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EFFECT OF SUBMERGENCE AT SEEDLING STAGE ON MORPHOLOGICAL AND YIELD ATTRIBUTES OF RICE VARIETIES

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ABSTRACT

An experiment was conducted during June to December, 2013 to observe the effect of submergence at seedling stage on some of the morphological attributes and yield of some T. aman rice (*Oryza sativa* L.) varieties. Four submergence duration, viz., control (no submergence), six days submergence, ten days submergence and fourteen days submergence and six varieties, viz., BRRI dhan51, BRRI dhan46, BRRI dhan34, BRRI hybrid dhan1, BRRI hybrid dhan2, ACI hybrid1 were used for this experiment. The experiment was laid out in split plot design with three replications. All parameters were significantly affected by the submergence duration and variety. The highest (8.50 t ha^{-1}) grain yield was found from the combination of no submergence with BRRI hybrid dhan1 and the lowest (1.20 t ha^{-1}) from the combination of fourteen days submergence with BRRI dhan34. BRRI dhan51 followed by BRRI hybrid dhan1 showed higher submergence tolerance and thus proved as tolerant varieties. On the other hand, BRRI dhan34 and ACI hybrid1 were susceptible to submergence.

Keywords: Submergence, T. aman Rice, seedling stage, morphology, yield

INTRODUCTION

In Bangladesh rainfed lowland rice covers an area of 4.5 million hectares (Islam *et al.*, 1997) 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 growing stage the crop is often submerged by flash flood due to continuous rainfall as well as due to on rush of flood water from adjoining rivers. Such flood may continue for a week or more inflicting heavy damage to standing crop. As a result yield of rice grain is severely decreased (Zeigler and Puckridge, 1995). Submergence at the seedling stage causes deterioration in the plant quality resulting in a poor stand and causes substantial yield loss. Dey and Upadhyaya (1996) reported that abiotic stress like submergence caused 140 kg/ha yields loss in Bangladesh. Sometimes it causes total crop failure. So, flooding is a major constraint in case of T. *Aman* rice establishment (Haque, 1980). 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 (Mackill, 1986). 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, find out the highest submergence period for different varieties in which rice plant can survive and identify the suitable submergence tolerant varieties for flood prone area.

MATERIALS AND METHOD

An experiment was conducted during the period from July to December, 2013 in T. *Aman* season. The experiment was conducted in the Sher-e-Bangla Agricultural University farm, Dhaka to observe the effect of submergence at seedling stage on some of the morphological attributes and yield of some T. aman rice varieties. Rice variety BRRI dhan51, BRRI dhan46, BRRI dhan34, BRRI hybrid dhan1, BRRI hybrid dhan2 and ACI hybrid1 were used as the test crop. At the time of first ploughing cowdung at the rate of 3 tha^{-1} was applied. The experimental plots were fertilized with @ 109, 134, 59,

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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 @ 89 kg N ha^{-1} in three equal splits at 10, 30 and 50 DAT (Days After transplanting). The entire amounts of TSP, MoP, gypsum and zinc sulphate were applied at final land preparation as basal dose.The experiment was laid out in a split 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 block was encircled by the 50 cm high soil wall ridge, which was hundred percent water leakage proof. In total, there were 72 plots. The treatment was randomly assigned to each unit plot. The size of each unit plot was 3m x 2m. The distance between two blocks and two plots were kept 1 m and 0.80 m respectively. Dated on 11 August 2013 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 seedling stage (14 DAT) 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 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 through drain 6 days after transplanting, where the water level was raised up to 40 cm height to submerge the rice plants. The water in submersed sub-blocks containing different varieties of rice was made turbid time to time by stirring the mud inside the sub-blocks. The water in the sub-block was drained out as per treatment after 6 days (D_1), 10 days (D_2) and 14 days (D3. The data were recorded at different stage on plant height, survival percent after submergence, panicle length, grains $panicle^{-1}$, sterile spikelets $panicle^{-1}$, weight of 1000- grain , yield (t ha^{-1}).

RESULT AND DISCUSSION

Plant height (cm)

Statistically significant variation was observed in case of plant height of rice at 10, 20, 30, 40, 50 and 60 days after transplanting and at harvest under the treatment of different submergence duration. The tallest plant (21.93, 38.57, 63.91, 74.00, 86.04, and 85.65 cm at 10, 20, 30, 40, 50 and 60 DAT, respectively) was recorded from D_3 (fourteen days submergence) treatment, while the shortest plant (18.46, 31.89, 54.94, 60.48, 71.54 and 82.26 cm at 10, 20, 30, 40, 50 and 60 DAT, respectively) was observed from D_0 (no submergence) (Figure 1). Increased submergence duration increased plant height.

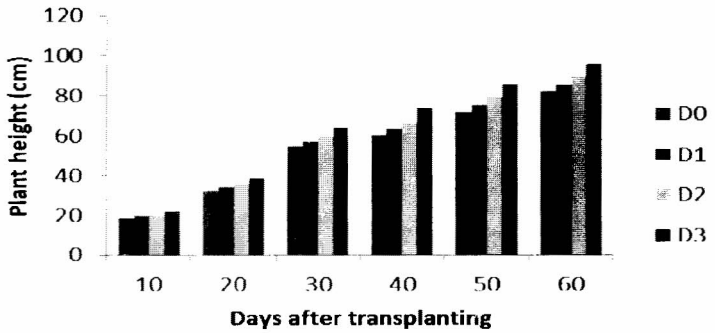

Fig. 1. Effect of submergence on plant height of T. aman rice at different days after transplanting

Plant height of the cultivars was measured at 10, 20, 30, 40, 50 and 60 days after transplanting and at harvest (Fig. 2). The height of the plant was significantly influenced by variety at all the sampling dates. The V_5 (BRRI hybrid2) variety produced the tallest plant (21.94, 37.58, 65.72, 72.81, 83.19 and 96.50 cm at 10, 20, 30, 40, 50 and 60 DAT, respectively) and V_1 (BRRI dhan51) produced shortest (19.75, 29.45, 46.83, 52.85, 65.81 and 71.72 cm at 10, 20, 30, 40, 50 and 60 DAT, respectively).

Probably the genetic makeup of varieties was responsible for the variation in plant height. This confirmed by BRRI (1991) that plant height differed due to varietal variation.

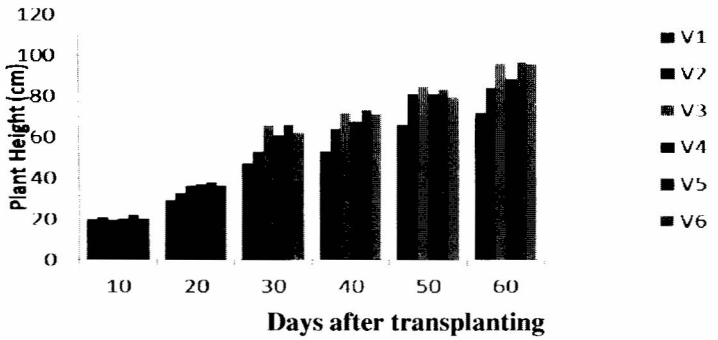

Fig. 2. Effect of variety on plant height of T. aman rice at different days after transplanting

Plant height at different day after transplanting was significantly affected by the interaction between submergence and variety (Table 1). The tallest plant (23.33, 40.56, 71.33, 81.78, 97.67 and 104.90 at 10, 20, 30, 40, 50 and 60 DAT, respectively) was found from D_3V_5 (Fourteen days submergence with BRRI hybrid 2) and shortest plant (16.93, 19.23, 29.33, 31.87, 44.39 and 66.56 cm at 10, 20, 30, 40, 50 and 60 DAT, respectively) from D_0V_1 (no submergence with BRRI dhan51).

Table 1. Combined effect of submergence and varieties on plant height of T. aman rice

Treatment	Plant height (cm)					
	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
D_0V_1	18.00 d	28.00 j	42.00 i	49.00 g	60.33 f	66.56 k
D_0V_2	18.11 cd	34.44 efg	49.22 ghi	63.80 def	74.44 cde	81.78 hi
D_0V_3	18.33 cd	37.33 a-e	58.66 c-g	63.89 def	76.89 cd	89.11 fg
D_0V_4	19.33 bcd	34.96 efg	49.22 ghi	61.11 f	74.78 cde	88.22 fg
D_0V_5	21.78 a-d	39.33 ab	66.00 a-d	67.00 c-f	80.56 bc	86.11 gh
D_0V_6	20.00 a-d	34.51 efg	62.00 a-d	68.56 b-f	74.67 cde	91.22 efg
D_1V_1	18.56 bcd	30.33 ij	46.89 hi	49.05 g	66.22 def	67.45 k
D_1V_2	20.00 a-d	31.11 hij	50.00 f-i	62.00 f	76.00 cd	81.67 hi
D_1V_3	18.44 bcd	35.78 c-f	60.66 b-e	67.50 c-f	80.11 bc	91.22 efg
D_1V_4	20.89 a-d	35.22 def	59.44 b-f	66.22 c-f	80.44 bc	74.11 j
D_1V_5	22.00 abc	35.82 c-f	66.45 a-d	73.00 a-d	81.67 abc	93.45 def
D_1V_6	20.44 a-d	35.07 ef	59.67 b-f	64.11 def	80.44 bc	97.67 bcd
D_2V_1	19.33 bcd	28.36 j	49.22 ghi	50.56 g	61.89 ef	74.33 j
D_2V_2	18.78 bcd	33.78 fgh	51.22 e-i	62.56 ef	78.56 cd	78.00 ij
D_2V_3	19.33 bcd	34.67 efg	63.44 a-d	73.89 a-d	85.78 abc	97.89 bcd
D_2V_4	20.55 a-d	36.33 b-f	56.56 d-h	66.67 c-f	83.89 abc	93.00 def
D_2V_5	22.00 abc	36.89 b-f	67.45 abc	73.89 a-d	85.11 abc	99.11 bc
D_2V_6	19.78 a-d	36.89 b-f	62.66 a-d	72.56 a-e	79.78 bc	102.30 ab
D_3V_1	20.33 a-d	31.78 ghi	56.55 d-h	62.78 ef	74.78 cde	78.56 ij
D_3V_2	23.33 a	38.56 a-d	59.89 b-e	67.33 c-f	87.89 abc	94.56 cde
D_3V_3	23.22 a	37.78 a-e	66.45 a-d	77.78 ab	92.78 ab	102.80 ab
D_3V_4	20.67 a-d	37.78 a-e	69.55 ab	75.44 abc	83.11 abc	98.33 bcd
D_3V_5	23.33 a	40.56 a	71.33 a	81.78 a	94.67 a	104.90 a
D_3V_6	21.67 a-d	39.00 abc	67.00 abc	78.89 a	83.00 abc	94.78 cde
CV (%)	14.56	8.55	8.82	7.78	8.79	9.34

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).

Table 2. Effect of submergence on survival percentage after submergence of T. aman rice

Treatment	Survival percent after submergence
D_0	84.56 a
D_1	67.78 a
D_2	64.56 a
D_3	23.56 b
CV (%)	13.22

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).

Table 3. Effect of varieties on survival percentage after submergence of T. aman rice

Treatment	survival percent after submergence
V_1	66.17 a
V_2	56.17 c
V_3	55.17 c
V_4	60.33 bc
V_5	62.83 ab
V_6	60.00 bc
CV (%)	13.22

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).

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).

Panicle length (cm)

Length of panicle showed statistically significant differences due to different duration of submergence. The longest panicle length (23.56 cm) was found at D_0 and the lowest panicle length (23.11 cm) was recorded D_3 treatment (Table 5).

The panicle length varied significantly due to variety as shown in Table 6. The longest panicle length (24.83 cm) was obtained in cultivar BRRI dhan51 and the lowest panicle length (22.33 cm) was recorded in BRRI dhan34.

Interaction effect of submergence and variety was found significant on panicle length (Table 7). The highest panicle length (26.33 cm) was recorded in combination of no submergence with BRRI hybrid dhan2 (D_0V_5). However, the lowest panicle length (24.00) was recorded from the combination of fourteen days duration submergence with BRRI dhan34 (D_3V_3).

Table 4. Combined effect of submergence and varieties on survival percentage after submergence of T. Aman rice

Treatment	Survival percent after submergence
D_0V_1	92.67 a
D_0V_2	74.67 a-e
D_0V_3	81.33 abc
D_0V_4	87.33 ab
D_0V_5	87.33 ab
D_0V_6	84.00 abc
D_1V_1	79.33 a-d
D_1V_2	65.33 cde
D_1V_3	56.00 ef
D_1V_4	76.67 a-d
D_1V_5	78.67 a-d
D_1V_6	67.33 b-e
D_2V_1	72.67 a-e
D_2V_2	60.00 def
D_2V_3	43.33 f
D_2V_4	68.67 b-e
D_2V_5	66.00 cde
D_2V_6	60.00 def
D_3V_1	43.33 f
D_3V_2	21.33 g
D_3V_3	9.33 g
D_3V_4	23.33 g
D_3V_5	24.67 g
D_3V_6	19.33 g
CV (%)	13.22

Grains panicle^{-1}

Significant variation was recorded for number of grains panicle^{-1} due to differences in duration of submergence. The highest number of filled spikelets panicle^{-1} (102.20) was obtained from D_0 treatment and the lowest number of filled spikelets panicle^{-1} (75.99) was attained from D_3 treatment (Table 5).

The tested varieties were affected significantly by different submergence duration in respect of number of grains panicle^{-1} (Table 6). The V_1 (BRRI dhan51) showed significantly highest number (122.5) of grains panicle^{-1}. The lowest number of grains panicle^{-1} (65.93) was found in V_3 treatment. BRRI (1994) reported that number of grains panicle^{-1} significantly differed among different varieties.

Interaction effect of submergence and variety was found significant on grains panicle^{-1} (Table 7). From the results of Table 5 it may be observed that the highest (135.90) number of grains panicle^{-1} was found in D_0.

Table 5. Effect of submergence on yield contributing character of T. aman rice

Treatment	Panicle length	Grains panicle^{-1}	Sterile grains panicle^{-1}
D_0	23.56 a	102.20 a	17.64 c
D_1	23.39 a	100.20 ab	18.95 bc
D_2	23.28 a	97.96 ab	22.11 ab
D_3	23.11 a	75.99 b	22.63 a
CV (%)	13.99	10.08	14.70

Table 6. Effect of varieties on yield contributing character of T. aman rice

Treatment	Panicle length	Grains panicle^{-1}	Sterile grains panicle^{-1}
V_1	24.83 a	122.5 a	12.31 c
V_2	22.75 c	78.86 bc	15.9 bc
V_3	22.33 c	65.93 c	17.95 abc
V_4	23.33 b	98.29 abc	24.26 ab
V_5	23.58 b	115.9 ab	24.38 ab
V_6	23.17 b	83.01 abc	27.79 a
CV (%)	13.99	10.08	14.70

Sterile spikelets panicle^{-1}

Number of unfilled grains panicle^{-1} varied significantly for duration of submergence. The lowest number of unfilled grains panicle^{-1} was found from D_0 (17.64) treatment and the highest number was recorded from D_3 (22.53) treatment (Table 5).

Results showed that variety had significant effect in respect of the number of unfilled grains panicle^{-1} (Table 7). The V_1 (BRRI dhan51) showed the lowest number (12.31) of unfilled grains panicle^{-1} and V_3 produced highest number (27.79) of unfilled grains panicle^{-1} and this variation might be due to genetic characteristics. Chowdury *et al.* (1993) also reported differences in number of unfilled grains panicle^{-1} due to varietal differences. Combined effect of different submergence duration and varieties showed significant response on unfilled grains panicle^{-1} (Table 7).

Table 7. Interaction effect of submergence and varieties on yield contributing character of T. aman rice

Treatment	Panicle length	Grains panicle^{-1}	Sterile grains panicle^{-1}
D_0V_1	26.00 ab	135.90 a	11.00 i
D_0V_2	23.67 abcd	121.80 abc	14.99 efghi
D_0V_3	22.67 abcd	121.30 abcd	18.14 defghi
D_0V_4	24.00 abcd	133.10 ab	12.82 fghi
D_0V_5	26.33 a	135.30 a	11.41 hi
D_0V_6	22.00 bcd	130.90 ab	11.60 ghi
D_1V_1	23.00 abcd	101.30 abcdef	19.98 defghi
D_1V_2	23.33 abcd	98.05 bcdef	11.60 ghi
D_1V_3	23.67 abcd	84.34 defg	18.72 defghi
D_1V_4	23.67 abcd	84.93 cdefg	27.05 abcd
D_1V_5	23.00 abcd	100.20 abcdef	24.09 bcde
D_1V_6	22.00 bcd	80.33 efg	31.24 ab
D_2V_1	22.67 abcd	112.80 abcde	15.08 efghi
D_2V_2	23.33 abcd	86.15 cdefg	15.75 efghi
D_2V_3	23.33 abcd	86.21 cdefg	20.44 defghi
D_2V_4	22.33 abcd	85.62 cdefg	24.89 bcde
D_2V_5	24.33 abcd	84.69 cdefg	20.20 defghi
D_2V_6	25.33 abc	81.28 efg	21.48 cdefg
D_3V_1	21.67 cd	87.19 cdefg	27.52 abcd
D_3V_2	24.00 abcd	57.18 g	22.98 bcde
D_3V_3	21.00 d	11.87 h	21.23 cdefgh
D_3V_4	23.33 abcd	72.95 fg	34.03 a
D_3V_5	22.00 bcd	85.82 cdefg	22.14 bcdef
D_3V_6	23.33 abcd	78.56 efg	30.92 abc
CV (%)	13.99	10.08	14.70

It was observed that lowest (11.00) number of unfilled grains panicle^{-1} was observed from D_0V_1, and the highest (34.03) number of unfilled grains panicle^{-1} from D_3V_4.

1000-grain weight

Statistically significant difference was recorded for weight of 1000 grains due to variation in duration of submergence. The highest weight of 1000 grains (27.15 g) was observed from D_0 treatment, while the lowest weight was recorded from D_3 (26.33 g) treatment (table 8).

Table 8. Effect of submergence on thousand grain weight and yield of T. aman rice

Treatment	1000 grain wt	Yield t/ha
D_0	27.15 b	6.23 a
D_1	27.06 b	5.95 ab
D_2	27.09 b	5.00 b
D_3	26.33 a	3.78 c
CV (%)	7.70	6.93

Variety had significant effect on 1000-grain weight (Table 9). The maximum 1000-grain weight (29.37 g) was found in V_1 treatment. The lowest thousand seed weight (19.95g) was found in V_3 treatment. Interaction of submergence and variety showed significant effect on 1000-grain weight (Table 10). The lowest (19.43 g) thousand seed weight was observed from D_3V_3 treatment which was statistically similar with D_3V_2, D_3V_4, and D_3V_6 and the highest (31.39 g) thousand seed weight from D_0V_1.

Table 9. Effect of varieties on thousand grain weight and yield of T. aman rice

Treatment	1000 grain weight	Yield t/ha
V_1	29.37 a	3.58 cd
V_2	27.32 b	4.38 c
V_3	19.95 c	2.30 d
V_4	28.23 ab	7.83 a
V_5	29.32 a	7.33 ab
V_6	27.26 b	6.05 b
CV (%)	7.70	6.93

Grain yield

Grain yield per hectare of rice varied significantly due to submergence duration. The highest grain yield was found from D_0 (6.23 tha^{-1}) whereas the lowest yield was recorded from D_3 (3.78 tha^{-1}) treatment (Table 8).

Grain yield is a function of interplay of various yield components such as grains $panicle^{-1}$ and 1000-grain weight (Hassan *et al.*, 2003). In present experiment variety had significant effect on grain yield (Table 9). Again it was evident from Table 10 that V_4 (BRRI hybrid dhan1) produced the highest (7.83 t ha^{-1}) grain yield. Grain yield differences due to varieties were also reported by IRRI (1978) reported variable grain yield among tested varieties of rice.

From the table 10 it was also evident that interaction of submergence and variety significantly affected the grain yield. Significantly the highest (8.50 t ha^{-1}) grain yield was found from the combination of D_0V_4 (no submergence with BRRI hybrid 1) and the lowest (1.20 t ha^{-1}) from D_3V_3 (fourteen days submergence with BRRI dhan34).

Table 10. Combined effect of submergence and varieties on thousand grain weight and yield of T. aman rice

Treatment	1000 grain weight	Yield t/ha
D_0V_1	31.39 a	4.50 de
D_0V_2	28.69 abcde	4.70 cde
D_0V_3	27.96 abcde	3.50 ef
D_0V_4	28.49 abcde	8.50 a

Treatment	1000 grain weight	Yield t/ha
D_0V_5	26.69 bcde	8.00 a
D_0V_6	30.09 ab	8.20 a
D_1V_1	29.71 abc	4.40 de
D_1V_2	28.41 abcde	4.50 de
D_1V_3	29.87 abc	3.00 efg
D_1V_4	27.76 abcde	8.20 a
D_1V_5	28.11 abcde	7.60 a
D_1V_6	28.31 abcde	8.00 a
D_2V_1	27.07 bcde	4.20 de
D_2V_2	27.72 abcde	4.30 de
D_2V_3	25.59 de	1.50 fg
D_2V_4	30.51 ab	7.80 a
D_2V_5	29.79 abc	7.20 ab
D_2V_6	29.15 abcd	5.00 bcde
D_3V_1	25.87 cde	4.20 de
D_3V_2	19.79 f	4.00 e
D_3V_3	19.43 f	1.20 g
D_3V_4	20.45 f	6.80 abc
D_3V_5	24.81 e	6.50 abcd
D_3V_6	20.11 f	3.00 efg
CV (%)	7.70	6.93

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 vegetative stage. BRRI dhan51 showed the highest submergence tolerance level among the tested varieties followed by BRRI hybrid dhan1. BRRI dhan51 followed by BRRI hybrid dhan1 showed higher submergence tolerance in submerged conditions and 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.

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