonas fluorescens* (Pf 1) at 2.5 kg/ha mixed with 50 kg FYM and 25 kg of soil and broadcast the mixture uniformly before transplanting.

Application of inorganic fertilizers

- Apply fertilizer nutrients as per soil test recommendations
- If the above recommendation are not able to be followed, adopt blanket recommendation as follows:

Nutrients	**N**	**P_2O_5**	**K_2O**
	(kg/ha)		
Short duration varieties (**Dry season**)			
a) Cauvery delta & Coimbatore tract	150	50	50
b) For other tracts	120	40	40
Medium and long duration varieties (**Wet season**)	150	50	50
Hybrid rice	175	60	60
Low N responsive cultivars (like Improved White Ponni)	75*	50	50

*For Ponni, N should be applied in three splits at Active tillering (AT), panicle initiation (PI) and harvest (H) stages.

Split application of N and K

- Apply N and K in four equal splits *viz.,* basal, tillering, panicle initiation and heading stages.
- Tillering and panicle initiation periods are crucial and should not be reduced with the recommended quantity.

Application of P fertilizer

- P may be applied as basal and incorporated.
- When the green manure is applied, rock phosphate can be used as a cheap source of P fertilizer. If rock phosphate is applied, the succeeding rice crop need not be supplied with P. Application of rock phosphate + single super phosphate or DAP mixed in different proportions (75:25 or 50:50) is equally effective as SSP or DAP alone.

Application of Zinc sulphate

- Apply 25 kg of zinc sulphate mixed with 50 kg dry sand just before transplanting.
- It is enough to apply 12.5 kg zinc sulphate /ha, if green manure (6.25 t/ha) or enriched FYM, is applied.
- If deficiency symptom appears, foliar application of 0.5% Zinc sulphate + 1.0% urea can be given at 15 days interval until the Zn deficiency symptoms disappear.

Application of gypsum

- Apply 500 kg of gypsum/ha (as source of Ca and S nutrients) at last ploughing.

Foliar nutrition

- Foliar spray of 1% urea + 2% DAP + 1% KCl at PI and 10 days later for all varieties.

Neem treated urea

- Blend the urea with crushed neem seed or neem cake 20% by weight. Powder neem cake to pass through 2mm sieve before mixing with urea. Keep it overnight before use (or) urea can be mixed with gypsum in 1:3 ratios, or urea can be mixed with gypsum and neem cake at 5:4:1 ratio to increase the nitrogen use efficiency.

Coal-tar treated urea

- For treating 100 kg urea, one kg coal-tar and 1.5 litres of kerosene is required. Melt coal-tar over a low flame and dissolve it in kerosene. Mix urea with the solution thoroughly in a plastic container, using a stick. Allow it to dry in shade on a polythene sheet. This can be stored for a month and applied basally.

Weed management

- Manual weeding is also essential to remove the weeds closer to rice root zone.
- Cultural practices like dual cropping of rice-*Azolla*, reduces the weed infestation to a greater extent.
- Summer ploughing and cultivation of irrigated dry crops during post-rainy periods reduces the weed infestation.

Pre-emergence herbicides

- Use Butachlor 1.25kg/ha or Anilophos 0.4kg/ha as pre-emergence application. Alternatively, pre-emergence application of herbicide mixture viz., Butachlor 0.6kg + 2,4 DEE 0.75kg/ha, or Anilophos + 2, 4 DEE 'ready-mix' at 0.4kg/ha followed by one hand weeding on 30-35 DAT will have a broad spectrum of weed control.
- Any herbicide has to be mixed with 50kg of dry sand on the day of application (3-4 DAT) and applied uniformly to the field with thin film water on the 3 DAT. Water should not be drained for next 2 days from the field (or) fresh irrigation should not be given.

Post - emergence herbicides

- If pre-emergence herbicide application is not done, hand weeding has to be done on 15th DAT.
- 2,4-D sodium salt (Fernoxone 80% WP) 1.25 kg/ha dissolved in 625 litres with a high volume sprayer, three weeks after transplanting or when the weeds are in 3-4 leaf stage.

Water management

- Puddling and leveling minimizes the water requirement
- Maintain 2.5cm of water over the puddle and allow the green manure to decompose for a minimum of 7 days in the case of less fibrous plants like sunnhemp and 15 days for more fibrous green manure plants like Kolinchi (*Tephrosia purpurea*).
- At the time of transplanting, a shallow depth of 2cm of water is adequate since high depth of water will lead to deep planting resulting in reduction of tillering.
- Maintain 2 cm of water up to seven days of transplanting.
- About 5cm submergence has to be continued throughout the crop period.
- Moisture stress due to inadequate water at rooting and tillering stage causes poor root growth leading to reduction in tillering, poor stand and low yield.
- Critical stages of water requirement in rice are, a) panicle initiation, b) booting, c) heading and d) flowering. During these stages, the irrigation interval should not exceed the stipulated time so as to cause the depletion of moisture below the saturation level.
- During booting and maturity stages, continuous inundation of 5cm and above leads to advancement in root decay and leaf senescence, delay in heading and reduction in the number of filled grains/panicle and poor harvest index.
- Provide adequate drainage facilities to drain excess water or strictly follow irrigation schedule of one day after disappearance of ponded water. Last irrigation may be 15 days ahead of harvest.

Harvesting

- Taking the average duration of the crop as an indication, drain the water from the field 7 to 10 days before the expected harvest date as draining hastens maturity and improves harvesting conditions.
- When 80% of the panicles turn straw colour, the crop is ready for harvest. Even at this stage, the leaves of some of the varieties may remain green.
- Confirm maturity by selecting the most mature tiller and dehusk a few grains. If the rice is clear and firm, it is in hard dough stage.
- When most of the grains at the base of the panicle in the selected tiller are in a hard dough stage, the crop is ready for harvest. At this stage harvest the crop, thresh and winnow the grains.
- Dry the grains to 12% moisture level for storage. Grain yield in rice is estimated only at 14% moisture for any comparison.
- Maturity may be hastened by 3-4 days by spraying 20% NaCl a week before harvest to escape monsoon rains.

Yield:

- Grain yield varies between 4000 and 6000 kg/ha depending on the management and climatic conditions. Straw yield of 8000-10000 kg/ha can normally be obtained.

II. WET SEEDED PUDDLED LOWLAND RICE

Area

- Direct wet seeding can be followed in all the areas wherein transplanting is in vogue.

Season: As that of transplanted rice

Field preparation

- On receipt of showers during the months of May-July, repeated ploughing should be carried out so as to conserve the moisture, destroy the weeds and break the clods.
- After inundation of water, puddling is to be done as like transplanting rice. More care should be taken to level the field to table top level.
- Stagnation of water in patches during germination and early establishment of the crop leads to uneven crop stand.
- Land leveling has say over efficient weed and water management practices.
- Provision of shallow trenches (15cm width) at an interval of 3m all along the field will facilitate the draining of excess water at the early growth stage.

Varieties

All the varieties recommended for transplanting can do well under direct wet seeded conditions also. However, the following varieties are more suited.

Varieties	Duration (days)	Time of sowing
Ponmani	160 to 165	August
Co 43, IR20, ADT 38 ADT 39, Ponni, Improved White Ponni	125 to135	September
ADT 36, ADT 37	105 to 110	1-10th October

Sowing

- Follow a seed rate of 60 kg/ha
- Pre-germinate the seeds as like wet nursery
- Seed treatments as adopted for transplanted rice
- Sow the seeds by drum seeder or broadcast uniformly with thin film of water.
- Dual cropping of rice-green manure is economic for nutrient budget and efficient for grain production. For this method use 'TNAU Rice-Green manure seeder'.

After cultivation

- Thinning and gap filling should be done 14-21 days after sowing.
- If dual cropped with green manure, incorporate the green manure when grown to 40cm height or at 30 days after sowing, whichever is earlier, using Cono-weeder.
- Green manure incorporated fields to be operated again with rotary weeder a week later in order to aerate the soil and to exploit organic acids formed if any.

Manures and fertilizer application

- For direct wet seeded lowland rice, the recommendation is same at that of transplanted rice.
- Apply N and K as 25% each at 21 DAS, at active tillering, PI and heading stages.

Weed management

- In wet seeded rice, pre-emergence application of pretilachlor 0.75kg/ha on 8 DAS or pretilachlor + safener (Sofit) @ 0.45kg/ha on 3-4 DAS followed by one hand weeding on 40 DAS.

Water management

- During first one week, just wet the soil by thin film of water.
- Depth of irrigation may be increased to 2.5cm progressively along the crop age.
- Afterwards, follow the schedule as given to transplanted rice.

Other package of practices: As recommended in transplanted rice

III. DRY SEEDED RAINFED UN-PUDDLED LOWLAND RICE (Rainfed rice)

The crop establishment, growth and maturity depend up on the rainfall received. There will be standing water after crop establishment for a minimum period of few days to a maximum up to grain filling, depending up on the rainfall. This type of cultivation in Tamil Nadu is called as **'rainfed rice'**, with the assumption that the soil moisture will be under unsaturated (dry) condition during establishment or entire growth period, with reference to tropical climate.

Area

- Coastal districts of Tamil Nadu like Kanchipuram, Tiruvallur, Pudukottai, Ramanathapuram, Virudhunagar, Sivagangai and Kanyakumari.

Season

- June-July (Coastal northern districts)
- September-October (Coastal southern districts)

Field preparation

- Dry plough to get fine tilth taking advantage of rains and soil moisture availability.
- Apply Gypsum @ 1 t/ha basally wherever soil crusting and soil hardening problem exist.
- Perfect land leveling for efficient weed and water management.
- Provide shallow trenches (15 cm width) at an interval of 3m all along the field to facilitate draining excess water at the early growth stage.

Varieties

- Short duration varieties as mentioned in season and varieties including local land races suitable for those tracts.

Sowing

- Seed rate: 75kg/ha dry seed for any recommended variety.
- Seed hardening with 1% KCl for 16 hours (seed and KCl solution 1:1) and shade dried to bring to storable moisture. This will enable the crop to withstand early moisture stress.
- On the day of sowing, treat the hardened seeds first with *Pseudomonas fluorescens* 10g/kg of seed and then with *Azophos* 2000g or *Azospirillum and Phosphobacteria* @ 600g each per ha seed, whichever is available.
- Drill sow with 20 cm inter row spacing using seed drill.
- The seeds can also be sown behind the country plough.

- Depth of sowing should be 3-5 cm and the top soil can be made compact with leveling board.
- Pre-monsoon sowing is advocated for uniform germination.

After cultivation

- *Azospirillum* inoculants 10 packets (2000g/ha) and Phosphobacteria 10 packets (2000g/ha) or 20 packets (4000g/ha) of Azophos mixed with 25 kg of FYM may be broadcasted uniformly over the field just after the receipt soaking rain / moisture.
- Thinning and gap filling should be done 14-21days after sowing, taking advantage of the immediate rain
- Spray Cycocel 1000 ppm (1 ml of commercial product in one lit. of water) under water deficit situations to mitigate ill-effects.
- Foliar spray of Kaolin 3% or KCl 1% to overcome moisture stress at different physiological stages of rice.

Manures and fertilizer application

- Blanket recommendation : 50:25:25 kg NPK/ha
- Apply a basal dose of 750 kg of FYM enriched with fertilizer phosphorus (P at 25 kg/ha)
- Apply N and K in two equal splits at 20-25 and 40-45 days after germination.
- If the moisture availability from the tillering phase is substantial, three splits (25 kg N and 12.5 kg K at 20-25, 40-45 and 60-65 DAS) can be adopted.
- N at PI may be enhanced to 40 kg, if the tiller production is high (may be when the estimated LAI is greater than 5.0) and moisture availability ensured by standing water for 10 days.
- Basal application of $FeSO_4$ at 50 kg/ha is desirable for iron deficient soil.
- Foliar spray of 1% urea + 2% DAP + 1%KCl at PI and 10 days later may be taken up for enhancing the rice yield if sufficient soil moisture is ensured

Weed management

- First weeding can be done between 15 and 21 days after germination.
- Second weeding may be done 30-45 days after first weeding.
- Apply Pendimethalin 1.0kg/ha on 5 days after sowing or Pretilachlor + safener (Sofit) 0.45kg/ha on the day of receipt of soaking rain followed by one hand weeding on 30 to 35 days after sowing.

Harvesting: Same as that for wet rice cultivation

Yield: Grain yield levels vary widely depends on the moisture availability. Normally 50-75% of the normal can be obtained.

DRY SEEDED RAINFED UN-PUDDLED LOWLAND RICE WITH SUPPLEMENTAL IRRIGATION

It is called as **semi-dry rice**. Crop establishment is as that of rainfed rice but the rain water collected in village tank (Kanmai) is supplemented to protect the crop during peak vegetative and reproductive phases. Interaction between applied nutrients and crop is positive here due to better moisture availability than rainfed rice and hence, varieties may be improved ones and nutrient levels may be higher than the previous system.

Area

- Kanchipuram/Tiruvallur, Ramanathapuram, Sivaganga, Kanyakumari, Nagapattinam/ Tiruvarur and Pudukottai.

Seasons

- July to August - Kanchipuram, Tiruvallur, Kanyakumari
- August – Nagapattinam, Tiruvarur, Pudukottai
- September to October - Ramanathapuram, Sivaganga

Field preparation: Refer Rainfed rice.

Varieties

- Short duration varieties as mentioned in season and verities including local land races suitable for those tracts.
- Since there is supplemental irrigation high yielding improved short duration varieties can yield more yield than the land races.

Sowing, **After cultivation, Manures and fertilizer application, Weed management, Water management, Harvest:**

Refer rainfed rice.

DRY SEEDED IRRIGATED UN-PUDDLED LOWLAND RICE

It is also be called 'semi-dry rice'. It is a contingent plan to command areas, anticipating the release of water; rice crop can be established under rainfed condition up to a maximum of 45 days as that of previous two situations. Field is converted to wet condition on receipt of canal water. Conversion depends up on receipt of canal water and nutrient management is decided according to the period of irrigation.

Area: Tiruvarur and Nagapattinam districts

Season: *Samba / Thaladi* seasons command areas.

Field preparation: Refer Rainfed rice.

Varieties

- Medium duration varieties, if sown in August and short duration varieties beyond September, as mentioned in season and varities.
- Since there is assured irrigation from canal, high yielding improved short or medium duration varieties can be cultivated depending up on the situation (month of sowing, nearness to canal, depth of standing water during NEM etc).

Sowing, **after cultivation, Manures and fertilizer application, Weed management, Water management, Harvest:** Refer Rainfed rice.

DEEP WATER RICE

- Cultivation is like the methods described in this section except the harvest. Harvest may some times restricted only to panicle because of the standing water even after maturity.

DRY SEEDED UPLAND RICE

Area

- There are small batches in and around Dharmapuri district. Rainfall availability in these tract is better than the rainfed rice cultivated in other parts of Tamil Nadu. There is no bund to stagnate the water. Moisture availability is there but crop growth depends on the nutrient status.

Other cultural practices

- As recommended to semi-dry rice
- Nutrient may be split applied depending up on the growth.
- LCC based N application is more suitable for this tract.

Intercropping: Blackgram for every four rows of rice.

Grain yield: Grain yield depends up on the moisture availability and nutrient status.

TRANSPLANTED HYBRID RICE

Seed rate	20 kg/ha
Nursery	Basal application of DAP at 2 kg/cent of nursery area. Sparse sowing of seeds at one kg/cent of nursery area will give robust seedlings with 1-2 tillers per seedling at the time of planting. If the soil is heavy, apply 4 kg gypsum/cent of nursery area, 10 days before pulling of seedlings.
Age of seedling	20 to 25 days
Spacing (cm)	20 x 10 (50 hills/m^2) or 25 x 10 (40 hills/m^2) according to soil fertility
Seedlings/ hill	One (along with tillers if already produced)
Fertilizer	175:60:60 kg NPK/ha

- **Other package of practices:** Same as in transplanted rice.

SYSTEM OF RICE INTENSIFICATION (SRI) CULTIVATION

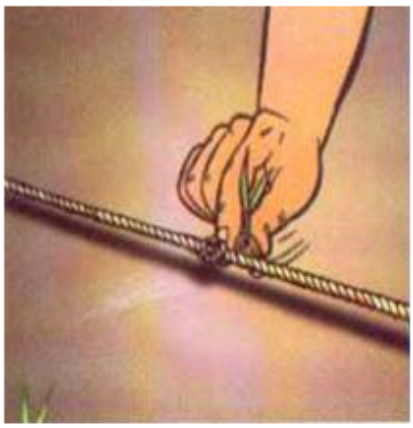
Season

- Dry season with assured irrigation is more suitable.
- Difficulty in crop establishment may be seen in areas with heavy downpour (North east monsoon periods of Tamil Nadu)

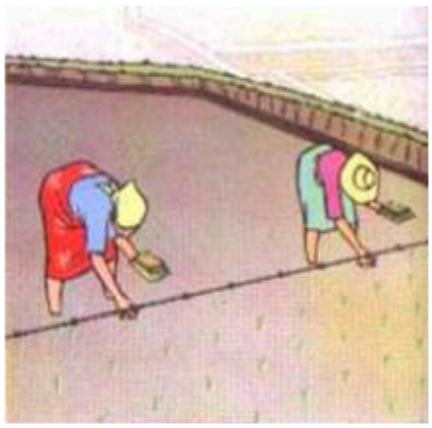
Varieties: Hybrids and varieties with heavy tillering.

Components of System of Rice Intensification (SRI) Cultivation

Young Seedling
(14 days old)



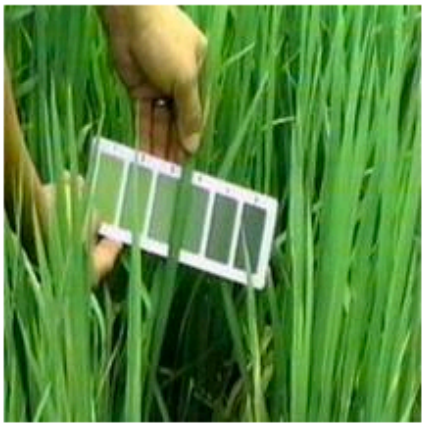
Single Seedling/hill



Square Planting

Weeding by Cono Weeder

Alternate Wetting & Drying



LCC based N Management

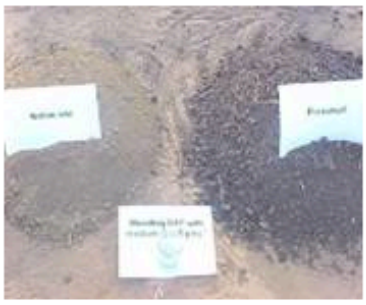
NURSERY

Seed rate: 7- 8 kg for single seedling/hill.

Preparation of nursery area

Prepare 100 m^2 nursery to plant 1 ha area. Select a leveled area near the water source. Spread a plastic sheet or used polythene gunny bags on the shallow raised bed to prevent roots growing deep into soil.

Nursery Management



Soil Mixture

Blending Soil Mixture

Wooden Frame

Filling the Wooden Frame

Sowing Sprouted Seeds

Lifting Seedlings

Lifting Seedling Mat

Preparation of soil mixture: Four (4) m^3 of soil mix is needed for each 100 m^2 of nursery. Mix 70% soil + 20% well-decomposed pressmud / bio-gas slurry / FYM + 10% rice hull. Incorporate in the soil mixture 1.5 kg of powdered di-ammonium phosphate or 2 kg 17-17-17 NPK fertilizer.

Filling in soil mixture: Place a wooden frame of 0.5 m long, 1 m wide and 4 cm deep divided into 4 equal segments on the plastic sheet or banana leaves. Fill the frame almost to the top with the soil mixture. Pre-germinating the seeds 2 days before sowing: Soak the seeds for 24 hr, drain and incubate the soaked seeds for 24 hr, sow when the seeds sprout and radical (seed root) grows to 2-3 mm long.

Sowing: Sow the pre-germinated seeds weighing 90-100 g/m^2 (100g dry seed may weigh 130g after sprouting) uniformly and cover them with dry soil to a thickness of 5mm. Sprinkle water immediately using rose can to soak the bed and remove the wooden frame and continue the process until the required area is completed.

Watering: Water the nursery with rose-can as and when needed (twice or thrice a day) to keep the soil moist. Protect the nursery from heavy rains for the first 5 DAS. At 6 DAS, maintain thin film of water all around the seedling mats. Drain the water 2 days before removing the seedling mats for transplanting.

Spraying fertilizer solution (optional): If seedling growth is slow, sprinkle 0.5% urea + 0.5% zinc sulfate solution at 8-10 DAS.

Lifting seedling mats: Seedlings reach sufficient height for planting at 15 days. Lift the seedling mats and transport them to main field.

MAIN FIELD PREPARATION

- Puddled lowland prepared as described in transplanted rice.
- Perfect leveling is a pre-requisite for the water management proposed hereunder

Mainfield

Square Planting

Transplanted Young Seedling

Transplanting

- Single seedling of 15 days old.
- Square planting of 25 x 25 cm.
- Fill up the gaps between 7 and 10 DAT.
- Transplant within 30 minutes of pulling out of seedlings.

Irrigation management

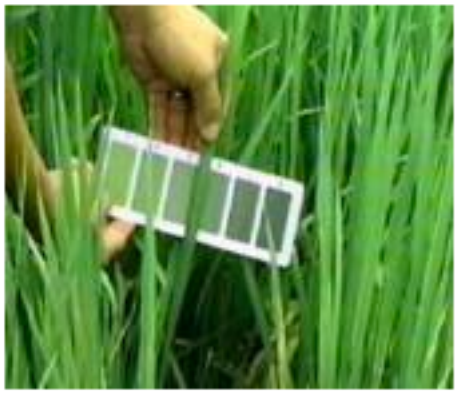
- Irrigation only to moist the soil in the early period of 10 days
- Restoring irrigation to a maximum depth of 2.5cm after development of hairline cracks in the soil until panicle initiation

- Increasing irrigation depth to 5.0cm after PI one day after disappearance of ponded water

Weed management

- Use rotary weeder / Cono weeder
- Moving the weeder with forward and backward motion to bury the weeds and as well to aerate the soil at 7-10 days interval from 10-15 days after planting on either direction of the rows and column.

Nutrient Management



LCC based N Management

Grown up System of Rice Intensification (SRI) field

Nutrient managements

- As per transplanted rice.
- Use of Leaf colour chart (LCC) has more advantage in N management.

N management through LCC

- Time of application is decided by LCC score
- Take observations from 14 DAT in transplanted rice or 21 DAS in direct seeded rice.
- Repeat the observations at weekly intervals up to heading
- Observe the leaf colour in the fully opened third leaf from the top as index leaf.
- Match the leaf colour with the colours in the chart during morning hours (8-10 am).
- Take observation in 10 places.
- LCC critical value is 3.0 in low N response cultures like 'White ponni' and 4.0 in other cultivars and hybrids.
- When 6/10 observations show less than the critical colour value, N can be applied @ 35kg N/ha in dry season and 30kg N/ha in wet season per application.
- Green manure and farm yard manure application will enhance the growth and yield of rice in this system approach.

Other package of practices as recommended to transplanted rice

GENETICALLY MODIFIED RICE

This types of rice that have been genetically modified for agricultural purposes. The rice genome is usually modified using particle bombardment via the use of a gene gun or more commonly, a process known as agro-bacterium mediated transformation. Rice plants can be modified in DNA to be herbicide resistant, resist pests, increase grain size, generate nutrients, flavours or even produce human proteins. The natural movement of genes across species, often called horizontal gene transfer or lateral gene transfer, can also occur with rice through gene transfer mediated by natural vectors. The cultivation and use of genetically modified varieties of rice is however controversial and not legal in some countries.

Herbicide resistant varieties

Some companies introduce herbicide resistance in the non-target crop so as to make their herbicides more effective on their targets. Most traditional herbicides work on dicotyledons and do not work on grasses. The incorporation of herbicide resistance in cereal crops allows the use of broad-spectrum herbicides that work on all undesirable plants including monocotyledonous weeds. Monsanto conducts research on rice that can tolerate glyphosate (active ingredient in the herbicide with trade name of "Roundup") to produce "Roundup Ready rice". Bayer's line of herbicide resistant rice is known as Liberty Link. Bayer crop science is currently attempting to get their latest variety (LL62) approved for use in the EU.

Nutritional value (Golden rice)

Half of the world population's main food source is rice. In Asia, white rice is eaten three times a day. The main concern about white rice is that it has insufficient concentrations of vitamin A. It has been suggested that rice could be fortified to reduce the level of nutritional vitamin A deficiencies. Golden rice was originally created by Dr. Ingo Potrykus and his team in Zurich, Switzerland. This genetically modified rice is capable of producing beta-carotene in the endosperm (grain) which is a pre cursor for vitamin A production. In addition, Golden rice had increased iron content. Potrykus's goal is to distribute the rice to poor countries whose citizens suffer blindness and even death from a lack of vitamin A. Currently, the company SynGenta owns the license for commercial distribution of golden rice.

Pest resistance

BT rice is modified to express the cryIA(b) gene of the *Bacillus thuringiensis* bacterium. The gene confers resistance to a variety of pests including the rice borer through the production of endotoxins. The Chinese Government is currently doing trials on insect resistant cultivars. The benefit of this is that the farmers did not need to spray their crops to control fungal, viral, or bacterial pathogens. In comparison, conventional rice is sprayed three to four times per growing season to control pesticides.