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Effects of transplanting dates and varietal selection on growth parameters of Rice (*Oryza sativa* L.)

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Abstract
A field study was conducted at the experimental farm Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura Sopore to evaluate the influence of different transplanting dates and rice varieties on various growth parameters. Three transplanting dates (7th June, 14th June, and 21st June) and four rice varieties (Jehlum, SR-1, SR-2, and SR-3) were tested in a factorial design. Results indicated that transplanting dates and varieties significantly affected plant height, tiller production, leaf area index, dry matter accumulation, relative growth rate, and leaf number per culm at different growth stages. Early transplanting (7th June) resulted in taller plants (128.09 cm) at maturity compared to late transplanting (118.86 cm). Variety SR-2 recorded the highest plant height (133.73 cm), dry matter accumulation (130.88 q ha^{-1}), and leaf area index (5.36) at 60 DAT. Tiller production peaked at 60 DAT across all treatments, with SR-3 producing the highest number of tillers (468.77 m^{-2}). Maximum leaf area index of 5.02 was achieved with 7th June transplanting at 60 DAT. Early transplanting generally favored growth parameters during later developmental stages, while variety SR-2 consistently performed better across most parameters.

Keywords: Transplanting date, varieties, plant height, tillering, leaf area index, dry matter accumulation, growth analysis, Oryza sativa

Introduction

Rice (Oryza sativa L.) is one of the most important cereal crops globally, serving as a staple food for more than half of the world's population and contributing significantly to food security in developing countries. With the global population projected to reach 9.7 billion by 2050, there is an urgent need to enhance rice productivity to meet the increasing food demand. Rice cultivation covers approximately 165 million hectares worldwide, with Asia accounting for about 90% of global production and consumption.

The success of rice cultivation largely depends on appropriate crop management practices, among which transplanting time and variety selection are critical factors that significantly influence plant growth, development, and ultimately yield. The timing of transplanting affects various physiological processes including germination, vegetative growth, reproductive development, and grain filling, while varietal selection determines the genetic potential and adaptability of the crop to specific environmental conditions.

Transplanting date is a crucial agronomic decision that affects the entire growth cycle of rice. The optimal transplanting time ensures that the crop experiences favorable environmental conditions during critical growth phases such as tillering, panicle initiation, flowering, and grain filling. Early transplanting may expose the crop to unfavorable temperature conditions during early growth stages, while delayed transplanting can result in exposure to adverse weather conditions during the reproductive phase, potentially reducing yield and quality. The relationship between transplanting date and environmental factors such as temperature, photoperiod, solar radiation, and rainfall distribution plays a pivotal role in determining crop performance. Temperature is particularly important as it influences enzyme activity, metabolic processes, and developmental rates. Photoperiod sensitivity in rice varieties affects the timing of flowering and grain filling, making the synchronization of transplanting date with favorable photoperiodic conditions essential for optimal growth.

Growth analysis provides valuable insights into the physiological processes underlying crop performance and serves as a tool for understanding the effects of various management practices. Plant height is an important morphological characteristic that influences light interception, lodging resistance, and harvest index. It is controlled by genetic factors but can be significantly modified by environmental conditions and management practices. Tillering capacity is a genetically controlled trait that determines the number of productive culms per plant and directly influences grain yield potential. The tillering pattern follows a predictable sequence where tiller production increases during the vegetative phase, reaches maximum at around flowering, and then declines due to tiller mortality during grain filling. Environmental factors such as light quality, nutrient availability, and water management significantly affect tillering behavior.

Materials and Methods

The field experiment was conducted during the kharif season of 2018 at the experimental farm Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura Sopore. The site is located at 32°37′N latitude and 75°22′E longitude at an elevation of 1584 meters above mean sea level, representing a mid to high altitude temperate zone.

The experiment was designed as a factorial randomized block design (RBD) with three replications. The treatments comprised two factors: Factor A included three transplanting dates (7^{th} June, 14^{th} June, and 21^{st} June) and Factor B consisted of four rice varieties (Jehlum, SR-1, SR-2, and SR-3). This resulted in 12 treatment combinations with a total of 36 experimental plots, each measuring 6 m^2 (2m × 3m). The experimental soil was silty-clay loam with neutral pH (6.7), normal electrical conductivity (0.10 dS m^{-1}), medium organic carbon content (0.67%), and medium levels of available nitrogen (255.6 kg ha^{-1}), phosphorus (20.3 kg ha^{-1}), and potassium (119.21 kg ha^{-1}).

Seedlings were raised in wet nursery beds using 80 kg ha^{-1} seed rate. Mature seedlings (30 days old for first transplanting, 25 days old for subsequent dates) were transplanted at three seedlings per hill with 20 cm × 20 cm spacing. Fertilizer application included 120:60:30:20 kg ha^{-1} of $N:P_2O_5:K_2O:Zn$ with half nitrogen as basal dose and remaining nitrogen top-dressed in two equal splits during maximum tillering and panicle initiation stages.

Growth parameters measured at 20-day intervals included:

- Plant height (cm) using meter scale from soil surface to leaf apex during vegetative stage and panicle tip after emergence
- Tiller number per m^2 through direct counting
- Leaf area index (LAI) calculated as total leaf area per unit ground area
- Dry matter accumulation (q ha^{-1}) through destructive sampling, sun-drying, and oven-drying at 60-70°C to constant weight
- Relative growth rate (RGR) using formula: $RGR = (\log_e W_2 - \log_e W_1)/(T_2 - T_1)$
- Number of leaves per culm through direct counting

Data were subjected to analysis of variance using OPSTAT software package, and treatment means were compared using least significant difference (LSD) test at 5% probability level.

Results

Plant Height

Plant height increased consistently up to 100 DAT across all treatments, with marginal increases thereafter. At 20 DAT, transplanting dates showed no significant effect on plant height (23.63-24.77 cm). However, from 40 DAT onward, 7th June transplanting resulted in significantly taller plants (128.09 cm at maturity) compared to 21st June transplanting (118.86 cm), while remaining statistically similar to 14th June transplanting (122.99 cm).

Table 1: Plant height (cm) of rice as influenced by dates of transplanting and varieties

Treatments	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT	Maturity
Transplanting Dates						
7th June	23.63	71.72	94.70	120.20	126.66	128.09
14th June	23.70	77.97	98.61	114.17	120.24	122.99
21st June	24.77	78.47	104.92	111.05	117.75	118.86
SE (m)	0.42	1.36	1.77	2.05	2.16	2.26
CD ($p \leq 0.05$)	N.S	4.01	5.21	6.04	6.35	6.47
Varieties						
Jehlum	24.27	75.13	95.94	114.10	118.18	119.92
SR-1	24.44	73.01	95.54	111.80	116.19	118.53
SR-2	23.29	81.63	107.83	123.84	131.28	133.73
SR-3	24.14	75.82	98.34	115.82	119.58	121.08
SE(m)	0.49	1.57	2.01	2.37	2.49	2.60
CD ($p \leq 0.05$)	N.S	4.63	5.92	7.12	7.33	7.48

Among varieties, SR-2 consistently recorded the tallest plants at all measurement intervals, reaching 133.73 cm at maturity, followed by SR-3 (121.08 cm), Jehlum (119.92 cm), and SR-1 (118.53 cm). At 40 and 60 DAT, SR-1 and Jehlum showed similar plant heights, while SR-2 maintained its superiority throughout the growing period.

Tiller Production

Tiller number per m^2 increased up to 60 DAT and then gradually decreased until maturity across all treatments. Maximum tiller production was recorded at 60 DAT, with values ranging from 418.83 to 478.83 tillers m^{-2}.

Table 2: Tiller number of rice as influenced by dates of transplanting and varieties

Treatments	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT	Maturity
Transplanting Dates						
7^{th} June	164.50	265.25	478.83	396.16	365.75	349.00
14^{th} June	165.41	275.91	451.83	365.25	340.83	318.83
21^{st} June	170.53	281.08	418.83	345.91	323.08	291.75
SE (m)	1.92	3.52	5.66	4.17	4.39	4.13
CD ($p \leq 0.05$)	N.S	10.33	16.63	12.24	12.88	12.11
Varieties						
Jehlum	167.66	278.00	451.33	370.77	349.00	323.22
SR-1	162.44	271.22	445.33	370.66	345.00	319.22
SR-2	156.44	262.55	422.88	352.22	329.11	300.66
SR-3	174.33	284.55	468.77	382.77	352.44	336.11
SE(m)	2.22	4.06	6.54	4.82	5.07	4.77
CD ($p \leq 0.05$)	6.52	11.93	19.28	14.14	14.17	13.99

Transplanting on 21st June produced significantly higher tillers at 40 DAT (281.08 m⁻²) compared to earlier transplanting dates. However, from 60 DAT to maturity, 7th June transplanting consistently recorded higher tiller numbers (478.83 at 60 DAT, declining to 349.00 at maturity). Variety SR-3 demonstrated superior tillering capacity, producing 468.77 tillers m⁻² at 60 DAT and maintaining 336.11 tillers m⁻² at maturity.

Leaf Area Index: Leaf area index peaked at 60 DAT across all treatments before gradually declining with crop maturity. Maximum LAI values ranged from 4.62 to 5.02 at 60 DAT.

Table 3: Leaf area index of rice as influenced by dates of transplanting and varieties

Treatments	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT	Maturity
Transplanting Dates						
7th June	0.17	2.17	5.02	4.65	3.87	2.53
14th June	0.18	2.34	4.77	4.46	3.47	2.32
21st June	0.20	2.44	4.62	4.15	3.22	2.24
SE (m)	0.018	0.04	0.08	0.08	0.06	0.04
CD ($p \leq 0.05$)	N.S	0.12	0.25	0.24	0.18	0.13
Varieties						
Jehlum	0.17	2.19	4.62	4.41	3.33	2.32
SR-1	0.18	2.13	4.47	3.99	3.20	1.96
SR-2	0.20	2.64	5.36	5.19	3.98	2.90
SR-3	0.17	2.24	4.75	4.57	3.46	2.51
SE(m)	0.021	0.04	0.09	0.09	0.07	0.05
CD ($p \leq 0.05$)	N.S	0.13	0.29	0.27	0.21	0.15

Early in the season (up to 40 DAT), 21st June transplanting recorded higher LAI values (2.44). However, from 60 DAT to maturity, 7th June transplanting maintained higher LAI values (5.02 at 60 DAT, declining to 2.53 at maturity). Variety SR-2 consistently maintained the highest LAI throughout the growing season, reaching a maximum of 5.36 at 60 DAT and maintaining 2.90 at maturity.

Dry Matter Accumulation

Dry matter production showed significant variation among treatments. Up to 60 DAT, 21st June transplanting accumulated significantly higher dry matter (53.25 q ha⁻¹). However, from 80 DAT to maturity, 7th June transplanting showed superior dry matter accumulation, reaching 130.41 q ha⁻¹ at maturity.

Table 4: Dry matter production (q ha⁻¹) of rice as influenced by dates of transplanting and varieties

Treatments	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT	Maturity
Transplanting Dates						
7th June	2.00	12.50	48.41	89.66	128.41	130.41
14th June	2.03	14.00	50.08	84.66	119.58	123.08
21st June	2.08	14.58	53.25	80.58	113.25	114.33
SE (m)	0.048	0.21	0.60	1.52	2.17	2.16
CD ($p \leq 0.05$)	N.S	0.62	1.78	4.47	6.36	6.34
Varieties						
Jehlum	2.00	12.55	43.55	80.77	114.77	119.44
SR-1	2.10	13.33	48.55	84.00	118.77	120.44
SR-2	2.50	14.88	50.66	89.55	127.22	130.88
SR-3	2.30	14.00	49.55	85.55	120.88	125.33
SE(m)	0.55	0.24	0.70	1.76	2.50	2.49
CD ($p \leq 0.05$)	N.S	0.72	2.06	5.17	7.35	7.47

Among varieties, SR-2 demonstrated the highest dry matter accumulation capacity, achieving 130.88 q ha⁻¹ at maturity, followed by SR-3 (125.33 q ha⁻¹), SR-1 (120.44 q ha⁻¹), and Jehlum (119.44 q ha⁻¹).

Relative Growth Rate

Relative growth rate varied significantly during early growth periods. At 20-40 DAT, 21st June transplanting recorded higher RGR (0.130 g g⁻¹ day⁻¹), while from 40-60 DAT onward, 7th June transplanting maintained higher values (0.068 g g⁻¹ day⁻¹).

Table 5: Relative Growth Rate (RGR) g g⁻¹ day⁻¹ of rice as influenced by dates of transplanting and varieties

Treatments	20-40 DAT	40-60 DAT	60-80 DAT	80-100 DAT	100-Maturity
Transplanting Dates					
7th June	0.122	0.068	0.031	0.018	0.00161
14th June	0.127	0.064	0.026	0.018	0.00159
21st June	0.130	0.065	0.021	0.017	0.00151
SE (m)	0.0009	0.001	0.0001	0.0001	0.00015
CD ($p \leq 0.05$)	0.0026	0.003	N.S	N.S	N.S
Varieties					
Jehlum	0.122	0.067	0.025	0.019	0.0017
SR-1	0.127	0.064	0.026	0.017	0.0016
SR-2	0.125	0.066	0.026	0.017	0.0016
SR-3	0.130	0.064	0.026	0.017	0.0013
SE(m)	0.0009	0.0001	0.0001	0.0001	0.00017
CD ($p \leq 0.05$)	0.0030	N.S	N.S	N.S	N.S

Among varieties, SR-3 showed slightly higher RGR during 20-40 DAT (0.130 g g⁻¹ day⁻¹), while differences were minimal in later growth stages.

Number of Leaves per Culm

Leaf number per culm increased up to 60 DAT (anthesis) before gradually declining. Maximum leaf numbers ranged from 4.37 to 4.73 at 60 DAT. Early transplanting (7th June) generally maintained higher leaf numbers from 60 DAT to maturity (4.73 at 60 DAT, declining to 2.68 at maturity). Variety SR-2 recorded the highest number of leaves per culm at 60 DAT (5.23), maintaining 2.91 leaves at maturity.

Conclusions

The study demonstrates that both transplanting dates and variety selection significantly influence rice growth parameters. Early transplanting (7th June) generally favored growth characteristics during later developmental stages, particularly for tiller retention, leaf area maintenance, and dry matter accumulation. Among varieties, SR-2 consistently performed better across most growth parameters, while SR-3 showed superior tillering capacity. These findings suggest that for optimal growth performance, early transplanting combined with appropriate variety selection (SR-2 for overall growth, SR-3 for high tillering) would be most beneficial. The interaction between transplanting time and variety characteristics highlights the importance of integrated crop management approaches for maximizing rice production potential.

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