A NEW DOUBLE CROPPING SYSTEM TO OVERCOME THE INSTABILITY OF RICE PRODUCTION IN THE MUDA IRRIGATION AREA, MALAYSIA

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ABSTRACT

In the Muda irrigation area, about 24% of yield increase per unit area was attained during the 14 years since the beginning of the double cropping practice through the introduction of higher-yielding varieties and the application of a large amount of fertilizer. However, after double cropping spread to the whole area, the yield became extremely unstable mainly due to the insufficient supply of irrigation water and severe occurrence of rice tungro disease. Consequently the yields in 1982 decreased to the levels recorded in the initial year of double cropping.

It was considered that the severe occurrence of rice tungro disease was caused by year-round cultivation mainly resulting from the insufficient supply of irrigation water. To overcome the yield instability a new double cropping system incorporating a complete fallow period to be implemented over the whole Muda area during the dry season was proposed.

Introduction

In recent years, rice double cropping culture has been rapidly spreading in the tropical countries of Southeast Asia with the development of water resources and improvement of irrigation facilities. However, yields of rice in double cropping culture are extremely unstable and stagnant mainly due to serious damage caused by rice tungro disease and brown planthopper (BPH), *Nilaparvata lugens* (Stal) attacks. This problem is likely to jeopardize rice double cropping in the areas. Under such conditions, since 1978, the Tropical Agriculture Research Center has been carrying out a cooperative research project with the Muda Agricultural Development Authority (MADA) to establish an advanced rice double cropping system to achieve consistently high yields in the Muda area.

In this report, a new rice double cropping system for stable production of high yields of rice is presented. The principle of this system may be useful for the application of the rice double cropping culture in the tropical monsoon areas.

1 Unstable yields and causes

Rice yields in the Muda double cropping area were technically analyzed on the basis of the data from crop cutting surveys conducted by MADA. Total rice production obtained by double cropping in the Muda area increased to 2.35 times of that by single cropping on the average. However the yield was extremely unstable depending on the years, that is, the coefficient of variance of the total rice production was 20.2% for double cropping as compared with 1.7% for single cropping (Fig. 1).

The fluctuations in the total production included both the fluctuations in yield per unit area (coefficient of variance: 8.7%) and cropping area (18.1%) (Fig. 2). The former fluctuation

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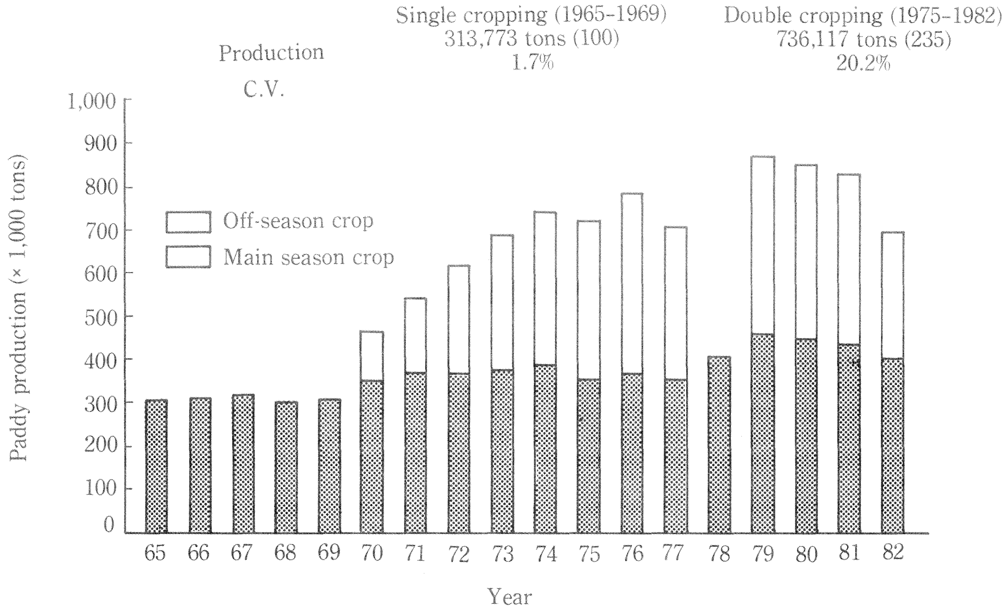


Fig. 1 Record of paddy production in the Muda area.

was caused by the insufficient quantity of irrigation water (main season crop in 1975 to 1978), the increased amounts of application of fertilizer (1979, 1980 and 1981), which has been supplied free by the government since 1979, and the severe occurrence of rice tungro disease (1982 and 1983). The latter was brought about by the shortage of irrigation water (off-season crop in 1979, main season crop in 1981).

The damage due to rice tungro disease in 1982 was reflected in the 29.5% decrease in yield per unit area for the off-season crop and 10.2% for the main season crop, which offset the yield increase associated with the new technology introduced from the onset of double cropping (Fig. 2).

2 Mechanism of occurrence of unstable yields

Yield instability in the Muda area can be ascribed to two main factors (Fig. 3). The first one is the insufficient amount of irrigation water which is due to the instability in the source of irrigation water as 44% of the irrigation requirement depends on rainfall (YASHIMA, 1986) and to the insufficient use of irrigation water resulting from year-round cultivation with erratic schedules which are caused by the low canal density, the labor shortage and the farmers' attitude to scheduled cropping (Fig. 2). The second factor, the severe occurrence of rice tungro disease, appears to be closely related to year-round cultivation and heavy application of fertilizer (Fig. 3), based on the data recorded in the Muda area and in advanced rice double cropping areas in Southeast Asia.

3 A new rice double cropping system to achieve stable and high yields

To overcome the instability of yields of rice double cropping culture in the Muda area, the authors proposed a new rice double cropping system in which a complete fallow period of one month implemented simultaneously over the whole Muda area in the dry season is incorporated into a systematic staggered cropping method with the introduction of a terminal irrigation unit (Fig. 4, Fig. 5).

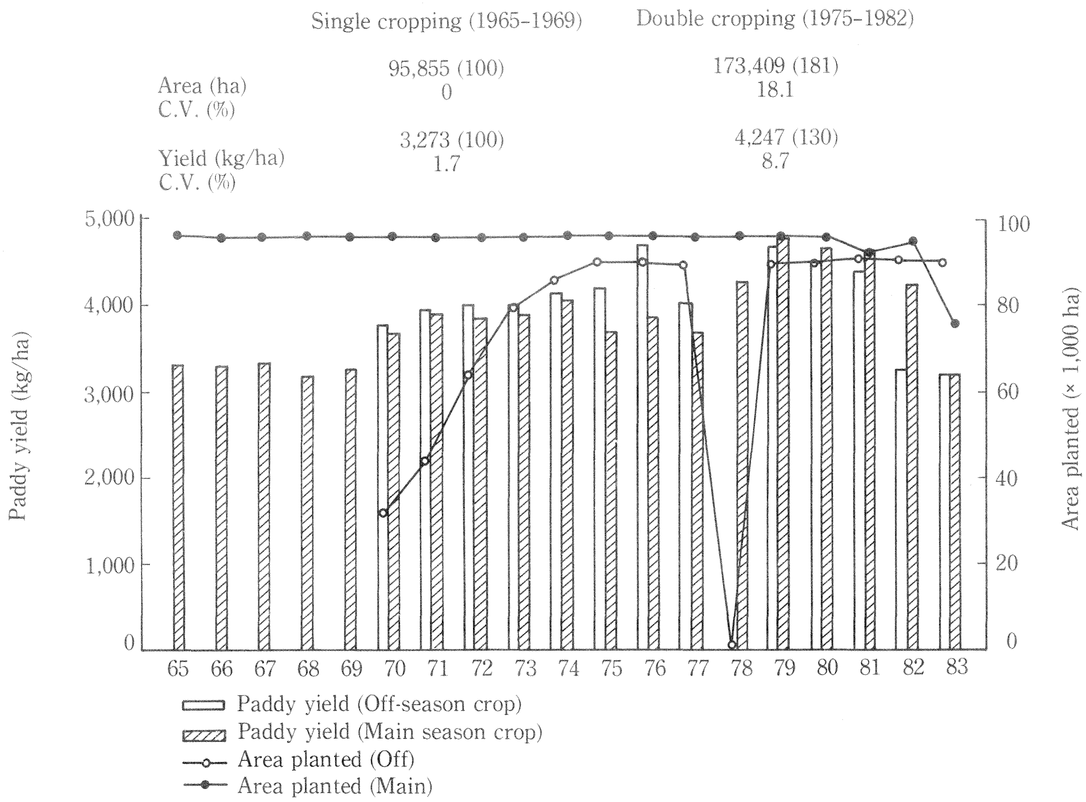


Fig. 2 Record of paddy yield and area planted in the Muda area.

1) Necessity of adopting one month fallow period

Rice tungro disease is a virus disease mainly transmitted by the green leafhopper *Nephotettix virescens* Distant. At present, the use of resistant varieties and pesticides has been adopted for the control. However, there is a risk of possible development of new biotypes, resistance to insecticides, resurgence of insects in an area subjected to chemical control and chemical pollution due to extensive, simultaneous use of chemicals with a high residual activity. Rice tungro disease could be controlled by the removal of *Oryza sativa* and other *Oryza* species serving as host plants or potential host plants for the green leafhopper, including plants infected with rice tungro disease in the area.

The selection of a one month simultaneous fallow period is based on the ecological characteristics of the green leafhopper, which may be controlled by about 10 days of complete fallow period in the absence of any host plants including potential host plants. However, to kill all the host plants, including rice stubbles, ratoons, volunteer rice plants, and weeds belonging to other *Oryza* species in the area, a period of one month of simultaneous fallow is required.

2) Systematic staggered cropping method

In the systematic staggered cropping method, the current irrigation block is divided into 3 to 4 systematic staggered cropping units including 5 terminal irrigation units (A to E) in each cropping unit. In the terminal irrigation units in which water can be supplied within a week, irrigation is staggered for a week each in the order of A to E with the completion of irrigation of each cropping unit within 5 weeks. The cropping schedule in the systematic staggered cropping

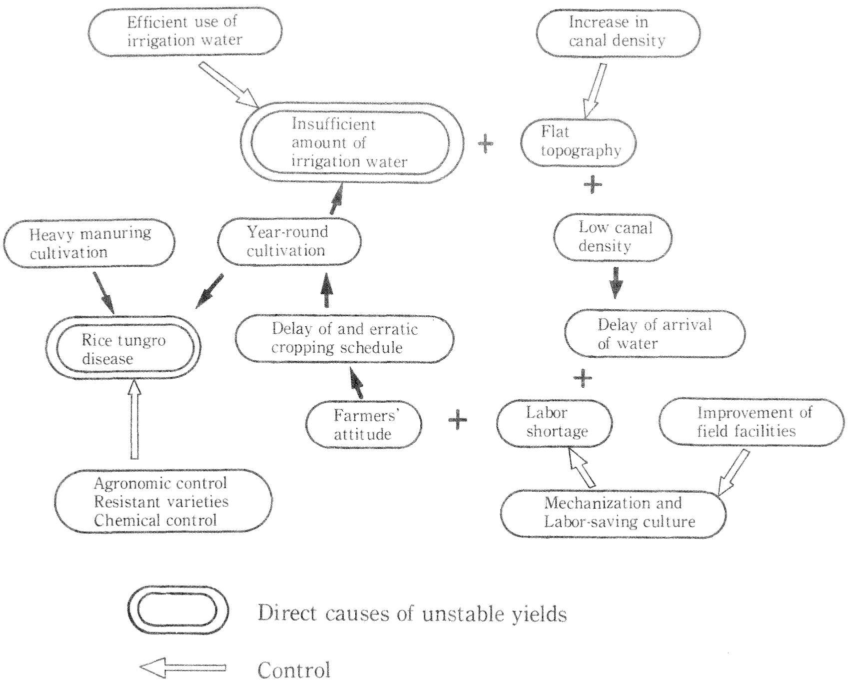


Fig. 3 Mechanism of occurrence of unstable yields and measures of control.

units follows the irrigation supply. The introduction of this method requires the increase in the density of irrigation canals and farm roads (Fig. 5).

3) Time lag of staggered cropping in the Muda area

The time lag of staggered cropping in the Muda area for the new rice double cropping system is at least 75 days to enable the irrigation water to be distributed over the whole Muda area under the current irrigation capacity of the area. Consequently the double cropping period for each plot will cover 275 days (365-15-75 days, Fig. 4).

4) Varieties suitable for the new rice double cropping system

Generally the varieties with a longer growing period produce higher yields (Fig. 6). However they are not suitable due to the limited cropping period in the Muda area associated with double cropping (Fig. 4). Also the double cropping period in a plot varies with the cultural systems, as shown in Fig. 7. Therefore the most suitable growing period for the varieties for the new rice double cropping system was estimated at 125 days to obtain maximum total production in the area under the present systems of cultivation (Table 1).

5) Cultural practices for the new rice double cropping system

The effective use of irrigation water is the most important factor for the new double cropping system to be successful. For this purpose, the following cultural practices are recommended.

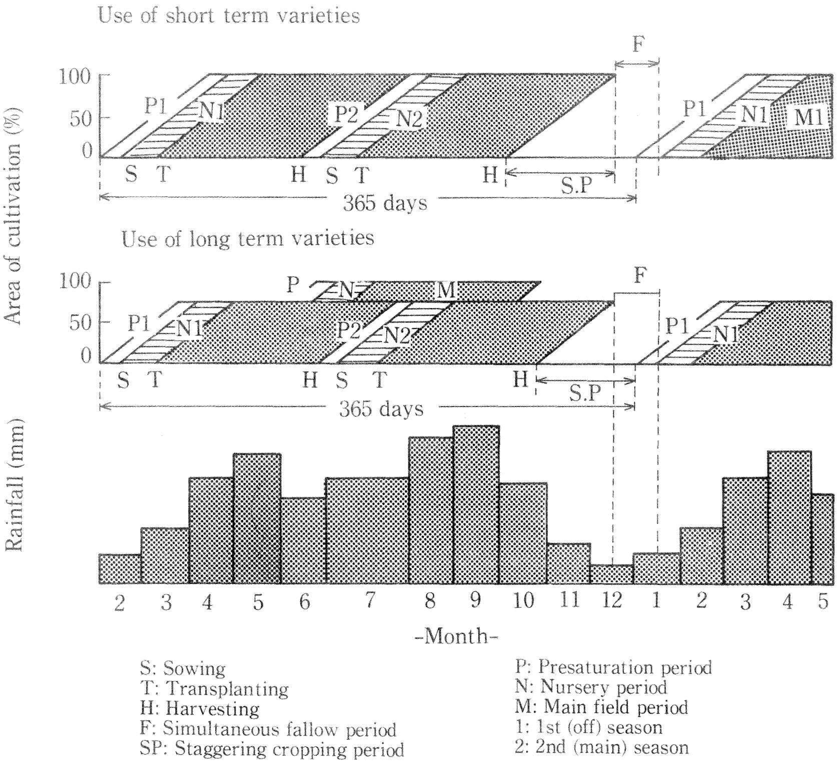


Fig. 4 Outline of new rice double cropping system in the Muda area.

(1) Shortening of the presaturation period for the off-season crop and fallow period betwen the off- and main croppings.

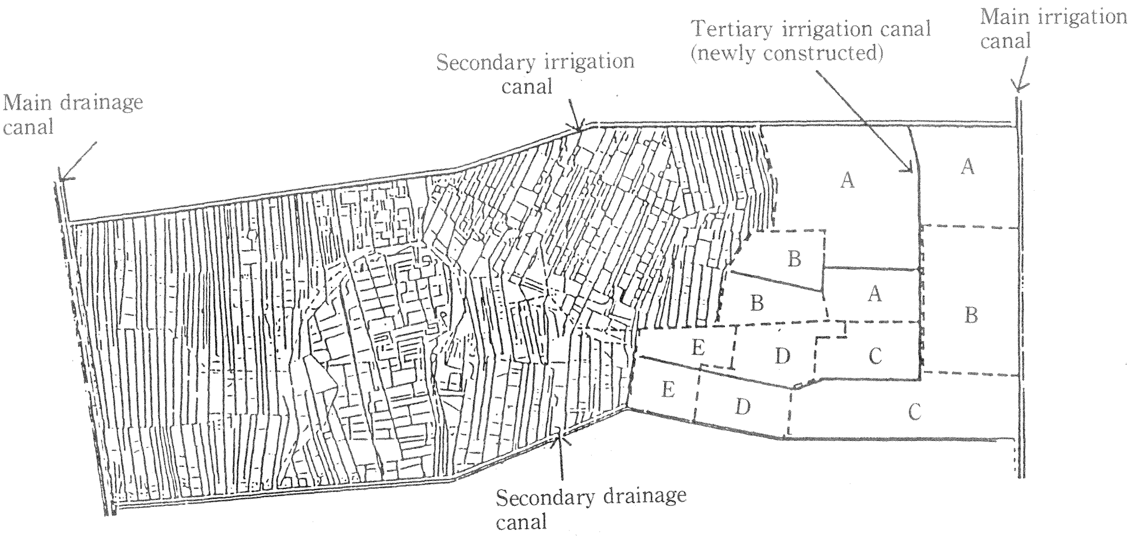
According to the data collected in the ACRBD-4 irrigation block, the presaturation period in a plot before the transplanting of the off-season crop lasted 57 days on the average. This period could be shortened to 40 days, i.e. 15 days for the irrigation of the nursery plots prior to sowing and 25 days for the irrigation of the seedlings in the plots. Presaturation for the main fields is included in the above presaturation period as irrigation to the nursery plots and the main fields is no separated.

The fallow period betwen the off-season and main season crops lasted 66 days on the average in the ACRBD-4 irrigation block. This period could also be shortened to 30 to 40 days (burning of straws of previous crops at approximately 10 days after harvesting, 1st plowing at approximately 15 dah*, 1nd plowing at approximately 25 days dah, sowing at approximately 30 dah). The shortening of this period would result in the reduction of the irrigation requirement not only in the fallow period but also in the 2nd cropping period by avoiding the dry season in starting the 2nd cropping at an earlier date.

(2) Separated irrigation to nursery plots and main fields.

This practice which may lead to a saving of the presaturation water of about 58% compared with the present practice, could be implemented under the current conditions of the irrigation

* dah : days after harvest



A, B ..... E : Terminal irrigation unit
Total area from A to E : Systematic staggered cropping unit
Farm roads are established along every irrigation canal and drainage canal

Fig. 5 Systematic staggered cropping method introduced to ACRBD-4 Irrigation Block.

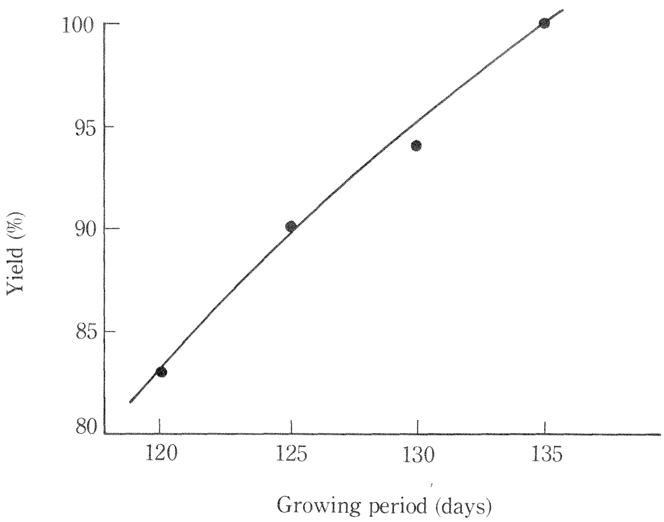


Fig. 6 Relationship between the growing period of varieties and the yields.

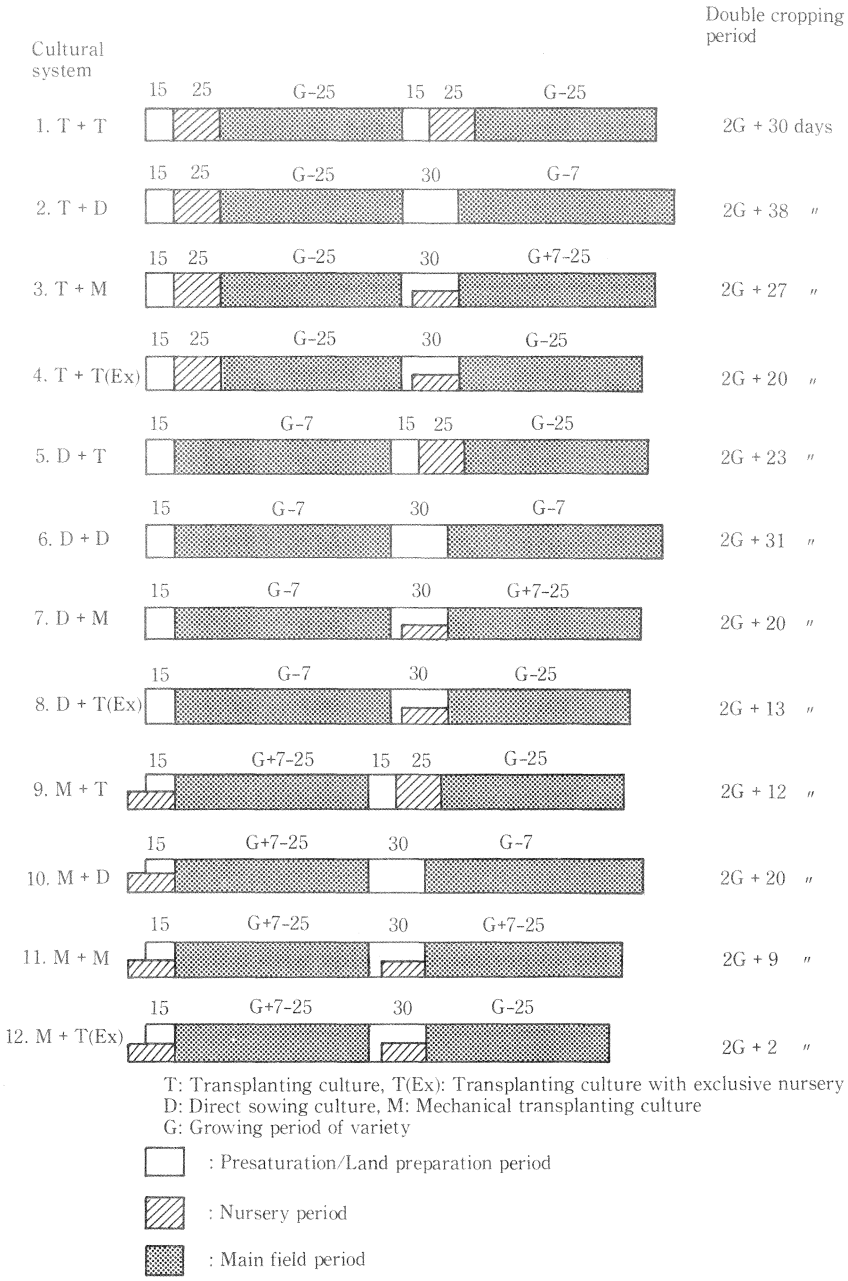


Fig. 7 Double cropping period in a plot with various cultural systems.

facilities with the introduction of a community nursery or commercial nursery which could be located in the fields along the existing irrigation canals.

(3) In-field water management.

In-field water management in the Muda area should be centered on the promotion of the effective use of irrigation water. Generally the yield decrease caused by deep water is approximately 10% in the fields with a water depth of 12.5 to 15.0 cm as compared with those where the water depth is shallow, i.e. 2.5 to 5.0 cm although the extent of the decrease depends

Table 1 Relationship between the varieties used and the total production in the Muda area by the adoption of the new rice double cropping system

Variety	120 days		125 days		130 days		135 days	
Cultural system	% of double cropping	Total production	% of double cropping	Total production	% of double cropping	Total production	% of double cropping	Total production
T + T	98.5%	165.0	86.4%	169.1*	74.2%	165.3	62.0*	162.0
T + D	88.8	158.6	76.6	161.3*	64.5	156.8	52.3	152.3
T + M	100.0	166.0	90.0	172.0*	77.8	168.5	65.7	165.7
T + T(E)	100.0	166.0	98.5	178.8*	84.6	176.0	74.2	174.2
D + T	100.0	166.0	94.9	175.9*	82.7	172.8	70.5	170.5
D + D	97.3	164.2	95.1	176.1*	73.0	164.2	60.8	160.8
D + M	100.0	166.0	98.5	178.8*	84.6	176.0	74.2	174.2
D + T(E)	100.0	166.0	100.0	180.0	94.9	183.5*	82.7	182.7
M + T	100.0	166.0	100.0	180.0	96.1	184.6*	83.9	183.9
M + D	100.0	166.0	98.5	178.8*	86.4	176.0	74.2	174.2
M + M	100.0	166.0	100.0	180.0	99.7	187.7	87.6	187.6
M + T(E)	100.0	166.0	100.0	180.0	100.0	188.0	96.1	196.1*

Note: 1) Total production is expressed by index.
2) Yields of 120 day, 125 day, 130 day varieties were calculated as being 83%, 90% and 94% of the yield of a 135 day variety, respectively.
3) Yield of single cropping area was calculated on the basis of the yield achieved with a 135 day variety.
4) * : Maximum total production.

Table 2 Yields obtained in the experimental fields with a depth of water of 15 cm

(Variety: MR 1)

Cropping season	Plot No.	Seedlings used	Planting density	Missing hills	Lodging	Paddy yield
		days old	hills/m^2	%	%	kg/ha
Main season (1981)	1	23	16	14.9	0	5,983
	2	23	16	8.9	0	6.257
	3	43	16	0.4	0	6,220
	4	43	16	1.0	0	5,855
Off-season (1982)	1	23	10	0.9	0	5,540
	2	33	10	0.2	0	5,521
	3	43	10	0	0	5,336
	4	43	20	0	100	4,791

on the varieties used (MATSUSHIMA, 1968; NOZAKI and WONG, 1978; SUGIMOTO, 1971; YAMADA, 1978). However it is possible to achieve yields of more than 5 tons per ha even in fields with a water depth of 15 cm (Table 2). Moreover deep water fields prevent the growth of weeds and play a buffer role in alleviating the effects of the unstable supply of irrigation water. For the in-field water management in the Muda area, it is therefore recommended that the depth of water in the fields should be kept constantly at 5 to 10 cm throughout the growing period of rice and that drainage should not be practiced before the depth of water in the field reaches 15 cm.

The advantages of the new rice double cropping system may be as follows:

(1) Ecological control of rice tungro disease by implementation of a complete fallow period lasting one month in the dry season.

(2) Saving of irrigation water with the introduction of the systematic staggered cropping method and with the fallow period set in the dry season.

(3) Increase in the soil bearing capacity of the paddy fields by the simultaneous fallow of one month in the dry season (ANYOJI, 1978), and promotion of mechanization associated with the increased soil bearing capacity.

(4) Yield increase due to soil-drying brought about by the fallow in the dry season (NOZAKI, 1983).

4 Conclusion

Based on the results of this study, it was demonstrated that the instability of rice yield in the Muda double cropping area is due to the insufficient supply of irrigation water and the severe occurrence of rice tungro disease.

It was considered that the severe occurrence of rice tungro disease was caused by year-round cultivation mainly resulting from the insufficient supply of irrigation water. Outbreaks of rice tungro disease associated with rice double cropping under year-round cultivation are commonly observed in the advanced rice double cropping area of Southeast Asia. It is therefore suggested that the incorporation to the double cropping system of a simultaneous fallow period, aimed at eradicating from the area the host plants and the potential host plants harboring rice pests and vectors of diseases during the dry season is essential to achieve stable and high yields of rice in the double cropping fields of the tropical monsoon areas. In the development of the infrastructure for rice double cropping provision should be made for the establishment of the facilities required for the implementation of the new double cropping system.

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Discussion

Soetjipto Partohardjono (Indonesia): In your recommended practice to control tungro disease by systematic staggered planting (cropping) in the Muda area, how large is the cropping unit and what is the size of each block (A-E)?

Answer: The area of a systematic staggered cropping unit is approximately 150 ha and the size of the irrigation block is approximately 30 ha each. However to be effective the control of tungro through the complete one month fallow period should involve the whole Muda area, namely 100,000 hectares.

Matsushima, S. (Japan): Why is there a shortage in irrigation water in the Muda area? Is it due to a fundamental defect in planning at the beginning? I agree with you that for controlling tungro disease one month complete fallow period is necessary. Also a period of one month is required for drying the soil to promote nitrogen mineralization in soil.

Answer: With regard to the reasons for the shortage in irrigation water in the Muda area, this problem will be taken up by other speakers. I agree with you. The yield increase due to soil drying brought about by the fallow period in the dry season is one of the advantages of the new rice double cropping system.

Perez, A.T. (ADB): 1. To control tungro disease, would you recommend that several varieties resistant to tungro disease be planted? 2. Would you recommend that rice stubbles be burned to eliminate the source of virus inoculum in addition to the removal of wild rice and volunteer plants at the time of an epidemic?

Answer: 1. It is certainly a good practice. However the varieties should have the same growth duration. 2. Such a measure would not be as effective as the implementation of a complete simultaneous fallow period over the whole area in order to eradicate potential host plants.

Abu Baker Taib (Malaysia): With regard to the questions of Dr. Perez, I would like to add that many varieties are available, such as IR42 whose milling quality is not suitable for the farmers. Also the farmers are burning stubbles and straws after harvesting in January, February or March. They also perform dry plowing and apply weedicides on the ridges to eliminate any alternate hosts.