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Effects of different planting densities and schedules on chilli-cabbage intercropping

(Kesan berbagai-bagai jarak dan masa penanaman terhadap tanaman selingan cili dan kubis)

A. C. Leong* and A. Zaharah**

Key words: chilli, cabbage, intercropping, planting density, transplanting, yield, LER, net returns

Abstrak

Sistem penanaman selingan cili dengan kubis telah dikaji selama dua musim di tanah bris dan tanah gambut dari 1985 hingga 1987. Kajian dijalankan dalam kombinasi rawatan faktorial 3 x 3 berulang dengan empat perlakuan bandingan. Jarak penanaman yang paling sesuai untuk cili ialah 60 cm x 60 cm dengan penanaman serentak atau tidak lebih dari seminggu selepas kubis ditanam. Kubis sebagai tanaman selingan boleh ditanam pada jarak 60 cm x 45 cm atau 45 cm x 45 cm. Penggunaan bahan sungkupan plastik bersinar meningkatkan hasil cili dengan pengurangan jangkitan virus manakala pengurusan air yang cekap penting untuk mendapatkan hasil kubis yang tinggi. Sistem penanaman selingan ini mencatatkan hasil, kadar setara luas tanah dan pulangan bersih sehektar yang lebih tinggi berbanding dengan tanaman tunggal.

Abstract

The chilli-cabbage intercropping system was studied over two crop cycles on bris and peat from 1985 to 1987. A replicated 3^2 factorial design with four controls was used. The best planting distance for chilli was 60 cm x 60 cm with transplanting carried out simultaneously or not later than 1 week after the planting of cabbage. Cabbage as an intercrop can be planted either at 60 cm x 45 cm or 45 cm x 45 cm. Use of reflective mulch can improve the chilli yield significantly by reducing the incidence of virus while good water management is important to achieve high cabbage yield. This intercropping system recorded high yield, land equivalent ratio and net returns per hectare compared with the monocrops.

Introduction

Intercropping as a form of cropping system is slowly making a come back with vegetable farmers in Malaysia. This system increases total productivity in long-term crops by intercropping with a short-term crop. Intercropping also ensures more efficient use of solar (different canopy levels) and soil (deep vs. shallow rooted) resources (May 1982). Generally it has been reported that intercropping often produces higher yield than sole or monocropping (Andrews 1972; Willey 1979; Mead and Willey 1980; Leong 1990). In Malaysia, there is a general lack of basic agronomic information on the interaction between component vegetable species in a vegetable-based cropping system. Any cropping

*Division of Horticulture, MARDI (IPRS), P.O. Box 506, 82000 Pontian, Malaysia
**Division of Horticulture, MARDI, Telong, P.O. Box 186, 15720 Kota Bharu, Malaysia
Authors' full names: Leong Ah Chye and Zaharah Ariffin

system must be acceptable and has minimum problems to the farmers.

Chilli and lowland cabbage are commonly grown high-priced local vegetables. Chilli is a long-term crop that can be harvested up to 5 months or more after transplanting depending on the management. Lowland cabbage is a short-term crop harvestable at 55–75 days after transplanting, depending on the variety. Intercropping of chilli and cabbage can probably increase productivity compared with monocrops. The intercropping study of chilli with cabbage was carried out to determine the optimum yield, returns and compatibility between the two crops in relation to the best planting distance and time of transplanting.

Materials and methods

The study was conducted on peat in the Integrated Peat Research Station (IPRS), Johor and on bris (Rudua series) in Telong, Kelantan. On peat soil, the first and second crops were planted in July 1985 and August 1986. On bris, the crops were planted in June 1986 and August 1987.

Cabbage was intercropped with chilli at three planting distances *(Figure 1)*. Chilli was transplanted simultaneously (zero), 1 and 3 weeks after the transplanting of cabbage. The experiment was laid out in a 3 x 3 combination. In addition, four controls consisting of cabbage and chilli monocrops were tested at the normal spacing, namely

- cabbage planted at 60 cm x 45 cm;
- chilli planted at 60 cm x 60 cm simultaneously with cabbage;
- chilli planted at 60 cm x 60 cm at 1 week after cabbage; and
- chilli planted at 60 cm x 60 cm at 3 weeks after cabbage.

The 13 treatments were arranged in a randomized complete block design (RCBD) with three blocks. Fertilizer application was based on the requirements of the respective monocrop. The recommended fertilizer level for each monocrop was 250 kg N, 45 kg P, and 250 kg K per ha, and the total for the chilli and cabbage intercropping system was 500 kg N, 90 kg P and 500 kg K per ha. The fertilizers were split-applied for cabbage at 2 days and at 2, 3, 4, 5 and 7 weeks after transplanting. For chilli, the fertilizers were applied at 2 days and at 4, 8, 12 and 16 weeks after transplanting. In addition, chicken dung at 10 t/ha was incorporated as a basal in bris at 3 days before transplanting. The peat soil pH was raised to 5.0 by applying ground magnesium limestone (GML) at least 2 weeks before transplanting. The amount applied was based on the assumption that 2.5 t GML/ha can increase the soil pH by 0.15 unit (Chew 1971). Trace elements were applied as a basal dressing on peat 1 day before planting in accordance with recommendations by Leong et al. (1985). Prophylactic sprayings against common pests and diseases of chilli and cabbage were done in accordance with the recommendations by Mah et al. (1987).

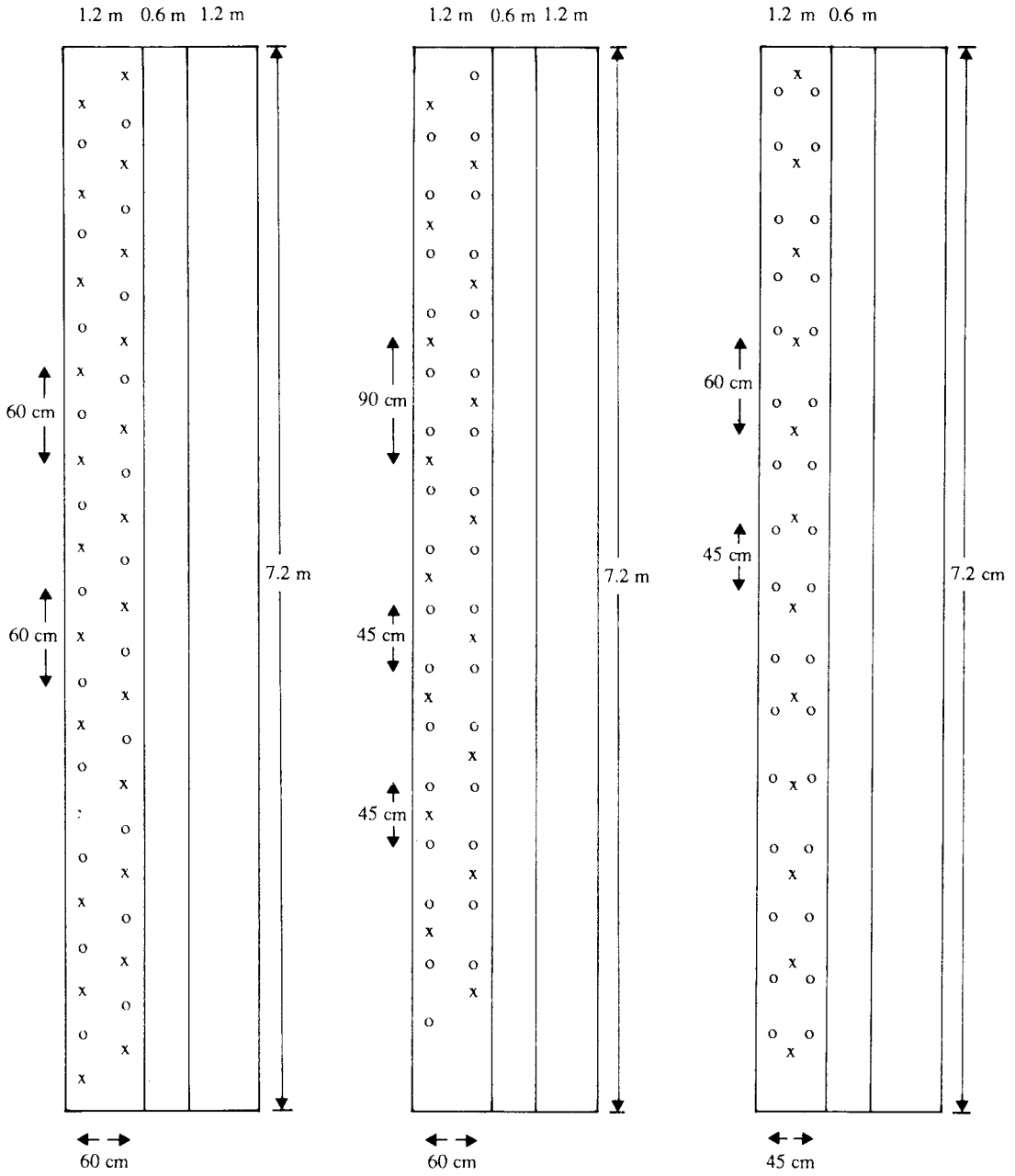
MARDI chilli variety MC 4 and MC 5 were used respectively on bris and peat, while the respective cabbage varieties were Summer Autumn and K-K Cross. Plot yields were recorded. Chilli was harvested until the end of production.

The ANOVA for chilli and cabbage was conducted using the RCBD model *(Table 1* and *Table 2)*.

Results and discussion

Chilli yields

Chilli planted at 60 cm x 60 cm produced significantly higher yield than the other planting distances in the first cycle and both cycles on bris and peat respectively *(Table 3)*. Chilli transplanted simultaneously with or at 1 week after cabbage recorded significantly higher yields than that transplanted at 3 weeks after cabbage in both cycles and soils. Interaction effects were noted in the first and second cycle respectively on bris and peat *(Table 4)*. Chilli as a monocrop transplanted simultaneously as cabbage, yielded significantly higher than those transplanted



x = chilli @ 60 cm x 60 cm
o = cabbage @ 60 cm x 60 cm

x = chilli @ 60 cm x 90 cm
o = cabbage @ 60 cm x 45 cm

x = chilli @ 0 x 60 cm (single ro
o = cabbage @ 45 cm x 45 cm

Figure 1. The spatial arrangement of chilli and cabbage on beds in individual plot

Table 1. ANOVA for chilli yield in the first and second crop cycle on bris and peat

Source	df	MS			
		1st crop cycle, bris	2nd crop cycle, bris	1st crop cycle, peat	2nd crop cycle, peat
Replicate	2	359.82**	17.52ns	49.62ns	99.97ns
Treatment	11	451.92**	52.56**	54.87ns	356.26**
Error	22	34.41	9.77	26.01	48.21
Total	35				
Breakdown of treatments					
Control vs. treatment	1	295.95*	15.94ns	16.73ns	36.75ns
Between control	2	668.71**	18.62ns	58.24ns	390.66**
Planting distance (D)	2	600.43**	19.27ns	95.50*	730.71**
Time of transplanting (T)	2	834.11**	157.14**	91.71*	653.81**
D x T	4	117.17*	7.16ns	23.97ns	82.93ns

Table 2. ANOVA for cabbage yields in the first and second crop cycle on bris and peat

Source	df	MS			
		1st crop cycle, bris	2nd crop cycle, bris	1st crop cycle, peat	2nd crop cycle, peat
Replicate	2	294.31**	368.48**	90.66ns	4.82ns
Treatment	9	68.67ns	49.86ns	203.60**	57.44**
Error	18	30.22	73.65	35.58	10.93
Total	29				
Breakdown of treatments					
Control vs. treatment	1	8.54ns	1.12ns	528.58**	199.80**
Planting distance (D)	2	194.87**	2.24ns	555.48**	78.20**
Time of transplanting (T)	2	28.29ns	38.84ns	62.23ns	43.73ns
D x T	4	40.80ns	91.37ns	17.09ns	20.82ns

Table 3. Least significant difference test on chilli yields on bris and peat

	Yield (t/ha)			
	1st crop cycle, bris	2nd crop cycle, bris	1st crop cycle, peat	2nd crop cycle, peat
Planting distance (cm)				
60 x 60	14.66	3.37	3.20	22.87
60 x 90	11.07	2.62	1.16	17.58
0 x 60	8.37	2.26	1.04	16.70
Transplanting time (weeks)				
0	14.42	3.97	2.02	20.74
1	12.43	3.37	2.92	20.90
3	7.23	0.93	0.47	15.13
SE	0.75	0.40	0.65	0.89
LSD (5%)	2.21	1.18	1.92	2.62
C.V.(%)	18.9	37.4	103.0	14.3

Table 4. Least significant difference test for the interaction effects of planting distance and transplanting time on chilli yield on bris and peat

Treatment	Yield (t/ha)	
	1st crop cycle, bris	2nd crop cycle, peat
60 cm x 60 cm+		
0*	17.43	26.65
1	18.05	25.20
3	8.48	16.77
60 cm x 90 cm		
0	15.97	17.81
1	10.18	20.28
3	7.02	14.65
0 x 60 cm		
0	9.87	17.77
1	9.06	17.23
3	6.21	14.00
SE	1.31	1.55
LSD (5%)	3.82	4.51
C.V.(%)	18.9	14.3

+Planting distance
*Time of transplanting (weeks)
0 = chilli planted simultaneously with cabbage
1 = chilli planted 1 week after cabbage
3 = chilli planted 3 weeks after cabbage

at 1 and 3 weeks later in the first cycle on bris and the second cycle on peat *(Table 5)*.

Results indicated that the best planting distance for chilli in the chilli-cabbage intercropping system was 60 cm x 60 cm on both bris and peat. This planting distance gives the same plant population per hectare as that for monocropping, indicating the importance of maintaining high yield of the dominant crop in the intercropping system. Yield variation between the first and second crop cycle was attributed to severe virus infection on both soil types. The disease resulted in leaf deformation and shoot-tip die-back leading to a shortening of the life cycle and lower yields in chilli. Planting of chilli in a new area as in the first crop cycle on sandy bris and the use of reflective mulch in the second on peat resulted in higher yields by reducing the level of virus infection in chilli.

The time of transplanting chilli had a definite effect on its performance and yield in relation to planting of cabbage. Chilli should be planted either simultaneously or at 1 week after cabbage.Transplanting of chilli at 3 weeks after cabbage resulted in stunted chilli plants due to shading. There is also a possibility of reduced capability of the chilli in competing for nutrients with the developing cabbage. These coupled with the carrying over effects of diseases especially virus and pests from earlier planting could have contributed to the yield reduction in chilli planted later. The interaction effects confirmed that the best planting distance for chilli was 60 cm x 60 cm and transplanting the chilli seedlings to be carried out simultaneously with or at one week after cabbage. The trend was similarly noted in the plots of chilli planted as monocrops. This reaffirmed the importance of time of transplanting chilli in relation to cabbage in the intercropping system.

Cabbage yields

Cabbage planted at 45 cm x 45 cm and 60 cm x 45 cm recorded significantly higher yields than planting at 60 cm x 60 cm in the first crop cycle on bris and in both crop cycles on peat *(Table 6)*. These two planting distances also recorded a higher plant population than the spacing of 60 cm x 60 cm. The transplanting time of chilli had no significant effect on the cabbage yields in both crop cycles and on both soils. No interaction effects were noted in both crops and soils. The control monocrop yielded significantly higher than the intercropping treatments in both crop cycles on peat *(Table 6)*. However, no significant differences were detected on bris.

Intercropped cabbage can be planted either at 45 cm x 45 cm or 60 cm x 45 cm on both soils. These two planting distances also recorded the same plant population per hectare as the monocrop. Therefore, it is important to maintain a high population of cabbage to achieve good yield in the intercropping system.

The transplanting time of chilli is not important since the intercropped yields were

Table 5. Least significant difference test on the yields of chilli monocrops on bris and peat

Transplanting time (weeks)	Yield (t/ha)			
	1st crop cycle, bris	2nd crop cycle, bris	1st crop cycle, peat	2nd crop cycle, peat
0	19.98	4.72	2.62	22.95
1	13.26	5.54	3.83	14.46
3	8.51	3.63	0.54	16.67
SE	1.31	0.70	1.14	1.55
LSD (5%)	3.84	2.04	3.33	4.54
C.V.(%)	18.9	37.4	103.0	14.3

Table 6. Least significant difference test on the yields of cabbage (planting distance of cabbage in brackets) on bris and peat

	Yield (t/ha)			
	1st crop cycle, bris	2nd crop cycle, bris	1st crop cycle, peat	2nd crop cycle, peat
Planting distance (cm)				
60 x 60 (60 x 60)	17.89	11.80	13.43	7.56
60 x 90 (60 x 45)	20.91	11.57	18.92	9.96
0 x 60 (45 x 45)	21.09	11.42	18.41	10.89
Control-monocrop	20.65	11.84	22.32	13.18
Transplanting time (weeks)				
0	19.29	10.74	16.57	8.51
1	19.95	12.33	16.13	8.52
3	20.65	11.71	18.06	10.32
SE	0.71	1.10	1.33	0.90
LSD (5%)	2.10	3.28	2.28	1.60
C.V. (%)	10.6	28.5	13.2	13.4
*LSD (5%)	2.97	4.64	3.22	2.35

*LSD values for control vs. treatments

comparable to those of the monocrops on bris indicating that intercropping with chilli had not affected the performance of cabbage. Additional application of chicken dung on bris may have contributed to the total available nutrients, thereby reducing the competition among component crops in the intercropping system. However on peat, which is noted for its low nutrient status, monocrop cabbage outyielded the intercropped treatments. Competition for nutrients was probably keener on peat and the different performance of the cabbage varieties on these two soils could have contributed to the differences in cabbage yields. The use of reflective mulch for chilli practically halved the cabbage yield on peat *(Table 6)*. Thus, besides competition for nutrients, there was also competition for water. Management of water under plastic mulch was a problem. The shallow rooted cabbage would have competed less effectively in both faculties than chilli, which has a deeper root system.

Table 7. Land equivalent ratio for chilli and cabbage intercropping on bris and peat

	Total LER			
	1st crop cycle, bris	2nd crop cycle, bris	1st crop cycle, peat	2nd crop cycle, peat
Planting distance (cm)				
60 x 60	1.91	1.71	1.12	1.83
60 x 90	1.80	1.53	1.03	1.72
0 x 60	1.61	1.45	0.99	1.64
Transplanting time (weeks)				
0	1.96	1.75	1.07	1.78
1	1.85	1.76	1.19	1.79
3	1.51	1.18	0.87	1.61

Table 8. Ex-farm prices for chilli and cabbage on bris and peat

Crop cycle	Ex-farm prices ($/kg)		Source
	Chilli	Cabbage	
Bris			
1st	2.68	0.30	Anon. (1986)
2nd	3.29	0.40	Anon. (1987)
Peat			
1st	2.79	0.55	Anon. (1985b)
2nd	2.82	0.40	Anon. (1986)

Land equivalent ratio

If time factor is not critical, land equivalent ratio (LER) is one of the methods used in assessing the yield advantage of intercropping. It is defined by Mead and Willey (1980) as:

$$LER = LA + LB = (YA + SA) + (YB + SB)$$

where *LA* and *LB* are the LER for the individual crop *A* and *B* respectively. *YA* and *YB* are individual crop yields in intercropping and *SA* and *SB* are their yields as sole crops.

Intercropping two or more crops together on the same area can often produce higher yields than sole crops (Mead and Willey 1980). As given in *Table 7*, suitable intercropping treatments recorded greater LER than chilli and cabbage monocrop (LER = 1). The yields obtained were reflected in the LER and confirmed that the best planting distance for the main crop, chilli, was at 60 cm x 60 cm and it should be transplanted not later than 1 week after cabbage. The intercropping system increased productivity of the land and further illustrated the yield advantage of inter over monocropping.

Estimated total net returns

The estimated production cost per hectare for chilli ($6 299) and cabbage ($4 692) were used (Leong et al. 1985; Anon. 1985) as collecting data on the production costs was difficult based on small experimental plots. The average ex-farm prices were obtained from the Federal Agriculture Marketing Authority (FAMA) for the duration of harvest of each crop *(Table 8)*.

Results indicate the economic advantage of intercropping chilli and cabbage over their respective monocrops in total net returns per hectare in a minimum-virus infected situation on the two soil types *(Table 9)*. This showed that the chilli-cabbage intercropping system is economically feasible. The best practice was again planting chilli at 60 cm x 60 cm and transplanting the seedlings simultaneously or not later than 1 week after cabbage.

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Table 9. Estimated total net returns for the chilli-cabbage intercropping system over two crop cycles on bris and peat

	Total net revenue ($'000)/ha			
	1st crop cycle, bris	2nd crop cycle, bris	1st crop cycle, peat	2nd crop cycle, peat
Planting distance (cm)				
60 x 60	33.67	4.82	5.32	56.54
60 x 90	25.30	2.26	2.60	42.57
0 x 60	17.78	1.03	2.03	39.00
Transplanting time (weeks)				
0	33.47	6.35	3.74	50.91
1	28.31	5.02	5.99	51.36
3	14.98	(–3.27)	0.68	35.83
Chilli monocrop	31.03	8.93	0.29	44.54
Cabbage monocrop	1.50	0.04	7.58	0.58

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