Effect of Temperature Associated with Early Growth Stimulus on Shortening of Heading Dates in Rice

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ABSTRACT

The heading date is known to be controlled by two kinds of genetic constituent, photosensitivity and basic vegetable phase. For the latter, the effect of temperature in early growth period is critical to determine the shortness of vegetative growth periods in plant' s life. A phytotron experiment on 55 rice cultivars, consisting of two ecotypes of rices, *indica* and *japonica*, was conducted at high and low temperature treatments at early growth stage to investigate the possible role of plant growth stimulus by high temperature to associate with shortening of heading date. The high temperature during the early growth stage stimulated the rice growth as measured by plant height with much difference of the growth response between *indica* and *japonica*. The conclusive finding that these growth stimulus in early growth stage was highly correlated with the acceleration of heading is, more or less, correlated with the heading of the late growth stage although we could not conclude the genes for early plant growth stimulus by high temperature is the same genes as the genes for accelerating of heading in the late growth stage of plants.

Key Words : rice, ecotype, heading, temperature

INTRODUCTION

Day length and temperature is two main ecological factors to determine the flowering of the rice plants which are often interrelated in nature. The plant may respond to temperature and photoperiod simultaneously, but the degree would vary according to the cultivars which is used for classification of rice (Wada, 1942; Lee, 1964). Temperature affects both the photoperiod-sensitive and photoperiod-insensitive cultivars. Generally, high temperature accelerates and low temperature delays heading (Ahn and Vergara, 1969; Hosoi and Takahashi 1973). Some reports, however, have shown that high temperature delays flowering (Asakuma and Iwashita, 1961; Azmi 1969).

The acceleration of the heading response by high temperature is an overall effect, but it does not indicate the specific effects on the different stages leading to flowering. The effect of temperature on the basic vegetative phase (BVP), photoinductive period, panicle differentiation and development, and critical photoperiod has not been fully studied.

There are much controversies about which effect of the low or high temperature treatment is responsible for the shortening or delaying of heading in rice. For

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example, Uekuri (1971, 1972) studied the effect of low temperature during the BVP and found a definite delay in attaining the photosensitive phase (PSP). The degree of extension of the BVP by low temperature varied with the cultivars used. Ahn (1968) reported that high temperature reduced the BVP but had very little effect on the PSP. Using the phytotron, Noguchi and Kamata (1965) showed that temperatures above 20℃ accelerate panicle initiation. Best (1959) also reported that panicle initiation was generally accelerated at 27 to 29℃. Vergara and Lilis (1968) showed that the vegetative primordium was converted to reproductive primordium at the same time or at the same morphological stage regardless of temperature (21 to 32℃). These results contradict those reported by Noguchi and Kamata (1965) and Best (1959). Temperatures below 15℃ inhibited initiation and bud development (Inouye 1964). Floral induction, however, is possible at 15 ℃(Noguchi and Kamata 1965). Since many test plants died in the growing process, 15℃ is assumed to be near the lowest limit for rice growth. The question still remains as to whether a critical temperature for photoinduction actually exists.

Regarding the development of the panicle primordium detailed microscopic studies have shown that high temperature accelerates panicle development (Madzhirova 1956). The critical temperature for young panicle differentiation has been reported to be 18℃ (Yatsuyanagi and Takeuchi, 1959). Best (1959) has also shown that panicle development, especially in its later stages, is accelerated at high temperatures (35 to 37℃). On the other hand, low temperature markedly retards panicle primordium development, and, below 25℃, the panicle may not emerge completely from the flag leaf sheath (Best, 1959). A night temperature of 24.4 ℃was found more favorable than 29 ℃ and 35℃ in accelerating the flowering (Manuel and Velasco, 1957). The delay in flowering with low temperature is the result of a delay in panicle exsertion, which, in turn, is the result of slow leafing interval (Vergara and Lilis, 1968).

Meantime the division of Asian cultivated rice into the two subspecies, *indica* and *japonica*, has been widely recognized by rice researcher. The *indica* rice cultivars is known to be less photosensitive as the *japonica* rice cultivars is known to be more photosensitive because of their geological distribution and selection pressures for the cultivated region. Generally, in *japonica* cultivars, late cultivars showed a high heading acceleration by both of short photoperiod and high temperature, however, early varieties was affected only by high temperature (Ahn, 1969). *Indica/japonica* hybrid showed less delayed heading in long day treatment than that of *japonica* type (Choi, 1983).

This study was conducted to investigate the possible roles of high temperature at early growth stage of rice plants to associate with acceleration of heading dates as Vegara and Lilis (1968) predicted the delay in flowering with low temperature is the result of a delay in panicle exsertion, which, in turn, is the result of slow leafing interval originated from the reduced growth by low temperature. The different responses between two rice ecotypes, *indica* and *japonica*, were also examined.

MATERIALS AND METHODS

Experimental location and plant materials

The experiment was conducted at National Crop Experiment Station located in Suweon city, Korea during the summer crop season. A set of fifty five rice accessions including thirty *indica* type cultivars and twenty five *japonica* type cultivars were used. The cultivars with different heading responses from early to late maturity was assigned to the each ecotype evenly which was examined in previous experiment in Korean climates. The seeds of *indica* cultivars were kindly provided by International Rice Germplasm Center

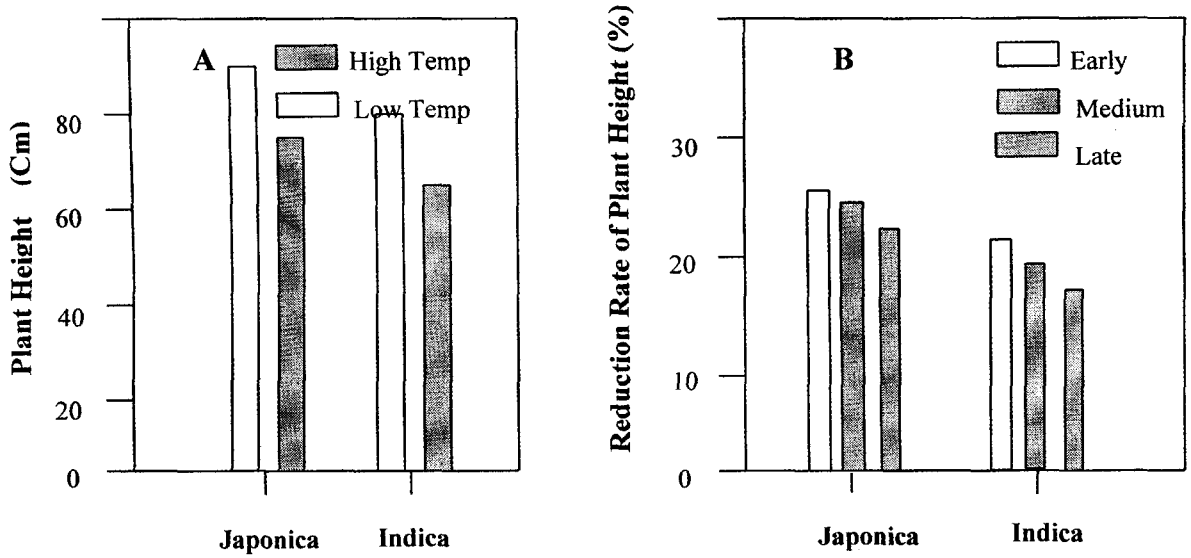

Fig. 1. Effect of temperature on the growth of rice plants as measured by plant height (A) and reduction rate of plant growth affected by low temperature treatment (B). The high temperature consisted of 30/25℃ and the low temperature, 23/18℃ in day/night shift, respectively.

(IRGC) at International Rice Research Institute (IRRI) in Philippines.

Temperature treatment at phytotron

On June 5, twenty day old seedlings grown in a greenhouse were transplanted to pots with three replications of complete randomized block design. One seeding per hill in three to five hills in a pot was treated as a replication. The pots were transferred to the respective phytotrons rooms to be subjected to the high and low temperature treatment. The high temperature consisted of day temperature of 30℃ for 12 hour and night temperature of 25℃ for 12 hour with illumination of natural sunlight. The low temperature consisted of day temperature of 23℃ for 12 h and nigh temperature of 18℃ for another 12 hour with the illumination of natural sunlight.

Data collection and statistical analysis

Plant growth was evaluated by measuring the plant heights at 30 days after transplanting during vegetative growth periods of rice plants. Three to five plants of each accession for the phytotron experiment and five to ten plants for the field experiment were measured for a replication. The heading date for each accession was scored when 50 % of the spikes has emerged from the boot of 50 % of the plants and converted to the number of days from transplanting to heading for the further data analysis. The reduction rate of plant growth was calculated by dividing the difference in plant height between low temperature and high temperature by plant height of high temperature in phytotron experiment. The difference in heading date in respective treatment was calculated by the difference by the days from transplanting to heading. SigmaStat 2.0 (Jandel Cooperation, U.S.A) was used for analysis of variance for the difference in plant growth and heading date. Fisher' s least significant difference (LSD) tests were used for comparison of means when the F ratio indicated significant difference among treatment. Regression analysis was computed to determine the

Table 1. Delay of heading date of rice cultivars as affected by low temperature treatment in phytotron.

Heading Habit	Ecotype	
	Indica	Japonica
Early	18.3 ±2.38	9.9 ±1.27
Medium	9.0 ± 2.75	10.5 ± 1.44
Late	11.6 ± 1.94	5.1 ±1.80

relationship between reduction in vegetative growth and delay of heading date.

RESULTS AND DISCUSSION

Effect of temperature on the early growth and acceleration of heading of rice

To see the extent of plant growth stimulus by higher temperature, the plants were subjected to 30/25℃ of day/night shift temperature for high temperature treatment and 23/18℃ for low temperature treatment during periods from transplanting to heading stage. The plant height was measured on 30 days after transplanting as the measure of plant growth affected by the temperature treatment. Significant differences of plant height both in level of temperature treatment and ecospecies treatments were observed (Fig. 1-A). The *indica* varieties showed the higher reduction than the *Japonica* varieties. Also there was a significant difference of reduction rate of plant growth between the ecospecies (Fig. 1-B). Eighteen to twenty eight percent of reduction was observed by low temperature treatment. The comparison of reduction was also conducted between groups of heading habits within each ecospecies. There was no significant difference in heading delay between the early and the medium group. Only the difference was noticed between the early and late groups.

The difference of heading date was observed both in levels of ecospecies and heading habit (Table 1). *Indica* showed the more delay of heading date of fifteen days by low temperature treatment than that of *japonica* varieties of eight days. Between the different group of heading habits, the late varieties showed less delay of heading by low temperature treatment. Only eight day delay of late varieties was observed compared to fourteen day delay of early varieties. The difference is more distinguished in *indica* varieties than *japonica* varieties. These findings are consistent with other observations that temperature affects both the photoperiod-sensitive and photoperiod-insensitive cultivars and generally, high temperature accelerates and low temperature delays heading (Ahn and Vergara, 1969; Hosoi and Takahashi, 1973). However, we could not find any evidence that these shortening of the heading is whether by the response of the specific genes which is regulated by the high temperature or by the overall effect of the plant growth stimulus which, in turn, accelerate the plant sexual organ development.

Correlation between vegetative growth and heading date

To find out the association between the reduction of plant growth during vegetative growth period and delay of heading, a linear regression was tested. It was found out that the reduction in plant height by low temperature treatment was significantly correlated with the delay of heading date ($r=0.415^{**}$) in all ecospecies of rice varieties in the phytotron study (Fig. 2). From the finding that there was a significant correlation between early growth stimulus and shortening of the heading by high temperature treatment suggested that the effect of the high temperature is an overall effect to plant growth to shortening of the plant' s vegetative growth periods.

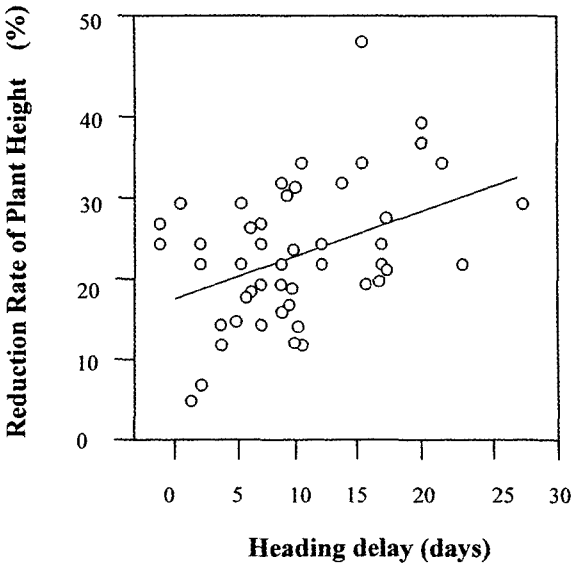

Fig. 2. Correlation between reduction rate of plant growth and delay of heading by low temperature

Although there was few scientific observation that the early growth stimulus was the cause of the shortening of the heading in rice, several reports indicated the involvement of growth stimulus accelerate the heading of the rice. For example, Uekuri(1971, 1972) and Ahn (1968) studied the effect of low temperature and found a definite delay in attaining the primodial initiation. A microscopic experiment (Madzhirova 1956) showed that regarding the development of the panicle primordium high temperature accelerates panicle development. Best (1959) has also shown that panicle development, especially in its later stages, is accelerated at high temperatures (35 to 37℃). On the other hand, low temperature markedly retards panicle primordium development. The delay in flowering with low temperature is the result of a delay in panicle exsertion, which, in turn, is the result of slow leafing interval (Vergara and Lilis, 1968). Although detailed microscopic evidence is not examined in this studuy, the findings of correlation between early growth stimulus and acceleration of the photoperiod response by high temperature suggested that the effect of the high temperature during the early growth stage is an overall effect with more and less fluctuation in different ecotypes of rice. Obviously, caution should be taken to draw the conclusion, there was not a different set of the genes responding to a critical temperature for specific sexual organ development.

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