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Nitrogen and potassium requirements of chinese cabbage (*Brassica rapa* L.) on oligotrophic peat

[Keperluan baja nitrogen dan kalium bagi kubis cina (*Brassica rapa* L.) di tanah gambut]

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Key words: nitrogen and potassium requiremens, chinese cabbage, peat, netted structure

Abstrak

Pada tahun 1998, Malaysia mengimport sayur segar dan dingin bernilai RM781 juta, dengan kubis cina bernilai RM14 juta. Kerugian dalam pertukaran asing perlu dikurangkan, lebih-lebih lagi sekiranya tanaman itu dapat ditanam di dalam negara. Kubis cina biasanya ditanam di tanah tinggi yang bercuaca sejuk di Sabah, Sarawak dan Semenanjung. Varieti sesuai yang tahan panas telah dikenal pasti tetapi tiada maklumat tentang penanamannya di tanah rendah. Dua varieti yang dikenal pasti selanjutnya dinilai pada tiga kadar nitrogen (N) dan kalium (K) di tanah gambut. Eksperimen berbentuk faktorial 2 x 3 x 3 dan blok rawak (RCB) dengan tiga replikasi telah dijalankan di bawah struktur jaring di Stesen MARDI Jalan Kebun, Kelang pada akhir tahun 1998 dan diulangi pada tahun 1999.

Varieti Tropic Queen memberikan hasil yang tinggi pada tanaman pertama, tetapi tiada perbezaan penghasilan dikesan pada tanaman kedua. Gerak balas kepada N ialah linear semasa tanaman pertama. Dalam tanaman kedua, kadar N yang lebih tinggi dibubuh untuk mengesahkan keputusan eksperimen tanaman pertama. Hasil (31.7 t/ha) pada kadar N tertinggi iaitu 300 kg N/ha adalah lebih rendah daripada hasil (32.8 t/ha) yang didapati pada kadar 250 kg N/ha, walaupun tiada 'cubic relationship' ketara. Oleh itu, kadar N 250 kg/ha ialah yang paling sesuai untuk kubis cina di tanah gambut. Perbezaan hasil tidak ketara antara kadar K yang berlainan dalam kedua-dua penanaman. Kadar K pada 150 kg/ha boleh disyorkan untuk tanaman kubis cina di tanah gambut. Semua perlakuan dan faktor interaksi kedua dan ketiga tidak ketara. Analisis foliar yang dijalankan pada penanaman pertama tidak menunjukkan perbezaan antara kadar peratus N dan peratus K pada baja N dan K yang berlainan. Ini menguatkan keputusan penghasilan yang didapati. Berdasarkan purata 29 t/ha, anggaran pulangan bersih sehektar pada harga ladang RM0.50/kg dan RM0.90/kg ialah RM7 740.60 dan RM19 340.60 sehektar masing-masing.

Abstract

In 1998, Malaysia's net import of fresh and chilled vegetables was RM781 million, with chinese cabbage accounted for RM14 million. There is a need to reduce the loss in foreign exchange, especially so when the crop can be grown locally. Chinese cabbage is traditionally grown in the cool climate of the

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highlands in Sabah, Sarawak and Peninsular Malaysia. Suitable heat tolerant varieties have been identified but there is no local information on chinese cabbage production in the lowlands. The two identified varieties were further evaluated at three rates of nitrogen (N) and potassium (K) on peat. The replicated 2 x 3 x 3 factorial experiment was laid out in a RCB design, under netted structure, in MARDI Research Station, Kelang in late 1998 and repeated in 1999.

The Tropic Queen variety recorded a significant higher yield in the first crop but no varietal yield differences were detected in the second crop. The response to N was linear in the first crop. In the second crop, a higher N rate was added to confirm the results of the first crop. It was noted that the yield (31.7 t/ha) at the highest N rate of 300 kg N/ha, was lower than the yield (32.8 t/ha) obtained at 250 kg N/ha, though no distinct cubic relationship was noted. Nitrogen rate at 250 kg/ha is therefore the most appropriate rate for chinese cabbage on peat. No yield differences were detected between the various K rates in both crops. Potassium at 150 kg/ha can be recommended for chinese cabbage on peat. All the treatments and their second and third factor interactions were non-significant. Foliar analysis carried out only in the first crop, showed no differences in percentage N and percentage K for the different N and K rates. This confirmed the yield results obtained. Based on an average yield of 29 t/ha, the estimated net returns/ha at an ex-farm price of RM0.50/kg and RM0.90/kg were respectively RM7 740.60 and RM19 340.60 per hectare.

Introduction

Chinese cabbage (*Brassica rapa* L. cv. group chinese cabbage) is a native of China and is currently grown all over the world (Siemonsma and Piluek 1993). In 1998 Malaysia imported fresh and chilled vegetables worth RM781 million, with chinese cabbage accounted for RM14 million (Anon. 2000). There is a dire need to reduce this loss in foreign exchange, especially so when the crop can be grown locally. Temperate varieties of chinese cabbage are traditionally grown in the cool climate of the highlands in both Sabah, Sarawak and Peninsular Malaysia. However due to land shortage in Cameron Highlands coupled with encouragement from the government, most highland farmers have opted for the more lucrative production of temperate cut flowers.

The best option is to grow suitable heat tolerant/resistant varieties of chinese cabbage in the humid lowlands.

Even in the lowlands, suitable land for vegetable cultivation is limited due to rapid industrialization and expansion in the planting of perennial crops. This frequently resulted in vegetables being planted on marginal and problem soil like peat. Malaysian peat soil requires physical and chemical amelioration before it can be used for crop cultivation.

The introduction of netted structures has boosted the production of leafy and headed brassica like cabbage, chinese cabbage and broccoli (Leong and Lim 1994; Leong and Illias 1999). The netted structures prevent the entry of common Lepidopterous pests of brassica vegetables. As a result the vegetable products are generally cleaner and of better quality, with minimal pesticide residues than those obtained from open field planting.

Currently there is hardly any local information on chinese cabbage production in Malaysian lowlands. This study on nitrogen (N) and potassium (K) requirements was therefore conducted to further improve the yield of chinese cabbage, after having identified potential lowland varieties.

Materials and methods

From an earlier varietal evaluation conducted on six heat tolerant varieties of chinese cabbage, two varieties were found to have the potential for production in the lowlands (Anon. 1997). The identified varieties were Tropic Emperor and Tropic Queen, sourced from South Korea. Both varieties have high tolerance to bacterial soft rot disease, often the scourge of lowland production of headed brassica.

The trial was conducted on drained oligotrophic peat in Kelang, Selangor under netted structure, over two crops in different locations. The first and second crop was transplanted respectively in mid-December 1998 and late July 1999. Soil analysis was carried out prior to planting. The average N, soluble P and K cation for the first and second crop were respectively 1.14%, 27.0 ppm, 0.51 meq/100 g and 1.20%, 43.2 ppm, 0.43 meq/100 g). Seeds of the two identified varieties were sown in seedling trays and transplanted about 24 days later.

The two varieties were evaluated at three rates of N and K in the first crop. The 2 x 3 x 3 factorial experiment was laid out in a randomized complete block (RCB) design with three replications. The rates of N and K applied in kg/ha were:

- 150 N, 200 N, 250 N
- 150 K, 200 K, 250 K

The fertilizers used were ammonium sulphate, triple superphosphate (TSP) and muriate of potash to supply N, P and K respectively. The fertilizers were split applied equally at basal, 2 and 4 weeks after transplanting. TSP was applied at the standard rate of 40 P kg/ha in the basal application only. The fertilizers were thoroughly mixed into the soil in the basal application. In the first and second side application, the fertilizers were applied in a circle and between the chinese cabbage rows. In both applications, the plants were irrigated immediately to avoid leaf scorching. Whenever necessary, daily irrigation for half or an hour depending on the weather and soil condition, was carried out using micro-jet sprinklers.

The seedlings were transplanted onto raised beds measuring 0.9 m x 3.2 m with 0.8 m inter-bed furrows. The plot size was 5.4 m^2. The planting distance used was 45 cm x 45 cm. The common symptom of tip-burn associated with internal dry rot of the chinese cabbage head were rectified by frequent spraying of calcium sulphate solution at 0.025% concentration, during the head formation stage.

Based on the results obtained in the first crop, only the N rate was increased further to 300 kg/ha in the second crop. All the other factors remained the same as in the first crop. Similarly the 2 varieties, 4 rates of N and 3 rates of K were arranged in a 2 x 4 x 3 factorial, laid out in a RCB design with three replications. The same agronomic and cultural practices, as in the first crop, were used.

The soil pH in the experimental sites was raised to 5.5 using ground magnesium limestone, at 2.5 t/ha for every 0.15 pH unit increase (Chew et al. 1986). Liming was carried out at about 2 weeks before transplanting. Common trace elements were applied as a basal dressing together with the major nutrients, in accordance with Leong et al. (1985). Manual weeding was carried out whenever necessary.

Harvesting was carried out at about 45 days after transplanting. The following maturity index were also used as indicators for harvesting mature chinese cabbage heads:

- erect head on spreading lower leaves, which are almost parallel to the soil
- compact and firm heads when pressed gently with both hands.

Yield and head size were recorded. Foliar analysis for percentage N and percentage K was carried out only in the first crop, using composite samples from harvested heads.

Results and discussion

Yield

In the first crop, the Tropic Queen variety recorded significantly higher yield than Tropic Emperor though no varietal differences were detected in the second crop *(Table 1)*. However, the yields obtained were much higher in the second compared to the first crop. The differences in the varietal performances could be attributed to site and climatic factors *(Plate 1)*. The total rainfall received, for the whole growth duration of the chinese cabbage from transplanting to the last harvest, were 516 mm and 279 mm respectively for the first and second crop. It appeared that Tropic Queen performed better during the wet season. During the drier months, with good supplementary irrigation no differences were detected between the varieties. Despite the differences, Tropic Queen appeared to be more adaptable and recorded consistently high yields on lowland peat in tropical Malaysia, irrespective of the weather (*Plate 2*).

Table 1. Effects of varieties and fertilizer rates on marketable chinese cabbage yield

Treatment	First crop (t/ha)	Second crop (t/ha)
Variety		
Tropic Emperor	25.65	31.48
Tropic Queen	28.78	30.93
F test	*	N.S.
N rate (kg/ha)		
150	25.87	30.12
200	27.33	30.23
250	28.45	32.77
300	–	31.70
LSD (5%)	1.935	1.781
K rate (kg/ha)		
150	27.01	31.59
200	26.76	31.44
250	27.88	30.56
F test	N.S.	N.S.
Mean	27.21	31.20
SE	2.845	3.051
C.V. (%)	10.4	9.7

*significant at $p = 0.05$
N.S. = Not significant

Significant yield differences were detected among the different N rates in the first crop *(Table 1)*. Nitrogen rate at 250 kg/ha recorded a significantly higher yield than treatment at 150 kg N/ha. No difference was detected between 200 N and 250 N kg/ha. However the relationship obtained was linear. This suggested that increasing the N rate further from 250 N kg/ha can probably increase the yield. With this in mind the N rate was increased to 300 N kg/ha in the "repeat" second crop. The results obtained indicated no significant yield differences between 150 N, 200 N and 300 N kg/ha *(Table 1)*. No differences were detected between 250 N and 300 N kg/ha. However treatment at 250 N kg/ha yielded significantly higher than 150 N and 200 N kg/ha. It was noted that the absolute yield obtained from the highest N rate was lower than those from 250 N kg/ha, though no distinct cubic relationship was detected. The reduction in yield is more apparent from

Plate 1. General view of the chinese cabbage crop under netted structure on peat

Plate 2. Close-up of the Tropic Queen variety

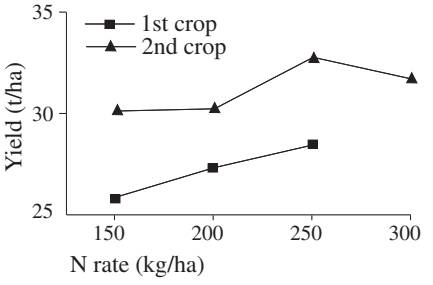

Figure 1. Yields of chinese cabbage over two crops

Figure 1. From the current study, N rate at 250 kg/ha is therefore the most appropriate rate for chinese cabbage on lowland peat under netted structure. This value corresponded well with the recommended N rate of 200 to 250 kg/ha for english cabbage, another headed brassica species, on Malaysian peat (Vimala and Chan 1997). No other information is available on the response of chinese cabbage to N and K rates in the hot humid tropics.

In Taiwan the recommended fertilizer rate for chinese cabbage is 210 N, 35 P and 49 K kg/ha (Anon. 1994). In contrast, the recommended rate for chinese cabbage in Bangladesh is only 69–115 N, 20–33 P and 60–100 K kg/ha (Islam and Haque 1992). In addition the Bangladesh farmers commonly applied 10 tons of cow-dung per ha. Elsewhere, Hill (1990) found that the fresh marketable head weight of chinese cabbage increased with increasing N up to 200 kg/ha. However Guillard and Allison (1988) noted that increasing N from 0 to 168 kg/ha increased chinese cabbage dry matter, while as little as 56 kg N/ha produced 95% of the dry matter produced with 224 kg N/ha. In Florida, Vavrina and Obreza (1993) similarly found the head weight of chinese cabbage increased by 14.2% as N was increased from 67 to 112 kg/ha, but only 5.0% as N increased from 112 to 157 kg/ha. Therefore the need for higher N rate at 250 kg/ha required by chinese cabbage on peat in Malaysia, is probably attributed to the absence of application of any organic fertilizer and the unpredictable weather. Frequent and unpredictable thunderstorms can cause severe leaching of the highly soluble ammonium sulphate fertilizer, the source of N in the current study.

No significant yield differences were detected between the different rates of K applied in both crops *(Table 1)*. The amount of K applied does not appear to be critical in determining the yield of chinese cabbage. This suggested that the lowest rate applied is more than sufficient for chinese cabbage on peat. Another possibility is the initial high K level in the soil, which probably had contributed to the crop K requirement. From the current study, the lowest rate at 150 K kg/ha is sufficient and can be recommended for chinese cabbage on lowland peat. However, future investigation should be carried out at lower rates than the recommended K rate for chinese cabbage.

No significant differences were noted between the two and three factors interaction in both crops.

Girth and height of harvested head

Generally no significant differences were detected between the varieties, N and K rates in the girth and height of the harvested heads, in the first and second crop *(Table 2)*. Significant differences between varieties were only detected in the second crop. The heads of Tropic Queen are longer but has a smaller girth than Tropic Emperor. The phenotypic expression could be attributed to varietal and environmental interaction. No interaction effect was noted between the two and three factors interaction.

The results suggested, that the head size of chinese cabbage were not influenced by different rates of N and K applied. Head size characteristics are innate traits of the individual variety and probably modified traits from interaction with the environment.

Nutrient content

The foliar analysis of percentage N and percentage K in the composite sample of the harvested heads was carried out only in the first crop. No significant differences in the

Table 2. Characteristics of head size of chinese cabbage

Treatment	1st crop		2nd crop	
	Girth (cm)	Height (cm)	Girth (cm)	Height (cm)
Variety				
Tropic Emperor	12.38	24.49	12.36	24.24
Tropic Queen	11.87	24.65	11.79	26.19
F test	N.S.	N.S.	*	*
N rate (kg/ha)				
150	12.13	24.52	11.90	25.16
200	12.56	24.73	11.93	25.33
250	11.71	24.47	12.05	25.21
300	–	–	12.37	25.16
F test	N.S.	N.S.	N.S.	N.S.
K rate (kg/ha)				
150	12.05	24.34	11.86	24.70
200	12.41	24.71	12.33	25.33
250	11.93	24.34	12.04	25.62
F test	N.S.	N.S.	N.S.	N.S.
Mean	12.12	24.57	12.08	25.21
SE	1.053	1.144	0.979	1.476
C.V. (%)	8.6	4.6	8.1	5.8

*significant at $p = 0.05$
N.S. = Not significant

Table 3. Foliar analysis of composite samples of cabbage head in the first crop

Treatment	Percentage N	Percentage K
Variety		
Tropic Emperor	4.16	5.66
Tropic Queen	3.83	5.24
F test	*	N.S.
N rate (kg/ha)		
150	3.92	5.60
200	4.08	5.34
250	3.99	5.42
F test	N.S.	N.S.
K rate (kg/ha)		
150	4.09	5.43
200	3.89	5.25
250	4.01	5.66
F test	N.S.	N.S.
Mean	4.00	5.45
SE	0.464	1.058
C.V. (%)	11.5	19.4

* significant at $p = 0.05$
N.S. = Not significant

percentage N and percentage K were detected between different N and K rates *(Table 3)*. The only significant difference in percentage N was detected between the varieties. The Tropic Emperor variety probably has a greater extracting ability for N than Tropic Queen. However the higher percentage N in Tropic Emperor was not reflected in the yield obtained *(Table 1)*. In fact Tropic Queen yielded significantly higher than Tropic Emperor.

The results showed that the amount of N and K applied in the study is sufficient in the production of chinese cabbage in lowland peat. No deficiency symptoms were noted in all the treatments. A higher percentage N in the foliar analysis does not necessarily record a higher yield.

Cost of production and return

The cost of production and return per ha of chinese cabbage is based on the estimation obtained from Anon. (1993). The estimated return was based on an average yield of 29

Table 4. Estimated return/ha of chinese cabbage at different ex-farm prices

Yield (t/ha)	Return	Income at different ex-farm prices (RM)	
		RM0.50/kg	RM0.90/kg
29	Gross	14 500.00	26 100.00
	Net	7 740.60 (4 360.90)	19 340.60 (15 960.90)
	Family labour	10 500.60 (8 500.90)	22 100.60 (20 100.90)

Figures in parenthesis indicate return based on 50% increase in materials and labour costs

t/ha at an ex-farm price of RM0.50 and RM0.90 per kg *(Table 4)*. The estimated net return/ha was good and competitive compared with other vegetable crops, with identical maturation period.

Conclusion

Suitable heat tolerant varieties of chinese cabbage can be successfully grown in lowland peat in hot humid Malaysia. Tropic Queen is the more suitable variety. The recommended fertilizer rate for Chinese cabbage, under netted structure, is 250 N, 40 P and 150 K kg/ha. Head size is not affected by the different rates of N and K, rather it is an innate characteristic of the individual variety. The net return/ha is high and very competitive compared to other vegetable crops. There is great potential to introduce chinese cabbage as a new lowland crop in Malaysia. The introduction would widen the choice of vegetables, suitable under netted structures, for local farmers.

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