TARC Report

Analytical Survey on Paddy Yields in the KADA Area of Peninsular Malaysia

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In the Kemubu Irrigation Project area, located in the northeastern coast of Peninsular Malaysia, the double cropping of rice is practiced on about 30,000 ha of paddy fields under the supervision of the Kemubu Agricultural Development Authority (KADA). With the purpose of knowing paddy yields and yield components as influenced by climatic factors in the KADA area, an analytical survey on paddy yields was carried out in about 40 lots[a] of farmers' fields distributed in that area during a period of 5 successive cropping seasons, from the 1977 off season through the 1979 off season.

Method of the survey

A total of 4 survey sites, each composed of 10 field lots covering an area of about 20 ha, were selected from 4 different terminal irrigation units of field, each composed of 30–150 lots. Each survey site included both high-yielding fields and low-yielding fields in each terminal irrigation unit, so as to represent the whole unit.

Sampling of rice plants for the measurement of paddy yield and yield components was made at 5 points in each field lot: the point of intersection of two diagonals and 4 points at the middle of 4 halves of the diagonals (Fig. 1). At each point 15 normal hills were sampled, making up a total of 75 hills per field lot.

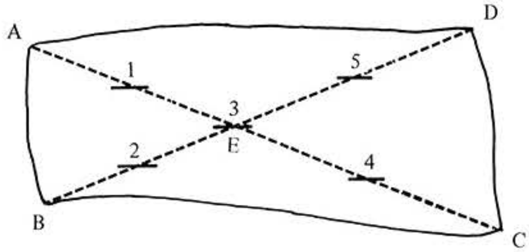

Fig. 1. A diagram showing 5 points for sampling in a field lot

Planting density (number of hills/m²) was measured, perfect grains were separated from imperfect grains, and yield components were measured. Although there were some differences in varieties grown and cultural practices among the field lots and the cropping seasons, this aspect was not taken into consideration for the analysis.

Data for the climatic factors were taken from daily data recorded at the Observatory of Kota Bharu, in the vicinity of the survey sites.

a) A total of 40 field lots was selected, but some of them were not available for the survey in some seasons.

Results and discussions

Paddy yields and yield components obtained in each of 5 cropping seasons are shown in Table 1. The yield was the highest for the 1978/79 main season (December–April), and it showed a decrease in the following order: 1977/78 main season ≒ 1979 off season (June–October) > 1978 off season > 1977 off season. In other words, the yields of main season crops were generally higher than those of off season crops.

In the 1977 off season, which showed the lowest yield, planting density and number of panicles/m² were found to be lowest among all the seasons. Although the number of spikelets/m² was about 27,000 for all the seasons, without appreciable seasonal differences, percentage of ripened grains varied among the seasons, showing the lowest value (76%) in the 1978 off season and the highest value (86%) in the 1978/79 main season. Weight of 1,000 grains was 19.6 – 20.0 g without much seasonal variations.

Climatic factors such as air temperature, rainfall and sunshine hours are given in Fig. 2. It can be seen in general that the off season crop starts its growth with a little rain and plenty of sunshine but its later growth period is exposed to less sunshine. On the contrary, the main season crop is exposed to heavy rains, less sunshine and low air temperature at the beginning but to little rain, plenty of sunshine and high air temperature

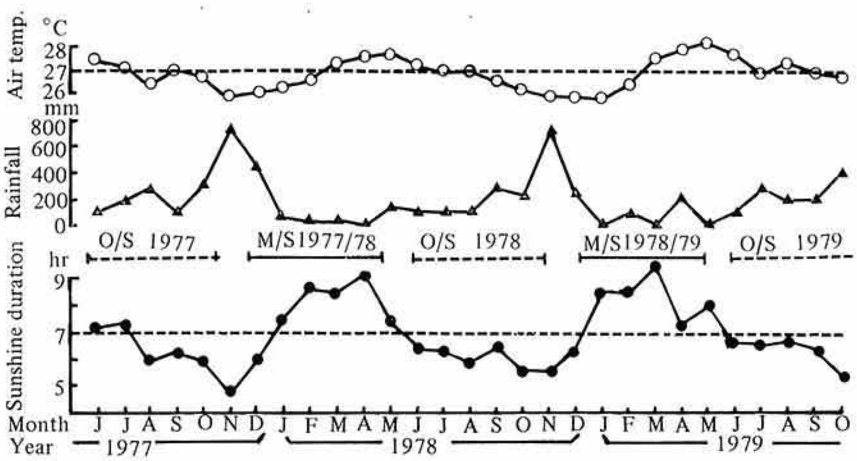

Fig. 2. Rainfall, daily sunshine hours and mean air temperature (Kota Bharu, Lat.: 6°10′N)
O/S: Off season M/S: Main season

Table 1. Paddy yields, yield components, daily sunshine hours during a 30 day-period (10 days before and 20 days after heading) and mean air temperature during the tillering stage (40 days after transplanting)

Cropping season	No. of field lots sampled	No. of hills/m²	No. of panicles/m²	No. of spike-lets/m²	Percent ripened grains	Wt. of 1,000 grains	Paddy yield	Sunshine duration	Air temp.
				×10³	%	g	t/ha	hr.	°C
Off season 1977	40	12.8	178	—	—	—	3.18	6.1	27.5
Main season 1977/78	36	14.7	215	26	82	20.0	4.24	8.8	26.1
Off season 1978	39	14.5	207	27	76	20.0	4.05	6.1	27.1
Main season 1978/79	40	14.0	202	27	86	19.6	4.44	8.8	25.9
Off season 1979	39	14.5	212	27	80	19.7	4.24	6.9	27.4

Table 2. Correlation coefficients between paddy yields and yield components

Items	M/S 1977/78 (n=36)	O/S 1978 (n=39)	M/S 1978/79 (n=40)	O/S 1979 (n=39)	Total (n=154)
No. of hills/m² vs. no. of panicles/m²	0.675***	0.711***	0.628***	0.711***	0.672***
No. of hills/m² vs. no. of spikelets/m²	0.558***	0.537***	0.582***	0.548***	0.525***
No. of panicles/m² vs. no. of spikelets/m²	0.470**	0.701***	0.736***	0.721***	0.658***
No. of hills/m² vs. yield	0.586***	0.440**	0.629***	0.586***	0.520***
No. of panicles/m² vs. yield	0.695***	0.690***	0.776***	0.627***	0.707***
No. of spikelets/m² vs. yield	0.794***	0.867***	0.873***	0.885***	0.838***
% of ripened grains vs. yield	-0.287	0.139	-0.422**	0.395*	0.105
No. of spikelets/m² vs. % ripened grains	-0.786***	-0.310*	-0.774***	-0.005	-0.387***
No. of spikelets/panicle vs. % ripened grains	-0.772***	-0.375*	-0.514***	-0.467**	-0.446***

* Significant at 5%, ** at 1% and *** at 0.1% levels

at the later growth period. As shown in Table 1, the mean daily sunshine hours during the 30 day-period, covering 10 days before heading and 20 days after heading, was shorter in the off seasons (6.1 hr for 1977 off season and 1978 off season, and 6.9 hr for 1979 off season) than in the main seasons (8.8 hr for 1977/78 main season and 1978/79 main season). On the other hand, mean air temperature during 40 days after transplanting was lower in the main seasons than in the off seasons, showing the lowest temperature (25.9°C) in the 1978/79 main season and the highest one (27.5°C) in the 1977 off season.

1) Paddy yields and yield components

As to the yields and yield components shown in 5 cropping seasons, the following relationships, as given in Table 2, were observed: Number of panicles/m² is closely correlated with number of hills/m² (planting density), and number of spikelets/m² is closely correlated with number of panicles/m². Therefore, there is also a positive correlation between number of hills/m² and number of spikelets/m². Although paddy yields are correlated with number of hills/m², number of panicles/m², and number of spikelets/panicle, the number of spikelets/m² showed the highest correlation coefficient, r=0.838, with paddy yields. However, correlation between paddy yields and percentage of ripened grains is not consistent, because there is a negative correlation between percentage of ripened grains and number of spikelets/panicle or number of spikelets/m².

Thus, it was made clear that number of spikelets/m² is the main factor contributing paddy yields. Then, there is a problem of how to increase the number of spikelets/m². There are two different ways to increase number of spikelets/m²: (a) by increasing number of panicles/m², or (b) by increasing number of spikelets/panicle. As mentioned above, the increase in number of spikelets/panicle induces the decrease in percentage of ripened grains. It usually occurs when the number of weak spikelets on the secondary rachis-branches is increased, rather than the increase of spikelets on the primary rachis-branches[1]. Therefore, it can be concluded that, for obtaining high yields, it is necessary to increase number of spikelets/m² by increasing number of panicles/m² with dense planting and proper fertilizer application, rather than by increasing number of spikelets/panicle. The increased number of spikelets/m² also induces a decrease in percentage of ripened grains, but this effect is rather small, and can be compensated by the increased number of spikelets/m².

2) Effects of air temperature and sunshine hours

As shown in Table 3, paddy yields are positively correlated with the mean daily sunshine hours during the 30 day-period (10 days before and 20 days after heading), but negatively correlated with the mean air tem-

Table 3. Correlation coefficients and partial correlation coefficients between climatic factors and paddy yields or yield components (n = 193)

Correlation coefficient		
Sunshine hours during the whole growing season (1) vs. yield	:	0.210**
Mean air temp. during the whole growing season (2) vs. yield	:	-0.232**
(1) vs. (2)	:	0.126
Correlation coefficient		
Sunshine hours in 30 days around heading (3) vs. yield	:	0.378***
Mean air temp. in 30 days around heading (4) vs. yield	:	0.144
(3) vs. (4)	:	0.542***
Partial correlation coefficient		
(3) vs. yield (effect of air temp. eliminated)	:	0.379***
(4) vs. yield (effect of sunshine hours eliminated)	:	-0.117
Correlation coefficient [a]		
(3) vs. percent ripened grains	:	0.501***
(4) vs. percent ripened grains	:	0.308***
(3) vs. (4)	:	0.505***
Partial correlation coefficient [a]		
(3) vs. percent ripened grains (effect of air temp. eliminated)	:	0.421***
(4) vs. percent ripened grains (effect of sunshine hours eliminated)	:	0.074
Correlation coefficient		
Mean air temp. at tillering stage vs. yield	:	-0.277***
Mean air temp. at tillering stage vs. no. of panicles/m^2	:	-0.114

a) Data for percent ripened grains were obtained from 4 seasons (n = 153). Accordingly, climatic data used were for the 4 seasons.

perature during the whole period of growth or during the tillering stage (during 40 days after transplanting). In the tropics, it is known that high sterility occurs at temperature higher than 35°C during the period of anthesis[4], but it is not observed in Malaysia. The mean daily sunshine hours in the 30 day-period around heading is also positively correlated with percentage of ripened grains.

These facts suggest that low temperature during the tillering stage tends to increase the number of panicles/m^2, and hence paddy yield. Moreover, abundant sunshine during the period around heading stage increases photosynthetic production, and increases percentage of ripened grains and yield.

These results are nearly in agreement with the report by Osada et al.[3], who stated that abundant sunshine with low temperature during the ripening period of dry season rice gave rise to maximum yield, while high temperature during the ripening period adversely effects yield increase in Thailand. These findings are also in agreement with the observation of Murata[2], who reported that in Japan abundant sunshine promoted yield increase, while air temperature higher than 21.5°C exerted a negative influence on yield.

According to the analysis of partial correlations (yield versus sunshine duration versus air temperature, and percentage of ripened grains versus sunshine duration versus air temperature), the air temperature during the period of 30 days around heading stage was not significantly correlated with yield and the percentage of ripened grains. Therefore, the higher yields obtained in the main season than in the off season could be ascribed to the increase of ripened grains contributed by the abundant sunshine before and after heading.

It can thus be concluded that the increased number of spikelets/m^2 caused by the increased number of panicles/m^2 was essential to increase paddy yield. In addition, low air temperature during the tillering stage and abundant sunshine during a period around heading were also effective in increasing yield.

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