d. STUDIES ON THE DEVELOPMENT OF ROOT SYSTEM AND CARBON ASSIMILATION OF PADDY RICE AS INFLUENCED BY TEMPERATURES.

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The production of rice grain is due to synthetic results of water and mineral absorptions, transpiration, assimilation, respiration and transmission of assimilation product to panicles. Generally speaking, these actions may be promoted with the rise of temperature within the limit of 15°C to 33°C. The mode of temperature changes differ between the two rice seasons of Taiwan; from low to high in the first crop and from high to low in the second crop. It is possible that the high temperatures at the heading stage of first crop and the low temperatures at the heading stage of second crop, reduce yield to some extent.

The present studies were aimed to investigate the root development, the changes in net assimilation rate under changing temperatures and the effect of temperatures on seed sterility.

Materials and Methods

Taichung No. 65 (Ponlai rice, Japonica type) and Pai-mi-fun (Native rice, Indica type) were used as materials, and the pot culture was applied. The root-examination-boxes were also used in addition to pots.

Each pot, filled with 27 Kgr. of soil which was taken from the experimental field of this Institute, was dressed with 1 gr. of ammonium sulphate, calcium superphosphate and potassium chloride. 30 pots for each variety were set in each plot respectively, so that those were 120 pots in total. The root-examination-boxes, one for each variety, were set in each plot. Three seedlings were planted in each pot and box. The experiments were carried out in a greenhouse divided into two parts, the one with most windows being closed except some pivoted one (taken as the high temperature plot) and the other with wire-windows (taken as the low temperature plot). The difference in night temperature between the two plots was below 1°C.

During the growing period, the pots in each plot were rearranged several times so as to remove the difference in environmental factors among them. Ordinary meteorological measurement and the temperatures of water and soil in pots were recorded six times a day during the growing season. The development of straws and roots, the leaf area and these oven dry weight, were measured at the intervals of 2-weeks, using plants in three pots each time. The rate of carbon assimilation was shown by "Net Assimilation Rate" (NAR) according to the "Growth analysis method". The development of root system was also investigated by using root-examination-boxes. The dates of transplanting and harvest were shown in Table 1.

Table 1. Dates of transplanting and harvest of two crop seasons

Plots	Items	1st crop		2nd crop	
		Ponlai rice	Native rice	Ponlai rice	Native rice
High temp. plot	Transplantation Harvest Total days	10, March 23, July 135	10, March 5, July 117	10, August 17, December 129	10, August 17, December 129
Low temp. plot	Transplantation Harvest Total days	10, March 23, July 135	10, March 5, July 117	10, August 17, December 129	10, August 17, December 129

Experimental Results

1. Effect of temperatures on the plant height and dry weight

It was found that the plant height in the high temperature plot was higher than that in the low temperature plot both in the first and second crops. However, this difference was relatively small in the second crop.

The oven dry weight of plants excluding root, was apparently promoted by high temperature in Taichung No. 65 (Ponlai rice), both in the first and the second crops, but the difference between two plots was relatively small in Pai-mi-fun (Native rice). The difference of dry weight which was measured at harvest time, in Taichung No. 65, in first crop was 1.7 times to that of second crop in high temperature plot, and 2.2 times in low temperature plot. Pai-mi-fun in first crop showed 1.7 and 1.8 times of difference to second crop for respective high and low temperature plots.

2. Effect of temperatures on the development of root

In the first crop, the oven dry weight of root in both varieties in high temperature plot was larger than that in the low temperature plot and the difference between two plots was significant. In the seconp crop, no remarkable difference between the two plots was found in both varieties of Pai-mi-fun and Taichung No. 65.

The process of root development between the first and second crop was compared with regard to the temperature effect. No difference in the root weight was found at the early stage of each crop, but from the tillering stage to the heading stage, it was larger in first crop than in second crop both of varieties as well as in the high and low temperature plots, after the heading stage it was larger in second crop than in first crop. The root weight of Pai-mi-fun was generally larger than that of Taichung No. 65 in both high and low temperature plots as well as in the first and the second crops, except that measured near the harvest time in the low temperature plot of second crop.

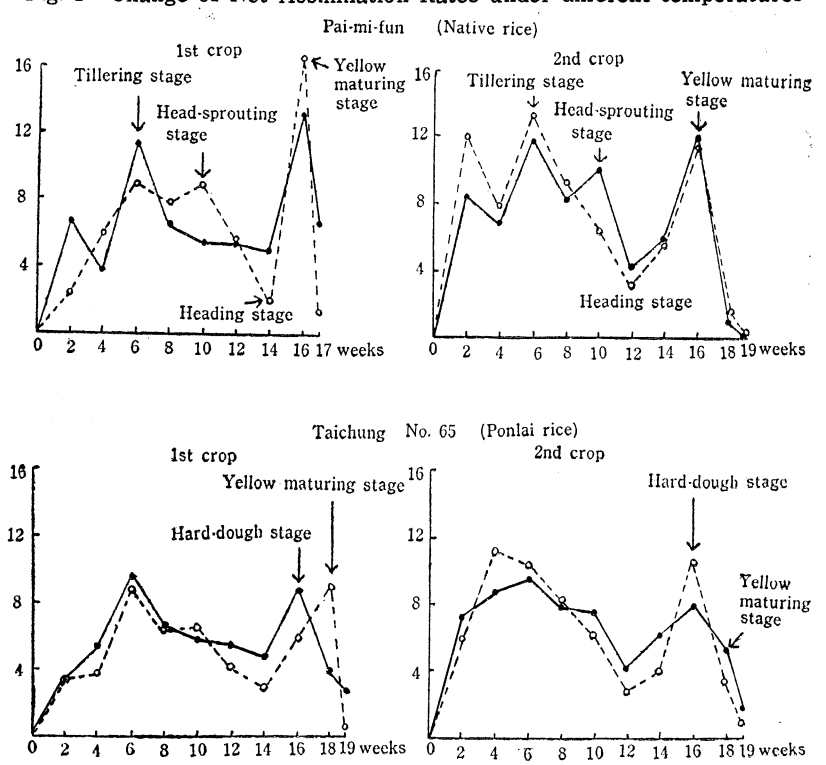
The changing mode of the "Relative Growth Rate" (RGR) of root as influenced by the change of temperatures through the growing stage was investigated at the intervals of two weeks. In the first crop, the "Relative Growth Rate" was found to be very high in the first half of growing stage in both varieties of Pai-mi-fun and Taichung No. 65. In the high temperature plot, the highest peak of RGR was seen at the tillering stage. In the low temperature plot, however, two peaks one at tillering stage and the other at head-sprouting stage, in parallel with the rise and drop of temperatures was observed. It may be due to the extremly high temperature at head-sprouting stage which brought about to reduce RGR in the high temperature plot. The sharp drop of RGR at the beginning of heading stage, in the low temperature plot may be affected by the low temperature.

In the second crop, the RGR of the two varieties were larger than that in the first crop. The high RGR was found in the first and the last stage of growth in both varieties. Pai-mi-fun showed three peaks at eary stage (two weeks after transplanting), tillering and yellow maturity stage, while Taichung No. 65, showed two peaks, one at the tillering stage and the other at hard-dough stage. The RGR in the earliest growing stage of high temperature plot of Pai-mi-fun was apparently lower than that in the low temperature plot, because of extremly high temperature. The similar tendency was also found at the tillering stage of Taichung No. 65.

3. The changes of "Net Assimilation Rate" (NAR)

The changes of "Net Assimilation Rate" under the different temperatures were also observed at the intervals of two weeks. The results are shown in Fig 1.

Fig. 1. Change of Net Assimilation Rates under different temperatures



Note: ——— High temperature plot

- - - - Low

Unit: mg/cm²/2 weeks

As seen in Fig 1, in the first crop, the NAR measured in the head-sprouting stage of the low temperature plot was higher than that of high temperature plot, in contrast to this, relatively high NAR was found in high temperature plot of both varieties in the second crop. It seems that these facts brought the good yield for respective plot of each season.

4. Effect of temperature on various Agronomic characters

The various agronomic characters in relation to the temperature effect were observed at maturity. The results are shown in Table 3.

Table 3.

Crop	Items	Taichung No. 65		Pai-mi-fun	
		High temp. plot	Low temp. plot	High temp. plot	Low temp. plot
1st crop	Plant height (cm)	143.0(110)	130.0(100)	180.0(111)	162.0(100)
	Number oftillers	21.0(108)	19.5(100)	22.5(105)	21.5(100)
	Total yield (gr/pot)	117.6(104)	113.1(100)	149.7(109)	137.2(100)
	Unripen grain	3.9(673)	0.6(100)	6.3(334)	1.9(100)
	Grain	27.6 (59)	46.5(100)	45.4 (69)	65.4(100)
	Straw	86.1(130)	66.1(100)	98.0(140)	69.9(100)
	Migration coefficient (%)	20.6 (55)	37.5(100)	26.1 (64)	40.8(100)
2nd crop	Plant height (cm)	125.7(107)	117.3(100)	162.3(101)	161.0(100)
	Number of tillers	16.8(117)	14.3(100)	13.0(100)	13.0(100)
	Total yield (gr/pot)	69.4(133)	52.3(100)	87.5(102)	85.4(100)
	Unripen grain	0.5 (71)	0.7(100)	1.2 (48)	2.5(100)
	Grain	34.0(152)	22.3(100)	43.6(104)	41.8(100)
	Straw	34.9(119)	29.3(100)	42.7(104)	41.1(100)
	Migration coefficient (%)	37.1(122)	30.3(100)	42.2(108)	39.1(100)

Note: Migration coefficient were shown by the rate of grain dry weight per total dry weight.

As the data in table 3 show, the growth in dry weight was apparently promoted by high temperature, but the grain yield was not always promoted. In the first crop, the grain yield in the high temperature plot was less than that in the low temperature plot, but in the second crop the high temperautre plot gave higher yield.

As shown in table 3, in the first crop, the coefficient of transmission of assimilation product was apparently lower in the high temperature plot than the low temperature plot, but it was just reversed in the second crop.

Further, the pollination as well as seed setting were greatly obstructed by extremly high temperature of first crop and extremly low temperature of the second crop after the flowering time. The percentage of seed sterility due to temperature effect is shown in Table 4.

Table 4. Comparison of seed sterility between high and low temperature plots

Crop	Taichung No. 65		Pai-mi-fun	
	High temp. plot	Low temp. plot	High temp. plot	Low temp. plot
1st crop	44.48(465)	9.56(100)	47.75(402)	11.89(100)
2nd crop	12.50 (72)	17.40(100)	18.20 (55)	33.20(100)

As table 4 shows, in the first crop, the rate of seed sterility in high temperature plot was four times higher than that of low temperature plot, in both varieties. But in the second crop, that of low temperature plots were 28–45 percent higher than high temperature plots.

Further, the native variety, Pai-mi-fun, in the high temperature plot grew many tillers from the node on high position of straw. This also suggested that the transmission of assimilation produdct to panicles was blocked under high temperature of the first crop.

Consideration

The effect of temperatures on the increase of root dry weight through the growing season was observed in this study. In the first crop (temperature changed from low to high), the development of root was promoted by the temperature but not clear in the second crop (temperature changed from high to low). The "Relative Growth Rate" of root at various growing stages was distinctly affected by the change of temperature. The changing mode of the "Net Assimilation Rate" affected by the change of temperatures, was quite similar to that of RGR of roots. It was found that both the RGR of root and the NAR were relatively high at the head-sprouting stage of the low temperature plot in the first crop and in the high temperature plot of the second crop. It is infered from these facts together with the facts that the water absorption and the nutrient absorption reached the climax at the head-sprouting stage, and brought the good yield for respective plot of each season.

On the other hand, the grain yield was apparently affected by the assimilation after heading, because it had been found by Togari (1954) that the two thirds of starch stored in the panicles were produced after 10 th day of heading. In the first crop, both the RGR of root and NAR during the heading stage in the high temperature plot were higher than that of low temperature plot, and the number of panicle was also more in high temperature plot. Theoretically these phenomena should be beneficial to the production of grain but the low yield was observed in high temperature plot on the contrary. The extremly high temperature after heading apparently obstracted the transmission of assimilation product to panicle and caused high rate of seed sterility may be its important reason. Further in the native rice "Pai-mi-fun" in high temperature plot grew many ineffective tillers from the node of high positions of straw. These ineffective tillers let to make the further drop of the migration coefficient.

In the second crop, both the RGR of root and the NAR, from the head-sprouting stage till the hard-dough stage were always lower than that under the high temperature, these facts can be considered that the important reasons of the low yield of the second crop. Further, the seed sterility under the low temperature condition were very high, it may be due to both the average and minimum temperatures after head-sprouting stage were lower than 25°C which is the limit of minimum temperature let to increase the sterility. Moreover, the migration coefficient was low, this is also the major cause of the low yield in the second crop.

DISCUSSION

Hsu: Have you made an experiment on the transmission of synthesized substance in the plant by chemical analysis ?

Wu: It has not been made yet, but the migration coefficient was expressed by the grain/total weight ratio as shown in table 3.

Chiu: You used three replications, but it seem to me not enough.

Wu: Because, the investigations on the leaf area and total dry weight of plant in various plots were quite laborous, if the replication was increased the investigation can not be finished in the same day, so that the records might be uncertainly.

Lin: I would like to suggest you to make chemical analysis by using leaf system to determine the assimilation.

Wu: The growth analysis was used in this experiment instead of chemical analysis. Because to study the process of plant growth in respect to the assimilation rate, the growth analysis method is better than chemical analysis method. For study the growth analysis, it is necessary to investigate the dry weights of straws and roots, and the areas of leaves.