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Effects of plant spacing and seedling age on yield performance of short-maturation rice varieties

(Kesan jarak tanaman dan umur anak semaian terhadap prestasi hasil varieti padi jangka pendek)

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Key words: plant spacing, seedling age, yield, short-maturation, rice, varieties

Abstrak

Data merangkumi hasil dan empat komponen hasil bagi tiga varieti padi selama empat musim menanam telah dianalisiskan. Hasil tiga varieti jangka pendek (< 124 hari), Y 790, Y 821 dan Sekencang, dipengaruhi secara ketara oleh jarak tanaman dan musim. Pada amnya, perbezaan hasil disebabkan oleh umur anak semaian tidak ketara. Jarak tanaman yang lebih rapat iaitu 15 cm x 15 cm telah meningkatkan hasil sebanyak 26% berbanding dengan jarak tanaman yang biasa iaitu 25 cm x 25 cm. Peningkatan hasil yang diperoleh daripada jarak tanaman yang rapat adalah disebabkan oleh lebih banyak bilangan tangkai dan bilangan biji seunit keluasan ekoran daripada peningkatan populasi tanaman. Terdapat juga perbezaan yang ketara dari segi hasil dan sebilangan komponen hasil antara varieti.

Abstract

The data on yield and yield components for three rice varieties over four cropping seasons were analysed. Yield of the three short-maturation varieties (< 124 days), Y 790, Y 821 and Sekencang, was found to be significantly affected by plant spacing and season. The overall yield difference due to seedling age was not significant. The closer plant spacing of 15 cm x 15 cm significantly increased the yield by 26% as compared with the conventional spacing of 25 cm x 25 cm. The increase in yield obtained at the closer spacing was mainly due to the larger number of panicles and spikelets produced per unit area as a result of higher population density. Significant differences among the varieties in terms of yield and some yield components were also observed.

Introduction

A new double cropping system with a 1-month complete fallow period in the dry season was introduced in the Muda granary area to ensure production of stable high yields of rice (Nozaki et al. 1987). The introduction of short-maturation varieties is necessary to ensure the success of this system and to ease staggering of planting, and short maturation should be among the criteria for future selection of varieties (Nozaki 1984).

However, short-maturation varieties tend to be associated with low yield,

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attributed to insufficient vegetative growth (Tanaka and Vergara 1967; Yoshida 1977 and 1978). Experiments in IRRI also indicated that by using very young seedlings and close spacing a yield of 6 t/ha could be obtained from short-maturation varieties (Tanaka and Vergara 1967).

In view of this, an experiment was initiated to study the effects of plant spacing and seedling age on the yield performance of three short-maturation varieties in the Muda area.

Materials and methods

Field experiments were carried out in farmers' fields in Tambak Bunga, Muda during the main seasons of 1985, 1986 and 1987 and off-season 1986. The soil in this area belongs to the Chengai series and is classified under Class II soil.

Sowing of seed was staggered to allow simultaneous transplanting of 15 and 25-day-old seedlings in 5 m x 5 m treatment plots. Transplanting was done manually using 2 seedlings per hill, at an average depth of 5 cm.

Two plant spacings, 15 cm x 15 cm and the conventional 25 cm x 25 cm, were compared using three short-maturation varieties (< 124 days), Y 790, Y 821 and Sekencang.

The 12 treatments were arranged in factorial combinations of 2 seedling ages x 2 spacings x 3 varieties and replicated three times in randomised complete block design.

Fertilizers were applied at the rate of 80:30:20 ($N:P_2O_5:K_2O$) kg/ha with half of the N (urea) and all the P_2O_5 (triple superphosphate) and K_2O (muriate of potash) as basal at 15 days after transplanting (DAT) and the remaining N at panicle initiation stage. Crop protection measures were carried out when necessary.

Grain yield per plot, exclusive of two guard rows for the 25 cm x 25 cm spacing and four guard rows for the 15 cm x 15 cm spacing, was harvested manually and adjusted to 14% moisture content. Yield components from four random sample hills per plot were also recorded.

Results and discussion

In the combined analysis of variance over four seasons, all the factor effects including seasons are considered to have fixed effects. In some annual crops such as maize or groundnut where their cultivations are often rotated throughout the years, the seasonal effects are evaluated as random effects. However in rice, very clear-cut effects attributable to two seasons, main and off have been observed.

In the tests of significance *(Table 1)*, each of the components of variance was tested against the error mean square of that variable.

Yield

The yield of short-maturation varieties was very significantly affected by plant spacing, variety and season, but the overall mean difference for the two seedling ages studied was not significant *(Table 1)*.

The closer plant spacing i.e. 15 cm x 15 cm always resulted in higher yield compared with conventional spacing of 25 cm x 25 cm among all the varieties in all the four seasons *(Figure 1)*. The overall effect of season on the performance of short-maturation varieties was also very obvious. This is revealed by the significantly lower mean yield in the off-season (OS) 1986 compared with that of the other three main seasons (MS). Low yield trend in the off seasons has been observed in Muda since 1979 both in farmers' fields *(Figure 2)* and in experimental plots (A'aini, A.R., MARDI Alor Setar, pers. comm. 1990). In the off seasons, the sunshine hours were relatively long during the early growth stages of the rice crop but gradually declined as the crop matured *(Figure 3)*. The reverse occurred in the main season resulting in relatively longer sunshine hours during the reproductive and ripening stages. Studies had shown that high solar radiation at reproductive and ripening stages were necessary for high yield (Tanaka

Table 1. Analysis of variance

Source of variation	df	Yield	Panicle/ hill	Spikelet/ panicle	% unfilled grain #	1 000 grain wt.##
		F ratio				
Block	8	3.65**	2.81*	1.09ns	1.67ns (1.91 ns)	1.06ns (1.07 ns)
Variety (V)	2	22.77**	1.49ns	13.89**	39.72** (45.69 **)	129.54** (133.68 **)
Plant spacing (P)	1	187.45**	639.85**	16.94**	2.08ns (2.36 ns)	1.15ns (1.16 ns)
Seedling age (SA)	1	2.50ns	0.16ns	1.51ns	0.00ns (0.00 ns)	0.00ns (0.01 ns)
V x P	2	2.44ns	3.89*	0.98ns	2.52ns (3.54 *)	3.40* (3.19 *)
V x SA	2	2.51ns	2.89ns	0.18ns	0.26ns (0.15 ns)	2.36ns (2.50 ns)
P x SA	1	0.11ns	3.71ns	0.42ns	0.01ns (0.07 ns)	0.20ns (0.24 ns)
V x P x SA	2	1.01ns	1.18ns	0.15ns	0.77ns (0.29 ns)	0.58ns (0.51 ns)
Season	3	131.32**	3.63*	3.99*	154.73** (157.43 **)	20.76** (21.59 **)
Season x V	6	4.93*	0.67ns	1.34ns	7.49** (10.54 **)	2.16ns (2.14 ns)
Season x P	3	0.88ns	2.92*	0.77ns	1.12ns (1.76 ns)	0.55ns (0.50 ns)
Season x SA	3	4.08**	1.40ns	0.83ns	2.68ns (3.19 *)	0.31ns (0.33 ns)
Season x V x P	6	2.48*	1.06ns	0.91ns	0.32ns (0.31 ns)	1.34ns (1.42 ns)
Season x V X SA	6	8.73**	0.75ns	0.24ns	0.51ns (0.38 ns)	0.58ns (1.44 ns)
Season x P x SA	3	0.43ns	2.53ns	0.52ns	2.90* (4.03 *)	1.33ns (0.56 ns)
Season x V x P x SA	6	2.63*	0.58ns	0.16ns	5.38** (4.69 **)	1.42ns (1.76 ns)
C.V. (%)		10.08	16.39	17.44	13.04 (23.65)	1.93 (3.79)

*$p < 0.05$
**$p < 0.01$
ns not significant at $p = 0.05$
#after arcsine transformation
##after square root transformation
( ) actual value

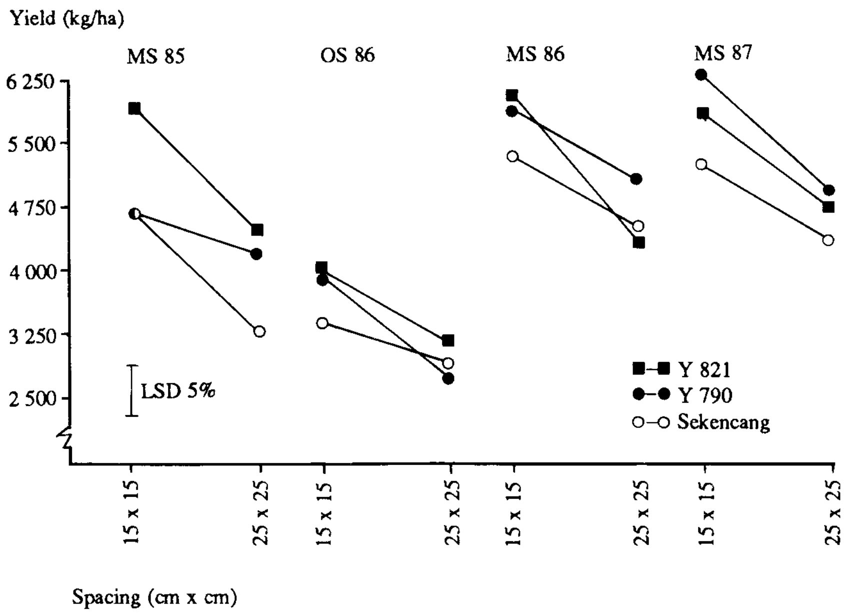


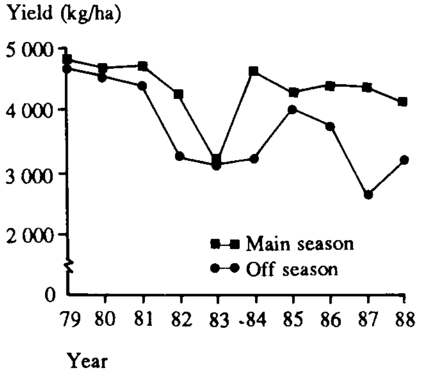
Figure 1. Interaction effects of spacing, variety and season on yield

and Vergara 1967; Yoshida 1978; Suhaimi et al. 1987).

There was no significant interaction between plant spacings and seasons on yield. However, significant interactions between varieties and seasons were indicated by yield performance of the varieties. Among the varieties tested, either Y 790 or Y 821 or both had significantly outyielded Sekencang in all the four seasons.

The occurrence of significant three-factor interactions, involving seedling age, variety and season, would suggest the effect of seedling age under specific conditions. However, a closer examination of the results, represented graphically in *Figure 4*, indicated that the effect of seedling age was inconsistent. For example in variety Y 790, older seedlings yielded significantly higher than younger seedlings only in the first two seasons of 1985 and 1986, while the results for these two seasons seemed to favour younger seedlings of varieties Sekencang and Y 821. Whereas for most of the other occasions, the results in *Figure 4* showed no significant yield advantage in the use of younger seedlings.

It is important to point out that, sometimes, experimental results can be affected by external causes which are beyond control. For example in the MS 1986, the water level in the field during transplanting was quite high and younger seedlings were submerged due to their shorter height. Studies have shown that seedling height is important in overcoming the effect of submergence (Anon. 1977 and 1978; Sariam and Zainal Abidin 1987).



Source: MADA, Alor Setar, Kedah

Figure 2. Mean yield in MUDA (1979–1988)

Table 2. Effect of plant spacing and variety on panicle number per hill and 1 000 grain weight*

Variety	No. pan./ hill	1 000-grain wt.
15 cm x 15 cm		
Y 790	7.3	4.76(22.68)
Y 821	7.3	4.66(21.69)
Sekencang	7.7	4.93(24.34)
25 cm x 25 cm		
Y 790	15.8	4.79(22.79)
Y 821	15.7	4.59(21.08)
Sekencang	14.3	4.92(24.20)
LSD (5%)	1.1	0.052

*after square root transformation
( ) actual 1 000-grain wt.

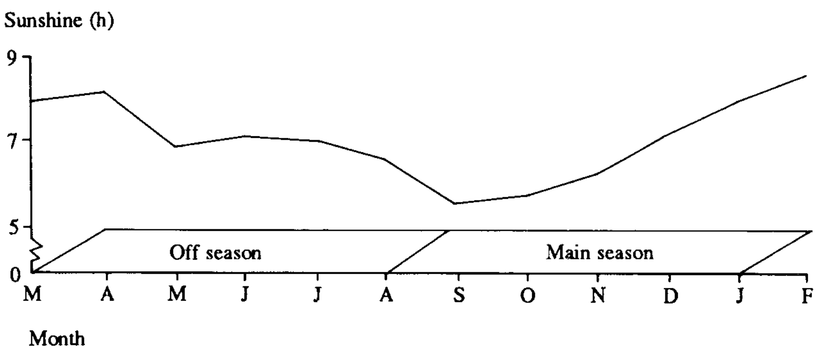


Figure 3. Mean sunshine hours in MUDA (1984–1989)

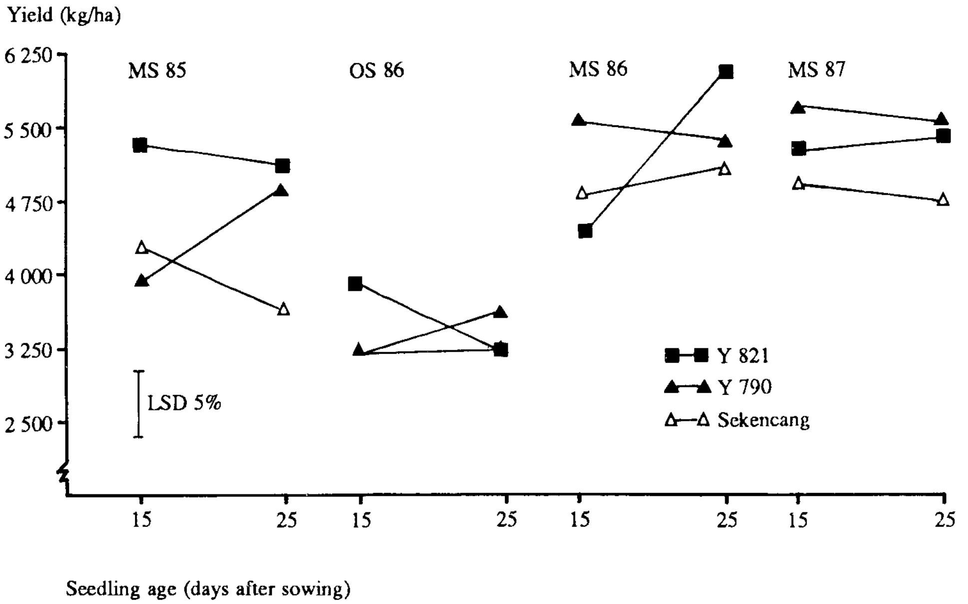


Figure 4. Interaction effects of seedling age, variety and season on yield

Yield components

Panicle number per hill

The number of panicles obtained per hill was significantly affected by plant spacing but there was neither significant varietal difference nor seedling age effect. Results in *Table 2* showed that the panicle number per hill was significantly reduced by closer planting. However, a higher yield was obtained because of higher plant density resulting in a larger number of panicles per unit area *(Figure 5)*.

The significant interactions between variety and plant spacing can be attributed to the smaller effect of closer spacing had on the panicle number per hill of variety Sekencang; though overall, the mean varietal differences in panicle number per hill were small *(Table 2)*.

The mean number of panicles per hill did not vary significantly between seasons except for the MS 1987 which was found to be significantly smaller than the other seasons. No unusual occurrences which might have an effect on the results were

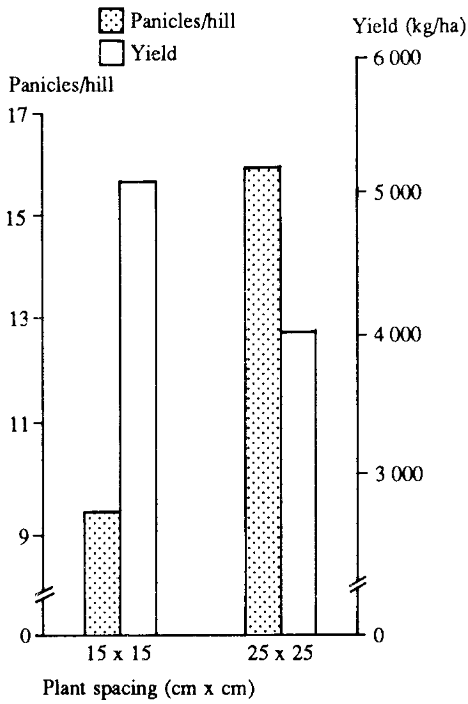


Figure 5. Effect of plant spacing on number of panicles per hill and yield

Table 3. Effect of season on four yield components

Season	No. panicle/ hill	Spikelet/ panicle	Unfilled grain (%)	1 000- grain wt.	Yield (kg/ha)
			*	**	
MS 1985	11.1	110.0	20.6 (12.7)	4.77 (22.75)	4571
OS 1986	11.8	124.8	33.6 (31.0)	4.71 (22.20)	3389
MS 1986	11.8	119.8	26.9 (20.8)	4.75 (22.57)	5254
MS 1987	10.7	124.8	18.6 (10.5)	4.87 (23.77)	5289
Mean	11.4	119.9	24.9 (18.7)	4.77 (22.82)	
C.V.(%)	16.4	17.4	13.0 (23.7)	1.93 (3.8)	
LSD 5% between seasons	0.86	9.65	1.50	0.043	214.9

*sin-1 sq root proportion of unfilled grain
**sq root 1 000-grain wt.
( ) actual values

Table 4. Effect of variety and season on unfilled grain*

Variety	Unfilled grain (%) MS 1985	OS 1986	MS 1986	MS 1987	Mean
Y 790	19.5	30.8	22.9	16.9	22.5
	(11.6)	(26.4)	(15.2)	(8.7)	(15.5)
Y 821	20.6	39.9	31.5	20.9	28.2
	(12.7)	(41.3)	(27.6)	(13.0)	(23.6)
Sekencang	21.8	30.0	26.2	18.1	24.0
	(13.8)	(25.2)	(19.6)	(9.8)	(17.2)

LSD 5% = 2.6
within seasons or between seasons within variety

*after arcsine transformation
( ) actual value

reported in the MS 1987. However, the significantly smaller panicle number per hill in the MS 1987, compared with the other seasons, did not seem to have any adverse effect on yield *(Table 3)*. This could be attributed to the significantly smaller percentage of unfilled grain, higher 1 000 grain weight and perhaps larger spikelet number per panicle in the MS 1987 compared with those in the other seasons *(Table 3)* which compensated for the lesser panicle per hill.

Spikelet number per panicle

The number of spikelets per panicle varied significantly according to varieties, plant spacing and season but seedling age again had no significant effect. At closer spacing, the mean spikelet number per panicle produced was 113 which was significantly less than 127 obtained from wider spacing (LSD 5% = 6.83).

Among the varieties, Y 821 produced a mean of 133 spikelets per panicle as compared with 114 for Y 790 and 112 for Sekencang and this was significant at 5% level (LSD = 8.36).

In the MS 1985, the number of spikelets per panicle produced was significantly smaller than those in the other three seasons *(Table 3)*. This could probably explain why among the three main seasons, MS 1985 also had significantly lower yield.

Unfilled grain

For the combined analysis for percentage of unfilled grain, the arcsine transformed values were used.

Generally, plant spacing and seedling age did not affect the percentage of unfilled grain in this study. However, there were significant differences due to variety and season.

The varietal differences were also affected by seasons *(Table 4)*. For example in the MS 1985, the differences among the varieties were not significant but in the subsequent seasons, significant varietal differences appeared. The high percentage of unfilled grain observed in the OS 1986 is a common occurrence in the off seasons in the Muda region and may be related to the lower level of solar radiation available at the reproductive and ripening stages. This finding is in agreement with those reported by Anon. (1976) and Yoshida (1978).

1 000-grain weight

Square root transformation of the 1 000-grain weight data was applied to stabilize the residual variances before the analysis.

Again, significant varietal and seasonal differences dominated but there were also different plant spacing effects on varieties (*Table 2* and *Table 3*). Wider spacing of 25 cm x 25 cm significantly decreased the 1 000-grain weight in variety Y 821 but had little effect on Y 790 and Sekencang. According to Anon. (1976), 1 000-grain weight was largely a varietal characteristic. However, the interaction effect of plant spacing with variety was small compared with the main effects of variety and season. Among the seasons, significantly higher mean 1 000-grain weight was recorded in the MS 1987 than in the other seasons *(Table 3)*.

Conclusion

Analysis of the yield and yield components showed that very significant yield increases, consistently over four cropping seasons, were achieved by adopting a closer plant spacing of 15 cm x 15 cm, instead of the conventional 25 cm x 25 cm plant spacing. With closer plant spacing, the yield obtained was 26% or 1 061 kg/ha more than the conventional plant spacing, averaged over the four seasons.

With mechanization of transplanting, the closer plant spacing would not impose an impractical demand on labour, though about 2.8 times more padi seedlings will be needed for the 15 cm x 15 cm plant spacing. Another alternative is direct seeding as higher population density would also be achieved with little labour or material inputs.

In terms of yield, varieties Y 790 and Y 821 generally performed significantly and consistently better than Sekencang. As only one off-season result was available, the evidence of significant seasonal yield depression associated with the off-season crop requires further investigation.

However, there is no significant yield improvement through the use of younger seedlings. Thus, for the short-maturation varieties tested, it implies that 15 to 25-day-old seedlings can be used. In rice growing areas with excess water (such as in the Krian region) since it will be a problem to transplant younger seedlings, older seedlings will be of advantage.

Analysis of the yield components shows that the significant yield increase produced by the closer plant spacing can be largely attributed to the increase in productive tillers or panicle number per unit area, though both the panicle number per hill and spikelet number per panicle in the closer plant spacing have been significantly reduced when compared with the wider plant spacing.

Generally, plant spacing does not seem to have any significant effect on the other two components of yield, percentage of unfilled grain and 1 000-grain weight. There are, however, significant differences in these two yield components due to the seasonal effect and varieties.

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References

Anon. (1976). *Ann. Rep.* p. 24. Los Banos, Philippines: IRRI

—— (1977). *Ann. Rep.* p. 345. Los Banos, Philippines: IRRI

—— (1978). *Ann. Rep.* p. 130. Los Banos, Philippines: IRRI

MADA. (1990). Cawangan perancang dan penilaian, MADA, Ampang Jajar, Alor Setar, Kedah

Nozaki, M. (1984). Interim report on the studies on rice double cropping in the Muda area. Improvement of cultural techniques. MADA-TARC cooperative study, 117 p. (mimeo.)

Nozaki, M., Ho, N. K. and Wong, H. S. (1987). A new double cropping system to overcome the instability of rice production in the Muda irrigation area, Malaysia. *Proc. int. symp. on technol. for double cropping of rice in the tropics* 30 Sept.– 3 Oct. 1986, Tsukuba, Japan, p. 89–97. Japan: TARC

Sariam, O. and Zainal Abidin, H. (1987). Penanaman padi dua kali ubah di Kerian. *Teknol. Padi, MARDI 3*:1–6

Suhaimi, O., Mohd. Aris, J. and Ismail, A. B. (1987). Agroclimatic environments and productivity of major rice growing areas in Peninsular Malaysia. *Proc. natl. rice conf.* 20–22 Jan. 1986 (Mohamad, O. and Hasim, H., ed.) p. 65–85. Serdang: MARDI

Tanaka, A. and Vergara, B. S. (1967). Growth habit and ripening of rice plants in relation to the environmental conditions in the Far East. *Rice Commn. Newsl. 6* (special issue)

Yoshida, S. (1977). Physiological consequences of altering plant type and maturity. *Int. Rice Commn. Newsl. 26:* 5–16

—— (1978). Tropical climate and its influence on rice. IRRI Res. Papers Ser. No. *20*

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