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Growth parameters and economics of rice varieties under aged seedling transplantation in north coastal Andhra Pradesh

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Abstract

A field experiment was conducted on sandy loam soil at the college farm of Agricultural College, Naira, Srikakulam to study the yield and yield attributes of old aged seedlings as influenced by different varieties in a split-plot design, comprised of three age of seedlings (30, 45 and 60 days old) assigned to main Plots and eight varieties (V₁: MTU-7029, V₂: BPT-5204, V₃: MTU-1061, V₄: MTU-1121, V₅: MTU-1223, V₆: MTU-1224, V₇: MTU-1262 and V₈: RGL-2537) were assigned to sub plots. Among the three age of seedlings for transplanting, planting of 30 days seedlings proved superior by recording higher growth parameters and economic returns compared to planting of 45 days and 60 days old seedlings. Among the varieties tested, the higher growth parameters and economic returns was noticed with MTU-1223 followed by RGL-2537 and MTU-1224.

Keywords: Age of seedlings, varieties, growth parameters, economic returns

Introduction

India must increase its annual grain output to 120 million tons by 2025 from the current 108.32 million tons to sustainably feed its rapidly growing population of 1.5 billion people (Ministry of Agriculture and Farmers Welfare, 2022-23) ^[10]. Rice (*Oryza sativa* L.) is predominantly a *kharif* season crop and is the most important food crop cultivated across India, contributing to over 40 per cent of total food grain production. Although, India ranked 1st in area and 2nd in production but struggling to have notable productivity among rice-growing countries. Rice is one of the most important food crops in the North coastal Andhra Pradesh (Srikakulam, Vizianagaram and Vishakhapatnam), with 3.20 lakh hectares of the actual area mostly sown during *kharif* (Directorate of Economics and Statistics, A.P, 2023) ^[11] with an average production of 3850 kg ha⁻¹ per year, which is conspicuously lesser crop productivity compared to both state and national level. Planting of *kharif* rice crop closely follows the onset of southwest monsoon in June/July and its subsequent progress through September to augment the water requirement at critical crop growth stages. Optimum window for nursery sowing and transplanting is critical for achieving higher grain yield. Rice grown after optimum planting window usually suffers from slow growth and poor crop stand and is prone to pests and diseases. Sah *et al.* (2023) ^[6] also reported that seeding age at transplanting is one of the most important factors that substantially regulate potential agronomic traits, i.e. tillering, panicle number and grain yield per unit of the land area. In North-Coastal Andhra Pradesh, most of the rice-growing area is under uncertain irrigation systems. Whenever monsoon is delayed, farmers are compelled to transplant rice late in the season with over-aged seedlings due to late release of canal water. Delayed transplanting usually extends the growth of seedlings in seedbed and shortens their growth period in main field which results in reduction in yield. Therefore, under such unavoidable circumstances, farmers are to be insured against yield loss by identifying rice varieties which can produce satisfactory yield even when transplanted overage seedlings. Hence, it is felt pertinent to evaluate recently released high-yielding rice varieties for their suitability under delayed transplanting conditions with over-age seedlings in the north coastal districts of Andhra Pradesh.

Materials and Methods

A field experiment was conducted on sandy loam soil at the college farm of Agricultural College, Naira, Srikakulam to study the yield and yield attributes of old aged seedlings as influenced by different varieties in a split-plot design, comprised of three age of seedlings (30, 45 and 60 days old) assigned to main Plots and eight varieties (V₁: MTU-7029, V₂: BPT-5204, V₃: MTU-1061, V₄: MTU-1121, V₅: MTU-1223, V₆: MTU-1224, V₇: MTU-1262 and V₈: RGL-2537) were assigned to sub plots. All the recommended packages of practices were followed to raise a good crop. Nursery field was thoroughly puddled and well levelled. The entire field area was demarcated into 24 plots each of size 3 m² (3 m×1 m) and individual plots were separated by bunds for 3 different aged seedlings of 30, 45 and 60 days respectively. The seed of eight varieties under investigation i.e., MTU 7029, BPT 5204, MTU-1061, MTU-1121, MTU-1223, MTU-1224, MTU-1262 and RGL-2537 were soaked in water for 24 hours, drained and incubated in moist gunny bags for 36 hours. The sprouted seeds were broadcasted uniformly over the well-prepared seedbeds. A fertilizer dose of 1.5: 0.5: 0.5 kg N, P₂O₅ and K₂O per 100 m² was applied as basal dose. The seedlings were uprooted according to the treatments and transplanted in the main field.

The plots were irrigated with a 2.5 cm depth of water and irrigated again on the appearance of hair line cracks on the soil surface. This practice was continued till the flowering stage of the crop. Nitrogen as Urea was applied in two splits i.e., 70% at the time of transplanting, and 30% at an active tillering stage in the subplots as N @ 150 kg ha⁻¹ and N @ 120 kg ha⁻¹. As per the treatments in the subplot, the entire quantity of phosphorus as a Single Super Phosphate was applied at the time of final puddling and potassium was applied in two splits, 50% at the time of transplanting and the remaining 50% at panicle initiation. The split pot design, developed by Fisher (1925) [12] was used to compile and analyse the collected data, consisting of both pre and post-harvest observations. Critical differences were determined for those parameters that were found to be statistically significant ($p < 0.05$) to compare the impact of the various treatments.

Results and Discussion

Plant height (cm)

Data pertaining to plant height of rice sampled at three stages viz., Active tillering, Panicle initiation and harvest are presented in table 1. Perusal of the data revealed that age of seedlings at the time of transplanting as well as varieties were found to exert a progressive and significant influence on plant height of rice at all the three stages of sampling. However, the interaction affect between the age of nursery and varieties was found to be absent. As regards plant height of rice, age of seedlings was found to influence this parameter to a statistically detectable magnitude at all the three stages viz., Active tillering, Panicle initiation and harvest. Throughout the crop growth, the tallest plants were noticed when rice seedlings transplanted at 30 days age which was however, found parity with 45 days old seedlings. Significantly shorter plants were noticed with 60 days old seedlings which was however on par with 45 days old seedlings at Active tillering. Significantly taller plants observed at all the three stages of sampling in plots which were transplanted with the youngest seedlings and the plant height was decreased with increase in age of seedlings at transplanting, might be due to the fact that the younger seedlings with large meristematic tissue activity resulting in greater mitosis to contribute to stem elongation. Further, higher phyllochrone production in younger

seedlings together with less pulling shock due to confinement of fibrous root system to shallow depths compared to old aged seedlings also might have contributed to greater plant height. Sah *et al.* (2023) [6] and Singh *et al.* (2023) [3, 4] also expressed similar views with respect to recording greater plant height in younger seedlings compared to aged ones

With regards to the influence of varieties on plant height of rice, marked differences were observed among the rice varieties tested at all the three stages viz., Active tillering, Panicle initiation and harvest. Throughout the crop growth, the plant height was found to be the highest with RGL-2537 which was however showed statistically parity with MTU-1061. The shortest stature was noticed in MTU-7029 which was however, comparable with MTU-1224. Statistically detectable disparities in plant height noticed among the varieties tried could be attributed to the genetic makeup of the individual cultivar, resultant of parentage. These findings are in corroboration with those reported by Nawaz and Khan (2023) [13].

Table 1: Plant height (cm) of rice at different stages as influenced by age of seedlings and varieties

Treatments	Active tillering	Panicle initiation	Harvest
Age of seedling(A)			
A ₁ : 30 days	75.86	84.15	117.67
A ₂ : 45 days	73.41	81.45	112.33
A ₃ : 60 days	70.53	77.98	102.96
SEm (±)	0.91	1.17	1.83
CD (P=0.05)	3.56	4.59	7.17
CV (%)	6.07	7.06	8.06
Variety (V)			
V ₁ : MTU-7029	60.24	70.02	93.56
V ₂ : BPT-5204	70.78	78.04	115.67
V ₃ : MTU-1061	80.78	88.98	119.33
V ₄ : MTU-1121	80.27	82.11	106.67
V ₅ : MTU-1223	76.89	82.47	114.00
V ₆ : MTU-1224	63.38	75.86	101.11
V ₇ : MTU-1262	70.73	82.26	115.00
V ₈ : RGL-2537	83.07	89.83	122.56
SEm (±)	1.81	2.05	2.66
CD (P=0.05)	5.16	5.86	7.60
CV (%)	7.40	7.59	7.19
Interaction			
SEm±	3.13	3.56	4.68
CD (P=0.05)	NS	NS	NS

Leaf area index

Leaf area index of rice computed at various growth stages viz., active tillering, panicle initiation and flowering are presented in table 2. Statistically detectable disparities were noticed in LAI of rice due to age of nursery at transplanting and different varieties tried. However, the interaction affect between the age of nursery and varieties was not statistically detectable.

LAI of rice altered statistically due to differences in the age of nursery at transplanting at various growth stages viz., active tillering, panicle initiation and flowering. Significantly higher leaf area index values were noticed when rice seedlings were transplanted at 30 days age, and was gradually decreased with increasing age of seedlings at transplanting, recorded the lowest with 60 days old seedlings. Larger LAI values observed with comparatively younger seedlings at different stages of rice crop growth might be the result of higher phyllochrone production leading to more number of leaves per culm and more culms per hill as they spend less time in crowded nursery and more time in the main field under relatively better growing ambience when

compared to aged seedlings. Singh *et al.* (2023)^[3, 4] and Sabil *et al.* (2023) also reported similar findings.

With regards to the influence of varieties on LAI of rice at active tillering, marked differences were observed among the rice varieties tested. Leaf area index was found to be the highest in MTU-7029 which was however, comparable with MTU-1223. Significantly lower values of LAI was observed in BPT-5204 which was however, statistically comparable with MTU-1061, MTU-1121, MTU-1224, MTU-1262 (V₇) and RGL-2537 (V₈).

Leaf area index at panicle initiation stage exerted statistically measurable influence on the Leaf area index of the rice due to different varieties. Leaf area index was found to be the highest with MTU-7029 which was however, found on par with MTU-1121 and MTU-1262. Leaf area index was found to be the lowest in BPT-5204 which was however, comparable with MTU-1061, MTU-1121, MTU-1223, MTU-1224, MTU-1262 and RGL-2537.

Leaf area index of rice at flowering was found to be the highest with MTU-7029 (V₁) which was however, comparable with MTU-1061 (V₃), MTU-1121 (V₄) and MTU-1223 (V₅). Significantly lesser LAI values were observed with BPT-5204 (V₂) which was however, found statistical parity with V₄ (MTU-1121), V₅ (MTU-1223), V₆ (MTU-1224), V₇ (MTU-1262) and V₈ (RGL-2537).

Among different varieties tried, significantly higher LAI values associated with MTU-7029 (V₁) at different stages of computation could be attributed profuse tillering and leaf production ability of this variety besides wider leaf lamina, a typical genotypic character of MTU-7029. Nawaz and Khan (2023)^[13] also reported similar results

Table 2: Leaf Area Index of rice at different growth stages as influenced by age of seedlings and varieties

Treatments	Active tillering	Panicle initiation	Flowering
Age of seedling (A)			
A ₁ : 30 days	1.44	3.10	4.90
A ₂ : 45 days	1.32	2.71	4.59
A ₃ : 60 days	1.22	2.42	4.15
SEm (±)	0.02	0.06	0.07
CD (P=0.05)	0.07	0.24	0.27
CV (%)	6.88	10.75	7.49
Variety (V)			
V ₁ : MTU-7029	1.42	3.04	4.85
V ₂ : BPT-5204	1.25	2.60	4.31
V ₃ : MTU-1061	1.33	2.73	4.72
V ₄ : MTU-1121	1.32	2.83	4.60
V ₅ : MTU-1223	1.37	2.70	4.58
V ₆ : MTU-1224	1.32	2.60	4.42
V ₇ : MTU-1262	1.33	2.79	4.51
V ₈ : RGL-2537	1.27	2.66	4.38
SEm (±)	0.03	0.09	0.11
CD (P=0.05)	0.09	0.27	0.32
CV (%)	7.13	10.28	7.37
Interaction			
SEm±	0.05	0.16	0.19
CD (P=0.05)	NS	NS	NS

Total number of tillers m⁻²

The data pertaining to total number of tillers m⁻² recorded at Active tillering, Panicle initiation and Flowering are presented in table 3. Perusal of the data revealed that there was a gradual increase in total number of tillers m⁻² from active tillering to panicle initiation stage and a slight decrease at flowering due to age of nursery at transplanting as well as different varieties tried. Total number of tillers m⁻² in rice recorded at Active tillering,

Table 3: No of tillers m⁻² of rice at different stages as influenced by age of seedlings and varieties

Treatments	Active tillering	Panicle initiation	Flowering
Age of Seedlings (A)			
A ₁ : 30 days	465	511	467
A ₂ : 45 days	404	442	384
A ₃ : 60 days	288	343	303
SEm (±)	7.16	7.68	4.85
CD (P=0.05)	28.12	30.16	19.06
CV (%)	9.09	8.71	6.12
Varieties :			
V ₁ : MTU-7029	391	422	379
V ₂ : BPT-5204	331	381	352
V ₃ : MTU-1061	333	436	364
V ₄ : MTU-1121	355	396	359
V ₅ : MTU-1223	447	481	425
V ₆ : MTU-1224	406	447	401
V ₇ : MTU-1262	402	445	390
V ₈ : RGL-2537	424	449	408
SEm (±)	6.86	11.06	9.33
CD (P=0.05)	19.59	31.57	26.62
CV (%)	5.33	7.68	7.20
Interactions :			
SEm±	11.89	19.16	16.16
CD (P=0.05)	S	S	S

Panicle initiation and Flowering stages was found to be significantly influenced by age of nursery at transplanting. Maximum number of total tillers m⁻² was registered when seedlings were transplanted at 30 days age (A₁), while it was the lowest with 60 days old seedlings (A₃). Perceptible decline in total number of tillers m⁻² observed with advancement of age of nursery from 30 days across 45 to 60 days could be attributed to the fact that the younger nursery established in the main field at tender age (A₁) passed through favourable growing environment for comparatively long period over successive advance aged nursery (A₂ & A₃) which might have enabled to put forth large number of tiller per clump and in turn more number of total tillers m⁻². While, in the case of older nursery, significant drop in tiller production might be due to the reason that when seedlings are allowed to stay for longer period of time (A₂ and A₃) in the nursery beds, the chances of primary tiller buds on the lower nodes of the main culm got degenerated increases, leading to reduced tiller production, in addition to greater pulling shock endured by aged seedlings. Similar findings were also reported by Singh *et al.* (2023)^[3, 4].

With regard to the influence of varieties on total tillers m⁻² of rice at Active tillering, marked differences were observed among the rice varieties tested. Total tillers m⁻² was found to be the highest in MTU-1223 (V₅) which shows statistical parity with V₈ (RGL-2537), while significantly lower number of total tillers m⁻² was observed in BPT-5204 (V₂) followed by MTU-1061 (V₃). As regards the interaction effect between age of nursery at transplanting and varieties tried, significantly large number of tillers m⁻² was noticed with MTU-1262 (V₇) when 30 days old seedlings (A₁) were transplanted which was however, found statistical parity with MTU-1223 (V₅) at the same age of nursery. Significantly lesser number of total tillers m⁻² were observed in MTU-1121 (V₄) when nursery of 60 days old was transplanted which was however, statistically comparable with MTU-1262 (V₇) at the same age nursery. (Table 3).

Total number of tillers counted at panicle initiation stage of rice was found to be significantly altered by age of nursery at transplanting as well as varieties. The interaction effect between

these two parameters was also found to be statistically detectable (Table. 4). With regard to total number of tillers m^{-2} as influenced by different varieties, V_5 (MTU-1223) produced significantly more number and exhibited its supremacy over other varieties. Number of tillers m^{-2} was observed to be minimum in V_2 (BPT-5204), which was however, comparable with V_4 (MTU-1121). With regard to interaction effect, variety MTU-1262 (V_7) when transplanted with youngest nursery (A_1) produced the highest total number of tillers m^{-2} and found significantly superior to any other treatment combinations. While, variety MTU-1121 (V_4) transplanted with the oldest nursery (A_3) recorded significantly lower tiller production which was however, comparable with MTU-1262 (V_7) at the same age of nursery (A_3).

At flowering stage, regarding varieties, MTU-1223 (V_5) showed its supremacy by producing the highest number of tillers m^{-2} compared to all other varieties tried. Total tillers m^{-2} were found to be significantly lower in BPT-5204 (V_2) which was however, found statistical parity with MTU-1121 (V_4). Regarding interaction effect, significantly large number of total tillers m^{-2} were registered with MTU-1262 (V_7) planted with the youngest seedlings (A_1) which were however statistically on par with MTU-1223 (V_5) at the same age of nursery (A_1). Total tillers m^{-2} of rice were observed to be minimum in MTU-1121 (V_4) when established with aged seedlings (A_3) which was however comparable with MTU-1262 (V_7).

Among different varieties tried, significantly large number of total tillers m^{-2} were found to associate with MTU-1223 at all the three intervals of sampling and this could be attributed to the varietal character which is largely governed by the genetic constitution of the cultivar. Statistically quantifiable superiority of MTU-1223 in producing total tillers m^{-2} when transplanted with 30 days old seedlings (A_1) might be due to synergistic interaction between innate potential of the cultivar and the extended favourable growing environment in which the crop spend the tillering phase. These results are corroborating the findings of Sah *et al.* (2023)^[6].

Dry Matter Production ($kg\ ha^{-1}$)

The data pertaining to drymatter production of rice recorded at Active tillering, Flowering and Harvest are presented in table 4. Perusal of the data revealed that there was a gradual increase in drymatter production ($kg\ ha^{-1}$) from active tillering to harvest stage due to age of nursery at transplanting as well as different varieties tried.

At active tillering stage, drymatter production ($kg\ ha^{-1}$) of rice altered to a statistically perceptible level due to differences in age of nursery at transplanting. Significantly higher drymatter production was noticed at Active tillering, Flowering and Harvest when 30 days old (A_1) rice seedlings were transplanted, while it was gradually decreased with increase in age of seedlings at transplanting

recorded the lowest with 60 days old seedlings (A_3). With regard to interaction effect between these factors on drymatter accumulation, it was not statistically noticeable at Active tillering whereas The interaction effect between these two parameters was also found to be statistically detectable at flowering and at harvest stages. Drymatter production is the result of plant height and number of tillers per clump of rice.

In the present field trial, rice nursery transplanted at 30 days age registered significantly taller plants and more number of tillers m^{-2} .

Transplanting nursery at comparatively lesser age creates an opportunity for the seedlings to harness edaphic and climatic

resources effectively for a prolonged period to accumulate more drymatter compared to older seedlings as the growing conditions enable the younger seedlings to access adequate growth resources under fairly accommodative situation in the main field than the preceding life they spend in the nursery bed under sheer competition for essential growth resources confirmed in lines by research findings of Singh *et al.* (2023)^[3, 4].

Table 5: Dry matter production ($kg\ ha^{-1}$) of rice at different stages as influenced by age of seedlings and varieties

Treatments	Active tillering	Flowering	Harvest
Age of seedling(A)			
A_1 : 30 days	2888	6192	13746
A_2 : 45 days	2608	5653	12539
A_3 : 60 days	2003	4445	10266
SEm ($\pm$)	32.02	97.71	171.94
CD (P=0.05)	125.73	383.64	675.13
CV (%)	6.28	8.82	6.91
Variety (V)			
V_1 : MTU-7029	2574	5564	12252
V_2 : BPT-5204	2401	5377	11964
V_3 : MTU-1061	2472	5224	12019
V_4 : MTU-1121	2429	5324	11624
V_5 : MTU-1223	2588	5667	12742
V_6 : MTU-1224	2487	5238	11993
V_7 : MTU-1262	2552	5501	12435
V_8 : RGL-2537	2492	5543	12437
SEm ($\pm$)	72.55	78.42	133.31
CD (P=0.05)	NS	222.81	380.47
CV (%)	8.71	4.33	3.28
Interaction			
SEm $\pm$	125.65	135.82	230.90
CD (P=0.05)	NS	S	S

Drymatter production ($kg\ ha^{-1}$) at Active tillering exerted statistically measurable influence on the drymatter accumulation of rice by different varieties (Table. 5 and 6). Drymatter production ($kg\ ha^{-1}$) was found to be the highest with V_5 (MTU-1223) which was however, found on par with V_1 (MTU-7029), and V_7 (MTU-1262). Drymatter production ($kg\ ha^{-1}$) was the lowest in V_2 (BPT-5204) which was however, comparable with V_4 (MTU-1121), V_3 (MTU-1061), and V_6 (MTU-1224).

Drymatter production ($kg\ ha^{-1}$) at flowering stage exerted statistically measurable influence on the drymatter accumulation of rice due to different varieties. Drymatter production ($kg\ ha^{-1}$) was found to be the highest with V_5 (MTU-1223) which was however, found on par with V_1 (MTU-7029), V_7 (MTU-1262) and V_8 (RGL-2537). Drymatter production ($kg\ ha^{-1}$) was the lowest in V_3 (MTU-1061) which was however, comparable with V_6 (MTU-1224), V_4 (MTU-1121) and V_2 (BPT-5204). With regard to interaction effect, MTU-1262 (V_7) when transplanted with youngest nursery (A_1) produced the highest drymatter production ($kg\ ha^{-1}$) which was however statistically on par with MTU-1223 (V_5), and RGL-2537 (V_8). While, MTU-1224 (V_6) transplanted with the oldest nursery (A_3) recorded significantly lower drymatter production ($kg\ ha^{-1}$) which was however, comparable with MTU-1262 (V_7), MTU-1061 (V_3), MTU-1121 (V_4) and MTU-1224 (V_6) at the same age of nursery (A_3).

At Harvest, drymatter production ($kg\ ha^{-1}$) with regard to varieties, MTU-1223 (V_5) registered maximum drymatter production which was however, comparable with MTU-1262 (V_7) and RGL-2537 (V_8). Drymatter production ($kg\ ha^{-1}$) was observed to be significantly lower in MTU-1121 (V_4) which was however, found statistical parity with and BPT-5204 (V_2). Differences in drymatter production ($kg\ ha^{-1}$) of rice at harvest

were found to be altered significantly due to interaction between age of seedlings at transplanting and various varieties tried (Table. 6). Significantly higher drymatter production (kg ha^{-1}) was registered with MTU-1262 (V_7) planted with the youngest seedlings (A_1) which was however, statistically on par with MTU-1223 (V_5) at the same age of nursery (A_1). Dry matter production (kg ha^{-1}) of rice at harvest was observed to be the lowest in MTU-1224 (V_4) when established with aged seedlings (A_3) which was however, comparable with MTU-1224 (V_6). Significantly higher drymatter production observed with MTU-7029 (V_1), MTU-1223 (V_5), MTU-1262 (V_7) and RGL-2537 (V_8) could be attributed to the fact that these varieties produced taller plants coupled with greater tillering ability over rest of the varieties tried. Further, with regard to interaction effect between aged of rice seedlings at transplanting and varieties which was found significant in the present investigation, voluminous literature is available in support of these findings since the genetic potential of the variety is best expressed under the most favourable growing environment, which was encountered by the seedlings of younger age. Similar results of higher drymatter production with younger seedlings were also reported by Oni *et al.* (2023) ^[14].

Days to 50% flowering and maturity

Data pertaining to days required to attain 50% flowering and maturity of rice as influence by age of nursery at transplanting as well as varieties are presented in table 6. Scrutiny of the data revealed that transplanting of rice with different ages and their interaction with varieties did not alter either days to reach 50% flowering or maturity of rice to a statistically perceptible magnitude. However, both these parameters were found to influence significantly due to different varieties tried.

Table 6: Days to 50% flowering and maturity of rice as influenced by age of seedlings and varieties.

Treatments	Days to 50% flowering	Days to maturity
Age of seedling(A)		
A_1 : 30 days	115	147
A_2 : 45 days	117	149
A_3 : 60 days	119	151
SEm ($\pm$)	2.05	2.20
CD (P=0.05)	NS	NS
CV (%)	8.59	7.26
Variety (V)		
V_1 : MTU-7029	119	151
V_2 : BPT-5204	113	145
V_3 : MTU-1061	118	150
V_4 : MTU-1121	108	140
V_5 : MTU-1223	118	150
V_6 : MTU-1224	110	142
V_7 : MTU-1262	122	154
V_8 : RGL-2537	126	158
SEm ($\pm$)	3.35	3.37
CD (P=0.05)	9.55	9.63
CV (%)	8.60	6.80
Interaction		
SEm $\pm$	5.80	5.84
CD (P=0.05)	NS	NS

As regards days to reach 50% flowering, rice variety RGL-2537 (V_8) took significantly more number of days compared to other varieties tried however, V_8 (RGL-2537) was statistically on par with MTU-1262 (V_7), MTU-1223 (V_5), MTU-1061 (V_3) and MTU-7029 (V_1). Significantly lesser number of days to attain 50% flowering in rice was observed in MTU-1121 (V_4) which was however found statistical parity with MTU-1224 (V_6) and BPT-5204 (V_2).

With regard to days to attain maturity of rice varieties, the trend as it was observed with days to 50% flowering was repeated without any deviation (Table 6)

Days to 50% flowering and maturity did not alter significantly due to age of rice nursery at transplanting since this parameter is largely governed by the genetic constitution of the rice variety and barely influence by other than genetic factors. Among different varieties tried, RGL-2537, MTU-1262, MTU-1223, MTU-1061 and MTU-7029 took significantly more number of days to attain 50% flowering and maturity due to its long duration nature compared to rest of the varieties tried. Similar findings also reported earlier by Sah *et al.* (2023) ^[6].

Economics

Perceptible differences were observed regard to gross, net returns and B:C ratio (Table 7) due to age of nursery at transplanting as well as varieties of rice tried.

Among seedlings of different ages tried, rice crop established by transplanting with 30 days old seedlings (A_1) exhibited its superiority in producing higher gross returns, which was higher by Rs 10715/- compared to 45 days old seedlings (A_2) and Rs 36329/- over planting of 60 days old seedlings (A_3). Similarly higher net returns also realized by planting 30 days old seedlings (A_1) which was higher by Rs 11564/- compared to 45 days old seedlings (A_2) and Rs 38828/- over planting of 60 days old seedlings (A_3). B:C ratio also maximum with 30 days old seedlings (A_1) and gradually declined with increasing age of seedlings at the time of transplanting. Higher grain yield couple with less cost of production in the crop transplanted with 30 day seedlings might have resulted in higher profits compared to 45 and 60 days aged seedlings. Singh *et al.* (2023) ^[3, 4] also reported similar results earlier.

With regards to influence of varieties on gross returns, net returns of rice and return per rupee invested on rice marked differences were observed among the varieties tried. The Higher gross returns, net returns of rice and return per rupee invested on rice were noticed with MTU-1223 (V_5) followed by RGL-2537 (V_8) and MTU-1224(V_6).The lowest gross returns, net returns of rice and return per rupee invested on rice were associated with MTU-1121 (V_4) followed by BPT-5204 (V_2). Profit of Rs 17190/- was the difference between the maximum and minimum among the varieties. The yield difference and difference in cost of production among the varieties might be the reason for difference in returns. Similar results were reported earlier by Mohapatra *et al.* (2021) ^[15].

As regards the interaction effect between age of nursery at transplanting and varieties tried, maximum gross returns and net returns were noticed with MTU-1262 (V_7) when 30 days old seedlings (A_1) followed by MTU-1061 (V_3) MTU-1223 (V_5), MTU-1224 (V_6) and MTU-7029 (V_1) at the same age of nursery. The gross returns and net returns were minimum with MTU-1121 (V_4) when nursery of 60 days old was transplanted.

Table 7: Gross, net returns (Rs ha⁻¹) and Return per rupee invested in rice as influenced by age of seedlings and varieties

Treatments	Gross returns	Net returns	Return per rupee invested
Age of seedling (A)			
A ₁ : 30 days	129598	79008	1.56
A ₂ : 45 days	118883	67444	1.31
A ₃ : 60 days	93269	40180	0.76
SEm (±)	1921.78	1921.78	0.04
CD (P=0.05)	7545.84	7545.84	0.14
CV (%)	8.26	15.13	14.65
Variety (V)			
V ₁ : MTU-7029	112549	60843	1.18
V ₂ : BPT-5204	109534	57827	1.12
V ₃ : MTU-1061	113600	61894	1.20
V ₄ : MTU-1121	104525	52818	1.03
V ₅ : MTU-1223	121715	70008	1.36
V ₆ : MTU-1224	116888	65182	1.27
V ₇ : MTU-1262	115162	63456	1.24
V ₈ : RGL-2537	117363	65656	1.27
SEm (±)	1946.34	1946.34	0.04
CD (P=0.05)	5554.85	5554.85	0.11
CV (%)	5.13	9.39	9.41
Interaction			
SEm (±)	3371.16	3371.16	0.07
CD (P=0.05)	S	S	NS

Conclusion

Among the three age of seedlings for transplanting, planting of 30 days seedlings proved superior by recording higher growth parameters like plant height, leaf area index, total no of tillers, dry matter production and days to flowering & maturity, gross returns, net returns and return per rupee invested on rice compared to planting of 45 days and 60 days old seedlings. Decrease in net returns by Rs 11564/- and 38828/- respectively due to planting 45 days and 60 days compared 30 days old seedlings

Among the Varieties tested, the higher plant height was found with RGL-2537, Leaf area index was found with MTU-7029, whereas total tillers m⁻² and drymatter production (kg ha⁻¹), gross returns, net returns of rice and return per rupee invested on rice was found to be the highest in MTU-1223 (V₅).

Further the study can be concluded as decline in returns are certain with increasing age of seedlings in rice over 30 days, however the profit loss can be minimized noticeably by choosing varieties Viz., MTU-1223, MTU-1224, MTU-1262 and MTU-1061 when 45 days old seedlings. transplanted and RGL-2537. and MTU-1223. when 60 days old seedlings.

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