イネ幼芽の中茎の伸長に及ぼす高温処理の影響第2報

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Effect of High Temperature Pre-treatment on the Elongation of Mesocotyl of Rice Plants

II. Elongation of the mesocotyl and coleoptile under various cultural temperatures*

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Previous work[1] in this laboratory has shown that mesocotyl elongation in rice plants of *japonica* and *indica* types was markedly stimulated by high temperature treatment of seeds before sowing under a dark condition at 30°C. In this case, it seems probable that the high temperature pre-treatment has an influence not only on the mesocotyl elongation but also coleoptile elongation.

By using an aseptic culture method,[2] the experiment was carried out to see the effect of the high temperature pre-treatment on the elongation of mesocotyl and coleoptile under various cultural temperatures in darkness.

MATERIALS and METHODS

The materials used were two paddy rice varieties of *japonica* type of *O. sativa L.*, Hoyoku and Nihonkai. The former is a late maturing variety and the latter matures with a medium earliness in Japan.

The basal culture medium was identical with the previous paper.[2] After husking, well matured seeds of medium size were sterilized by immersing in 75% alcohol for 30 seconds, then in 0.2% corrosive sublimate for 3 minutes, and were finally washed two or three times with sterilized water. The sterilized seeds were immersed in sterilized redistilled water for 14 hours at 25°C in darkness. At the end of immersion, adherent water on the surface of the seeds was removed with sterilized filter paper, and about twenty seeds were put into each empty glass tube, 13×100 mm. The tubes were covered with polyethylene film to prevent the seeds from drying. The tubes containing seeds were then treated at 40°C in darkness. After the high temperature pre-treatment, two seeds were sown in each tube containing the culture medium and the tubes were placed under each cultural temperature in darkness.

After emerging of the 1st leaf from the tip of coleoptile, length of the mesocotyl and coleoptile of about twenty plants in each lot was measured. As the experiments with the two varieties yielded nearly the same results, only the data with a variety, Hoyoku, will be presented in this paper. The seeds of this variety have been obtained through the kindness of the Agricultural Experiment Station of Saga Prefecture, Saga.

RESULTS and DISCUSSION

Effects of high temperature pre-treatment of seeds on mesocotyl and coleoptile elongation under various cultural temperatures

After high temperature pre-treatment of seeds for 0 or 10 days, two seeds were sown in each tube containing culture medium. These tubes were placed under constant temperatures of 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34 and 36°C (±0.5°C in each) in darkness. In this experiment, rice plants hardly grew at 14 and 36°C. The results are given in table 1.

Under all cultural temperatures, mesocotyl elongation was stimulated by the high temperature pre-treatment. The length increased with increasing cultural temperature and reached a maximum of 62 mm at 34°C. In control plants, however, mesocotyl length was almost the same under all

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Table 1. Effects of high temperature pre-treatment of seeds on the elongation of mesocotyl and coleoptile in rice plants under various cultural temperatures in darkness. (cv. Hoyoku, at 14-21 days after sowing)

Cultural temperatures (°C)	Treated plants			Control plants		
	Number of plants	Length in mm.		Number of plants	Length in mm.	
		Mesocotyl	Coleoptile		Mesocotyl	Coleoptile
16	21	18± 6.6	32± 8.4	22	1±0.7	32±4.5
18	20	24± 9.5	65± 5.8	22	1±0.5	44±4.3
20	22	37±14.2	70± 8.6	22	1±0.7	46±4.5
22	22	36±14.0	72± 7.4	23	1±0.8	46±4.0
24	20	45±14.5	67± 7.9	22	1±0.8	41±4.6
26	22	47±12.9	56±14.6	20	1±0.6	37±4.5
28	21	47±14.8	51± 9.6	22	1±0.7	39±3.3
30	22	49±14.4	43±11.5	22	1±0.8	32±4.5
32	22	51±12.2	30±17.3	22	1±0.7	30±4.7
34	20	62±12.9	10± 2.1	23	1±0.7	22±3.4

Experimental details of the pre-treatment of seeds are described in the text.

the cultural temperatures. At the temperatures of 16 and 18 °C, mesocotyl length of treated plants was about twenty times that of control plants. At the temperatures of 24, 26 and 28 °C, the length of the former was about forty-five times that of the latter. At 34°C, mesocotyl length of treated plants was about sixty times that of control plants.

On the other hand, coleoptile elongation was stimulated by the high temperature pre-treatment at the cultural temperatures ranging from 18 to 30 °C, while it was strikingly inhibited at 34 °C. Coleoptile length of treated plants was about one and a half times that of control plants at the temperatures ranging from 18 to 30 °C, while the length of the former was almost the same that of the latter at the temperatures of 16 and 32°C, respectively. At 34°C, coleoptile length of treated plants was about one half times that of control plants.

Plumule length (the sum of the length of the mesocotyl and coleoptile) was the longest at 22°C in control and 24°C in treated plants, respectively. In control plants, coleoptile length was longer than mesocotyl length under all cultural temperatures. The former was from twenty to forty-five as long as the latter. In treated plants, however, coleoptile length was always not longer than mesocotyl length. At the cultural temperatures ranging from 16 to 22°C, the former was about twice as long as the latter. At the temperatures of 26, 28 and 30°C, coleoptile and mesocotyl was almost the same in length. Moreover, coleoptile length was about three-fifths as long as mesocotyl length at 32°C and one-sixth at 34°C.

Effects of high temperature pre-treatment of seeds on parenchyma cell sizes in the mesocotyl and coleoptile

Just after measurements of the length of the mesocotyl and coleoptile, intact mesocotyl and coleoptile were fixed and stored in a solution of F.A.A.

Preparation of microtome sections and measurements of cell sizes (length and width) coincided with those of the previous paper.[2] In coleoptile, as the parenchyma cell size at the upper part of coleoptile was considerably smaller than those of the middle and lower parts, averages of the cell length and width were taken as a composite of twenty cell size measurements for the middle and lower parts of each coleoptile. The results are shown in fig. 1 and 2.

Parenchyma cell length in the mesocotyl was almost the same under all the cultural tempera-

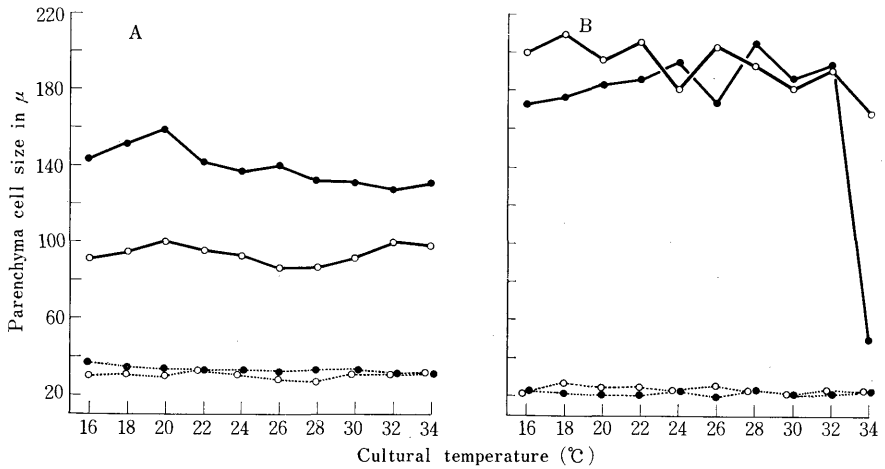

Fig. 1. Effects of high temperature pre-treatment of seeds on parenchyma cell sizes in the mesocotyl and coleoptile.
Open circles; Control plants, Closed circles; Treated plants.
Solid lines; Cell length, Broken lines; Cell width.
A; Mesocotyl, B; Coleoptile.

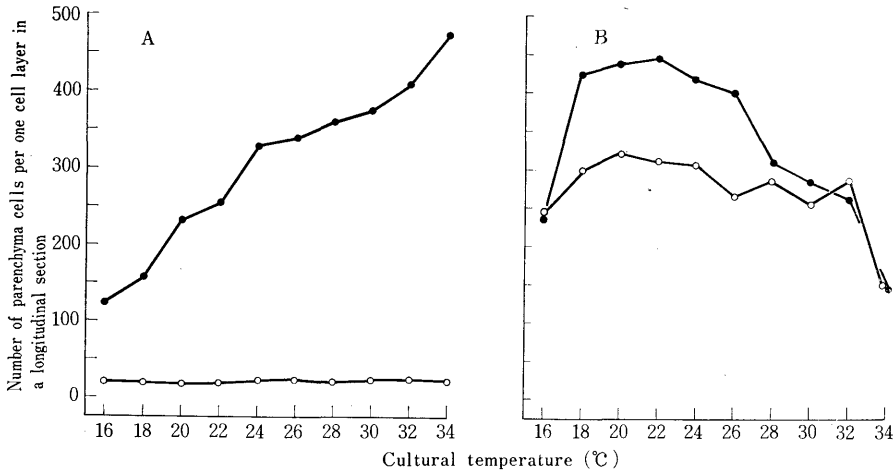

Fig. 2. Effects of high temperature pre-treatment of seeds on the number of parenchyma cells per one cell layer in a longitudinal section in mesocotyl and coleoptile.
Open circles indicate the mean number of cells in control plants and closed circles the mean number of cells in treated plants.
A; Mesocotyl, B; Coleoptile.

tures in treated and control plants, respectively. The cell length of treated plants was about one and a half times that of control plants. However, parenchyma cell width was the same in both of the control and treated plants in this examination.

The number of parenchyma cells per one cell layer in longitudinal sections of the mesocotyl was almost the same under all the cultural temperatures in control plants, though it increased with increasing cultural temperature in treated plants. The number of cells in treated plants was about five times that in control plants at 16

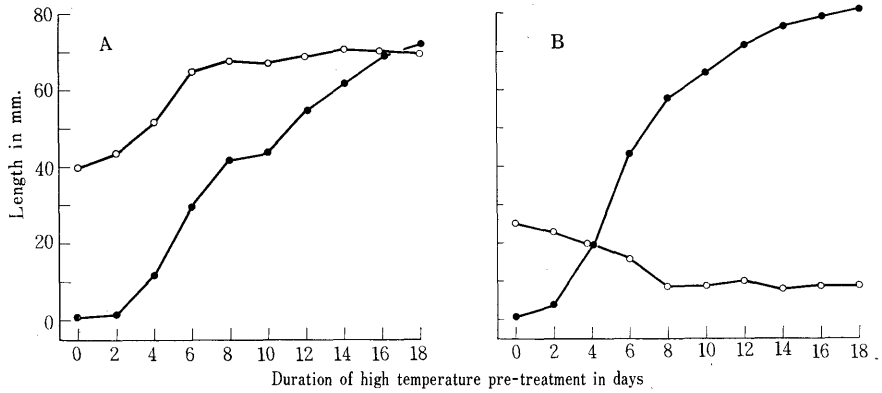

Fig. 3. Effects of the duration of high temperature pre-treatment of seeds on the elongation of mesocotyl and coleoptile in rice plants under darkness.
Open circles indicate the mean of coleoptile length and closed circles the mean of mesocotyl length. A; Cultured at 24°C, B; at 34°C.

and 18°C, about ten times at 20 and 22°C, about fifteen times at from 24 to 32°C, and about twenty times at 34°C, respectively.

From these results, it seems probable that stimulation of mesocotyl elongation in these paddy rice plants by high temperature treatment of seeds before sowing is mainly caused by cell multiplication.

On the other hand, parenchyma cell length of coleoptile was almost the same under all the treated and control lots, without a cultural lot at 34°C. In treated plants cultured at 34°C, the cell length was about one fourth times that of the plants cultured at the other temperatures. Moreover, parenchyma cell width was the same in all of the plants in this examination.

The number of parenchyma cells per one cell layer in longitudinal sections of the coleoptile was maximum at 22°C in treated and 20°C in control plants, and it gradually decreased with increasing or decreasing cultural temperatures. The number of cells in treated plants was about one and a half times that in control plants at the temperatures ranging from 18 to 26°C, though it was almost the same in treated and control plants at the temperatures of 16, 28, 30, 32 and 34°C, respectively.

Effects of the duration of high temperature pre-treatment of seeds on the mesocotyl and coleoptile elongation

As described above (table 1), plumule length was the longest at 24°C and mesocotyl length was at 34°C in treated plants under darkness. In order to obtain more detailed information on the effect of high temperature pre-treatment of seeds on the elongation of the mesocotyl and coleoptile in rice plants, the following experiment was conducted.

After pre-treatment at 40°C for 0, 2, 4, 6, 8, 10, 12, 14, 16 and 18 days, two seeds were sown in each tube containing of culture medium and transferred to 24 and 34°C in darkness. Length of mesocotyl and coleoptile was measured 14 days at 24°C and 21 days at 34°C after sowing. The results are given in fig. 3.

In both cultural temperatures of 24 and 34°C, mesocotyl length increased with prolonging of the duration of high temperature pre-treatment. Mesocotyl length cultured at 34°C was considerably longer than that cultured at 24°C in each treatment.

On the other hand, coleoptile length increased with prolonging of the duration of high temperature pre-treatment at 24°C, while it decreased at 34°C. In the plants received the pre-treatment for 8 days, coleoptile length of treated plants was about one and a half times that of control plants at 24°C, and about one-third times at 34°C. In the plants received the pre-treatment for 8 days

or more, coleoptile length was almost the same in each cultural temperature.

Summary

By using two paddy rice varieties in *japonica* type, Hoyoku and Nihonkai, effects of high temperature treatment of seeds before sowing on the elongation of the mesocotyl and coleoptile were examined under various cultural temperatures (16-34°C) in darkness. The following results were obtained.

1. Mesocotyl elongation was strikingly stimulated by the high temperature pre-treatment of seeds (40°C for 10 days) under all the cultural temperatures. Mesocotyl length in treated plants increased with increasing cultural temperature and reached a maximum at 34°C. At 34°C, the length of treated plants was about sixty times that of control plants.

2. Coleoptile elongation was stimulated slightly by the pre-treatment under the cultural temperatures of 18-30°C, while it was strikingly inhibited at 34°C.

3. Effect of high temperature pre-treatment of seeds on the elongation of mesocotyl increased with prolonging of the duration of the pre-treatment, though the effect on the elongation of coleoptile was nearly the same in the plants received the pre-treatment for 8 days or more.

4. The stimulation of mesocotyl and coleoptile elongation in paddy rice plants by high temperature treatment of seeds before sowing may be mainly caused by cell multiplication.

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〔和 文 摘 要〕

イネ幼芽の中茎の伸長に及ぼす高温処理の影響

第2報 中茎および鞘葉の伸長と培養温度

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前報[2]においては，種子を高温処理することによって暗黒下 (30°C) におけるイネ幼芽の中茎の伸長は著しく促進されるが，これは主に中茎の柔細胞の細胞数の増加によっていることが，日本型水稲“ホウヨク”を用いて明らかにされた．

ここでは，日本型水稲“ホウヨク”と“日本海”の2品種を用いて，種子の高温処理と中茎および鞘葉の伸長を培養温度 (16～34°C) との関係で実験した．

種子の消毒や高温処理の方法，および材料の固定やミクロトーム切片の作成方法などは，ほぼ前報[2]と同様であった．結果の概要はつぎの通りであった．

1) 種子の湿潤・高温処理 (25°C で14時間浸種後，40°C で10日間) による中茎の伸長促進は，全培養温度下でみられた．なお中茎の伸長促進の程度は，培養温度が高いほど大きかった．一方，鞘葉の伸長は培養温度18～30°C の範囲内では促進されたが，34°C では著しく抑制された．

2) 中茎の伸長は高温処理の期間が長いほど (最高18日間処理) 促進されたが，鞘葉の伸長は高温処理8日間でほぼ一定となった．

3) 培養温度の高低にかかわらず，高温処理による中茎および鞘葉の伸長促進は，主に細胞数の増加に起因しているようである．