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Optimizing transplanting age for enhanced yield and seed quality of *T. Aman* rice varieties in Subtropical Bangladesh: A study on varietal responses

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Abstract

A field experiment was conducted during the Aman season (July - December), in a subtropical region of Bangladesh, to address the prevailing challenge of low national *T. Aman* rice yield and the common farmer practice of using over-aged seedlings. The study aimed to determine the optimal seedling age and genotype combination for maximizing both grain yield and seed quality. Three rice varieties (BRRI Dhan32, BRRI Dhan62, and BRRI Dhan80) were evaluated across four transplanting ages (20, 25, 30, and 35 days), using a two-factor Randomized Complete Block Design (RCBD). Results demonstrated that the variety BRRI Dhan32 was statistically superior, yielding the highest grain (4.68 t.ha⁻¹), and exhibiting the best seed germination (88.33%), primarily due to its robust yield components, including a greater number of effective tillers and filled seeds per panicle. Seedlings transplanted at 30 days old (A3) significantly outperformed other ages, promoting optimal growth and development and resulting in a maximum yield of 4.83 t.ha⁻¹ and germination of 92.01%. Crucially, the interaction between BRRI Dhan32 and 30-day-old seedlings (V1A3) produced the highest combined performance, recording an exceptional grain yield of 5.12 t.ha⁻¹, superior germination (92.86%), and the highest vigor index (2152.49), largely attributable to enhanced 1000-seed weight. This research conclusively recommends cultivating BRRI Dhan32 with 30-day-old seedlings as a practical and effective strategy to significantly boost the productivity and quality of *T. Aman* rice, thereby enhancing national food security in subtropical environments.

Key words: seeding, yield quality, *T. Aman*, harvesting, rice

Introduction

Rice (*Oryza sativa* L.) is the staple food of Bangladesh and a cornerstone of its agrarian economy. Despite its profound significance, the national average rice yield (4.2 t.ha^{-1}) remains considerably lower than that of other major rice-producing countries, such as South Korea (7.50 t.ha^{-1}) and Japan (6.22 t.ha^{-1}) (FAO, 2013). This challenge is further exacerbated by limited arable land, high population pressure, and recurring environmental stresses (BBS, 2019). While the successful introduction of high-yielding varieties has significantly boosted national production (BRRI, 2021), the sustainable linear increase required to meet long-term food security has not been achieved, underscoring the urgent necessity of optimizing key cultural practices. Among the critical agronomic factors, the seedling age at transplanting is a primary, yet often underestimated, determinant that profoundly influences tiller production, seed formation, and overall yield-contributing characteristics (Faruk et al., 2009). Unfortunately, farmers in Bangladesh commonly use over-aged seedlings due to various cultivation constraints, a practice that is known to significantly retard crop performance and drastically reduce final yield, primarily stemming from a lack of awareness regarding optimal timing. Consequently, identifying the optimum seedling age for specific varieties and seasons is crucial for high-efficiency rice production (Sasaki, 2004; Aslam et al., 2015).

Research widely supports the notion that younger seedlings typically experience less transplanting shock, rejuvenate quickly, and are able to utilize more time for vegetative growth. This leads to better root development, stem elongation, and tillering, ultimately translating into higher seed yield (Akber, 2004; Naresh, 2012). Furthermore, earlier establishment allows for greater carbohydrate storage in vegetative organs for subsequent seed filling (Liu et al., 2017) and increased irrigation water productivity (Brar et al., 2012). Numerous studies have corroborated the benefits of young seedlings, with findings indicating optimal performance from seedlings ranging from

8- to 25-days-old for various attributes, including maximized effective tillers, seeds per panicle, and overall yield (Patra and Hoque, 2011; Krishna and Biradarpatil, 2009; Mukta, 2019; Islam et al., 2021; Chakraborty et al., 2015). Conversely, the use of older seedlings often results in slow recovery, production of fewer effective tillers, delayed maturity (Chakraborty, 2015; Mallik et al., 2018), and increased incidence of non-effective tillers and pest infestation. However, the findings on optimal age are not uniformly conclusive, as some studies suggest benefits from slightly older seedlings. For instance, 30-day-old seedlings have been noted to result in taller plants (Zohra et al., 2013), longer panicles (Rahimpour et al., 2013; Bagheri et al., 2011), and superior growth and yield parameters in certain varieties and conditions (Brar et al., 2012; El-Rewainy et al., 2007; Hossain, 2014). This variability highlights the complexity introduced by varietal differences. Agronomic management, particularly the selection of appropriate varieties, is paramount for optimizing rice growth and yield, as genetic variations significantly influence nutrient partitioning, growth rate, and final yield components. Research demonstrates substantial genotypic differences in traits such as panicle length, filled seeds, effective tillers, and 1000-seed weight across different cultivars (Sharma et al., 2017; Koirala et al., 2010; Kumar et al., 2017). Similarly, varietal effects on seed quality, particularly seed germination, have been consistently reported (Hossain, 2014; Sasaki et al., 2004; Soykot et al., 2025a).

Given the complexities of intensive cropping systems, environmental constraints that often prevent timely transplanting, and the varied findings regarding optimal seedling age across different environments, there is a clear and urgent need to evaluate the performance of *T. Aman* rice varieties under varying seedling ages. Despite extensive research on these factors individually, there remains considerable scope for further investigation into the precise interactive effects between specific varieties and different transplanting ages to achieve higher, sustainable yield and superior quality seed production. Therefore, this research was undertaken to address these critical gaps by

investigating the effects of variety, appropriate seedling age, and their synergistic interaction on the final grain yield and seed quality parameters of *T. Aman* rice, thereby providing essential data for enhancing national rice productivity.

Methodology

This experiment was conducted at the central research field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh (Agro-ecological zone of Modhupur Tract, AEZ-28; 23°74'N latitude, 90°35'E longitude, 8.2 m elevation), from July to December 2019, to evaluate the effect of seedling age on the yield and quality of *T. Aman* rice. The experimental site has a subtropical climate, and its topsoil is silty clay with a pH of 5.6 and 0.45% organic carbon, equipped with proper irrigation and drainage. The study employed a two-factor Randomized Complete Block Design (RCBD) with three replications, resulting in 36 unit plots, each measuring 4 m x 2.0 m. The two factors investigated were:

- Factor A: Variety (3 levels): BRRI Dhan32 (V1), BRRI Dhan62 (V2), and BRRI Dhan80 (V3), sourced from the Bangladesh Rice Research Institute (BRRI).

- Factor B: Age of seedling (4 levels): 20 days (A1), 25 days (A2), 30 days (A3), and 35 days (A4).

Seedbeds were prepared according to BRRI recommendations, and seeds were sown on staggered dates (June 20, 25, 30, and July 5, 2019), to achieve the desired seedling ages for transplanting. The main field was prepared in mid-July 2019, ensuring a good tilt. Fertilizers (N, P, K, S, B) were applied at recommended rates (160, 100, 100, 60, and 10 kg.ha⁻¹ respectively, in forms of urea, TSP, MP, Gypsum, and borax) based on BRRI guidelines (BRRI, 2019). Basal doses of all except urea were applied before transplanting; urea was split into three equal applications: basal, active tailoring (30 DAT), and panicle initiation (60 DAT). Seedlings were uprooted and transplanted on July 26, 2019, at a rate of 3 seedlings per hill, with a spacing of 25 cm between lines and 15 cm between hills. Essential intercultural opera-

tions included gap filling (10 DAT), need-based irrigation, manual weeding thrice (15, 30, and 45 DAT), and pest control (Malathion for leaf roller infestation). Crop harvest occurred when 80-90% of seeds turned golden yellow. Data for yield and yield attributes were collected from a central 1 m² area of each plot, while 10 hills from outside this area were used for yield attribute data. Seed and straw yields were recorded and adjusted to 14% moisture content.

Data collection encompassed a wide range of parameters:

- Plant characters: Plant height (30, 60, 90 DAT, and at harvest), and tillers.hill⁻¹ (30, 60, 90 DAT).

- Yield attributes and yield: Effective, non-effective, and total tillers.hill⁻¹, panicle length, filled, unfilled, and total seeds.panicle⁻¹, 1000-seed weight, seed yield, straw yield, biological yield, and harvest index.

- Seed quality parameters: Germination percentage, seedling root and shoot length, seedling root and shoot dry weight, and vigor index (calculated as per Soykot et al., 2025b).

All collected data were statistically analyzed using MSTAT-C software. Analysis of variance (ANOVA) was performed, and the significance of treatment differences was determined using the Least Significant Difference (LSD) at a 5% level of probability.

Results and Discussion

The experiment investigated the influence of seedling age on the yield and seed quality of *T. Aman* rice varieties. Data analysis revealed significant effects on various growth and yield parameters.

Metrological conditions

The experimental site is characterized by a subtropical climate. During the growing season (July to December), the environmental conditions were conducive to *T. Aman* rice cultivation. The total rainfall recorded during the period was 1421 mm, with the highest precipitation occurring in July (481 mm) and August (337 mm) during the

vegetative stage. The average monthly temperature ranged from a minimum of 20.1° C in December to a maximum of 30.5° C in August. These climatic factors, particularly the transition from the high-temperature, high-rainfall monsoon to the cooler, drier ripening phase in November and December, significantly influenced the phenology and yield attributes of the tested varieties.

Plant height

Varietal effect: Plant height varied significantly by variety, with BRRI Dhan32 consistently producing the tallest plants (e.g., 123.40 cm at harvest) across all growth stages, while BRRI Dhan62 showed the shortest (98.33 cm). This is attributed to genetic differences (Hossain, 2014). Figure 1 demonstrates the effect of variety on plant height at different days after plantation.

Effect of seedling age: 30-day-old seedlings (A3) consistently resulted in the tallest plants (e.g., 115.20 cm at harvest), significantly outperforming other ages (Fig. 2), with 20-day-old seedlings (A1) being the shortest (109.90 cm).

Interaction effect: A significant interaction was observed. BRRI Dhan32 with 30-day-old seedlings (V1A3) consistently produced the tallest plants (e.g., 128.20 cm at harvest), while V2A1 (BRRI Dhan62 with 20-day-old seedlings) showed the shortest (Table 1).

Tillers per hill

Varietal effect: BRRI Dhan32 consistently produced the highest number of tillers per hill (e.g., 20.22 at harvest), while BRRI Dhan62 had the lowest (17.92), indicating varietal genetic influence. Effect of seedling Age: 30-day-old seedlings (A3) led to the highest tiller count (e.g., 20.68 at harvest), contrasting with 20-day-old seedlings (A1), which had the lowest (18.38) (Kumar et al., 2017). Interaction effect: The V1A3 combination (BRRI Dhan32 with 30-day-old seedlings) resulted in the highest tillers per hill (e.g., 21.70), while V2A1 had the lowest. Table 2 shows the variety, age and tiller number comparison on researched sample.

Effective tillers per hill

Varietal effect: BRRI Dhan32 exhibited the highest effective tillers (17.30), with BRRI Dhan62 having the lowest (14.90) (Hossain, 2014). Figure 3 summarizes the tillers per hill of *T. Aman* rice

Effect of seedling age: 30-day-old seedlings (A3) produced the highest effective tillers (16.69), while 20-day-old seedlings (A1) had the lowest (15.48) shown in Figure 4.

Interaction effect: V1A3 (BRRI Dhan32 with 30-day-old seedlings) yielded the highest effective tillers (18.39), with V2A1 showing the lowest (14.43) (Table 3 after panicle length interactions).

Panicle length (cm)

Varietal effect: BRRI Dhan32 exhibited the maximum panicle length (28.53 cm), while BRRI Dhan62 had the minimum (25.40 cm) (Debnath, 2010). Figure 5 shows the panicle length differences among varieties.

Effect of seedling age: 30-day-old seedlings (A3) produced the maximum panicle length (28.15 cm), with 20-day-old seedlings (A1) showing the minimum (25.90 cm). Figure 6 shows the seeding age number of panicle length of *T. Aman* rice.

Interaction effect: V1A3 (BRRI Dhan32 with 30-day-old seedlings) resulted in the longest panicles (30.48 cm), with V2A1 showing the shortest (24.03 cm). Table 3 covers both effective tillers and panicle length interactions.

Filled seeds per panicle

Varietal effect: BRRI Dhan32 produced the highest filled seeds per panicle (117.1), whereas BRRI Dhan62 had the lowest (98.6) (BRRI, 2021). Figure 7 clarifies the effect of filled seeds panicle in different sample varieties.

Effect of seedling age: 30-day-old seedlings (A3) yielded the maximum filled seeds per panicle (124.9), while 20-day-old seedlings (A1) had the minimum (93.8). Figure 8 depicts the seeding age effect on different varieties of sample.

Interaction effect: V1A3 (BRRI Dhan32 with 30-day-old seedlings) led to the highest filled seeds per panicle (136.2), with V2A1 showing the lowest (83.0).

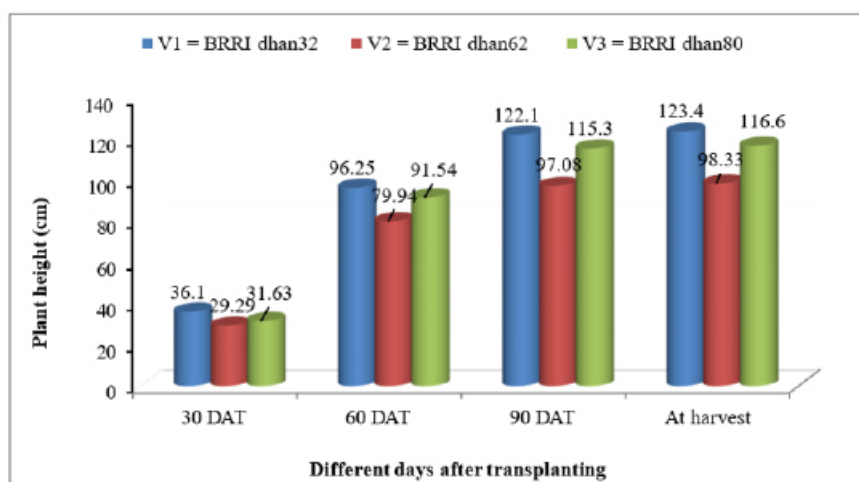


Fig. 1. Effect of variety on plant height at different days after transplanting (LSD0.05=1.40, 2.57, 3.92 and 3.96 at 30, 60, 90 and at harvest, respectively)

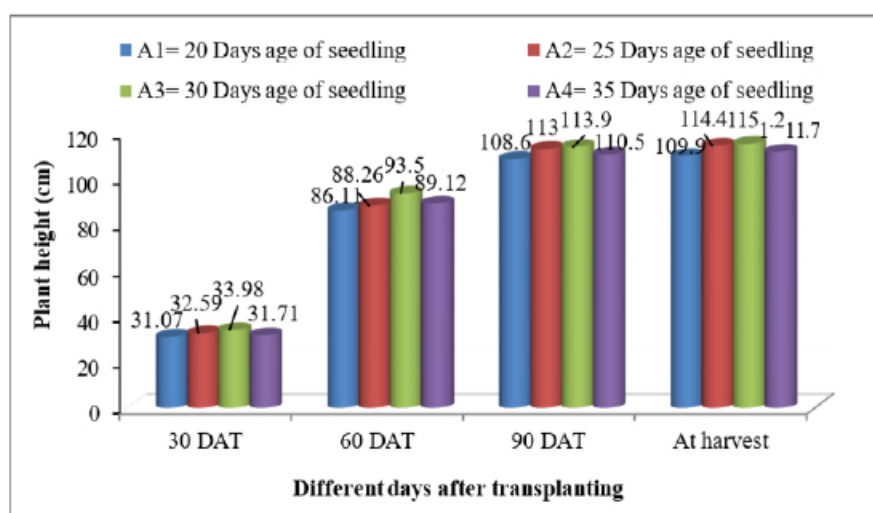


Fig. 2. Effect of seedling age on plant height on *T. Aman* rice at different days after transplanting (LSD0.05 =1.62, 2.97, 4.52 and 4.57 at 30, 60, 90 and at harvest, respectively)

Unfilled seeds per panicle

Varietal effect: BRRI Dhan32 had the lowest unfilled seeds per panicle (15.54), while BRRI Dhan62 had the highest (24.27) (Zohra et al., 2013). Figure 9 shows different sample varieties effect on unfilled seed per panicle.

Effect of seedling age: 30-day-old seedlings

(A3) resulted in the minimum unfilled seeds per panicle (17.99), while 20-day-old seedlings (A1) showed the maximum (24.64). Figure 10 clarifies the unfilled grain per panicle on seedling age for *T. Aman* rice.

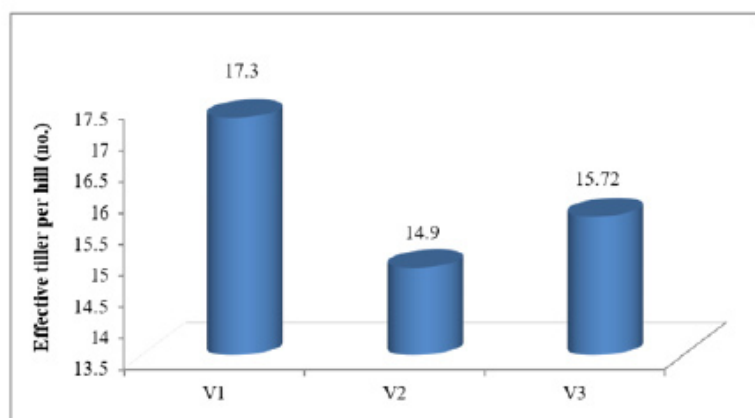
Interaction effect: V1A3 (BRRI Dhan32 with 30-day-old seedlings) showed the lowest unfilled seeds per panicle (10.73), while V2A1 had the

Table 1. Interaction effect of variety and seedling age on plant height of rice at different days after transplanting

Treatment	Plant height (cm) at different days after transplanting			
	30 DAT	60 DAT	90 DAT	At harvest
V1A1	34.36 bc	92.45 bc	122.8 a-c	124.1 a-c
V1A2	36.01 ab	93.81 bc	125.6 ab	127.2 ab
V1A3	38.65 a	104.0 a	127.0 a	128.2 a
V1A4	35.37 bc	94.75 b	113.0 de	114.3 de
V2A1	27.64 g	76.90 d	92.33 f	93.58 f
V2A2	29.20 fg	80.62 d	95.35 f	96.60 f
V2A3	30.52 ef	81.01 d	94.90 f	96.15 f
V2A4	29.79 e-g	80.25 d	105.7 e	107.0 e
V3A1	31.20 d-f	88.98 c	116.2 cd	117.5 cd
V3A2	32.57 c-e	90.36 bc	118.0 b-d	119.3 b-d
V3A3	33.50 b-d	95.48 b	119.9 a-d	121.1 a-d
V3A4	29.24 fg	91.35 bc	107.1 e	108.4 e
LSD (0.05)	2.80	5.14	7.83	7.92
CV (%)	5.12	3.40	4.15	4.15

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

(V1=BRRI Dhan32; V2=BRRI Dhan62; V3=BRRI Dhan80; A1=20 days old seedling; A2=25 days old seedling; A3=30 days old seedling and A4=35 days old seedling).



V1=BRRI Dhan32; V2=BRRI Dhan62; V3=BRRI Dhan80

Fig 3. Effect of variety on number of effective tillers per hill of *T. Aman* rice (LSD0.05=0.68)

highest (31.07). Table 4 covers both filled and unfilled seeds interactions.

1000-seed weight

Varietal effect: BRRI Dhan32 produced the

highest 1000-seed weight (26.36 g), while BRRI Dhan62 had the lowest (23.87 g) (Pramanik and Bera, 2013). Figure 11 shows the variety on 1000 seed weight of *T. Aman* rice.

Effect of seedling age: 30-day-old seedlings

Table 2. Effect of variety, age of seedling and their interaction on tiller number per hill of *T. Aman* rice at different days after transplanting (DAT)

Treatment	Number of total tiller per hill at different days after transplanting			
	30 DAT	60 DAT	90 DAT	At harvest
Variety				
V1	3.80 a	13.42 a	15.31 a	20.22 a
V2	2.95 c	11.07 c	13.39 b	17.92 b
V3	3.30 b	11.94 b	15.06 a	19.57 a
LSD (0.05)	0.16	0.53	0.64	0.82
CV (%)	5.50	5.12	5.18	4.94
Seedling age				
A1	2.76 c	11.46 c	13.42 c	18.38 c
A2	3.43 b	12.38 ab	14.84 b	19.86 ab
A3	3.69 a	12.94 a	16.26 a	20.68 a
A4	3.60 a	11.79 bc	13.82 c	19.16 bc
LSD (0.05)	0.18	0.61	0.74	0.94
CV (%)	5.50	5.12	5.18	4.94
Interaction of different variety and seedling age				
V1A1	3.15 e	12.61 b-d	13.66 e-g	19.62 b-d
V1A2	3.53 bc	13.08 bc	15.57 bc	20.51 a-c
V1A3	4.78 a	14.71 a	18.39 a	21.70 a
V1A4	3.74 b	13.26 b	13.60 e-g	19.04 c-e
V2A1	2.51 f	10.66 hi	12.55 g	17.57 e
V2A2	3.20 e	11.84 d-g	13.77 e-g	17.93 e
V2A3	2.59 f	11.32 f-i	14.23 d-f	18.44 de
V2A4	3.49 b-d	10.46 i	13.00 fg	17.75 e
V3A1	2.62 f	11.10 g-i	14.04 d-f	17.96 e
V3A2	3.30 c-e	12.21 c-f	15.18 b-d	21.12 ab
V3A3	3.71 b	12.80 b-d	16.16 b	21.89 a
V3A4	3.56 bc	11.64 e-h	14.87 c-e	20.70 ab
LSD (0.05)	0.31	1.05	1.28	1.63
CV%	5.50	5.12	5.18	4.94

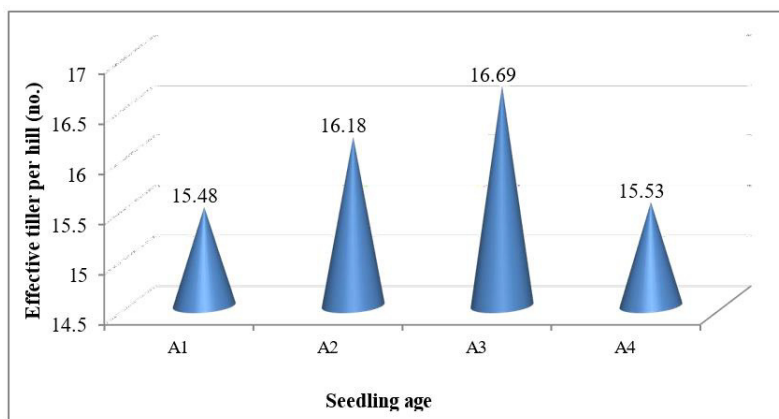
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. (V1=BRRI Dhan32; V2=BRRI Dhan62; V3=BRRI Dhan80; A1=20 days old seedling; A2=25 days old seedling; A3=30 days old seedling and A4=35 days old seedling).

(A3) yielded the highest 1000-seed weight (27.69 g), while 20-day-old seedlings (A1) showed the minimum (21.09 g). Figure 13 shows the effect of different age of seeding on 1000 seed weight of *T. Aman* rice.

Interaction effect: V1A3 (BRRI Dhan32 with

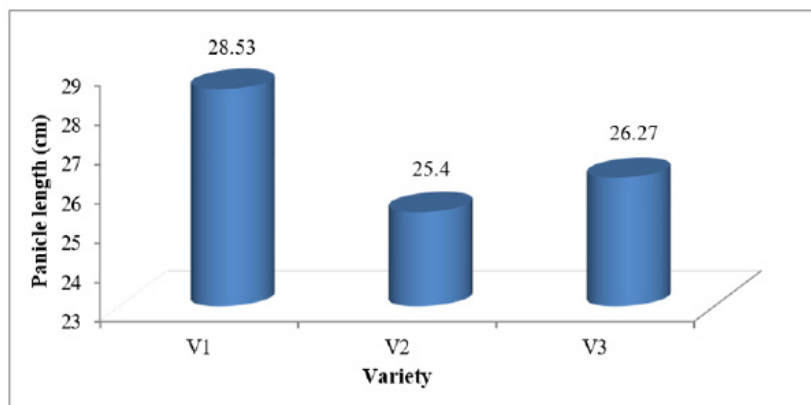
30-day-old seedlings) resulted in the highest 1000-seed weight (29.67 g) (Azam et al., 2012). Table 5 depicts the interaction effect of variety and seeding age on 1000 seed weight.

Seed yield



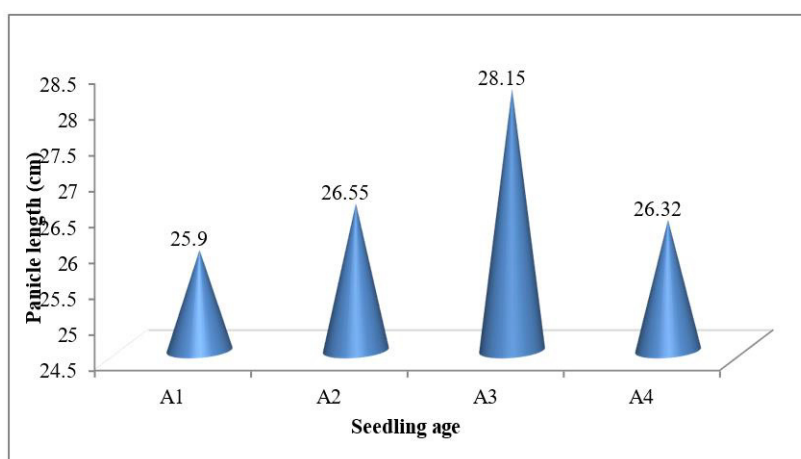
A1=20 days old seedling; A2=25 days old seedling; A3=30 days old seedling and A4=35 days old seedling.

Fig. 4. Effect of seedling age on number of effective tillers per hill of *T. Aman* rice (LSD0.05=0.79)



V1=BRRI Dhan32; V2=BRRI Dhan62; V3=BRRI Dhan80

Fig. 5. Effect of variety on panicle length of *T. Aman* rice (LSD0.05=1.14)



A1=20 days old seedling; A2=25 days old seedling; A3=30 days old seedling and A4=35 days old seedling

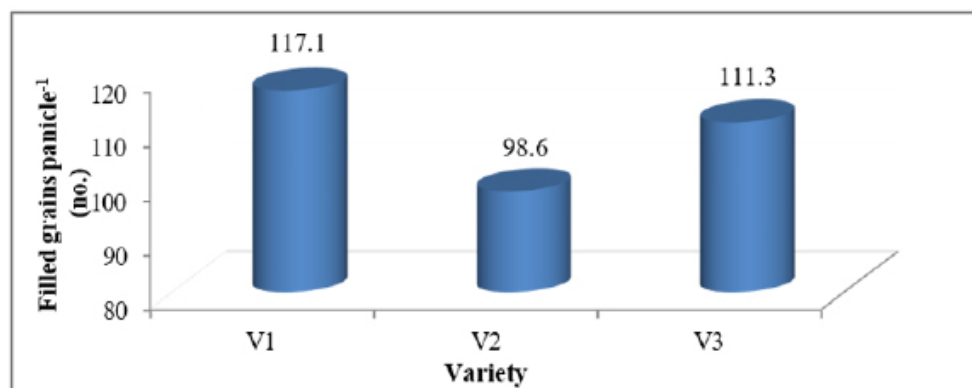
Fig. 6. Effect of seedling age on number of panicle length of *T. Aman* rice (LSD0.05=1.32)

Table 3. Interaction effect of variety and seedling age on effective tiller.hill⁻¹ and panicle length of *T. Aman* rice

Treatment	Effective tiller.hill ⁻¹ (no.)	Panicle length (cm)
V1A1	16.81 bc	27.67 bc
V1A2	17.33 ab	28.30 ab
V1A3	18.39 a	30.48 a
V1A4	16.66 b-d	27.68 bc
V2A1	14.43 f	24.03 f
V2A2	15.05 ef	24.82 ef
V2A3	15.52 c-f	26.81 b-e
V2A4	14.58 f	25.93 c-f
V3A1	15.36 c-d	26.60 c-f
V3A2	16.17 b-e	26.53 b-e
V3A3	16.16 b-e	27.17 b-d
V3A4	15.20 d-f	25.36 d-f
LSD (0.05)	1.37	2.28
CV%	5.05	5.03

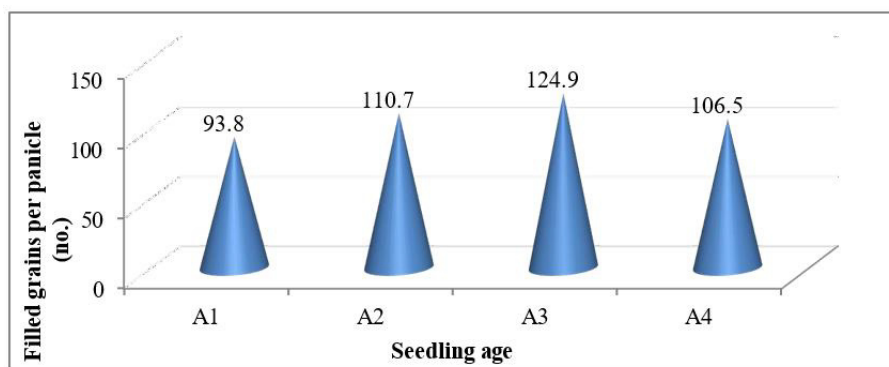
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(V1=BRRI Dhan32; V2=BRRI Dhan62; V3=BRRI Dhan80; A1=20 days old seedling; A2=25 days old seedling; A3=30 days old seedling and A4=35 days old seedling)



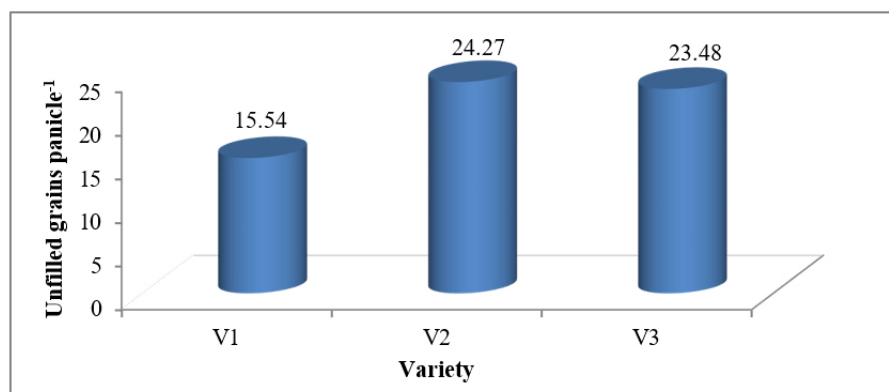
V1=BRRI Dhan32; V2=BRRI Dhan62; V3=BRRI Dhan80

Fig. 7. Effect of different *T. Aman* rice varieties on number of filled seeds.panicle⁻¹ (LSD0.05=5.55)



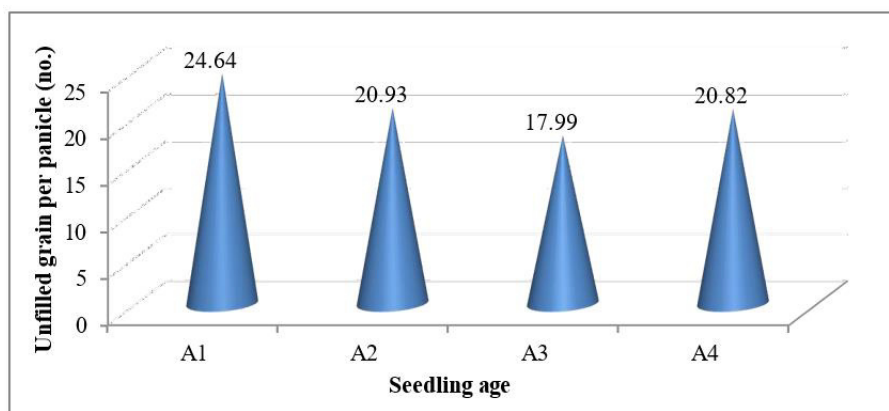
A1= 20 days old seedling; A2=25 days old seedling; A3=30 days old seedling and A4=35 days old seedling

Fig. 8. Effect of different age of seedling on number of filled seeds.panicle⁻¹ of *T. Aman* rice (LSD0.05=6.41)



V1=BRR I Dhan32; V2=BRR I Dhan62; V3=BRR I Dhan80

Fig. 9. Effect of different *T. Aman* rice varieties on number of unfilled seed per panicle (LSD0.05=0.53)



A1=20 d0ays old seedling; A2=25 days old seedling; A3=30 days old seedling and A4=35 days old seedling

Fig. 10. Effect of different age of seedling on number of unfilled seed per panicle of *T. Aman* rice (LSD0.05=0.61)

Table 4. Interaction effect of variety and different age of seedling on filled seeds.panicle⁻¹ and unfilled seeds.panicle⁻¹ of *T. Aman* rice.

Treatment	Filled seeds.panicle ⁻¹ (no.)	Unfilled seeds.panicle ⁻¹ (no.)
V1A1	101.4 cd	18.28 g
V1A2	119.4 b	15.90 h
V1A3	136.2 a	10.73 i
V1A4	111.6 bc	17.26 g
V2A1	83.0 e	31.07 a
V2A2	99.2 d	23.79 c
V2A3	115.6 b	20.31 f
V2A4	96.6 d	21.89 e
V3A1	97.0 d	22.28 de
V3A2	113.7 b	23.10 cd
V3A3	123.0 b	22.93 c-e
V3A4	111.4 bc	22.60 b
LSD (0.05)	11.10	1.05
CV%	4.12	2.94

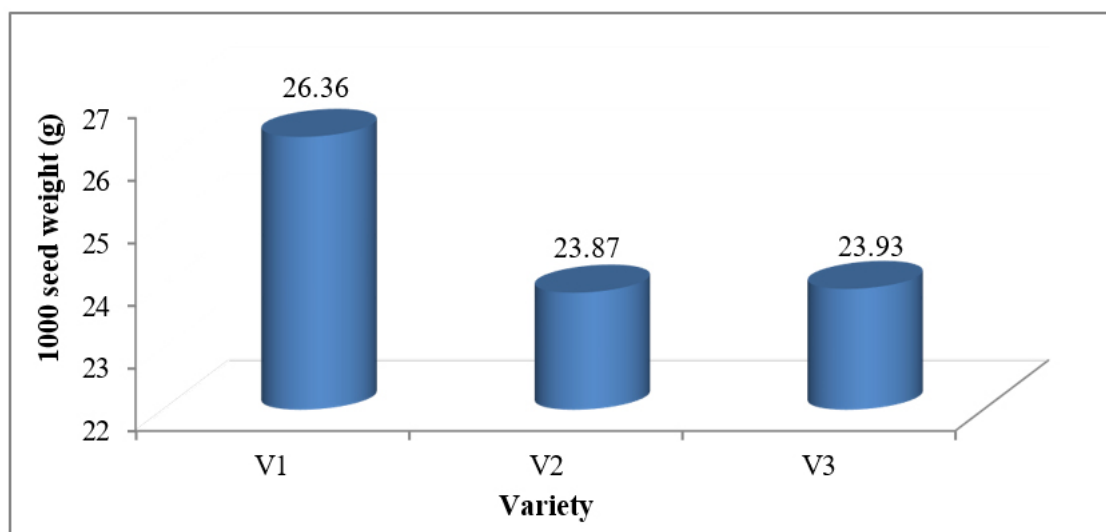
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Table 5. Interaction effect of variety and seedling age on 1000 seed weight, seed yield and straw yield of rice

Treatment	1000 seed weight (g)	Seed yield (t.ha ⁻¹)	Straw yield (t.ha ⁻¹)
V1A1	23.03 d	4.41 c-e	4.91 e
V1A2	26.86 b	4.60 cd	5.76 c
V1A3	29.67 a	5.12 a	6.93 a
V1A4	25.88 bc	4.59 c	6.25 b
V2A1	20.64 e	4.08 e	4.01 g
V2A2	24.37 cd	4.31 de	4.96 e
V2A3	26.53 b	4.61 cd	6.04 bc
V2A4	23.93 cd	4.12 e	5.23 de
V3A1	19.60 e	4.29 f	4.89 fg
V3A2	24.26 cd	4.50 cd	5.45 ef
V3A3	26.87 b	4.77 b	5.63 cd
V3A4	25.01 b-d	4.30 e	5.27 de
LSD (0.05)	2.06	0.37	0.47
CV%	4.93	4.81	5.14

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

(V1=BRRI Dhan32; V2=BRRI Dhan62; V3=BRRI Dhan80; A1=20 days old seedling; A2=25 days old seedling; A3=30 days old seedling and A4=35 days old seedling)



V1=BRRI Dhan32; V2=BRRI Dhan62; V3=BRRI Dhan80

Fig. 11. Effect of variety on 1000 seed weight of *T. Aman* rice (LSD0.05=1.03)

Varietal effect: BRRI Dhan32 significantly produced the highest seed yield (4.68 t.ha⁻¹), outperforming other varieties. BRRI Dhan62 yielded the lowest (4.28 t.ha⁻¹) (Zohra et al., 2013). Figure 12 confines the seed yield of different varieties of *T. Aman* rice.

Effect of seedling age: 30-day-old seedlings (A3) produced the highest seed yield (4.83 t.ha⁻¹), while 20-day-old seedlings (A1) had the lowest (4.26 t.ha⁻¹) (Krishna and Biradarpatil, 2009; Patra and Haque, 2011). Figure 13 defines the effect of different age seeding.

Interaction effect: V1A3 (BRRI Dhan32 with 30-day-old seedlings) resulted in the highest seed yield (5.12 t.ha⁻¹), while V2A4 showed the lowest (4.12 t.ha⁻¹). (Table 5 after Straw yield interactions.)

Straw yield

Varietal effect: BRRI Dhan32 produced the highest straw yield (5.46 t.ha⁻¹), while BRRI Dhan62 had the lowest (5.06 t.ha⁻¹) (Patel, 2000). Figure 14 shows the effect of straw yielding on *T. Aman* rice.

Effect of seedling age: 30-day-old seedlings (A3) significantly increased straw yield to the highest level (6.20 t.ha⁻¹), with 20-day-old seedlings

(A1) showing the lowest (4.60 t.ha⁻¹) (Azam et al., 2012). Figure 15 shows the effect of seeding age on straw yield of *T. Aman* rice.

Interaction effect: V1A3 (BRRI Dhan32 with 30-day-old seedlings) produced the highest straw yield (6.93 t.ha⁻¹), while V2A1 showed the lowest (4.01 t.ha⁻¹). (Table 5 here, covering 1000-seed weight, seed yield, and straw yield interactions).

Biological yield

Varietal effect: BRRI Dhan32 produced the maximum biological yield (10.64 t.ha⁻¹), with BRRI Dhan62 showing the minimum (9.34 t.ha⁻¹). Figure 16 depicts the effect of variety on biological yield of *T. Aman* rice.

Effect of seedling age: 30-day-old seedlings (A3) resulted in the highest biological yield (11.03 t.ha⁻¹), while 20-day-old seedlings (A1) had the lowest (8.86 t.ha⁻¹). Figure 17 shows the effect of seeding age on biological yield of *T. Aman* rice.

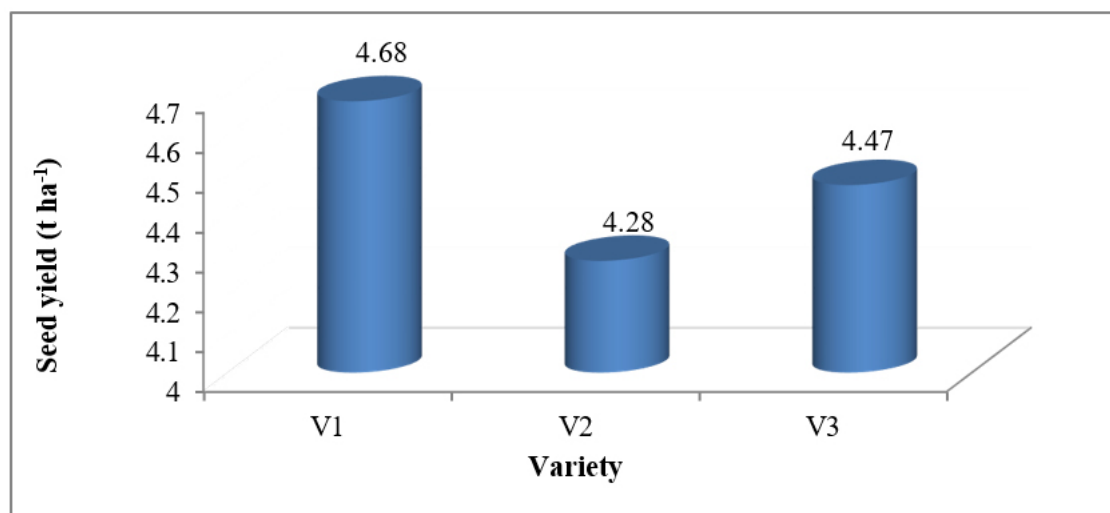
Interaction effect: V1A3 (BRRI Dhan32 with 30-day-old seedlings) produced the highest biological yield (12.05 t.ha⁻¹), while V2A1 showed the lowest (8.09 t.ha⁻¹) (Table 6).

Table 6. Interaction effect of variety and seedling age on biological yield and harvest index of rice

Treatment	Biological yield (t.ha ⁻¹)	Harvest index (%)
V1A1	9.32 d	47.32 d
V1A2	10.36 c	44.40 g
V1A3	12.05 a	42.49 k
V1A4	10.84 b	42.34 k
V2A1	8.09 e	50.43 a
V2A2	9.27 d	46.49 e
V2A3	10.65 b	43.29 i
V2A4	9.35 d	44.06 h
V3A1	9.18 d	46.73 e
V3A2	9.85 c	45.23 f
V3A3	10.4 b	45.87 f
V3A4	9.57 c	44.93 g
LSD (0.05)	0.84	0.08
CV%	4.96	0.36

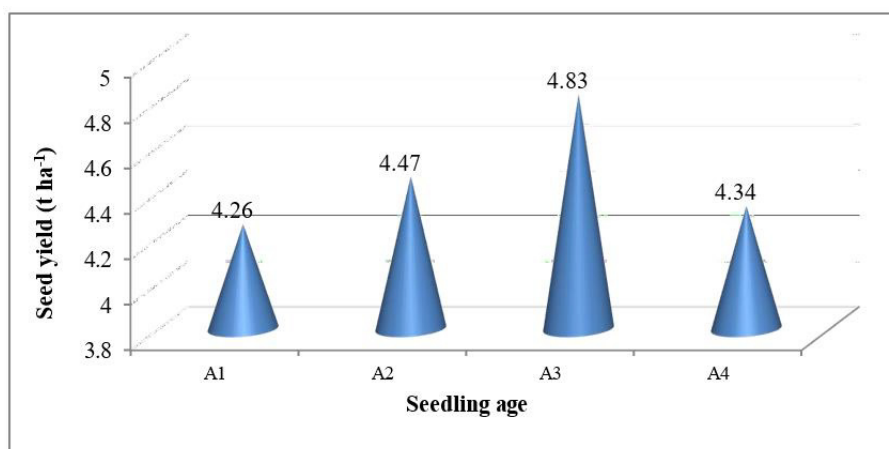
In a column means having similar letter(s) are statistically identical and those having dissimilar letter differ significantly as per 0.05 level of probability.

(V1=BRRI Dhan32; V2=BRRI Dhan62; V3=BRRI Dhan80; A1= 20 days old seedling; A2=25 days old seedling; A3 = 30 days old seedling and A4=35 days old seedling).



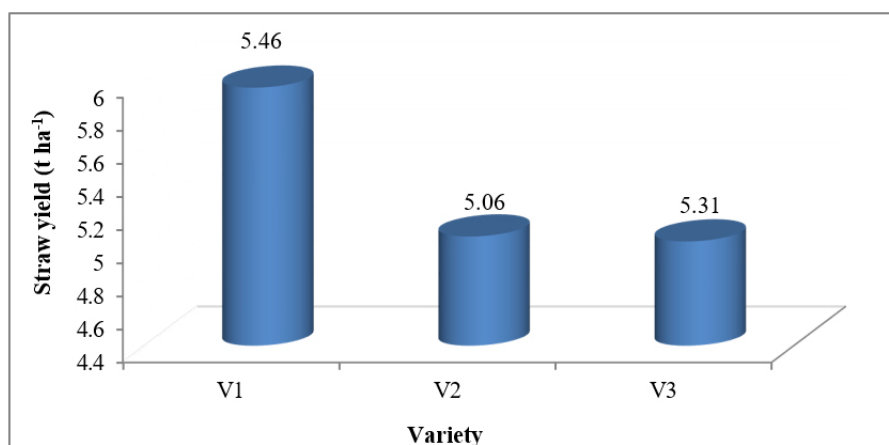
V1=BRRI Dhan32; V2=BRRI Dhan62; V3=BRRI Dhan80

Fig. 12. Effect of variety on seed yield of *T. Aman* rice (LSD0.05=0.19)



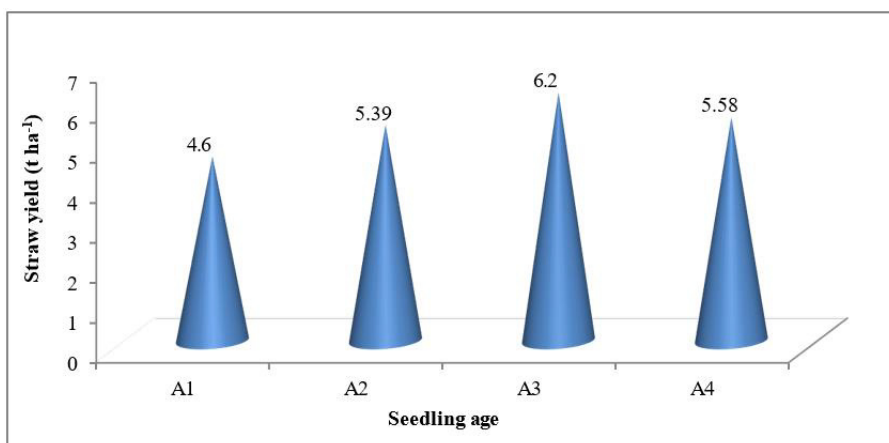
A1= 20 days old seedling; A2= 25 days old seedling; A3 = 30 days old seedling and A4 = 35 days old seedling

Fig. 13. Effect of different age of seedling on seed yield of *T. Aman* rice (LSD0.05=0.21)



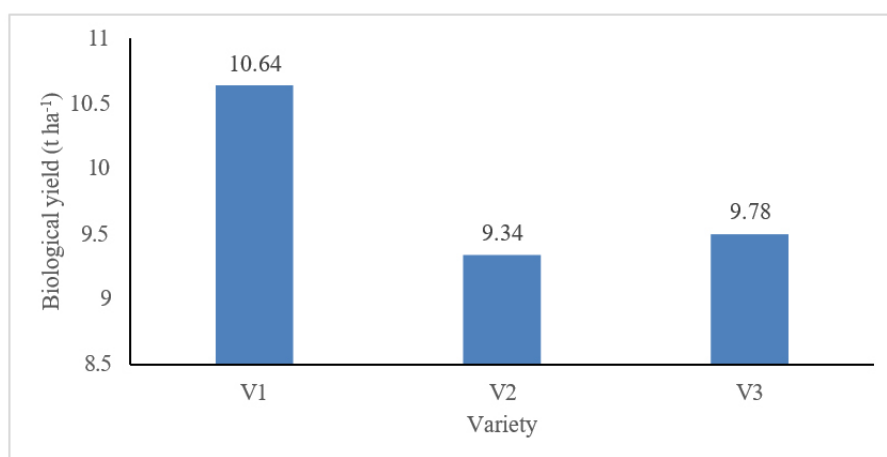
V1=BRRRI Dhan32; V2=BRRRI Dhan62; V3=BRRRI Dhan80

Fig. 14. Effect of variety on straw yield of *T. Aman* rice (LSD0.05=0.23)



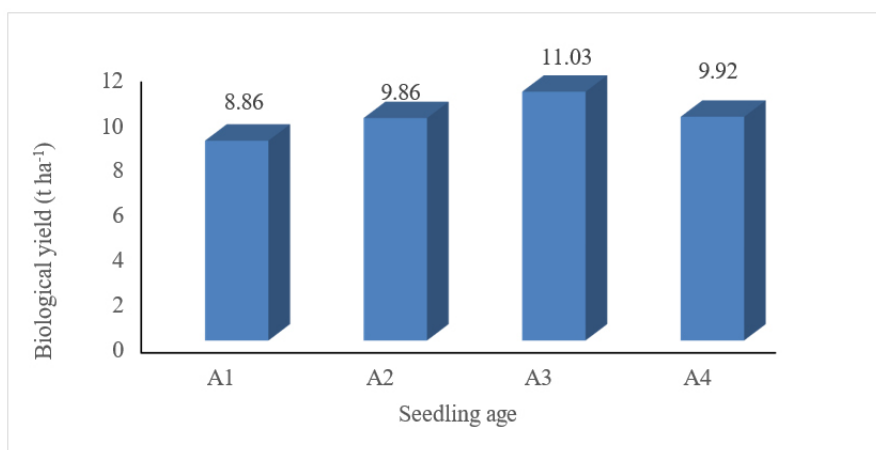
A1=20 days old seedling; A2=25 days old seedling; A3=30 days old seedling and A4=35 days old seedling

Fig. 15. Effect of seedling age on straw yield of *T. Aman* rice (LSD0.05=0.27)



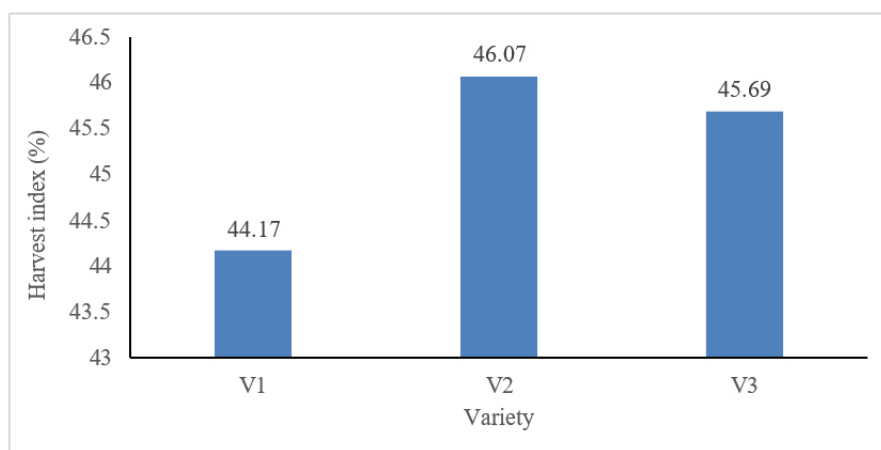
V1=BRRI Dhan32; V2=BRRI Dhan62; V3=BRRI Dhan80

Fig. 16. Effect of variety on biological yield of *T. Aman* rice (LSD0.05=0.42)



A1=20 days old seedling; A2=25 days old seedling; A3=30 days old seedling and A4=35 days old seedling

Fig. 17. Effect of seedling age on biological yield of *T. Aman* rice (LSD0.05=0.48)



V1=BRRI Dhan32; V2=BRRI Dhan62; V3=BRRI Dhan80

Fig. 18. Effect of variety on harvest index of *T. Aman* rice (LSD0.05=0.04)

Harvest index

Varietal effect: BRRI Dhan62 had the highest harvest index (46.07%), followed by BRRI Dhan80 (45.69%). BRRI Dhan32 showed the lowest (44.17%). Figure 18 shows the effect of variety on harvest index of *T. Aman* rice.

Conclusion

This comprehensive study clearly demonstrates that both variety and seedling age significantly influence the growth, yield attributes, and ultimate yield of *T. Aman* rice, with notable interaction effects. Among the tested varieties, BRRI Dhan32 consistently emerged as the superior performer, exhibiting the tallest plants, highest number of tillers per hill (both total and effective), longest panicles, and critically, the highest number of filled seeds per panicle and 1000-seed weight. Consequently, BRRI Dhan32 delivered the maximum seed, straw, and biological yields. Crucially, the research unequivocally identifies 30-day-old seedlings (A3) as the optimal transplanting age. This seedling age consistently promoted vigorous plant growth, maximized tillering, improved panicle characteristics, reduced unfilled grains, and ultimately led to the highest yields across all parameters. This superiority was evident when compared to younger (20 and 25 days old) and older (35 days old) seedlings, highlighting a critical window for optimal establishment and productivity. The synergistic interaction between BRRI Dhan32 and 30-day-old seedlings (V1A3) consistently resulted in the most favorable outcomes for almost all growth and yield parameters, including the highest seed, straw, and biological yields. This specific combination significantly minimized yield-limiting factors, such as unfilled grains, and maximized yield components. In conclusion, for maximizing the yield and quality of *T. Aman* rice in the Agro-ecological zone of Modhupur Tract (AEZ-28), the cultivation of BRRI Dhan32 with 30-day-old seedlings is strongly recommended. This combination represents a robust and highly effective management strategy for rice farmers in similar agro-climatic conditions, promising enhanced productivity and resource use efficiency.

Future research could explore the physiological mechanisms underlying the superior performance of 30-day-old seedlings with BRRI Dhan32, to further refine rice cultivation practices. While the current findings identify 30-day-old seedlings of BRRI Dhan32 as optimal for the study region, it is recommended that multi-year field trials (ideally spanning three years) be conducted in the future, to account for the potential influence of varying climatic and agronomic conditions on rice productivity.

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