PHOTOPERIODIC STUDIES ON RICE

VII. The effect of night temperature on photoperiodic induction

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Abstract: 1. Three daylength sensitive rice varieties, Shinriki, Shuang-chiang and Wan-tze were subject to the short day treatment of 9L+15D. During the 15D period, they were placed at the following temperature levels: 15°, 20°, 24°, 28° and 32°C. It was found that all three varieties failed to head at the night temperature of 15°C. The optimum night temperature was 24° up to 28°C for Shinriki and 28°C for Shuang-chiang and Wan-tze. At temperatures lower or higher than the above, heading was delayed.

2. A daylength insensitive variety Norin No. 11 with a very short growth period was subject to the following night temperature level: 15°, 20°, 24°, 28°, 32° and 34°C. It was found that low temperatures suppressed floral bud initiation and the growth of floral buds already initiated. However, there was still heading at 15°C.

3. The authors express doubts about the temperature sensitivity indicators of rice varieties as suggested by Japanese investigators.

INTRODUCTION

It has been well known that temperature can influence the effects of short day treatment in short day plants. That is high temperauure can promote and low temperature can suppress the effects (Garner & Allard 1930; Benedict 1940; Murneek 1940; Owen, Carsner & Stout 1940; Pawar & Thompson 1950; Leopold & Guernsey 1953a, b; Rappaport & Bonner 1960; Noguchi & Kamata 1965). Some workers have pointed out the importance of night temperature in photoperiodic induction (Roberts and Struckmeyer 1938, 1938; Mann 1940; Roberts 1943; Lang & Melchers 1943).

We have studied the effects of night temperature on floral bud initiation in certain short day and photoperiod insensitive varieties of rice.

Experiment I

Materials: Short day rice varieties Shuang-chiang, Wan-tze and Shinriki.

Methods: Seeds were planted in pots on June 10, 1959. The short day treament of 9L +15D was carried on from July 14 to September 13. During the light periods the mean of highest daily temperatures was 31.9±2.4°C, and the mean of the mean daily temperatures was 27.8±1.3°C. There were five night temperature treatments: 15°, 20°, 24°, 28°, and 32°C. The experiment was conducted in the temperature controlled darkroom of the Horticulture Department, National Taiwan University.

Results: The mean numbers of days from the beginning of treatment to the beginning of heading of different varieties under short day treament at different night temperatures are shown in Table 1.

Table 1. The mean numbers of days between the start of treatment and heading of three short day varieties subject to short day treatment at different night temperatures.

Variety / Night temp. (°C)	Shinriki	Shuang-chiang	Wan-tze
15	*	*	*
20	41.54±2.58	55.33±4.46	56.17±2.27
24	33.22±2.08	38.58±1.94	35.32±1.74
28	33.75±1.77	34.70±2.05	32.91±1.40
32	42.45±2.28	39.86±1.70	37.30±1.02

* Upon examination of the growing points on September 20 (61 days after the beginning of treatment) the authors found the floral buds in Shinriki had been initiated, their length being under 2 mm.

The data in Table 1 can also be shown as in Figure 1.

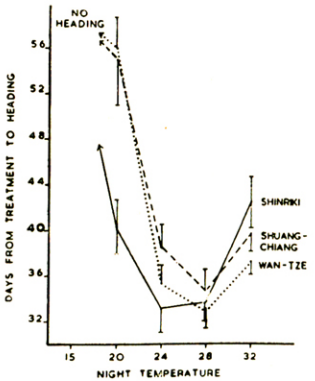

Fig. 1. The effects of different dark period temperatures during short day treatment on the duration between the beginning of treamant and the beginning of heading.

The period between the beginning of the treatment and heading for Shinriki was shortest at the night temerature of 24°C, and the next shortest was at 28°C. This period for the other two varieties was shortest at 28°C. In general, at night temperatures lower than 28°C (24°C for Shinriki), the period between the beginning

of treatment and heading would increase. The lower the temperature was the longer this period would be. The degree of prolongation was more marked in Shuang-chiang and Wan-tze than in Shinriki.

At the night temperature of 15°C, all three varieties failed to head before the conclusion of the experiment. However, it was found on the 61st day of short day treatment that floral buds had been initiated in Shinriki but not in the other two varieties.

At night temperatures higher than 28°C, the period between the beginning of treatment and heading of all three varieties was found to be slightly prolonged.

Plant growth as represented by culm length, seed fertility and number of seeds per head are shown in Table 2. There was favorable growth at the night temperatures of 24°C and 28°C for Shinriki and at 28°C for Shuang-chiang and Wan-tze.

Table 2. Differences in some agronomic characters among three short day varieties at different dark period temperatures.

Variety / Temp. (°C) / Character	Shinriki				Shuang-chiang				Wan-tze			
	20	24	28	32	20	24	28	32	20	24	28	32
Culm length (cm)	35.8	37.7	39.8	36.7	38.5	41.8	51.5	46.1	51.7	55.9	60.3	57.1
Seed fertility (%)	2.0	46.8	44.6	9.5	20.0	34.9	34.0	4.4	49.1	67.1	63.9	58.2
No. of seeds per head	22.5	25.2	28.2	23.7	23.0	31.8	29.4	24.5	22.4	28.2	25.5	24.9

The data given in Table 2 shows that culm length incrased for all three valieties of rice as temperatures increased from 20° to 24° to 28°C but at 32°C all showed a shortening in culm length.

The data also shows that seed fertility for all three varieties was highest where the temperature was 24°C; below or above this temperature seed fertility was not so good. Shinriki only had 2% fertility at 20°C and 9.5% at 32°C temperature; while Wan-tze had as high as 49.1% at 20°C and 58.2% at 32°C showing that seed fertility in Wan-tze was not so greatly effected by temperature as the other two varieties.

The number of seeds per head was highest at 28°C in Shinriki and at 24°C in Shuang-chiang and Wan-tze, however the number of seeds per head was not very different at any of the temperatures.

Experiment 2

Materials: Daylength insensitive variety Norin No. 11.

Methods: Seeds were planted in pots on July 13, 1957. There were a total of 48 pots, with 12 plants in each pot. Six night temperature treatments were used, i. e., 15°, 20°, 24°, 28°, 30° and 34°C. The daily treatment period started from 5 p. m. up to 8 a. m. of the following day. During the period from July 14 to August 17, eight tests were initiated every five days. For example, six pots were used in the first test on July 14, while the remaining 42 pots were kept at the night tem-

perature of 28°C. After the second test was started on July 19, 36 pots were left at the night temperature of 28°C. The other tests followed the same practice. During the entire experiment, the mean day time temperature was 27.8±1.30°C.

Results: The numbers of days from seeding to heading of all the treatments are presented in Table 3.

Table 3. The numbers of days from seeding to heading of daylength insensitive variety Norin No. 11 at different night temperatures during different test periods.

Date of initial treatment		Night temperature (°C)					
		15	20	24	28	32	34
July	14	55.41±0.90 (54.41)*	42.31±0.85 (41.31)	37.29±0.99 (36.29)	37.48±0.91 (36.35)	36.93±0.62 (35.93)	37.86±1.29 (36.86)
	19	50.81±1.54 (44.81)	42.60±1.24 (36.60)	36.80±0.41 (30.80)	(31.35)	36.71±1.07 (30.71)	36.47±1.73 (30.47)
	24	48.83±1.19 (37.83)	41.25±0.97 (30.25)	37.00±0.39 (26.00)	(26.35)	37.86±1.83 (26.86)	40.62±2.14 (31.62)
	29	45.85±0.69 (29.85)	42.36±1.45 (26.36)	37.55±1.29 (21.55)	(21.35)	36.93±1.38 (20.93)	38.69±1.38 (22.69)
Aug.	3	44.27±2.25 (23.27)	39.62±1.21 (18.61)	37.08±0.91 (16.08)	(16.35)	37.77±0.73 (16.77)	37.82±1.33 (16.82)
	8	42.29±2.30 (16.29)	37.82±0.72 (11.83)	36.91±1.58 (10.91)	(11.35)	36.31±1.84 (10.31)	40.00±2.55 (14.00)
	13	41.55±1.13 (10.55)	37.73±1.79 (6.13)	38.00±1.41 (7.00)	(6.35)	36.67±1.92 (5.67)	37.70±1.25 (6.70)
	17	41.85±2.19 (5.85)	38.75±2.69 (2.75)	39.77±1.48 (3.77)	(1.35)	38.28±2.24 (2.27)	37.20±0.42 (1.20)
Average		46.38	40.31	37.56	37.43	37.19	38.30

* The figures in brackets are the numbers of days from the beginning of treatment to the beginning of heading.

It must be pointed out that Norin No. 11 is a daylength insensitive variety with a very short growth period. According to our observation, the floral buds had already been initiated within one week after seeding at night temperatures between 24°C and 34°C. Since the plants used in the second and the following tests had been kept at the night temperature of 28°C, their growing points had actually undergone differentiation in varying degrees before they were subject to different night temperature treatments. Therefore, strictly speaking only the first test was started before floral bud inititation.

In general, the number of days from seeding to heading were very similar when grown at night temperatures ranging from 24°C to 34°C, but heading was prolonged at 20°C and was further prolonged at 15°C. (However, there was still heading at 15°C.) From the 5th through the 8th tests, the number of days from seeding to heading at a night temperature of 20°C was close to those when the night temperature ranged from 24°C to 34°C. As the dates of initial treament were advanced, the numbers of days from seeding to heading at night temperature of 15°C became smaller as compared to the earlier tests. Nevertheless, they still showed meaningful differences with higher night temperature treatments.

The data in Table 3 can also be shown as in Fingure 2.

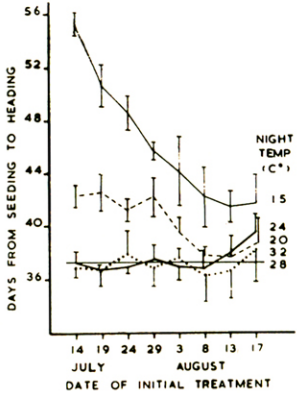

Fig. 2. The numbers of days from seeding to heading of daylength insensitive variety Norin No. 11 at different night temperatures during different test perieds.

DISCUSSION AND CONCLUSION

As indicated by the results of the experiments, the lowering of night temperatures to 20°C and 15°C definitely suppresses floral bud initiation and the growth of the floral buds already initiated. Among daylength sensitive varieties, Shinriki was slightly more adapted to low night temperature than Shuang-chiang and Wan-tze. The daylength insensitive variety Norin No. 11 was even more adapted to low night temperature than Shinriki. Both Norin No. 11 and Shinriki are Japanese varieties, formed in higher a'titude regions where the temperature is lower. Shuang-chiang and Wan-tze are native Taiwan varieties, formed in low altitude regions where the temperature is higher. The differences in ecotypes among the four varieties are clear on the basis of their reactions to low night temperatures. Norin No. 11 was formed in Hokkaido and thus was more resistant to low night temperature than Shinriki. Wada (1952) has divided rice varieties into three groups based on their reactions to daylength and temperature. The first group of varieties is insensitive to daylength, yet sensitive to temperature. The second group is sensitive to daylength, but not to temperature. The third group is sensitive to both daylength and temperature. Both Wada (1952) and Noguchi (1960) placed the Hokkaido variety Norin No. 11 under group 1 and considered it as a temperature sensitive variety. However, our results clearly showed that Norin 11 was far less sensitive to tem-

perature than the Taiwan varieties Shuang-chiang and Wan-tze and was also not so sensitive as the Japanese variety Shinriki. Hence, we think there is room for further examination if the Japannese investigators would use the difference in the number of days of growth between those plants grown inside and outside the greenhouse as the temperature sensitivity indicator of a variety.

Takimoto and Hamner (1964) pointed out that in the morning glory there was no floral bud initiation at the night temporature of 15°C. In rice, except Norin 11, developed in the extreme north (Hokkaido, Japan), there was either no floral bud initiation, or very late initiation at the night temperature of 15°C.

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