TARC Notes

Varieties and nitrogen application for rice double cropping in the Muda irrigation area of Malaysia

In the Muda Irrigation Project area, accounting for about 100,000 ha, the rice double cropping is widely practiced. Average yield of paddy is about 3 ton/ha, with relatively higher yields in the off season than in the main season. The off season crop is grown from March to August. Dry weather with high temperature, plenty solar radiation and low precipitation prevails from 1 to 2 months before the cropping to the transplanting time, but after that precipitation increases, reaching 200 mm in monthly average during the ripening period. On the other hand, the main season crop is grown from August to January. The precipitation of 250–300 mm in monthly average lasts for a period from sowing to heading, and then dry weather follows.

According to the survey made by the authors in fields of 120 farmers in 6 kampongs in 1974, the average rate of nitrogen application was about 50 kg N/ha, with somewhat lower rates in the main season than in the dry season. In the off season two varieties, Mahsuri and C4-63 (Jaya) were planted to 72% of the total cropped area, while in the main season the percentage was 44%. In place of these two varieties, Bahagia, Mat Candu, Seribugantang and other local varieties were grown.

Nitrogen response of C4-63 and Bahagia was tested in farmer's fields located at each of 12 soil series areas during a period from 1971 main season to 1973 off season. In some cases, varieties such as RD1, IR 262-43-8-11, Bahagia ×Ria, and Ria secondary were used in place of C4-63. But, since all these varieties are akin to C4-63 in their fertilizer response, they are referred to C4-63 all together in the following analysis.

Extent of yield increase caused by nitrogen application was found to be different with seasons and varieties as shown in Fig. 1 and Table 1. The nitrogen response of C4-63 was higher than that of Bahagia in both seasons, showing a yied increase even at 120 kg N/ha, whereas Bahagia showed the yield ceiling at 100 kg N/ha in the main season and at 80 kg

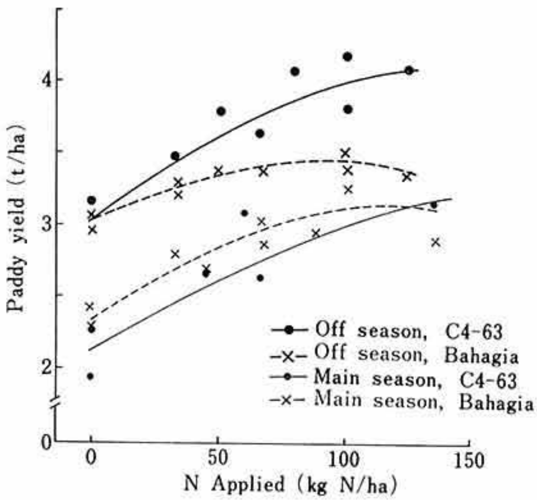

Fig. 1. Nitrogen response of C4-63 and Bahagia by seasons

Table 1. Effect of nitrogen application in the main and off seasons crops (paddy kg/ha)

Varieties	Off season crop				Main season crop			
	A	B	A−B	(A−B)/B	A	B	A−B	(A−B)/B
C4−63	4,061	3,053	1,008	33%	3,115	2,043	1,072	52%
Bahagia	3,517	2,968	549	18	3,285	2,419	866	36

Note) A : The highest yield obtained by nitrogen application.
B : Yield without nitrogen application.
A−B : Yield increase caused by nitrogen application.
(A−B)/B : Percent yield increase.

N/ha in the off season.

Yields of both varieties were considerably lower in the main season than in the off season. However, C4-63 outyielded Bahagia in the off season, but this relation was reversed in the main season, because the extent of yield decrease in the main season was apparently greater with C4-63 (23–33% decrease) than Bahagia (7–18% decrease).

Amount of yield increase of C4-63 due to nitrogen application was almost same for both seasons, although the percentage of increase was higher in the main season. On the contrary, both of the amount and percentage of yield increase of Bahagia were apparently lower in the off season than in the main season. This point is different from results of former reports[1,6], and is considered to be caused by following two factors: the difference in available soil nitrogen between two seasons, and the varietal difference in nitrogen response.

1) The availability of soil nitrogen is considered to be very high for the off season crop due to an increased mineralization of soil nitrogen by soil drying and high soil temperature[3,5] before the cropping, whereas it is low for the main season crop immediately following the off season crop[2].

2) Bahagia approached the yield ceiling at such a high level of available soil nitrogen in the off season, being less nitrogen-responsive than C4-63, but it outyielded C4-63 at the low nitrogen level in the main season.

As the seasonal difference in solar radiation seems to influence the effect of nitrogen application[6], the amount of solar radiation during the period from transplanting to harvest was calculated by the Sugimoto's method using sunshine hours. Average of the experimental years for the main (September–January) and off season (April–August) were 441.4 and 473.6 cal/cm^2/day respectively. Higher solar radiation in the off season may benefit the effect of nitrogen applied to nitrogen responsive varieties.

From these results, it is concluded that the choice of varieties should be made by taking into account the ecological difference between both seasons and nitrogen requirement of varieties.

Table 2 shows an economic comparison of fertilizer use between two varieties in both seasons. Yields were taken from curves in Fig. 1, and the net return was calculated by subtracting all costs incurred by fertilizer use from the gross return. In the off season C4-63 offered higher return while in the main season

Table 2. Economic efficiency of applied nitrogen (1974 M$/ha)

Applied nitrogen (kg/ha)	Off season crop				Main season crop			
	C4—63		Bahagia		C4—63		Bahagia	
	A	B	A	B	A	B	A	B
0	1,439	0	1,410	0	1,008	0	1,108	0
22	1,528	89	1,445	35	1,080	72	1,173	65
45	1,608	169	1,475	65	1,151	143	1,232	124
67	1,671	232	1,486	[76]	1,206	198	1,277	169
90	1,708	[269]	1,475	65	1,250	242	1,298	[190]
112	1,690	251	1,445	35	1,278	270	1,289	181
134	—	—	—	—	1,285	[277]	1,240	132

Note) A : Net return=gross return/ha—all costs incurred by fertilizer use (fertilizer price, and labor cost for fertilizer application and for harvesting, threshing and transportation of additional paddy produced by yield increase).

B : Net reutrn over the no-nitrogen application.

□: Maximum net return over the no-nitrogen application.

Bahagia did. Economical rate of nitrogen application was shown to be about 90 kg N/ha, which is almost twice that of farmer's practice in this area. This suggests that more application of nitrogen would be beneficial.

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Mechanism of sterility caused by high temperature at flowering time in indica rice

High temperature appears to be a crucial physical constraint in rice grain production in areas such as Pakistan, Middle East and tropical Africa. Even in tropical Asia, several reports suggest that high temperature-induced sterility could be an important constraint in the dry season crop of rice.

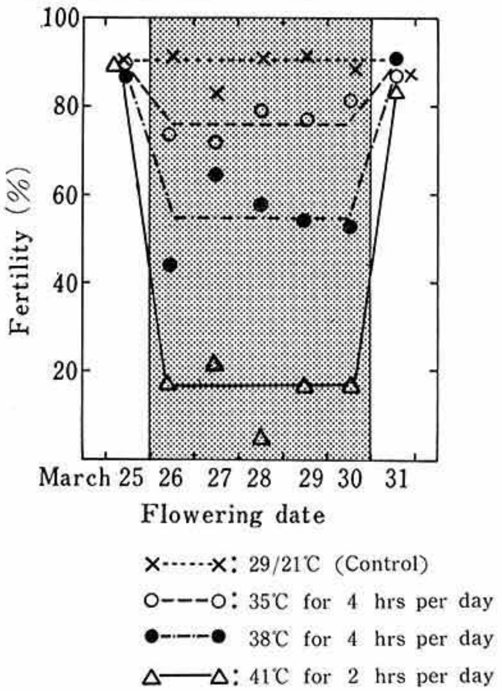
The present study was designed to identify the most sensitive stage of rice spikelets to high temperature and to investigate the mechanism of high temperature-induced sterility. Experiments herein reported were conducted in the IRRI phytotron.

Pregerminated seeds of a selection IR747B2-6 were sown in a circular pattern in 4-*l* plastic pots with 20 seeds per pot and the plants were grown in the glasshouse. The temperature was kept at 29°C between 0900 and 1700 hours and 21°C during the night while the relative humidity was maintained above 70%. Daylength was that of natural condition.

Tillers were removed once a week from 3 weeks after sowing to about 1 month before heading. This procedure facilitated to produce uniform main culms for the spikelet fertility test.

At flowering, plants were transferred to natural light growth cabinets maintained at 35, 38 and 41°C, and exposed to respective high temperatures for different lengths of time. After the high temperature treatment, the plants were transferred back to the glasshouse room maintained at 29°/21°C. Marks were given with different colors of magic pens on the surface of spikelet glumes to record flowering date or flowering time of the day. This technique made it possible to examine direct relationship between the high temperature treatment and fertility of the spikelets flowered during the treatment.

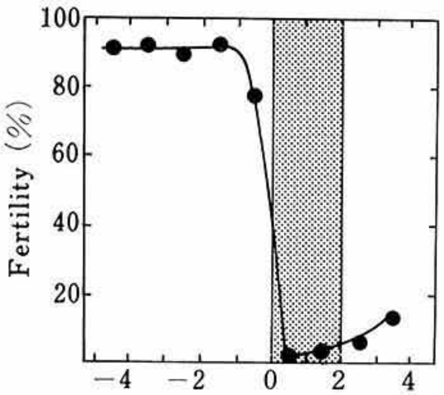
As shown clearly in Fig. 1, percent fertility decreased with the spikelets flowered during the treatment but it was almost as high as that of normal plants with the spikelets flowered before or after the treatment. Thus, it can be concluded that sterility is induced by high temperature on the flowering day, whereas high temperature before or after the flowering day has little influence on fertilization of spikelets.



Variety : IR 747 B-2-6
Treatment : For each of 5 days from March 26 to March 30

Fig. 1. Effect of high temperature treatments on fertility of spikelets which flowered on the days before, during or after the treatments

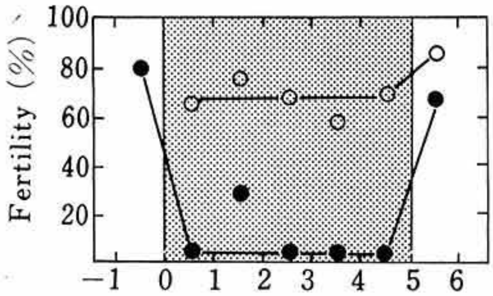
To examine further the most sensitive time to high temperature, plants were exposed to 41°C for 2 hrs at different time of the day (0900-1100, 1100-1300, 1300-1500, and 1500-1700 hours). The data thus obtained are summarized in terms of percent fertility as a function of a number of hours before or after the time of anthesis, irrespective of the time of the day of the treatment (Fig. 2). Percent fertility of spikelets flowered during the high temperature treatment was very low whereas that of those flowered one hour before the



Hours to flowering from the beginning of high temperature treatment

Variety: IR 747 B-2-6
Treatment: 41℃ for 2 hrs

Fig. 2. Effect of high temperature treatment on fertility of spikelets which flowered at the time before, during or after the treatment



Days to flowering from the beginning of high temperature treatment

●——● Not pollinated

○——○ Pollinated

Variety: IR 747 B-2-6
Treatment: 38℃ for 8 hrs for each of 5 test days

Fig. 3. Effect of artificial pollination on the fertility of spikelets exposed to high temperature during anthesis

treatment was not affected at all. Percent fertility of spikelets which flowered after the treatment remained low. These results indicate that the anthesis stage and also the subsequent stage of fertilization occurring within one hour after anthesis are most sensitive to high temperature.

In a separate experiment, the ability of pistil in the fertilization was examined by artificial pollination. Pollens taken from the spikelets which flowered at 29°C were given onto the stigmas of spikelets exposed to high temperature. As shown in Fig. 3, without the artificial pollination percent fertility of spikelets went down to about 3% when the plants were exposed to 38°C for 8 hrs. The percent fertility was, however, increased by artificial pollination to 65%. These observations indicate that high temperature largely affects process of pollination or viability of pollens but it does not disturb the ability of pistil in the fertilization. Microscopic observations of the pollens on stigmas revealed that the occurrence of unfertilized spikelets could be attributed to insufficient pollination or to decreased number of germinated pollens on stigmas or to both.

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