Pertanika J. Trop. Agric. Sci. 19(1): 55-60 (1996)

ISSN: 0126-6128

Effect of Water Depth, Seedling Age, and Day Length on Elongation Induced by Short-duration Flooding Treatment in Rice

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Keywords: deepwater rice, photoperiod sensitivity, elongation

ABSTRAK

Percubaan yang dijalankan terhadap usia anak benih dan kedalaman air yang berbeza menunjukkan bahawa anak benih jangkamasa pendek, iaitu berusia tiga minggu yang direndam selama tujuh hari, berkesan dalam menilai potensi pemanjangan dalam varieti padi air dalam. Kedalaman air 90-100 cm adalah mencukupi untuk membuktikan keupayaan pemanjangan dan anak benih berusia tiga minggu untuk memberi perbandingan yang lebih baik antara varieti moden memanjangan dan varieti moden tak memanjang. Varieti menghasilkan kepanjangan ruas yang maksimum di bawah keadaan hari yang pendek sementara ruas yang paling pendek diperolehi dalam rawatan hari yang panjang. Pemanjangan ruas mungkin hanya disebabkan oleh kesan kepanjangan hari atau kesan lindungan terhadap asimilasi. Percubaan selanjutnya perlu diadakan untuk mengesahkan penemuan ini.

ABSTRACT

Experiments conducted on seedling age and different water depths revealed that short-duration, 7-day flooding of 3-week-old seedling was effective in assessing elongation potential in deepwater rice varieties. Water depths of 90-100 cm were sufficient to express elongating ability and 3-week-old seedlings gave better contrast between elongating modern varieties and non-elongating modern varieties. Maximum internode length was under short-day-length conditions while shortest internodes were obtained in the long day treatment. Internode elongation may be due only to the signal effect of day length or the shading effect on assimilation. Further experiments should be conducted to confirm these findings.

INTRODUCTION

Survival of plants during flooding depends on various factors such as age of seedlings, water depth and day length (Gomosta 1985). Attempts have been made to screen varieties for elongation ability under conditions of prolonged flooding, but the disadvantage of this method is the lack of control on survival of the non-elongating plants. This leads to inaccuracy in observation and progeny testing of all individuals. In order to overcome problems of testing under prolonged flooding, short-duration flooding treatment is preferred. Khan *et al.* (1987) observed maximum elongation within 24 hours of submergence and suggested that shorter-period flooding may prove fruitful. Thakur and HilleRisLambers (1988) and Dwivedi (1992) found short-duration flooding (7 days' submergence) useful to compare hybrid populations before and after flooding treatments. The available information on the effect of seedling age, water depth and day length is adequate. Therefore, the present study was undertaken to determine the appropriate water depth and seedling age for testing elongation ability under short-duration flooding suitable for genetic studies. In addition, the effect of day length treatment on elongation was studied.

MATERIALS AND METHODS

Optimum Water Depth for Testing Rapid Elongation in Deepwater Rice Varieties

Experiment 1: Twelve varieties, including IR42 and BKNFR76106-16-0-1 (non-elongating semi-dwarf); NDGR207, Bhatin and IR28273-R-R-R-29-38-2-3-3 (non-elongating tall); IR11141-6-1-4 and IR11288-B-B-69-1 (elongating modern varieties); IR40905-11-3-1-2-3-2 and Leb Mue Nhang 111 (elongating tall); Baisbish, Barogar and Kalaungi (floating rice), were used to determine the optimum water depth for testing rapid elongation at the seedling stage (Table 1). The experiment was conducted at the International Rice Research Institute (IRRI). Plants were raised in small plastic pots of size 5 × 5 × 5 cm. The experiment was laid out in a split plot design with three replications with five water depths (main plots) and twelve entries (sub-plots).

Three-week-old seedlings were transferred to a concrete tank where different water depths (80, 90, 100, and 120 cm) were introduced and maintained. Plants were submerged for 7 days as suggested by Thakur and HilleRisLambers (1988). Plant height from the base of the culm to the tip of tallest leaf was recorded before and after

TABLE 1

Varietal mean for percent elongation at various water depths

Variety	Percent elongation at various water depths* (cm)					
	80	90	100	110	120	Control (no flooding)
Non-elongating semi-dwarf						
IR42	18.4 fg	16.6 d	21.3 c	17.9 de	10.8 hi	3.7 ab
BKNFR76106-16-0-1	7.9 h	7.5 c	9.2 d	11.4 e	7.7 f	2.8 b
Non-elongating tall						
NDGR207	34.5 bc	25.1 c	27.7 c	32.8 c	19.0 efg	4.0 ab
Bhatin	32.6 cd	40.7 a	38.3 b	35.9 bc	32.3 bc	4.5 ab
IR28273-R-R-R-29-38-2-3-3	13.9 gh	8.2 e	13.5 d	12.0 e	18.0 fgh	7.9 ab
Elongating modern variety						
IR11141-6-1-4	25.9 de	23.9 c	24.8 c	18.1 de	23.2 def	5.4 ab
IR11288-B-B-69-1	21.4 ef	19.7 de	28.7 c	15.1 e	15.4 gh	9.1 ab
Elongating tall						
IR40905-11-3-1-2-3-2	19.9 efg	22.5 cd	28.0 c	24.7 d	17.8 fgh	9.9 b
Leb Mue Nhang 111	48.0 a	44.8 a	48.4 a	37.4 bc	25.8 cde	9.4 ab
Floating						
Baisbish	38.6 bc	41.3 a	41.8 a	50.3 a	35.6 ab	2.9 ab
Barogar	40.5 b	33.9 b	45.8 b	41.8 b	29.8 bcd	9.1 ab
Kalaungi	37.3 bc	32.5 b	51.5 a	42.1 b	41.8 a	10.9 a
Depth mean	28.2	26.4	31.5	28.3	23.1	6.1
F value	140.3	237.5	154.8	143.5	122.7	

* In a column, means followed by a common letter are not significantly different at the 5% level.

submergence. Plant elongation was computed by subtracting the plant height before flooding from that after the short-duration flooding treatment. In the control treatment, increase in plant height was calculated by subtracting plant height at 21 days from the height attained by plants at 28 days without flooding.

Appropriate Seedling Age for Assessing Elongation in Some Rice Varieties

Experiment 2: Three seedling ages (2, 3 and 4 weeks) with 9, 21 and 21 entries respectively (Table 2) were laid out in a completely randomised design with three replications to assess variation in plant elongation ability induced by flooding and to select the most appropriate seedling age to be used for further work in the genetics of elongation ability. Seedlings of all ages were submerged for 7 days in 100-cm water depth in the submergence tanks at IRRI.

TABLE 2

Plant elongation (increase in plant height) at various seedling ages following submergence for seven days

Variety	Plant elongation (cm) at seedling ages			Elongation score from previous tests (SES)*
	2 wk	3wk	4 wk	
Group A (Elongating traditional type)				
Saingar	–	37	13	1
Barogar	–	37	20	1
LMN 111	–	42	21	1
Jalmagna	24	27	36	1
NDGR407	25	–	–	1
Chakia-59	–	34	16	3
IR40905-11-3-1-5-3-3	–	25	16	3
NC492	–	28	20	3
Baisbish	26	23	21	3
NDGR150	22	22	7	5
FRG15	–	24	9	5
Madhukar	–	20	105	
NDGR207	15	21	12	5
Group B (Elongating modern type)				
IR11141-6-1-4	17	16	12	5
IR282773-R-R-R-39-28	-	17	18	5
IR11288-B-B-69-1	13	12	11	5
Group C (Non-elongating type)				
Ghoghari	–	18	10	7
Shayma	–	15	9	7
IR42 (Susceptible check)	14	9	8	9
FR13A	–	13	5	9
BKNFR76106-16-0-1	–	8	5	9
IR36	11	9	7	9
CV (%)	9.2	17.6	25.0	

* Standard Evaluation System (IRRI, 1988)

Plant height was recorded before and after the flooding, and was used to calculate plant elongation as adapted in the previous experiment.

Effect of Day Length on Plant and Internode Elongation in Three Deepwater Rice Varieties

Experiment 3: Three varieties, Jalmagna (floating, photoperiod sensitive), IR11141-6-1-4 (deepwater rice, photoperiod insensitive) and RD19 (deepwater rice, weakly photoperiod sensitive) were studied for their response to different day lengths. The pot experiment was laid out in a split plot design with three replications at the Plant Physiology Greenhouse, IRRI. Seedlings at the two-leaf stage were subjected to various periods of 14-hour and 10-hour day length. After 28 days of day length treatment seedlings were submerged in 100-cm water depth for 7 days. Plant elongation and internode length were recorded on 15 randomly selected plants. Two to four plants were examined for panicle primordium initiation before and after the flooding treatment.

RESULTS AND DISCUSSION

Optimum Water Depth

Varieties differed for plant elongation after 7 days' flooding at various water depths (Table 1). Plant elongation rate was higher in Kalaungi, Baisbish and Leb Mue Nahung 111 in almost all depths followed by Barogar and Bhatin. Comparatively less increase was recorded at 80-cm water depth. This may be ascribed to insufficient water depth for full potential elongation as the canopy of most plants emerged above the water during flooding. 11288-B-B-5q-1 and IR11141-6-1-4 (elongating modern varieties) and NDGR207 (non-elongating, tall) were at par showing moderate elongation. Other entries like IR28273-R-R-R-29-38-2-3-3 and IR11288-B-B-69-1 showed relatively less elongation, probably due to their poor seedling growth at the time of flooding. Lowest increase in plant height was recorded in BKNFR76106-16-0-1 and IR42.

By and large, relatively more elongation was recorded at 90 and 100 cm water depth in all floating and deepwater rice varieties. The slight decline in plant elongation at 110 and 120 cm water depths could be due to the inability of plants to emerge above such water depths. Table 2 shows the F values computed for different depths were 140.3 (for 80 cm water depth), 237.5 (90 cm), 159.2 (100 cm), 143.5 (110 cm), and 122.7 (120 cm). Comparatively higher F values for greater elongation at 90 and 100 cm depths support the above findings. This is in agreement with the findings of HilleRisLambers *et al.* (1988) who first used it for comparing various testing methods.

Greater water depths restrict the plant's ability to elongate. As a result there was no clear-cut trend among different varieties at increased water depths. For the purpose of genetic studies, 90-100 cm water depth for seven days might be sufficient to test elongation ability at the early seedling age because using these depths floating types can easily be distinguished from non-floating ones.

Appropriate Seedling Age

Plants stayed alive at all three ages and could be measured individually after flooding. Among the three ages of seedlings, percentage of increase after flooding was highest in the 2-week-old followed by the 3-week-old and 4-week-old seedlings. Entries differed significantly for plant elongation. The comparatively lower elongation in the 4-week-old seedlings might be due to their being taller than the younger ones and thus needing comparatively less elongation for survival.

TABLE 3
Analysis of variance for percent elongation in 12 varieties at 5 water depths and control

Source	D.F.	M.S.
Replications	2	32.0^{ns}
Water depths (d)	5	3013.1**
Error (a)	10	18.6
Varieties (v)	11	1861.0**
Depths × Varieties (d × v)	55	113.9**
Error (b)	132	17.8

CV (a) = 18.0%, CV (b) = 17.6%
** = Significant at 1% level; ns = Not significant.

Table 3 shows that 3-week-old seedlings gave better contrast between elongating and non-elongating modern varieties. If the more minute differences between these two type are to be detected, 4-week-old seedlings should be used. BKNFR76106-16-0-1 and NDGR207, both non-elongating entries, were likewise best separated from the elongating deepwater types in the 4-week treatment.

Day Length Effect and Plant Elongation

Table 4 shows significant differences among the treatments for plant elongation and internode length. Greatest plant elongation was recorded for Jalmagna followed by RD19 and IR11141-6-1-4. The trend for internode length was similar. In addition, varieties × treatment interaction was also found to be significant for internode length after flooding treatment. Invariably all three varieties had maximum internode length at short day length while shortest internode length was obtained with long day treatment.

None of the varieties initiated panicle primordia in any of the treatments even up to 7 days after flooding treatment. Therefore, internode elongation may only be due to the signal effect of short day length or the shading effect on assimilation as other factors were kept constant.

The effect of day length treatment was significant in the case of the two elongation modern varieties but not in the case for traditional Jalmagna. This may be due to the intrinsic tall plant height of the latter, which prevented it from responding strongly to flooding. The fact that there was no gradual transition from long internodes to short internodes with decreasing duration of short day treatment favours the explanation that internode elongation is a signal function of short days.

CONCLUSION

Experiments conducted with different entries to study the effect of water depth, seedling age and day length on elongation

TABLE 4
Treatment and variety means for plant elongation and internode length of three rice varieties.

Days subject to treatment		Jalmagna		IR11141-6-1-4		RD 19	
10h	14h	Pl. elongation (cm)	Internode (cm)	Pl. elongation (cm)	Internode (cm)	Pl. elongation (cm)	Internode (cm)
28	0	57.2	83.8	33.6	25.4	44.2	37.0
21	7	64.1	79.2	29.4	25.4	42.8	36.2
14	14	61.5	78.1	30.4	25.1	32.4	28.3
0	28	64.5	77.3	38.7	15.4	36.7	1.4

	Plant elongation	Internode length
S.E.D.	4.2	2.2
CV (%)	11.8	6.9

resulting from a short period of submergence (7 days) indicate that three-week-old seedlings with 90-100 cm water depth are most effective for assessing elongation ability at the seedling stage. The test was non-lethal. Results further indicated that short day treatment induced maximum plant elongation in some varieties.

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(Received 7 July 1993)
(Accepted 11 December 1995)