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Early production of robust seedlings through modified mat nursery for enhancing rice (*Oryza sativa*) productivity and profit

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ABSTRACT

A modified rice (*Oryza sativa* L.) mat nursery was developed at the Soil and Water Management Research Institute (SWMRI), Thanjavur, India. It produced robust seedlings in 15 days after sowing (DAS) that were similar in size as that of 25 to 30 days old seedlings produced in traditional nursery. Seedling mats could be easily transported and easily separated. The modified rice mat nursery could save the cost on seed, water and labour and thereby an overall saving of cost by about 50% was achieved. Soil + pressmud mixture (1:1 w/w) produced the most vigorous seedlings in 15 days, recording the maximum seedling height (20.8 cm), root length (9.9 cm), leaves/seedling (4.2) and seedling-vigour index (8.2). Soil alone or 90% soil + 10% rice husk mixture also produced healthy seedlings. Other organic manures can be used for mat nursery provided it is fully decomposed and well mixed with soil. Seedlings of 15 days age when planted gave 16–20% higher yield than the rice crop planted with 25 days old seedlings of traditional wet nursery.

Key words : Modified rice mat nursery, Young seedling, Productivity, Profitability

Integrated Crop Management for rice (ICM-R) has modified certain crop-management practices of the system of rice intensification (SRI) developed in Madagascar. It is a selective combination of crop management options like young (14 days to 15 days) seedlings, wider spacing mechanical weeding and soil stirring by a rotating hoe, intermittent irrigation, and integrated use of organic and inorganic sources of nutrients. Use of young seedlings is fundamental and assumes more significance in ICM-R. According to Herrera and Zandstra (1980), old seedlings mature later because of the delayed formation of tillers and longer time to recover from transplanting shock. Planting of 15 days old seedlings at 1/hill gave higher rice yield than 21 days old seedlings in North Samatra, Indonesia (Makarim *et al.,* 2002). In the traditional wet-bed nursery, seedlings do not attain the expected size (15 to 20 cm height) even at 25–30 days after seeding (DAS) because of high seeding rate and poor nursery management. In Tamil Nadu, the seed rate adopted by farmers for wet-bed nursery is as high as 80 to 100 kg/800 m^2 nursery area to plant 1 ha, and the resultant seedlings are naturally thin and delicate. This is the reason we decided to develop the modified rice mat nursery (MRMN) by using good seed, low seed rate, thin sowing (50 to 100 g seed/m^2) and adequate nutrient management to produce sturdy seedlings within 14 or 15 days.

MATERIALS AND METHODS

Development of modified rice mat nursery

The management techniques for the mat nursery were standardized by non-replicated preliminary trials at the SWMRI Farm, Thanjavur, India, during 2002–2003.

Selection of suitable medium: Various organic materials like pressumud (a by-product from sugarcane industry), farmyard manure of cattle manure, composted coir pith, soil + gypsum or rice hull ash were evaluated. Among the media tried, 4-cm thick pressmud mat @ 18 kg/m mat nursery) produced good seedlings. The visual rate of scoring was also good for the seedlings raised in pressmud medium in terms of foliage colour, seedling vigour, and seedling sturdiness. About 1,800 kg pressmud is required to raise 100 m^2 mat nursery required for planting 1 ha main field.

Thickness of mat nursery: The height or thickness of the medium plays a key role for proper root and shoot development. The 4-cm thick medium was found to be adequate to produce healthy robust seedlings in 15 days.

Lining for spreading the medium: Polyethylene lining was found to be ideal and economical at a cost of about Rs 300.00 (US$ 6.60)/100 m^2 mat nursery. If carefully

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handled, the polyethylene sheet can be reused for 2 to 3 seasons. The use of dried banana leaves is eco-friendly, but it is highly labour intensive on collection, transportation, and spreading.

Seed rate: The seed rate of 5 kg/100 m² mat nursery was sufficient to transplant 1 ha with seedling/hill. The seed rate was worked out assuming the use of clean quality seed having the germination percentage of not less than 90% and 1,000 grain weight of 16 g, square planting at 22.5 cm × 22.5 cm spacing with single seedling per hill.

Nutrient management : (a) The seed-bed medium blended with well-powdered DAP @ 0.5 g/kg medium produced the healthy, robust and tall seedlings compared to the medium blended with bio-fertilizer mixture; (b) drenching of 0.5% urea solution at 9 DAS was found to give better seedling growth than drenching with 0.5% DAP.

For preparing the mat nursery, selection of suitable medium is critical. Considering the bulky nature of pressmud and the high cost involved in collection and transportation to the nursery site, we decided to test soil alone and soil + organic materials to prepare the medium for the nursery.

Trial I

The field experiment on mat nursery was conducted at the Soil and Water Management Research Institute (SWMRI), Thanjavur, and Tamil Nadu Rice Research Institute (TRRI), Aduthurai, Tamil Nadu, India, during February-March 2003. The experimental design used was randomized block with 7 treatments and 3 replictions. The treatments were: (i) sole pressmud, (ii) sole farmyard manure (FYM), (iii) sole field soil, (iv) soil + pressmud mixture at 1:1 (w/w), (v) soil + FYM mixture at 1:1 (w/w), (vi) soil + pressmud mixture at 2:1 (w/w), and (vi) soil + FYM mixture at 2:1 (w/w). The plot (nursery bed) size was 1.5 m². The seed-bed medium blended with well-powdered DAP was poured inside a pre-fabricated wooden frame placed over the polyethylene layer (as mentioned above). The pre-germinated seeds of rice variety 'ADT 43' were sown on 26 February 2003 @ 5 kg dry seed/100 m² (equal to 50 dry seed or 100 g wet seed/m²). The seeds were properly covered with the medium and gently pressed with hand; then water was sprinkled uniformly to saturate the medium. The seed frame was carefully removed and the sowing process was continued till the required area was sown. The mat nursery was watered 2–3 times a day up to 5 DAS. After the 5th day, water was let in between the mat nursery beds to keep the beds soaked. At 9 DAS, 0.5% urea solution was sprinkled on seedlings. Water was drained 2 days prior to lifting and transportation of seedling mats to the main field for transplanting. Ten random seedlings were lifted carefully on 12 March 2003. Root length was measured from the origin of root to the tip of the longest root and the seedling height from the point of origin of shoot up to the tip of the finally emerged leaf. The seedling vigour index was calculated using the formula of Abdul-Baki and Anderson (1973).

Seedling = Seedling dry weight (g) × % germination of seed vigour index

Trial II

The trial II was designed based on the observations of Trial I and conducted during May 2003 at the TRRI farm, Aduthurai, only. It had 4 treatments arranged in randomized block design with 5 replications. The treatments were (i) soil alone, (2) 70% soil + 20% FYM + 10% rice husk, (iii) soil + pressmud (1:1 w/w), and (4) 90% soil + 10% rice husk. The rice variety 'ADT 43 was sown on 2 May 2003. The nursery management practices and recording of observations were similar to that of Trial I. The seedlings were pulled out on 16 May 2003 for observations.

Productivity of rice

Fifteen days old young seedlings of modified rice mat nursery were test varified with 25 days old traditional wet nursery seedlings for assessing the productivity at the TRRI, Aduthurai, and the SWMRI, Thanjavur, situated in the old and new Cauvery Delta Zone of Tamil Nadu, India, during wet season 2002–03. The variety 'ADT R 45' (110 days) was transplanted under the improved ICM-R and traditional method of rice cultivation. Number of panicles was recorded from 1 m² area at randomly selected spots in each treatment plot. Grain yield from a 5 m² net plot was recorded and expressed at 14% moisture content. The cost of cultivation and gross return were worked out and the benefit : cost ratio was derived from dividing the gross return by cost of cultivation for each treatment.

RESULTS AND DISCUSSION

Seedling growth

Rice seedlings grown with soil + pressmud (1:1 w/w) exhibited the best seedling characteristics (Table 1), with root length 9.9 cm, seedling height 20.8 cm, and tillers/seedling 0.7. Soil alone treatment produced seedlings of similar stature as that of soil + pressmud (1:1 w/w). Maximum leaf length was 13.7 cm for seedlings grown in soil alone treatment in contrast to 12.2 cm for soil + pressmud (1:1 w/w) medium. The seedling vigour index was 6.1 for soil + pressmud (1:1 w/w), followed by pressmud alone (5.4) and soil alone (5.2) treatment. Seedlings were stunted with yellowish green to scorched leaves in media with FYM, probably due to some toxicity. This observa-

Table 1. Growth characteristics of 15 days old rice seedlings of modified mat nursery, SWMRI, Thanjavur and TRRI, Aduthurai Farm, Tamil Nadu, India, February–March 2003.

Treatment	SWMRI, Thanjavur					TRRI, Aduthurai				
	Root length (cm)	Seeding height (cm)	No. of leaves/ seedling	Leaf length (cm)	Seedling vigour index	Root length (cm)	Seedling height (cm)	No. of leaves/ seedling	Leaf length (cm)	Seedling vigour index
T_1, Soil alone	5.7	20.5	4.5	13.7	5.2	6.7	21.0	4.1	12.4	5.8
T_2, Pressmud alone	9.7	18.3	5.0	11.0	5.4	7.1	19.0	4.6	11.5	6.0
T_3, FYM alone	4.7	14.3	3.0	8.7	4.0	5.1	12.9	3.4	9.1	5.6
T_4, Soil + pressmud (2:1 w/w)	6.6	17.6	5.2	12.2	5.2	8.0	18.2	4.3	12.0	6.1
T_5, Soil + FYM (2:1 w/w)	5.3	14.5	3.4	9.2	4.9	5.9	15.8	3.9	12.7	5.9
T_6, Soil + pressmud (1:1 w/w)	9.9	20.8	4.2	12.9	6.1	10.4	21.6	4.5	13.1	6.4
T_7, Soil + FYM (1:1 w/w)	5.5	16.7	3.8	9.2	4.3	6.4	17.0	4.1	9.4	5.6
LSD (P=0.05)	1.8	3.0	1.3	1.7	NA	0.6	0.6	0.1	0.5	0.5

SWMRI, Soil and Water Management Research Institute; TRRI, Tamil Nadu Rice Research Institute
NA, Not statistically analysed

tion indicates that FYM is not suitable for mat nursery. Other organic manures, if used for mat nursery, must be fully decomposed and mixed well with the soil. If poorly decomposed manure is not used, seedlings will turn yellow and die due to toxicity in the medium.

In the revised second trial conducted at the TRRI, Aduthurai, seedlings grown in soil + pressmud (1:1 w/w) medium produced the longest roots (7.5 cm), with seedling height of 17.0 cm and seedling vigor index of 8.2. The root length was 6.0 cm in soil + rice husk medium with the seedling vigour index of 6.1 followed by soil alone treatment (Table 2). Thus, soil + pressmud and soil + rice husk were found suitable for mat nursery to produce robust and healthy seedlings in 15 days. Here again, the medium with

Table 2. Growth characteristics of 15 days old rice seedlings of modified mat nursery, SWMRI farm, Thanjavur, India, May 2003

Treatment	Root length (cm)	Seedling height (cm)	No. of leaves/ seedling	Seedling vigour index
Soil alone	5.7	15.7	3.6	5.6
Soil 70% + farmyard manure 20% + rice husk 10%	3.8	11.5	3.3	4.0
Soil 50% + pressmud 50%	7.5	17.0	3.9	8.2
Soil 90% + rice husk 10	6.0	14.1	3.8	6.1
LSD (P=0.05)	0.8	1.1	0.5	NA

N.A., Not statistically analysed

FYM had stunted seedlings with yellowish leaves. Thus, it is better to avoid FYM for preparing mat nursery.

Economic of mat nursery

The economics of raising modified rice mat nursey in comparison with conventional rice wet nursery is given in Table 3. In addition to the benefits of limited land and water use, the modified rice mat nursery reduces the cost of seedling production by about Rs 1,600 (35 US $) to plant 1 ha) field. Modified rice mat nursery reduced the cost on seed by 85–90%, fertilizer by 90%, labour by 34% and water use by 55%. There was an overall cost saving of 50% under modified rice mat nursery as compared to the conventional wet nursery.

Rice productivity and profitability

Transplanting of young (15 days) seedlings recorded the highest number panicles (452/m^2 and 424/m^2) at the TRRI and the SWMRI respectively. Similarly, young seedlings registered the highest grain yield (7,061 kg/ha and 6,583 kg/ha), representing an increase of 20% and 16% over 25 days old traditional nursery seedlings (Table 4). Randriamibarisoa and Uphoff (2002) reported a yield increase of 1.4–2.5 tonnes/ha due to young seedling effect under SRI method of planting. Singh and Bhattacharya (1976) also reported a reduced tiller production from planting aged rice seedlings. Production of rice seedlings under modified mat nursery and transplanting young and healthy seedlings under the ICM-R increased the profitability through reduced cost of cultivation (in the nursery) and enhanced productivity. Transplanting of young seedling thus, recorded the maximum benefit : cost of 3.2 and 2.7 at Aduthurai and Thanjavur, respectively, compared to the traditional method of cultivation using aged seedlings.

Generally, rice varieties are sensitive to the age of seedlings at the time of transplanting. In careful consideration of this fact, we have developed a modified mat nursery to produce young, robust, and healthy seedlings in 15 days. Soil alone or soil + rice husk mixture (9:1 w/w) or soil +

Table 3. Economics of rice seedling production in modified mat nursery in relation to traditional wet nursery to transplant 1 ha main field

Input	Detail	Modified rice mat nursery (MRMN)	Traditional rice nursery (TRN)	Differential cost and in kind saving for MRMN	% saving in MRMN over TRN	Remarks
Land	a. Recommended area	100 m^2	800 m^2	–700 m^2	87.5	The MRMN can be raised conveniently in any place having water and drainage facility
Seed	a. Recommended seed rate b. Farmer's adoption/field	5–10 kg/100 m^2 to plant 1 ha 10–15 kg/100 m^2 to plant 1 ha	60 kg/800 m^2 to plant 1 ha 100 kg/800 m^2 to plant 1 ha			For a variety with 16 g 1,000-grain weight; other varieties with heavier grains will require 50–60 % higher seed rates
	c. Total seed cost @ Rs 11.50/kg(Rs)	115 to 173	1,150	–978 to 1,035	85.0–90.0	
Fertilizer	a. Recommended DAP (in TN, India) b. Adoption by farmers/researchers on field	1.875 kg for 100 m^2 nursery 2 kg for 100 m^2 nursery	40 kg for 800 m^2 nursery 20 kg for 800 m^2 nursery			
	c. Total nursery fertilizer cost @ Rs 9.20/kg	18	184	–166	90.0	
Water	Total water requirement for nursery	18.0 m^3/0.75= 24.0 m^3	26.5 m^3/05= 53.0 m^3	–29.0 m^3	55.0	Water application efficiency is taken as 75% for MRMN and 50% for CRN
Labour	a. Total labour (land preparation to pulling out seedling)	3 men+21 women	21 men+5 women			
	b. Total labour + tiller cost @ Rs 70/day for men, Rs 50/day for women labour and Rs 200 for power tiller	1,214	1,840	–626	34.0	It is possible to avoid the use of men labour in MRMN
Materials	Cost of plastic sheet (100 m^2), wooden frame, sprinkler can, etc.	193	--	+193	NIL	Locally made leaf mats, used sacs, or similar materials can be used as base for MRMN. New plastic sheets can be used for 2 seasons minimum; hence 50% of the cost alone is included, cost of wooden frme, sprinkling can are shared over years
	Total cost	1,540 to 1,600	3,175	–1,575 to 1,635 (US $ 34 to 35)	49.6 to 51.5	Excluding the savings in land and water use (Exchange rate Rs 46/US $)

Table 4. Effect of seedling age on productivity and profitability of rice, SWMRI, Thanjavur, and TRRI, Aduthurai Farm, Tamil Nadu, India, wet season (2002–03).

Treatment (seedling) age)	TRRI, Aduthurai			SWMRI, Thanjavur		
	Panicles m^2	Grain yield (kg/ha)	Benefit : ratio	Panicles/m^2	Grain yield	Benefit : ratio
Traditional nursery (25 days)	377	5874	2.6	344	5,557	1.9
Modified mat nursery (15 days)	452	7,061 (20)	3.2	424	6,583 (16)	2.7
LSD (0.5%)	25	163	N.A.	21	121	N.A.

N.A., Not statistically analyzed

*% increase in rice grain yield by panting young seedlings over aged (traditional) seedlings is given in parentheses,

pressmud mixture (1:1 w/w) can serve as the medium for the mat nursery. The seedlings reach a height of 18–20 cm with 4–5 leaves in 15 days. Modified mat nursery saves costs on seed (85–90%), fertilizer (90%), labour (34%) and water (55%) compared to the traditional rice wet nursery. The young seedlings of modified rice mat nursery outyielded the aged traditional nursery seedlings and achieved the maximum benefit : cost ratio. It is therefore highly economical and affordable to farmers. Mat nursery is especially suitable for rainfed lowland rice areas where it can be started when the main field is flooded and ready for land preparation.

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