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Growth and Yield Response of Some Rice Genotype under Different Duration of Complete Submergence

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Authors' contributions

This work was carried out in collaboration between all authors. Author TS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KUA and NN gave the guidance and managed the analyses of the study. Authors MSI and MSJ managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: An experiment was conducted to observe the effect of complete submergence at vegetative stage of plants for different duration on the growth and yield of some rice varieties.
Study Design: The experiment was laid out in randomized complete block design having split plot arrangement with three replications.
Place and Duration of Study: This experiment was conducted at the department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh between June 2016 and July 2017.
Methodology: For this experiment, different submergence duration (D_0 = no submergence, D_1 = six days submergence, D_2 =ten days submergence and D_3 = fourteen days submergence) and six rice varieties (V_1 = BRRI dhan51, V_2 = BRRI dhan46, V_3 = BRRI dhan34, V_4= BRRI hybrid dhan1, V_5 = BRRI hybrid dhan2 and V_6 = ACI hybrid1) were used. The experiment was laid out in a split

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plot design with three replications. The whole field was divided into three equal blocks each containing 24 plots. Each block was subdivided into four sub blocks. As such there were 12 sub blocks. Each sub blocks was encircled by the 50 cm high soil wall ridge, which was hundred percent water leakages proof. In total, there were 72 plots. The treatment was randomly assigned to each unit plot. The size of each unit plot was 3 m × 2 m. The distance between two blocks and two plots were kept 1m and 0.80 m respectively. The plant was submerged completely in unit plot to a depth of 40 cm above the soil level. The water level was higher than the plant height. The field conditions were made as similar as possible to the conditions which occur during actual flooding in nature.

Results: All parameters were significantly affected by the submergence duration. The cultivars also significantly varied for the studied traits. The highest number of leaves was achieved in BRRI dhan51. The highest grain yield m^{-2} was found from D_0 (0.62 kg) whereas the lowest yield was recorded from D_3 (0.38 kg) treatment. The V_4 (BRRI hybrid dhan1) produced the highest (0.78 kg) grain yield m^{-2} and the lowest grain weight m^{-2} (0.23 kg) was found from V_3 (BRRI dhan34). The highest (0.85 kg) grain yield m^{-2} was found from the combination of D_0V_4 and the lowest (0.12 kg) from D_3V_3 treatment. The test genotypes showed wide variation in percent of yield reduction at different submergence duration. The highest percent reduction of yield (65.71) was found from the combination of D_3V_3 and the lowest (2.22) from D_1V_1 treatment.

Conclusion: BRRI dhan51 followed by BRRI hybrid dhan1 showed lower grain yield reduction % in submerged conditions compare to control by attaining good yield contributing characters and thus proved as tolerant varieties. On the other hand, BRRI dhan34 and ACI hybrid1 were susceptible to submergence.

Keywords: Submergence; transplanting; Aman rice; seedling stage; yield.

1. INTRODUCTION

Rice (*Oryza sativa* L.) can grow well in paddy fields (unlike other cereal) and is highly tolerant of excess water stress from submergence (in which part or all of the plant is under water). Rice handles submergence stress by internal aeration and growth controls. Plants require water for growth but excess water that occurs during submergence is harmful or even lethal. A submerged plant is defined as a plant standing in water with at least part of the terminal above the water or completely covered with water [1]. Submergence subjects plants to the stresses of low light, limited gas diffusion, effusion of soil nutrients, mechanical damage and increased susceptibility to pests and diseases [2,3]. Basically, flooding (*i.e.*, submergence) can be classified into flash flooding and deepwater flooding in accordance with the duration of flooding and the water depth [1,4,5]. Flash flooding which generally lasts less than a few weeks is caused by heavy rain but the depth is not very deep. On the other hand, deepwater flooding which lasts for several months, occurs during the rainy season and the water depth reaches several meters [1,6].

In Bangladesh rainfed lowland rice covers an area of 4.5 million hectares [7] and is grown by transplanting Aman rice from June-September at the peak period of monsoon rainfall. As a result following seedling transplantation as well as at early vegetative stage of the crop is often completely submerged by flash flood due to continuous rainfall as well as due to onrush of flood water from adjoining rivers. Such flood may continue for a week or more inflicting heavy damage to standing crop. As a result growth and yield of rice plant is severely decreased [8]. Complete submergence at the vegetative stage of rice causes deterioration in the plant quality resulting in a poor stand and causes substantial yield loss. Dey and Upadhyaya [9] reported that abiotic stress like complete submergence at vegetative stage caused 140 kg/ha yields loss in Bangladesh. Sometimes it causes total crop failure. So, Submergence caused by flooding is a major constraint in case of transplanting aman rice establishment [10]. The successful development of high yielding rice cultivars with submergence tolerance may be an effective alternative for saving huge losses of rice production. Varietal differences in terms of submergence tolerance have been shown to exist by several workers [11]. For the development of modern high yielding variety with submergence tolerant traits, identification of submergence tolerant varieties are very important. Based on these facts, the specific objectives of the present study were to observe the effect of submergence on the morphological attributes and yield of rice at vegetative stage and to find out the highest submergence period for different varieties in which rice plant can survive that might be suitable for flood prone area.

2. MATERIALS AND METHODS

An experiment was conducted during the period from July to December, 2017 in transplanting aman season. The experiment was conducted in the Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh to observe the effect of submergence at early vegetative stage on growth and yield of some transplanting aman rice varieties. Four submergence duration such as control (no submergence), six days submergence, ten days submergence and fourteen days submergence and six transplanting aman varieties such as BRRI dhan51, BRRI dhan46, BRRI dhan34. BRRI hybrid dhan1, BRRI hybrid dhan2, ACI hybrid1 were used for this experiment. At the time of first ploughing cowdung at the rate of 3tha^{-1} was applied. The experimental plots were fertilized with at the rate of 109, 134, 59, 8 kg ha^{-1} in the form of Urea, Triple Superphosphate (TSP), Muriate of Potash (MoP), Gypsum and Zinc Sulphate respectively one day before transplanting. Urea was top dressed at the rate of 89 kg N ha^{-1} in three equal splits at 10, 30 and 50 DAT (Days After Transplanting). The entire amounts of Triple Superphosphate (TSP), Muriate of Potash (MoP), Gypsum and Zinc Sulphate were applied at final land preparation as basal dose. The experiment was laid out in randomized complete block design having split plot arrangement with three replications. The whole field was divided into three equal blocks each containing 24 plots. Each block was subdivided into four sub blocks. As such there were 12 sub blocks. Each sub block was encircled by the 50 cm high soil wall ridge, which was hundred percent water leakages proof. In total, there were 72 plots. The treatment was randomly assigned to each unit plot. The size of each unit plot was 3 m × 2 m. The distance between two blocks and two plots were kept 1m and 0.80 m respectively. Dated on 11 August 2017 the rice seedlings were transplanted in lines each having a line to line distance of 25 cm and plant to plant distance 15 cm in the well prepared plots.

The plant was submerged completely at early vegetative stage (30 Days After Transplanting) in unit plot to a depth of 40 cm above the soil level. The water level was higher than the plant height. This was done to ensure that the conditions were made as similar as possible to the conditions which occur during actual flooding in nature. The D_0 or controlled sub-blocks were irrigated as prescribed for the high yielding transplanting aman varieties of rice. The other sub-blocks D_1 (6 days submergence), D_2 (10 days submergence) and D_3 (14 days submergence) were irrigated similar to natural condition in 30 DAT, where the water level was raised up to 40 cm height to submerge the rice plants. The water in submersed sub-blocks was made turbid time to time by stirring the mud for creating natural flooding condition. The water in the sub-block was drained out as per treatment after 6 days (D_1), 10 days (D_2) and 14 days (D_3) of submergence. The parameters which were measured in this experiment are leaves plant^{-1}, days to 50% and 100% booting, days to 50% and 100% panicle emergence and days to maturity of rice, yield and yield reduction percent. The recorded data on various parameters were statistically analyzed by using MSTAT statistical package programme. Difference between treatment means were determined by Duncan`s new Multiple Range Test (DMRT) according to Gomez, K. A. and Gomez, A. A. [12].

3. RESULTS AND DISCUSSION

3.1 Leaves Plant^{-1}

Number of leaves was significantly influenced by submergence. The number of leaves was counted at 10, 20, 30, 40, 50 and 60 days after transplanting and at harvest. The highest number of leaves (3.49, 5.07, 15.39, 29.10, 52.33 and 52.0 at 10, 20, 30, 40, 50 and 60 DAT, respectively) was recorded from D_0 (no submergence) treatment, while the lowest number of leaves (3.04, 3.24, 11.33, 25.51, 49.22 and 48.25 cm at 10, 20, 30, 40, 50 and 60 DAT, respectively) was observed from D_3 (Fourteen days submergence) (Fig. 1).

Number of leaves was significantly influenced by variety at all the sampling dates (Fig. 2). The V_1 (BRRI dhan51) variety produced the highest number of leaves (3.31, 4.42, 14.60, 30.46, 53.00 and 54.46 cm at 10, 20, 30, 40, 50 and 60 DAT respectively) and V_3 (BRRI dhan34) produced shortest (3.15, 3.58, 12.27, 22.23, 44.71 and 44.42 cm at 10, 20, 30, 40, 50 and 60 DAT, respectively) number of leaves. Probably the genetic makeup of varieties was responsible for the variation in number of leaves. This confirms the reports of BRRI [13] that plant height differed due to varietal variation.

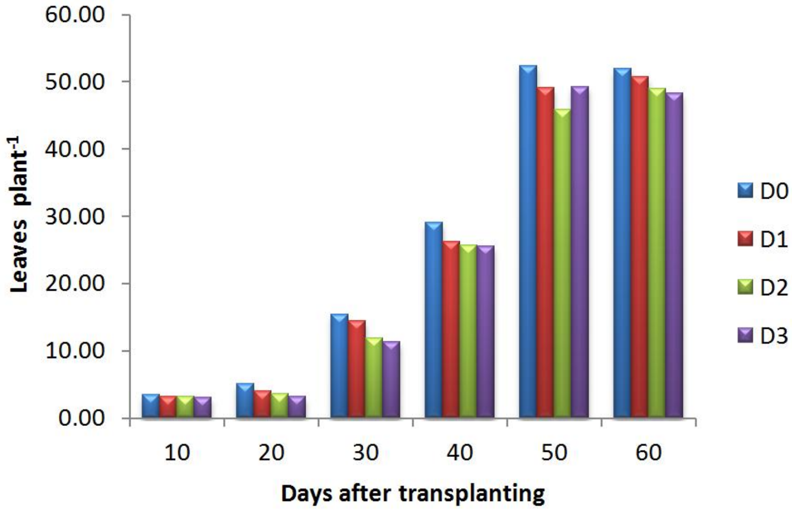

Fig. 1. Effect of submergence on number of leaves per plant of rice at different days after transplanting

D0 = No submergence; D1 = Six days submergence; D2 =Ten days submergence; D3 = Fourteen days submergence

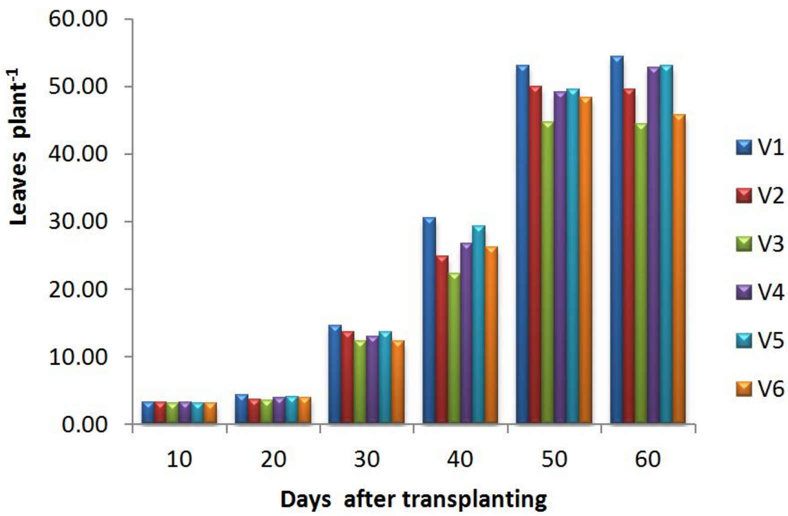

Fig. 2. Effect of variety on number of leaves per plant of rice at different days after transplanting

V_1 = BRRI dhan51, V_2 = BRRI dhan46, V_3 = BRRI dhan34 V_4= BRRI hybrid dhan1, V_5 = BRRI hybrid dhan2 and V_6 = ACI hybrid1

Interaction between submergence and variety was significantly affected on number of leaves per plant at different days after transplanting (Table 1). The maximum number of leaves per plant (3.83, 5.67, 19.08, 35.50, 59.58 and 64.25 at 10, 20, 30, 40, 50 and 60 DAT, respectively) was found from D_0V_1 (no submergence with BRRI dhan51) and lowest number of leaves per plant (3.00, 2.50, 9.17, 16.50, 38.75 and 39.17 at 10, 20, 30, 40, 50 and 60 DAT, respectively) from D_3V_3 (fourteen day submergence with BRRI dhan34). High phenotypic co-efficient of variation (PCV) and genotypic co-efficient of variation (GCV) subject to obtain maximum number of leaves per plant obtained by Ukkund et al. [14] and Singh et al. [15]. An increased tiller number per hill may increase leaves number per plant.

3.2 Survival Percent after Submergence

Survival percent after submergence was statistically influenced by duration of submergence. The maximum survival percent after submergence (84.56) was obtained from D_0

treatment. The minimum survival percent after submergence (23.56) was recorded from D_3 treatment (Table 2). The survival percent after submergence was significantly influenced by variety (Table 3). The maximum survival percent after submergence (66.17) was found in V_1 treatment. The V_3 (BRRI dhan34) achieved the minimum survival percent (55.17).

The survival percent after submergence was significantly influenced by variety (Table 4). The maximum survival percent after submergence (66.17) was found in V_1. The V_3 (BRRI dhan34) was showed the minimum survival percent after submergence (55.17).

The effect of submergence and variety were statistically significant on survival percent (Table 4). The highest survival percent after submergence (92.67) was found from D_0V_1 (No submergence with BRRI dhan51) and the lowest survival percent after submergence (9.33) from D_3V_3 (fourteen days submergence with BRRI dhan34).Survival percent after submergence decreases because some of the plant died due to their failure in competing for light and nutrients. This revealed that during the vegetative phases the rate of survivality decreases due to submergence [16]. Variable effect of variety on survival percent after submergence was also reported by Gomosta et al. [17] who noticed that survival percent after submergence differed among the varieties

3.3 Days to 50% Booting

A significant variation was observed in days to 50% booting due to different duration of submergence (Table 2). The D_1 treatment required the earliest of days to 50% booting initiation (60.78 days). D_0 treatment was the longest time of 50% booting initiation (63.83 days).

A significant difference was observed among the varieties in the days to 50% booting (Table 3). Delayed 50% booting initiation (72.75 days) was found in V_1 treatment and 50% booting initiation was earliest (48.5 days) in V_6, which was statistically similar to V_5 treatment.

Table 1. Interaction effect of submergence and varieties on leaves Plant^{-1} of rice

Treatment	Leaves plant^{-1}											
	10 DAT		20 DAT		30 DAT		40 DAT		50 DAT		60 DAT	
D_0V_1	3.83	A	5.67	a	19.08	A	35.50	A	59.58	a	64.25	a
D_0V_2	3.17	abc	5.33	abc	16.42	Ab	31.08	ab	48.75	a-d	54.42	a-d
D_0V_3	3.17	abc	4.00	a-f	14.42	a-d	27.75	abc	46.33	bcd	53.08	a-d
D_0V_4	3.25	abc	5.08	a-d	14.67	a-d	30.17	ab	52.42	abc	54.50	a-d
D_0V_5	3.17	abc	4.67	a-e	15.92	Abc	31.50	ab	51.67	abc	58.83	ab
D_0V_6	3.17	abc	4.25	a-f	14.92	a-d	31.17	ab	51.08	abc	55.42	a-d
D_1V_1	3.75	ab	3.33	c-f	12.83	a-d	28.58	abc	52.33	abc	49.92	a-d
D_1V_2	3.25	abc	5.08	a-d	15.42	Abcd	22.75	bcd	51.58	abc	54.25	a-d
D_1V_3	3.33	abc	4.08	a-f	10.17	Bcd	22.42	bcd	53.83	abc	50.58	a-d
D_1V_4	3.08	bc	3.42	b-f	14.00	a-d	28.33	abc	52.08	abc	52.67	a-d
D_1V_5	3.25	abc	5.08	a-d	13.58	a-d	28.67	abc	49.67	a-d	44.25	bcd
D_1V_6	3.50	abc	3.67	a-f	11.50	Bcd	23.33	bcd	47.25	bcd	46.00	bcd
D_2V_1	3.17	abc	3.67	a-f	11.75	Bcd	30.33	ab	42.58	Cd	57.58	abc
D_2V_2	3.25	abc	3.00	def	11.17	Bcd	25.58	a-d	51.33	abc	48.25	a-d
D_2V_3	3.08	bc	2.67	ef	10.17	Bcd	23.75	bcd	55.42	Ab	41.83	cd
D_2V_4	3.17	abc	3.58	a-f	12.75	a-d	27.83	abc	48.67	a-d	50.58	a-d
D_2V_5	3.17	abc	3.67	a-f	12.50	Bcd	29.92	ab	46.58	bcd	53.25	a-d
D_2V_6	3.08	bc	2.83	ef	13.33	a-d	24.50	bcd	49.67	a-d	51.50	a-d
D_3V_1	3.17	abc	3.83	a-f	16.00	Abc	26.08	a-d	49.83	a-d	49.17	Abcd
D_3V_2	3.08	bc	3.00	def	15.50	a-d	24.92	bcd	46.33	bcd	39.50	d
D_3V_3	3.00	c	2.50	f	9.17	d	16.50	d	38.75	d	39.17	d
D_3V_4	3.00	c	3.00	def	10.50	bcd	19.33	cd	43.50	bcd	44.00	bcd
D_3V_5	3.17	abc	3.58	a-f	9.67	cd	25.83	a-d	45.58	bcd	46.33	bcd
D_3V_6	3.00	c	2.92	ef	13.00	a-d	23.42	bcd	43.83	bcd	40.67	d
CV (%)	11.48		7.33		8.56		8.92		12.46		9.82	

D_0 = No submergence, D_1 = Six days submergence, D_2 =Ten days submergence, D_3 = Fourteen days submergence, V_1 = BRRI dhan51, V_2 = BRRI dhan46, V_3 = BRRI dhan34, V_4 = BRRI hybrid dhan1, V_5 = BRRI hybrid dhan2 and V_6 = ACI hybrid 1

Table 2. Effect of submergence on survival percentage after submergence, days to 50% and 100% booting, days to 50% and 100% panicle emergence and days to maturity of rice

Treatment	Survival percent after submergence		Day to 50% booting		Days to 100% booting		Days to 50% panicle emergence		Days to 100% panicle emergence		Days to maturity	
D_0	84.56	a	63.83	a	65.22	c	65.44	b	67.22	b	121.30	d
D_1	67.78	a	60.78	c	65.83	c	68.39	ab	70.17	ab	124.30	c
D_2	64.56	a	61.67	ab	66.67	b	69.50	ab	71.17	ab	125.30	b
D_3	23.56	b	61.89	ab	68.33	a	72.11	a	73.83	a	126.30	a
CV (%)	13.22		10.19		5.31		5.47		6.49		8.23	

D_0 = No submergence; D_1 = Six days submergence; D_2 =Ten days submergence; D_3 = Fourteen days submergence

Table 3. Effect of varieties on survival percentage after submergence, days to 50% and 100% booting initiation, days to 50% and 100% panicle initiation and days to maturity of rice

Treatment	Survival percent after submergence		Day to 50% booting		Days to 100% booting		Days to 50% panicle emergence		Days to 100% panicle emergence		Days to maturity	
V_1	66.17	a	72.75	a	79.33	a	81.67	a	82.83	a	120.00	d
V_2	56.17	c	72.42	a	78.83	a	82.08	a	83.33	a	120.00	D
V_3	55.17	c	66.92	ab	71.00	b	72.67	b	74.67	b	134.00	A
V_4	60.33	bc	61.42	b	65.75	b	67.33	c	69.33	c	124.00	C
V_5	62.83	ab	50.25	c	51.50	c	54.67	d	56.67	d	124.00	C
V_6	60.00	bc	48.50	c	52.67	c	54.75	d	56.75	d	130.00	B
CV (%)	13.22		10.19		5.31		5.47		6.49		8.23	

V_1 = BRRI dhan51, V_2 = BRRI dhan46, V_3 = BRRI dhan34 V_4= BRRI hybrid dhan1, V_5 = BRRI hybrid dhan2 and V_6 = ACI hybrid1

Table 4. Combined effect of submergence and varieties on days to 50% and 100% booting initiation, days to 50% and 100% panicle initiation and days to maturity of rice

Treatment	Survival percent after submergence		Day to 50% booting initiation		Days to 100% booting initiation		Days to 50% panicle initiation		Days to 100% panicle initiation		Days to maturity	
D_0V_1	92.67	a	74.33	ab	77.67	abc	78.67	cd	80.00	def	120.00	d
D_0V_2	74.67	a-e	73.33	ab	77.33	abc	79.33	c	80.67	cde	120.00	d
D_0V_3	81.33	abc	65.67	a-f	68.67	d-g	65.33	gh	67.33	ij	134.00	a
D_0V_4	87.33	ab	60.33	c-g	63.33	gh	64.33	h	66.33	j	124.00	c
D_0V_5	87.33	ab	45.67	h	49.33	j	52.33	j	54.33	l	124.00	c
D_0V_6	84.00	abc	45.33	h	58.33	hi	52.67	j	54.67	l	130.00	b
D_1V_1	79.33	a-d	73.67	ab	78.67	ab	80.67	bc	82.00	bcd	120.00	d
D_1V_2	65.33	cde	72.33	abc	77.67	abc	81.00	bc	82.33	bcd	120.00	d
D_1V_3	56.00	ef	65.67	a-f	70.33	def	74.00	e	76.00	g	134.00	a
D_1V_4	76.67	a-d	59.67	d-g	64.33	fgh	68.00	fg	70.00	hi	124.00	c
D_1V_5	78.67	a-d	56.00	e-h	50.67	j	53.33	j	55.33	l	124.00	c
D_1V_6	67.33	b-e	55.67	fgh	49.67	j	53.33	j	55.33	l	130.00	b
D_2V_1	72.67	a-e	66.00	a-f	80.00	a	82.67	ab	83.67	abc	120.00	d
D_2V_2	60.00	def	73.67	ab	80.00	a	83.33	ab	84.33	ab	120.00	d
D_2V_3	43.33	f	68.33	a-d	71.67	cde	75.00	e	77.00	fg	134.00	a
D_2V_4	68.67	b-e	63.67	b-g	66.67	efg	67.67	fg	69.67	hi	124.00	c
D_2V_5	66.00	cde	52.33	gh	52.00	j	54.00	j	56.00	l	124.00	c
D_2V_6	60.00	def	46.00	h	49.67	j	54.33	j	56.33	l	130.00	b
D_3V_1	43.33	f	77.00	a	81.00	a	84.17	a	85.67	a	120.00	d
D_3V_2	21.33	g	70.33	a-d	80.33	a	84.67	a	86.00	a	120.00	d
D_3V_3	9.33	g	68.00	a-e	73.33	bcd	76.33	de	78.33	efg	134.00	a
D_3V_4	23.33	g	62.00	b-g	68.67	d-g	69.33	f	71.33	h	124.00	c
D_3V_5	24.67	g	47.00	h	53.67	ij	59.00	i	61.00	k	124.00	c
D_3V_6	19.33	g	47.00	h	53.00	ij	58.67	i	60.67	k	130.00	b
CV (%)	13.22		10.19		5.31		5.47		6.49		8.23	

D_0 = No submergence, D_1 = Six days submergence, D_2 =Ten days submergence, D_3 = Fourteen days submergence, V_1 = BRRI dhan51, V_2 = BRRI dhan46, V_3 = BRRI dhan34, V_4 = BRRI hybrid dhan1, V_5 = BRRI hybrid dhan2 and V_6 = ACI hybrid 1

The combined effect of duration of submergence and variety on days of 50% booting initiation was found to be significant. Data in Table 4 Shows that, the days of 50% booting initiation was minimum (45.33 days) in D_0V_6, while it was maximum (77.00 days) in D_3V_1 treatment.

3.4 Days to 100% Booting

The submergence shows significant variation in the days to 100% booting initiation. The D_3 treatment required the maximum time of days to100% booting (68.33 days). D_0 treatment was the earliest in 100% booting (65.22 days) (Table 2).

There was a marked difference among the varieties in the days to 100% booting. 100% booting (79.33 days) was delayed in V_1 treatment and 100% booting initiation was earliest (51.50 days) in V_5 treatment (Table 3).

The combined effect of different submergence duration and variety on days to 100% booting was found to be significant. Data in Table 4 shows that the days to100% booting was minimum (49.33 days) in D_0V_5, while it was maximum (81.00 days) in D_3V_1 treatment.

3.5 Days to 50% Panicle Emergence

A significant variation was observed in days to 50% panicle emergence due to duration of submergence (Table 2). The D_0 treatment required the earliest to 50% panicle initiation (65.44 days). D_3 treatment showed the longest period to 50% panicle emergence (72.11 days).

A significant difference was observed among the varieties in the days to 50% panicle emergence (Table 3). 50% panicle emergence (82.08 days) was delayed in V_2 treatment and 50% panicle emergence was earliest (54.67 days) in V_5, which was statistically similar to V_6 treatment. BRRI [13] found that Days to panicle emergence significantly differed among different varieties.

The combined effect of different duration of submergence and variety on days to 50% panicle emergence was found to be significant. Data in Table 4 Shows that, the days of 50% panicle emergence was minimum (52.33 days) in D_0V_5, while it was maximum (84.67 days) in D_3V_2 treatment.

3.6 Days to 100% Panicle Emergence

The submergence shows significant variation in the days to 100% panicle emergence. The D_3 treatment required the maximum days to 100% panicle emergence (73.83 days). D_0 treatment was the earliest in 100% panicle emergence (67.22 days) (Table 2).

There was a marked difference among the varieties in the days to 100% panicle emergence. Delayed 100% panicle emergence (83.33 days) was found in V_2 treatment and 100% panicle emergence was earliest (54.67 days) in V_5 treatment (Table 3).

The combined effect of duration of submergence and variety on days of 100% panicle emergence was found to be significant. Data in Table 4 Shows that, the days to 100% panicle emergence was minimum (54.33 days) in D_0V_5, while it was maximum (86.00 days) in D_3V_2 treatment.

3.7 Days to Maturity

The submergence shows significant variation in the days to maturity. The D_3 treatment required the maximum time of days of maturity (126.30 days). D_0 treatment was the earliest in maturity (121.3 days) (Table 2).

There was a marked difference among the varieties in the days to maturity. Delayed maturity (134.00 days) was found in V_3 treatment and maturity was earliest (120.00 days) in V_1 and V_2 treatment (Table 3). BRRI [13] and Chowdury et al. [18] also reported differences in Days to maturity occurs due to varietal differences.

The combined effect of duration of submergence and variety on days of maturity was found to be significant. Data in Table 4 Shows that, the days of maturity was minimum (120.00 days) in D_0V_1, while it was maximum 134.00 days) in D_3V_3 treatment.

3.8 Yield m^{-2}

Grain yield $m^{-2}$of rice varied significantly for different submergence duration. The highest grain yield m^{-2} was found from D_0 (0.62 kg) whereas the lowest yield was recorded from D_3 (0.38 kg) treatment (Table 5).

Grain yield per plot is a function of interplay of various yield components such as number of productive tillers, grains panicle^{-1} and 1000-grain weight (Hassan et al. 2003). In present experiment variety had significant effect on grain yield (Table 6). The V_4 (BRRI hybrid dhan1) produced the highest (0.78 kg) grain yield m^{-2} and the lowest grain weight m^{-2} (0.23 kg) was found from V_3 (BRRI dhan34). Grain yield differences due to varieties were reported by Swain, et al. [19]. Variable grain yield among tested varieties of rice was reported by BRRI [20].

Table 5. Effect of submergence on thousand grain weight and yield of rice

Treatment	Yield/m^2		Percent reduction of yield	
D_0	0.62	a	0.00	d
D_1	0.60	a	5.23	c
D_2	0.50	b	19.02	b
D_3	0.38	c	31.03	a
CV (%)	6.88		7.89	

D_0 = No submergence, D_1 = Six days submergence, D_2 =Ten days submergence and D_3 = Fourteen days submergence

Interaction of submergence and variety significantly affected the grain yield m^{-2} (Table 7). The highest (0.85 kg) grain yield was found from the combination of D_0V_4 and the lowest (0.12 kg) from D_3V_3 treatment.

Table 6. Effect of varieties on thousand grain weight and yield of rice

Treatment	Yield/m^2		Percent reduction of yield	
V_1	0.36	d	3.86	e
V_2	0.44	c	6.91	d
V_3	0.23	e	30.43	a
V_4	0.78	a	6.63	d
V_5	0.73	a	9.00	c
V_6	0.61	b	26.10	b
CV (%)	6.88		7.89	

V_1 = BRRI dhan51, V_2 = BRRI dhan46, V_3 = BRRI dhan34, V_4= BRRI hybrid dhan1, V_5 = BRRI hybrid dhan2 and V_6 = ACI hybrid1

3.9 Percent Reduction of Yield

Percent reduction of yield of rice varied significantly for submergence. The highest percent reduction over control (31.00) was found from D_3 whereas the lowest percent reduction over control (5.23) was recorded from D_1 (six days submergence) treatment (Table 5).

Percent reduction of yield over control was evident from Table 6 that V_3 showed the highest (30.43%) yield reduction. The lowest percent reduction of yield (3.86%) was found in V_1.

From the Table 7 it was evident that the highest percent reduction of yield (65.71) was found from the combination of D_3V_3 and the lowest (2.22) from D_1V_1 treatment.

Table 7. Combined effect of submergence and varieties on yield and % reduction of yield of rice

Treatment	Yield/m^2		% reduction of yield	
D_0V_1	0.45	cd	0.00	n
D_0V_2	0.47	bcd	0.00	n
D_0V_3	0.35	de	0.00	n
D_0V_4	0.85	a	0.00	n
D_0V_5	0.80	a	0.00	n
D_0V_6	0.82	a	0.00	n
D_1V_1	0.44	cd	2.22	m
D_1V_2	0.45	cd	4.25	kl
D_1V_3	0.30	def	14.0	g
D_1V_4	0.82	a	3.52	l
D_1V_5	0.76	a	5.00	k
D_1V_6	0.80	a	2.40	m
D_2V_1	0.42	cd	6.60	j
D_2V_2	0.43	cd	8.50	i
D_2V_3	0.15	ef	42.00	c
D_2V_4	0.78	a	8.00	i
D_2V_5	0.72	a	10.00	h
D_2V_6	0.50	bcd	39.00	d
D_3V_1	0.42	cd	6.60	j
D_3V_2	0.40	d	14.89	f
D_3V_3	0.12	f	65.71	a
D_3V_4	0.68	ab	15	f
D_3V_5	0.65	abc	21	e
D_3V_6	0.30	def	63	b
CV (%)	6.88		7.89	

D_0 = No submergence, D_1 = Six days submergence, D_2 =Ten days submergence, D_3 = Fourteen days submergence, V_1 = BRRI dhan51, V_2 = BRRI dhan46, V_3 = BRRI dhan34, V_4 = BRRI hybrid dhan1, V_5 = BRRI hybrid dhan2 and V_6 = ACI hybrid 1

The response of 6 rice genotypes under different duration of submergence levels have been presented in different tables and discussed in this manuscript. Susceptible genotypes could be distinguished from submergence tolerant genotypes in respect of yield reduction. Difference among tolerant and moderate tolerant genotypes was clear even at 10 days and 14 days submergence. These results indicate that rice is moderately sensitive to submergence. The discriminating level for selection was observed at 10-14 days submergence as distinct differentiation of genotypes into tolerant, moderately tolerant and susceptible was observed at this level. Vamadevan et al. [21]

reported that variable grain yield reduction percent showed after submergence of tested varieties of rice.

4. CONCLUSION

Based on the results of the present study, the conclusion may be drawn as both variety and submergence duration has significant influence on morphological characters of rice at early vegetative stage. The tested genotypes showed wide variation in yield reduction percent in different submergence duration. BRRI dhan51 followed by BRRI hybrid dhan1 showed lower grain yield reduction % in submerged conditions compare to control by attaining good yield contributing characters and thus proved as tolerant varieties. On the other hand, BRRI dhan34 and ACI hybrid1 were susceptible to submergence. Thus proved as tolerant varieties. On the other hand, BRRI dhan34 and ACI hybrid1 were susceptible to submergence. However, to reach a specific conclusion and to provide reasonable recommendation, more research works on inbreeds and hybrid rice regarding the influence of submergence levels in *Aus* and *Boro* season are needed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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