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Study on intercropping cabbage with four leafy vegetables on peat

(Kajian terhadap penanaman kubis berselingan dengan empat jenis sayur berdaun di tanah gambut)

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Key words: cabbage, leafy vegetables, intercropping, fertilizer, yield, LER, net returns

Abstrak

Penanaman kubis berselingan dengan empat jenis sayur berdaun pada dua tahap pembajaan telah dikaji sebanyak dua kitaran tanaman di tanah gambut dalam tahun 1989 dan 1990. Perlakuan dikaji sebagai ujikaji faktorial 4x2 berulang dengan tanaman kubis tunggal sebagai bandingan dalam reka bentuk blok terawak lengkap. Menanam kubis berselingan dengan sayur berdaun sesuai dari segi agronomi kerana hasil kubis tidak terjejas. Kadar baja semasa yang disyorkan bagi tanaman kubis (250:40:250 NPK kg/ha) didapati cukup bagi keperluan kedua-dua tanaman kubis dan sayur berdaun. Ini menunjukkan peningkatan dalam kecekapan menggunakan nutrien. Kandungan nutrien makro dalam kepala daun kubis tidak menunjukkan perbezaan yang ketara antara dua kadar baja yang berlainan. Ini mengesahkan bahawa kadar baja semasa bagi tanaman kubis mencukupi untuk kedua-dua tanaman utama dan tanaman selingan. Semua sistem penanaman selingan mempunyai nisbah setara tanah (NST) yang lebih tinggi daripada NST petak bandingan. Dari segi hasil dan pulangan bersih sehektar, sistem penanaman selingan yang terbaik ialah kubis + daun bawang dan kubis + salad. Kedua-dua sistem ini berpotensi untuk mengurangkan jangkitan penyakit layu bakteria dan serangan perosak serangga *Hellula* pada tanaman kubis.

Abstract

Intercropping cabbage with four common leafy vegetables at two fertilizer levels was studied over two crop cycles on peat in 1989 and 1990. A replicated 4x2 factorial with cabbage monocrop as the control was laid out in a RCB design. Intercropping cabbage with leafy vegetables is agronomically compatible as its yield was not affected by any of the intercrops. The current recommended fertilizer level (250:40:250 of NPK kg/ha) for cabbage was sufficient to support both cabbage and the intercrops, indicating improved efficiency in nutrient utilization. Foliar analysis of composite sample of the cabbage heads showed no significant differences in levels of major nutrients, giving further evidence that the current recommended fertilizer rate was sufficient to support both the main crop and the intercrop. All the intercropping systems recorded total land equivalent ratios greater than that of the control. The best intercropping systems were cabbage + spring onion and cabbage + lettuce based on yield and net returns per hectare. The same intercropping systems appear to have the potential of reducing bacterial soft rot and Hellula infestation in cabbage.

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Introduction

Planting of two or more crops simultaneously or in relays can increase productivity in the longer-term main crop. Intercropping often produces higher yields in the main crop than sole cropping (Andrews 1972; Willey 1979; Mead and Willey 1980; Leong 1990; Leong and Zaharah 1991). Besides this, intercropping is often practised as a form of insurance against total crop loss (Harwood and Plucknett 1981).

Water pollution from fertilizer leachate and run-off is common in developing countries. As such there is a universal need to minimize water pollution caused by excessive application of fertilizers. Intercropping can probably reduce fertilizer pollutants through more efficient utilization of nutrients.

Transplanted cabbage normally grows rather slowly in the first 5 weeks. This period can be used for growing a shorter-term leafy vegetable intercrop. The four leafy vegetable intercrops studied can be harvested at 4–5 weeks after direct seeding or transplanting. With this premise, a study was conducted to determine the effects and compatibility of different leafy vegetables as intercrops with cabbage at different fertilizer levels on peat.

Materials and methods

The experiment was carried out on oligotrophic peat over two crop cycles at the Integrated Peat Research Station (IPRS), Johore. The first and second crop cycles were implemented respectively in July 1989 and June 1990. Four common leafy vegetables, viz. lettuce (*Lactuca sativa* L.), kangkung (*Ipomoea reptans* Poir), amaranthus (*Amaranthus viridis* L.) and spring onion (*Allium cepa* var. *ascalonicum*) were evaluated as intercrops of cabbage (*Brassica oleraceae* var. *capitata* L.). A lowland cabbage variety (K.K. Cross) was planted one day earlier than the intercrops. Four-week-old cabbage seedlings, raised on nursery beds, were used. Locally available imported bulbs and seeds of the four leafy vegetables were intercropped with cabbage at two fertilizer levels. The total fertilizer applied for level 1, i.e. the current recommended level for cabbage (Vimala, P., MARDI, Jalan Kebun, pers. comm. 1989) and level 2 (50% higher) were 250:40:250 and 375:60:375 of N:P:K in kg/ha, respectively. The sources for N, P and K respectively were ammonium sulphate, triple superphosphate and muriate of potash. These were split-applied in equal amounts at 2, 14, 21, 28, 35 and 49 days except for P which was totally applied 2 days after transplanting the cabbage.

The four intercropping treatments and the two fertilizer levels were arranged in a 4x2 factorial in one block together with monocrop cabbage as the control. The plot size was 3.4 m x 6.75 m. A randomized complete block design with four blocks was used. The spatial arrangements of the cabbage and the different intercrops and their planting densities are shown in *Figure 1.* Kangkung and amaranthus were sown directly onto the beds. Imported shallot bulbs were planted directly, and 4-week-old lettuce seedlings transplanted. Monocrops of the four leafy vegetables were grown only in the second crop cycle to enable the calculation of land equivalent ratio.

Liming with ground magnesium limestone (GML) at 8.3 t/ha was carried out at 3 weeks before planting, to raise the soil pH to 5.5, in the first crop cycle. No liming was carried out in the second crop cycle, as the soil pH was around 5.5 in the new site. Trace elements were applied as basal dressing one day before planting in accordance with Leong et al. (1985). Yields of cabbage and the intercrops, the number of cabbage plants infected with bacterial soft rot and Hellula infestation were recorded. The intercrops and cabbage were harvested respectively at 27–32 days and 52–70 days after planting. Four cabbage heads were taken randomly, at harvest, and cut into smaller pieces and mixed thoroughly. A composite sample of each treatment was

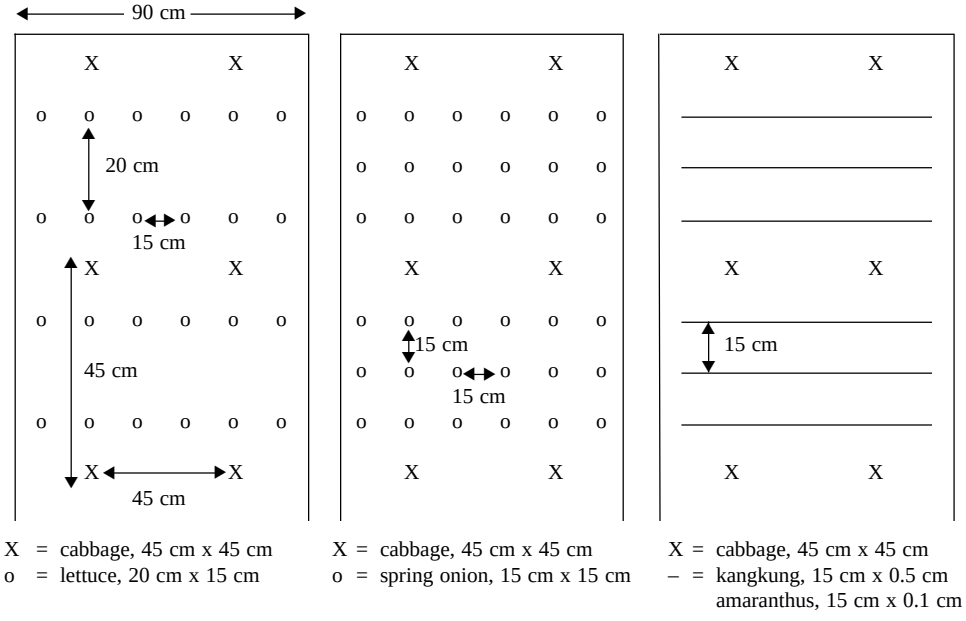

Figure 1. Spatial arrangements of cabbage and leafy vegetable intercrops

then taken to determine the percentages of N, P, K, Ca and Mg. The total net returns per hectare were estimated based on the yields and average prices of cabbage and the intercrops for the duration of the harvest.

Results and discussion

Cabbage yield

In the first crop cycle, no significant differences were detected between the intercropped and monocropped cabbage but in the second crop cycle, cabbage + spring onion recorded a significantly higher yield of cabbage than monocropped cabbage *(Table 1)*. This particular intercropping combination also gave significantly higher yields than cabbage + kangkung in both crop cycles. Cabbage yield from the cabbage + amaranthus intercropping system in the second crop cycle was not analysed because of poor or no germination of the amaranthus seed. Results showed that except for kangkung the intercrops with cabbage did not affect cabbage yield and are therefore agronomically compatible. The best intercropping systems were cabbage + spring onion and cabbage + lettuce *(Plate 1)*.

Table 1. Least significant difference test on the yields of cabbage with leafy vegetable intercrops on peat

	Yield (t/ha)	
Treatment	1st CC	2nd CC
Cabbage + lettuce	23.14	22.30
Cabbage + kangkung	19.37	20.41
Cabbage + spring onion	23.25	24.00
Cabbage + amaranthus	21.86	na
Cabbage (monocrop)	22.01	20.22
SE	0.87	0.96
LSD (5%)	2.55	2.87
C.V. (%)	11.2	12.4
°LSD (5%)	3.11	3.52

CC = crop cycle
°LSD values for monocrop vs treatment
Note: Cabbage yields in the different intercropping systems, were averaged over the two fertilizer levels
na = not analysed

In fact, a complementary effect was noted in these particular intercropping systems as indicated by higher yields obtained over the two seasons compared with the yield of cabbage monocrop.

Plate 1. Spring onion and lettuce intercropped with cabbage

No significant differences in cabbage yield were detected between the two fertilizer levels in both crop cycles *(Table 2)*. This showed that nutrient competition between the main crop and intercrop was minimal. The additional fertilizer application did not increase the yield of cabbage significantly, suggesting that the current recommended fertilizer level for cabbage was sufficient to support an additional leafy vegetable intercrop. The cabbage + leafy vegetable cropping system had apparently improved the efficiency of nutrient utilization on peat. Indirectly, this would reduce water pollution caused by excessive fertilizer application, as the recommended fertilizer level can support two crops with no detrimental effects on the main crop. No interaction effects between the different cropping systems and fertilizer levels were recorded in both cycles.

Leafy vegetable yields

Good consistent leafy vegetable intercrop yields were obtained in both crop cycles *(Table 3)*.

Higher fertilizer level significantly increased the yield of leafy vegetable intercrops *(Table 2)*. This could be attributed to the combined effects of the different species of leafy vegetables.

Table 2. Least significant difference test on the yields of cabbage and leafy vegetables at two fertilizer levels

	Yield (t/ha)	
Fertilizer level	1st CC	2nd CC
Cabbage		
Level 1	21.48	21.61
Level 2	22.32	22.90
SE	0.61	0.79
LSD (5%)	1.79	2.34
C.V. (%)	11.2	12.4
Leafy vegetables		
Level 1	11.85	11.11
Level 2	13.66	13.06
SE	0.61	0.53
LSD (5%)	1.80	1.55
C.V. (%)	19.2	14.3

CC = crop cycle
Note: Yields for the different fertilizer levels were averaged over the four intercropping systems

Table 3. Yields of leafy vegetable intercrops

Leafy vegetable intercrop	Yield (t/ha)	
	1st CC	2nd CC
Lettuce	10.26	10.96
Kangkung	18.62	14.94
Spring onion	8.42	10.35
Amaranthus	13.75	na

CC = crop cycle
na = not analysed

Table 4. Least significant difference test on the nutrient content in cabbage head

Treatment	Content (%) N	P	K	Ca	Mg
1st crop cycle					
Intercropping system					
Cabbage + lettuce	4.06	0.67	5.36	2.60	0.77
Cabbage + kangkung	4.13	0.62	5.00	2.40	0.79
Cabbage + spring onion	4.12	0.67	5.67	2.48	0.71
Cabbage + amaranthus	4.02	0.61	5.08	2.47	0.85
Cabbage (monocrop)	4.03	0.62	5.48	2.30	0.73
SE	0.08	0.03	0.18	0.18	0.56
LSD (5%)	0.24	0.09	0.54	0.52	0.17
C.V. (%)	5.70	14.30	9.80	20.70	21.30
°LSD (5%)	0.29	0.12	0.66	0.64	0.21
Fertilizer level					
Level 1	4.12	0.63	5.29	2.38	0.82
Level 2	4.04	0.66	5.26	2.57	0.74
SE	0.06	0.02	0.13	0.13	0.04
LSD (5%)	0.17	0.07	0.38	0.37	0.12
C.V. (%)	5.70	14.30	9.80	20.70	21.30
2nd crop cycle					
Intercropping system					
Cabbage + lettuce	4.18	0.69	4.82	1.94	0.38
Cabbage + kangkung	4.16	0.65	4.68	0.96	0.38
Cabbage + spring onion	4.06	0.64	4.64	0.96	0.38
Cabbage + amaranthus	na	na	na	na	na
Cabbage (monocrop)	4.27	0.70	5.06	1.07	0.41
SE	0.06	0.19	0.12	0.03	0.01
LSD (5%)	0.18	0.06	0.35	0.09	0.03
C.V. (%)	4.30	8.00	7.10	8.90	8.80
°LSD (5%)	0.23	0.07	0.43	0.11	0.04
Fertilizer level					
Level 1	4.14	0.63	4.71	0.94	0.37
Level 2	4.18	0.71	4.84	1.04	0.39
SE	0.04	0.01	0.08	0.02	0.01
LSD (5%)	0.13	0.04	0.25	0.06	0.02
C.V. (%)	4.30	8.00	7.10	8.90	8.80

°LSD values for monocrop vs treatment na = not analysed

The yields obtained from the leafy vegetables as intercrops will contribute additional income.

Nutrient content in cabbage heads

No significant differences in the percentages of N, P, K, Ca and Mg were detected, in the composite samples of cabbage heads, between the various cropping systems in both crop cycles *(Table 4)*. Similarly, no differences in the nutrient contents were detected between the various intercropping systems and the control. This showed that intercropping had not affected the nutrient uptake of cabbage as the main crop. The results were reflected in the cabbage yield obtained in both crop cycles.

Generally, there were also no significant differences in the nutrient contents in cabbage between the two fertilizer levels for both crop cycles, with the exception of P and Ca in the second

Table 5. Total LER and its components in the different intercropping systems in the second crop cycle only

Treatment	Land equivalent ratio				
	Cabbage	Lettuce	Kangkung	Spring onion	Total
Cabbage + lettuce	1.10	0.62	–	–	1.72
Cabbage + kangkung	1.01	–	0.98	–	1.99
Cabbage + spring onion	1.19	–	–	0.93	2.12
Cabbage	1.0	–	–	–	1.00
Lettuce	–	1.0	–	–	1.00
Kangkung	–	–	1.0	–	1.00
Spring onion	–	–	–	1.0	1.00

crop cycle. However, the significant differences were not reflected in the yields obtained in the second crop cycle. This reconfirmed that the current recommended fertilizer level for cabbage was sufficient to support a leafy vegetable intercrop.

Land equivalent ratio

The average yields of lettuce, kangkung and spring onion as monocrops obtained in the second crop cycle only were 17.56, 15.17 and 11.15 t/ha respectively. However, no yield data were obtained for the first crop cycle. Thus, the land equivalent ratio (LER) was computed based only on the second crop cycle.

According to Mead and Willey (1980), LER is obtained by the formula:

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

where, LA and LB = LER's for the individual crop

YA and YB = individual crop yields in intercropping

SA and SB = their yields as sole crops

All the intercropping treatments recorded a total LER greater than that of the controls *(Table 5)*. The cabbage + spring onion intercropping system recorded the highest LER.

Cabbage infected with soft rot

Bacterial soft rot is a common disease of lowland cabbage caused by *Erwinia caratovora*. No significant differences in infection were detected between the intercropping treatments and the monocrop control. In the second crop cycle, soft rot incidence in cabbage + spring onion was significantly reduced compared with the other intercropping treatments and the control *(Table 6)*. The results were positively reflected in the cabbage yields obtained. Since intercropping cabbage + spring onion is potentially capable of reducing soft rot infection, it should be investigated further.

Table 6. Number of cabbage plants infected with bacterial soft rot in cabbage with leafy vegetable intercrops on peat [log (x+1) transformation] based on per plot

Treatment	No. plants infected	
	1st CC	2nd CC
Cabbage + lettuce	2.02	2.61
Cabbage + kangkung	1.55	2.47
Cabbage + spring onion	2.19	1.83
Cabbage + amaranthus	1.35	na
Cabbage (monocrop)	1.62	3.02
SE	0.164	0.209
LSD (5%)	0.48	0.62
C.V. (%)	26.3	24.6
°LSD (5%)	0.59	0.76

CC = crop cycle
°LSD = values for monocrop vs. treatment
na = not analysed

Cabbage infected with Hellula sp.

The Hellula webworm is a common insect pest of lowland cabbage, causing unsaleable multiple heads. No significant differences in the total number of infected cabbage heads

Table 7. Number of cabbage plants infected with Hellula webworm sp. in cabbage with leafy vegetable intercrops on peat [log (x+1) transformation] based on per plot

	No. plants infected	
Treatment	1st CC	2nd CC
Cabbage + lettuce	1.57	2.01
Cabbage + kangkung	1.98	2.12
Cabbage + spring onion	1.47	2.02
Cabbage + amaranthus	1.79	na
Cabbage (monocrop)	2.18	2.59
SE	0.209	0.149
LSD (5%)	0.61	0.44
C.V. (%)	33.6	19.8
°LSD (5%)	0.75	0.54

CC = crop cycle
°LSD = values for monocrop vs. treatment
na = not analysed

Table 8. Ex-farm prices for cabbage and leafy vegetables

	Ex-farm prices (RM/kg)	
Crop	1st CC	2nd CC
Cabbage	1.04	0.70
Lettuce	1.35	1.35
Kangkung	0.66	0.40
Spring onion	1.44	1.04
Amaranthus	0.71	na
Source	Anon. (1989)	Anon. (1990)

CC = crop cycle
na = not analysed

Table 9. Estimated total net returns per hectare for cabbage-leafy vegetable intercropping over two crop cycles

Intercropping system	Returns (RM'000/ha)	
	1st CC	2nd CC
Cabbage + lettuce	28.99	21.49
Cabbage + kangkung	24.99	12.82
Cabbage + spring onion	24.28	15.58
Cabbage + amaranthus	24.41	na
Cabbage (monocrop)	17.81	9.08

CC = crop cycle
na = not analysed

were detected in the first crop cycle between the intercropping treatments and the control *(Table 7)*. However, in the second crop cycle, cabbage + lettuce or spring onion recorded a significantly smaller number of infested plants compared with the other intercropping treatments and the control. Thus, intercropping seems to reduce the Hellula population through association of certain crops and possibly could have contributed to the higher cabbage yields. The potential of reducing Hellula infestation through crop association should be investigated further.

Estimated total net returns per hectare

Production costs per hectare for monocrops of cabbage (RM5 077), lettuce (RM3 842), kangkung (RM2 361), spring onion (RM6 951)* and amaranthus (RM3 007) were estimated (Anon. 1988). These cost figures were used because of the difficulty in collecting production costs based on small experimental plots. The average ex-farm prices of the various vegetables are listed in *Table 8*. The estimated total net returns for the various intercropping systems based on these data are shown in *Table 9*.

Net returns from the various intercropping systems exceeded that of the cabbage monocrop in both crop cycles. This illustrated the economic advantage of intercropping over monocropping. The best intercropping system on peat in terms of consistently high returns was cabbage + lettuce and cabbage + spring onion.

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*cost of production for bulbs was used instead because of the non-availability of data on the production cost for spring onion

References

Andrews, D. J. (1972). Intercropping with sorghum in Nigeria. *Expl. Agric.* ***8:*** 139–50

Anon. (1988). *Anggaran kos pengeluaran dan pendapatan untuk tanaman dan ternakan* Serdang: MARDI

—— (1989). Laporan harga barang-barang terpilih, FAMA, Johor Bharu (mimeo.)

—— (1990). Laporan harga barang-barang terpilih, FAMA, Johor Bharu (mimeo.)

Hardwood, R. R. and Plucknett, D. L. (1981). Vegetable cropping systems. In *Vegetable farming systems in China* (Plucknett, D. L. and Beemor, H. L., ed.) p. 45–118. Colorado, Westfield: Westview Press, Inc.

Leong, A. C. (1990). The potential of long bean and cucumber as intercrops with ginger on Malaysian peat. *MARDI Res. J.* ***18(1):*** 45–52

Leong, A. C., Vimala, P. and Ding. T. H. (1985). A guide to chilli cultivation in Peninsular Malaysia. *Teknol. Sayur-Sayuran, MARDI* ***1:*** 14–9

Leong, A. C. and Zaharah, A. (1991). Intercropping common leafy vegetables with okra on Malaysian peat and bris. *MARDI Res. J.* ***19(2):*** 209–16

Mead, R. and Willey, R. W. (1980). The concept of land equivalent ratio and advantages in yield from intercropping. *Expl. Agric.* ***16:*** 217–28

Willey, R. W. (1979). Intercropping, its importance and research needs I. Competition and yield advantage. *Field Crop Abstracts* ***32:*** 1–20

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