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Partial submergence and field capacity interactions in transplanted rice

(Kesan interaksi keadaan separa tenggelam dengan keupayaan sawah bagi penanaman padi secara mengubah)

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Key words: field capacity, 50% plant height submergence, preceeding treatment, succeeding treatment

Abstrak

Kajian ini menunjukkan bahawa dalam keadaan basah yang terhad kulma pokok padi menjadi rendah dengan pertambahan tangkai yang ringan dan mempunyai bilangan spikelet yang berkurangan. Sebaliknya keadaan separa tenggelam menyebabkan kulma menjadi tinggi dengan tangkai yang berat dan mempunyai bilangan spikelet yang banyak. Tahap kesan-kesan tersebut akan meningkat sekiranya tempoh masa keadaan persekitaran tersebut bertambah. Apabila persekitaran itu berlaku berturut-turut, kesan persekitaran awal tidak dapat diatasi oleh kesan persekitaran yang berikut. Interaksi antara varieti-varieti dan keadaan persekitaran yang berturutan adalah rumit. MR 43 ialah baka padi yang toleran terhadap persekitaran tersebut.

Abstract

The study showed that field capacity reduced culm height with concomittent increase in the number of lighter, fewer spikelet-bearing panicles in the hill. Partial submergence increased culm height with lesser number of heavier, more spikelet-bearing panicles. When the duration of occurrence of these environments increased, the magnitude of their effects on the rice crop also increased. However, when these environments occur in succession, the effects of the preceeding environment could not be negated by those of the succeeding environment. This was particularly distinct when the duration of the preceeding environment was longer than the succeeding environment. Varietal interactions with the sequence of environment occurrence were complex. MR 43 is a tolerant variety suitable for such environments.

Introduction

For successful establishment of a transplanted crop, it is essential that timely seeding at the nursery stage and subsequently at transplanting are expediated. In the lowland rainfed rice areas, flooding may occur followed later on in the season by drought. Should the farmer be late in transplanting, the crop may experience drought followed by flooding. It is difficult to predict the nature and order of the succession of events.

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Studies on the influences of submergence or drought on transplanted rice were often carried out in isolation of each other. This approach does not allow one to study the interactions between the two environments should they occur in succession.

In an attempt to simulate the possible succession of events and for different phases of the crop growth cycle, a pot experiment was conducted in the pond at MARDI Bumbong Lima during the main season 1981/82. The primary objectives were to study the interactions between partial submergence and field capacity when they occur in succession at different growth phases, and to determine which particular environment would be more important in determining the subsequent growth and performance of the crop.

Materials and methods

Thirty-three day old seedlings of Mat Candu, Sekembang and MR 43 were transplanted into pots, 26 cm lower diameter, 30 cm upper diameter and 29 cm height. For each variety, two hills spaced at approximately 12.5 cm apart were transplanted in each pot. Fertilizer applications were the equivalents of 80N : 30P : 20K kg/ha.

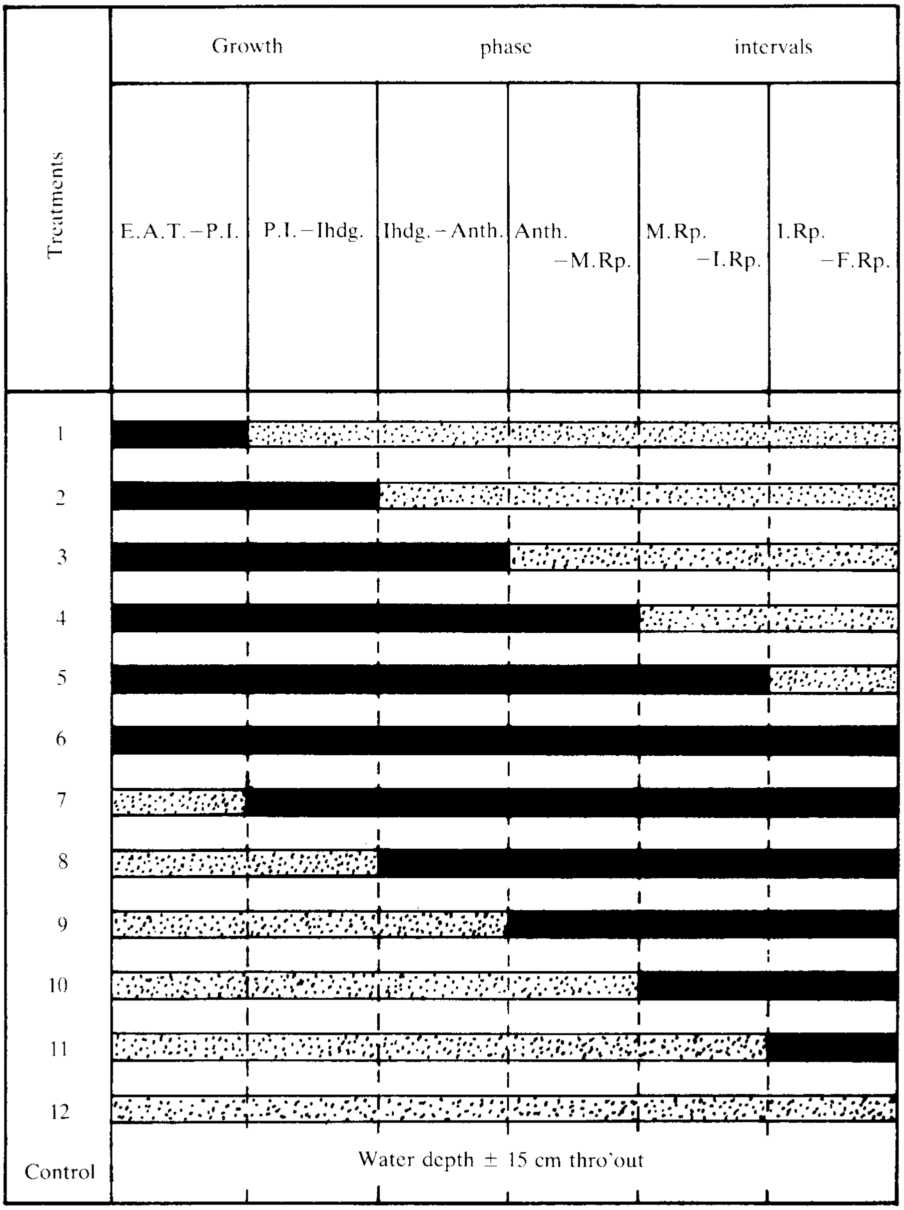
Basically the treatments involved three groups of pots: one group **(control)** was maintained at the shallow end of the pond. The water depth in these pots was maintained at 15 cm, as measured from the pot soil surface, throughout the growth season. The other two groups were similarly maintained over the deep end of the pond. At predetermined growth phases *(Figure 1)*, one of these groups of pots were submerged to a depth equivalent to 50% plant height at that instant and maintained at this level of submergence until the required time as predetermined. Then they were raised and supported by a platform above the pond water surface. The excess water in the pots were poured off. Daily watering of these pots was carried out only to achieve continuous wetness of the soil in the pots. Hereafter this treatment is referred to as **partial submergence treatment.**

The remaining group of pots were raised and supported on a platform above the water surface of the pond at this end. The standing water in these pots were poured off. Daily watering of these pots was carried out only to achieve continuous wetness of the soil in the pots. At predetermined times the pots were submerged to 50% of the plant height at that instant and maintained so for the required period. This treatment is referred to as **field capacity treatment.**

A completely randomised design layout was practised. At the predetermined times of treatment imposition, only pots with plants of uniform growth and at the required growth stage were selected for treatment. For each variety there were 13 treatments inclusive of control. For each treatment, six pots were used for observation and subsequent measurements and recordings. The total number of pots for each varietal group of treatments were 78. The grand total number of pots for the experiment was 234.

At harvest the following recordings were obtained: culm height, total panicle number per hill, panicle weight, panicle length, total spikelet number per panicle, total filled spikelets per panicle, and 1 000 grain weight. Culm height was the mean of six hills, one hill per pot being measured at harvest. For all the panicle parameters, both hills in the pot were used for the measurements. The average was used to represent the pot mean. In addition, pot yield (weight per panicle x panicle number per pot) was computed.

During storage prior to complete processing of the required data, a serious attack of *Sitophilus* occurred. Consequently, total filled spikelets and 1 000 grain weight were rejected for analysis.



Field capacity

50% Plant height submergence

E.A.T Early active tillering (26 D.A.T.)

P.I. Panicle initiation

Ihdg. Initial heading

Anth. Anthesis

M.Rp. Milk ripe

I.Rp. Initial ripening

F.Rp. Full ripe

Figure 1. Treatments imposed on Mat Candu, Sekembang and MR 43 in pond study (m/s 1981–82)

Table 1. Analysis of variance

Parameter	Source	df	MS	F-test
Culm height	Treatment	12	1 877.4598	22.7699**
	Variety	2	18 740.0500	227.2802**
	(Treatment x Var.)	24	245.1752	2.9735**
	Error	195	82.4535	
	Total	233		
Panicle number per hill	Treatment	12	191.7001	17.5762**
	Variety	2	30.1838	2.7674NS
	(Treatment x Var.)	24	53.0217	4.8613**
	Error	195	10.9068	
	Total	233		
Panicle length	Treatment	12	29.4740	28.3132**
	Variety	2	107.3077	103.0814**
	(Treatment x Var.)	24	2.8627	2.7500**
	Error	195	1.0410	
	Total	233		
Individual panicle weight	Treatment	12	4.5957	25.7174**
	Variety	2	4.9360	27.6217**
	(Treatment x Var.)	24	0.2995	1.6760*
	Error	195	0.1787	
	Total	233		
Total spikelet number per panicle	Treatment	12	24 292.4459	36.5844**
	Variety	2	34 313.2821	51.6758**
	(Treatment x Var.)	24	2 115.3700	3.1857**
	Error	195	664.0111	
	Total	233		
Pot yield	Treatment	12	752.4225	2.7954**
	Variety	2	3 094.6641	11.4972**
	(Treatment x Var.)	24	744.8226	2.7671**
	Error	195	269.1672	
	Total	233		

Results and discussion

During the growth duration of the rice crop, definite development and growth processes take place at definite growth phases. If the growth environment at any of these growth phases is not conducive, the predetermined development and growth processes will be affected. The results herein described are reflections of these responses.

Varietal influences were dominant in all the parameters measured except panicle weight and total spikelet number per panicle *(Table 1)*. The influences in these two parameters were about equal to or slightly stronger than treatment influences. For panicle number per hill, varietal influences were non-significant. Treatment influences were present in all the parameters and so were interactions between treatments and varieties.

Figure 2 and *Figure 3* show that generally field capacity treatments (1 to 6) result in lower culm height (except in treatments 1, 2 & 3), higher panicle number per hill (except in treatments 2, 4 & 5), and lighter panicles than in the control treatment. Panicle length was not affected. The total spikelet number per panicle was also less than that of control. Pot yield was significantly reduced in treatments 4, 5 and 6. These reductions could be attributed to the low total spikelet number per panicle and panicle weight.

In the partial submergence

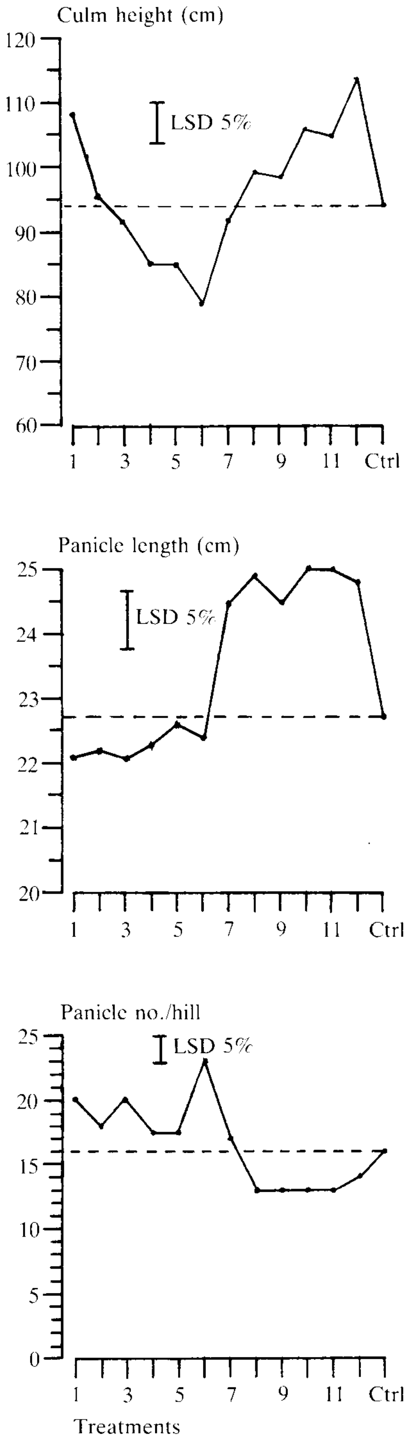


Figure 2. Treatment effects on culm height, panicle length and panicle number per hill [MS 1981–82]

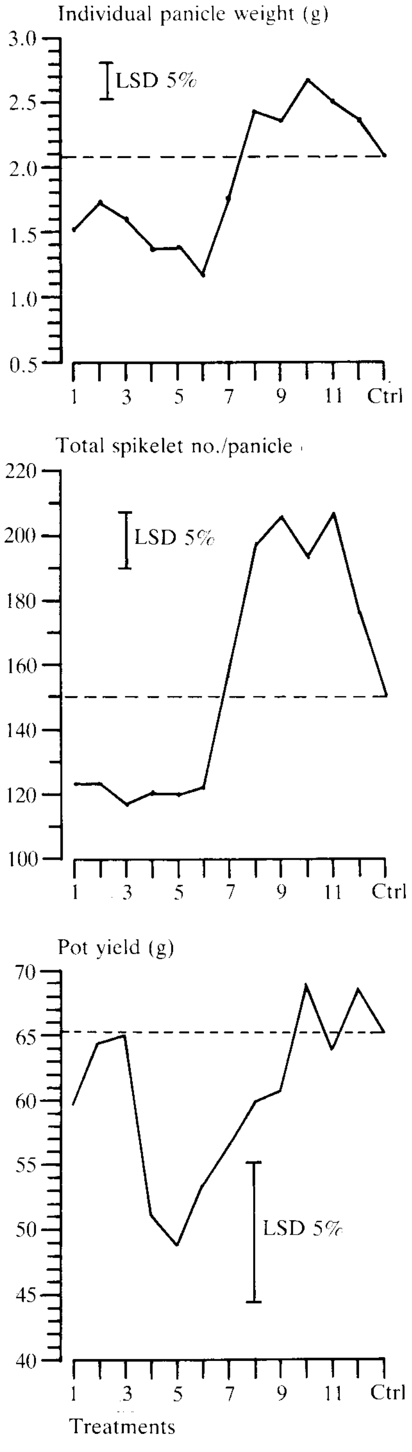


Figure 3. Treatment effects on individual panicle weight, total spikelet number per panicle and pot yield [MS 1981–82]

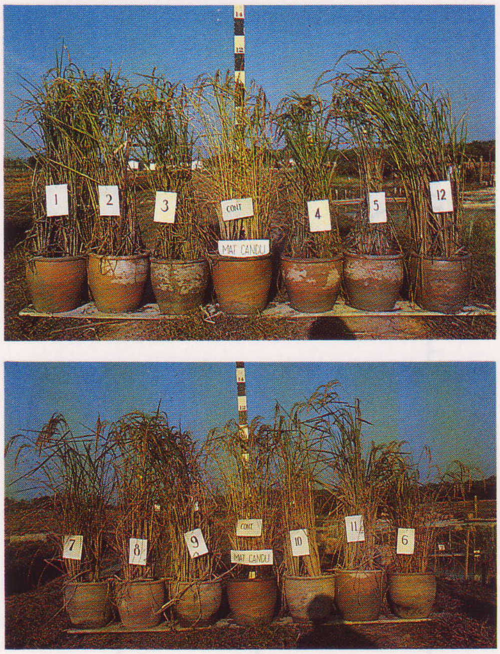


Plate 1. Treatment effects on Mat Candu (Treatments: L to R: 1, 2, 3, Control 4, 5, 6, 7, 8, 9, Control, 10, 11, 12)

Plate 2. Treatment effects on Sekembang (Treatment sequence as above)

treatments (7 to 12) *(Plate 2)* the opposite response was the case: taller plants (except in treatment 7, 8 & 9), fewer panicle number per hill (except in treatments 7 & 12), longer and heavier panicles (except in treatments 7 & 9). Total spikelet number per panicle was greatly increased (except in treatment 7). These effects did not significantly affect pot yield. However, the pot yields of treatments 10, 11 and 12 were significantly greater than those of treatments 4, 5 and 6. The higher yields were due to their longer and heavier panicles. The panicles also bore more spikelets.

In an environment wherein the water depth is constantly increasing, stimulation of rapid height increase took place at the expense of tiller production (Tay et al. 1980). Deep water at the active tillering stage would also reduce the tiller number resulting in reduced panicle number in the hill (Tay et al. 1980; Tay 1985). When Mahsuri, Sri Malaysia Dua and Murni were submerged in water at a depth of 50 cm at the booting phase, reduction in panicle length and 1 000 grain weight occurred but not in panicle number (Tay 1977). Sekembang when subjected to partial submergence at the ripening phase, resulted in reduced panicle weight and 1 000 grain weight, thus implying interference of the grain-filling process (Tay 1984). The common feature of the cited findings with the present result is the reduction in panicle number. The difference could be related to the fact that in this study there is a sequence of events.

Comparison among the field capacity treatments indicated that the reduction in culm height and panicle weight increased as the duration of field capacity treatment increased. The progressively long duration of field capacity treatment covered the growth phases wherein culm height, panicle number, spikelet number and panicle weight are determined (Yoshida 1981). Perhaps the daily watering of the pots to ensure soil wetness was inadequate to maintain the normal growth of the said parameters. Among the partial submergence treatments, the stimulation of culm elongation did not have dire consequence on pot yield even though positive effects were exercised on spikelet number per panicle and panicle weight. Herein the subsequent field capacity treatment did not affect the stated parameters.

When comparisons were made between corresponding treatments e.g. treatment 1 with 7, 2 with 8, etc. it was realised that when the duration of the preceeding treatment was longer than that of the succeeding treatment, e.g. in treatments 4 and 5 and 10 and 11, the effects of the preceeding treatment could not be negated by the succeeding treatment. Further, there is always the element of correlative responses: increases in panicle number result in reduction of spikelet number and panicle weight. Reduction in panicle number results in increases in panicle length with many spikelets and heavier panicles.

Continuous field capacity throughout the crop growth season (treatment 6) results in lower pot yield compared to both control and continuous partial submergence (treatment 12). The latter two were not significantly different from each other. The higher productivity in treatment 12 over that of treatment 6 was due to the presence of larger and heavier panicles bearing more spikelets. These plants lodged when removed from the deep water environment. In treatment 6, the higher panicle number per hill could not compensate for the reduction in panicle weight and total spikelet number per panicle. Again this may be related to the inadequate water supply stated earlier.

Singh and Tomar (1971) found that for transplanted T(N)1 and IR8 the continuous field capacity treatments yielded less than the flooded treatments irrespective of whether the flooded treatments were imposed throughout the cropping season or at any combination of the three growth phases (establishment to tillering, tillering to ear emergence, ear emergence to maturity) studied. No explanation was given for the difference in yield obtained. Their flood treatment was 8 to 10-cm water depth. Matsushima (1962) showed that zero centimeter standing water depth treatment yielded less than treatments with standing water depths. He attributed the low yield to poor plant growth: the result of denitrification of nitrogen in the soil.

At the other extreme, Pande (1976) showed that when Jaya was subjected to 25, 50 and 75% crop height submergence at three growth phases (seedling establishment to maximum tillering, maximum tillering to flowering, flowering to maturity) yield decreased with increase in water depth. The decrease in yield was attributed to decreased tillering (panicle number) resulting in decreased photosynthetic leaf surface. Matsushima (1962) working with traditional varieties, Pebifun and Radin China 4, showed that the yield was reduced when the plants were submerged above 50% plant height at any of the growth stages studied. He attributed the yield decrease to be due to damage or interference of the developmental physiology of the reproductive organs.

Interactions between treatments and varieties were very varied depending upon the variety, the treatment and the parameter in question *(Figure 4* and *Figure 5)*. The low yield of MR 43 in treatment 11 was due to the very low panicle number per hill (9) obtained. The low yields of Mat Candu in treatments 5 and 6 were due to low panicle weight (treatment 5), and low panicle weight and spikelet number per panicle (treatment 6). For Sekembang in treatment 4, the low yield was due to low panicle weight. Nevertheless, the overall varietal differences *(Table 2)* show that MR 43

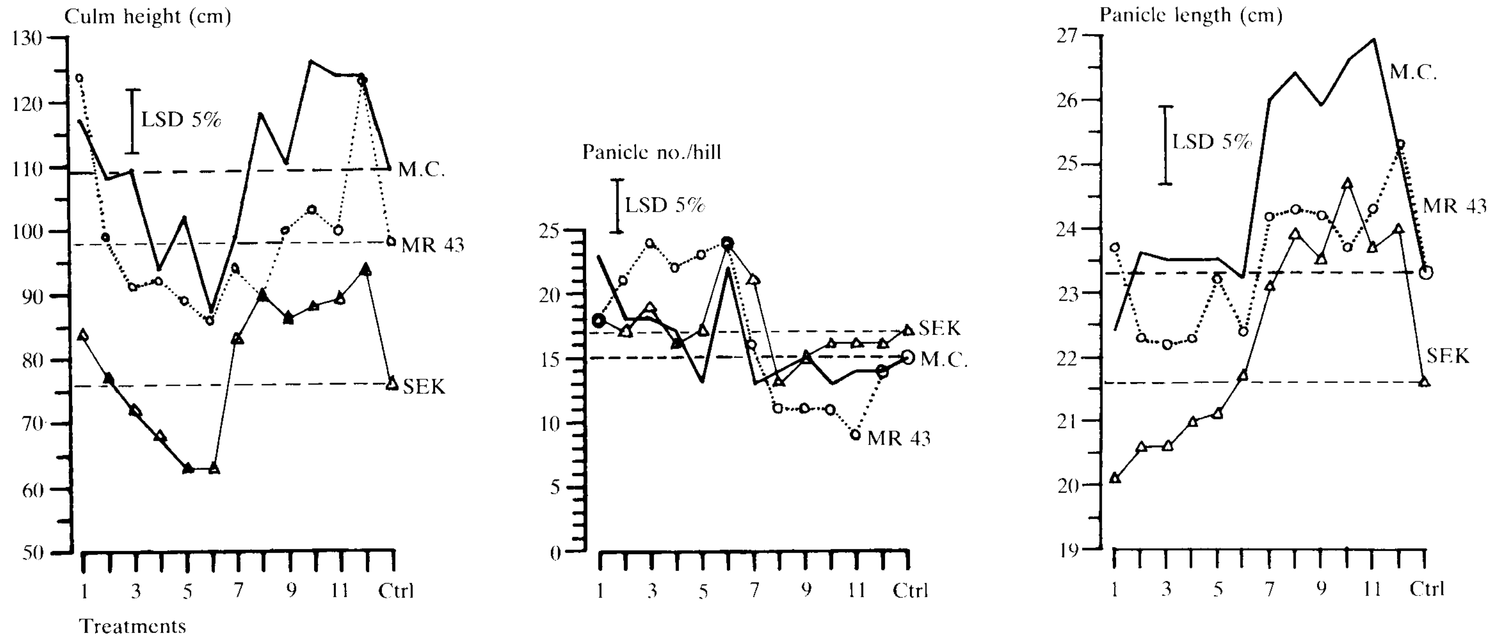


Figure 4. (Variety x Treatment) interactions for culm height, panicle number per hill and panicle length [MS 1981–82]

M.C. = Mat Candu SEK = Sekembang

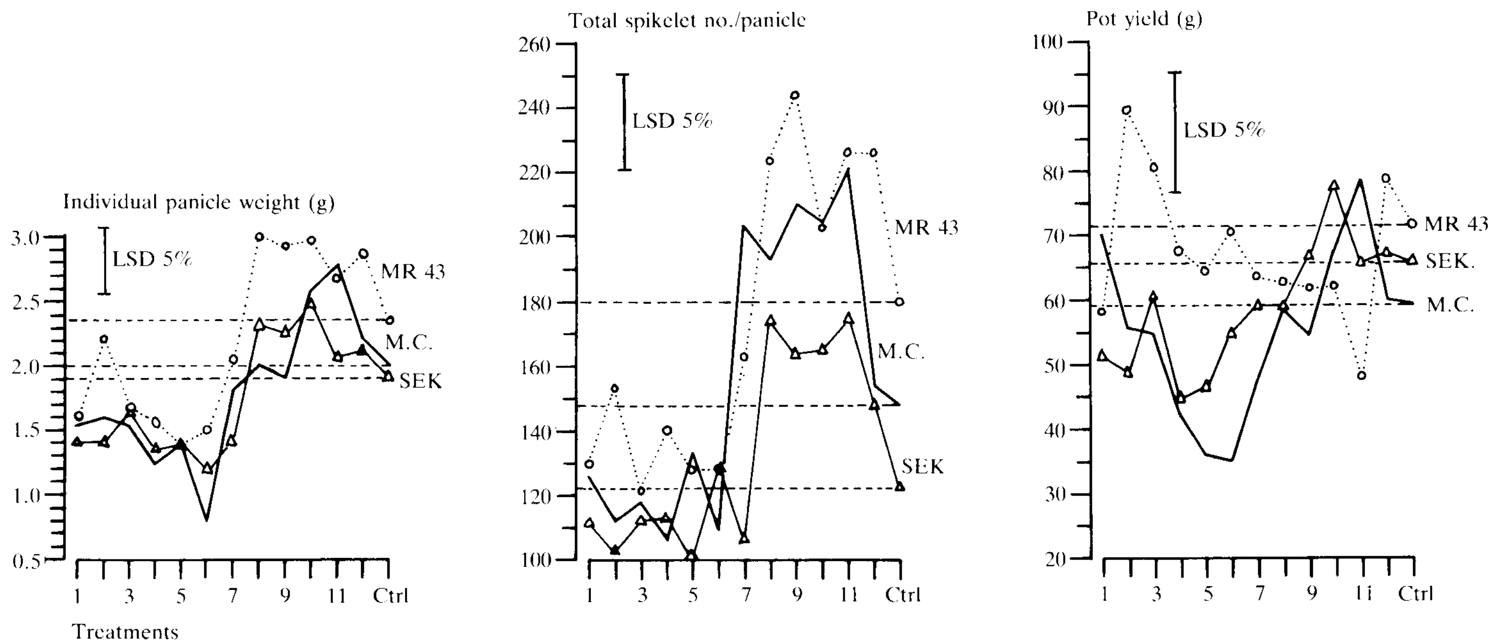


Figure 5. (Variety x Treatment) interactions for individual panicle weight, total spikelet number per panicle and pot yield [MS 1981–82]

Table 2. Overall varietal differences

Parameter	Variety			LSD 5%
	Mat Candu	Sekembang	MR 43	
Culm height (cm)	109.9	79.3*	99.2*	2.9
Panicle number per hill	16.0	17.0	17.0	NS
Indiv. panicle weight (g)	1.79	1.75	2.21*	0.13
Indiv. panicle length (cm)	24.6	22.3*	23.5*	0.3
Total spikelet per panicle	156.0	133.0*	175.0*	8.0
Pot yield (g)	55.2	58.9*	67.5*	5.2

*significantly different from Mat Candu at the 5% level

was superior in productivity among the three varieties tested. Its panicles were heavier and bore more spikelets.

Mat Candu is a tall, thick culm traditional variety once popular in the Kerian Laut District (deep mud and semideep water area). Sekembang (MR 10) and MR 43 are modern semidwarfs, the former meant to replace Mat Candu in the said district. In fact it did perform well and was readily accepted in the district when it was released. MR 43 was not released because it was susceptible to BPH and PMV, a serious disease in the Kerian – Sungai Manik area.

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