J. Trop. Agric. and Fd. Sc. 38(2)(2010): 153–160

Effect of organic fertilizer on the yield and nutrient content of leaf-mustard (*Brassica juncea*) organically grown under shelter

[Kesan baja organik terhadap hasil dan kandungan nutrien sawi hijau (*Brassica juncea*) yang ditanam secara organik di bawah pelindung]

P. Vimala*, M.N. Mohamad Roff**, O. Ahmad Shokri*** and A.H. Lim*

Keywords: organic cultivation, leaf-mustard cultivars, processed poultry manure, residual effects

Abstract

Four rates of organic fertilizer (0, 15, 30, 45 t/ha) were evaluated on three leaf-mustard cultivars, organically grown under shelter. Yield responses to increasing rates of organic fertilizer for all the three cultivars showed a quadratic trend. The first cultivar (V1) is represented by the equation $Y = -0.0088x^2 + 0.6887x + 1.241$, where Y = yield in t/ha and x = organic fertilizer in t/ha. The optimum rate of organic fertilizer (processed poultry manure) was 39.1 t/ha. Yield obtained at this rate was 14.7 t/ha. For cultivar 2, the yield response is represented by the equation $Y = -0.0028x^2 + 0.2859x + 0.699$. The optimum rate of organic fertilizer was 51.1 t/ha. The yield at this rate was 8.0 t/ha. For cultivar 3, a quadratic relationship represented by the equation $Y = -0.0112x^2 + 0.7517x + 0.971$ was obtained. The optimum rate of organic fertilizer was 33.6 t/ha and the yield at this rate was 13.6 t/ha. Fertilizer rates had a significant effect on P, K, Mn, B, Cu and Zn. A second crop grown on plots with residual fertilizers only, gave yields ranging from 60% to 76% of yields from plots with fertilizer added.

Introduction

Leaf-mustard, locally known by the generic name *sawi* is the most popular leaf vegetable in Malaysia, occupying more than 3,000 ha (DOA 2006). Several cultivars differentiated by their stem colour, leaf size and flowering habits are grown locally.

Leaf-mustards are usually heavily sprayed with insecticides because they are susceptible to attack by insect pest such as *plutella* (Ho 1965). The heavy spraying of pesticide to control insect damage can result in residues exceeding permissible level, thus posing a health hazard to consumers (Ramasamy and Nursiah 1988; Ong 1990; Anon. 2001; NPHL 2005).

This study was an attempt to grow leaf-mustard organically i.e. without using any chemical pesticides and fertilizers. To avoid the use of pesticides, insect proof shelters were used. Organically grown vegetables are increasingly sought after by health conscious consumers. Presently organic products command premium prices, both locally and elsewhere. As little information exists on the organic fertilizer requirement of leaf-mustard, various rates of processed poultry manure were evaluated to determine

*Strategic Resources Research Centre, MARDI Headquarters, Serdang, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia
**Horticulture Research Centre, MARDI Headquarters, Serdang, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia
***Technical Services Centre, MARDI Headquarters, Serdang, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia
Authors' full names: Vimala Purushotaman, Mohamad Roff Mohd Noor, Ahmad Shokri Othman and Lim Ah Hong
E-mail: roff@mardi.gov.my

optimum rates under shelter. The residual effect of the organic fertilizer applied was also investigated.

Materials and methods

Field details

The experiment was conducted on clay soil under a tunnel shaped shelter with plastic roof and netted sides at MARDI Serdang. The chemical properties of the soil are presented in *Table 1*.

Three leaf-mustard cultivars, locally known as *sawi-bunga* (green-stem, long, large leaves, early flowering), *sawi-putih* (greenish-white stem, late flowering) and *sawi Hong Kong* (green-stem, short, small leaves, early flowering) were evaluated.

The organic fertilizer used was processed poultry manure (PPM) which was applied on the planted area (3 m x 1 m) at 0, 15, 30 and 45 t/ha as basal and worked into the soil. The chemical properties of the PPM are presented in *Table 2*. Four days after the organic fertilizer application, leaf-mustard seeds were sown along three furrows on the 3 m x 1 m plots. Seedlings were thinned at 2 weeks after sowing to give 30 plants/row or 90 plants/plot. With an inter-plot space of 0.2 m, the effective plot size used for calculating yield in t/ha was 3 m x 1.2 m.

Two plots were allotted for each treatment for the first crop. A second crop of leaf-mustard was grown with fertilizer added on one plot, and without fertilizer on the other plot, to investigate the effects of residual fertilizers on the yield of the second crop. The experiment was arranged in a randomized complete block design with five replicates for the first crop and three replicates for the second crop. The plants were watered using drip irrigation. Harvesting was at 40 days from sowing and fresh yields were recorded.

Table 1. Soil chemical properties

Soil properties	Values
N (%)	0.14
Sol. P (ppm)	20.90
CEC (meq/100 g)	8.52
Total carbon (%)	1.93
Ex. Ca (meq/100 g)	3.82
Ex. Mg (meq/100 g)	2.13
B (ppm)	3.68
Fe (ppm)	7191
Mn (ppm)	47.86

Table 2. Nutrient content in processed poultry manure (PPM)

Nutrient	Composition	40 t/ha PPM (kg/ha)	45 t/ha PPM (kg/ha)
N (%)	3.2	1280	1440
P (%)	2.9	1160	1305
K (%)	4.2	1680	1890
Ca (%)	14.3	5720	6435
Mg (%)	1.1	440	495
Organic C (%)	22.3		–
pH	7.1		–

Preparation of samples and chemical analysis

Plant samples were obtained from the first crop, for nutrient analysis. The samples were oven dried at 65 °C for 48 h to constant weight and ground for nutrient analysis. All chemical analyses were done at the Analytical and Quality Assurance Laboratory at MARDI Serdang using in-house methods. Plant nitrogen was extracted using the micro-Kjeldahl method and determined using an autoanalyser. The nutrients P, K, Ca, Mg, B, Fe and Mn were determined using the ICP optical emission spectrometer (ICPOES).

Statistical analysis

Data obtained were subjected to statistical analysis, using analysis of variance procedures to test the significant effect of all the variables investigated. Means were separated by the least significant difference (LSD) method using the statistical package of SAS Institute Inc. U.S.A.

Table 3. ANOVA for first crop yield of leaf-mustard

Source of variation	DF	Mean square	F-value	Significance
Replicate	4	2346042	5.44	**
Fertilizer	3	46942352	108.82	***
Cultivar	2	17873395	41.43	***
Fertilizer x cultivar	6	2151222	4.99	***

Results and discussion

First crop

Yield Significant fertilizer x cultivar interaction was observed in this study *(Table 3),* thus overriding the main effects of fertilizer and cultivar. Hence, the relationship between fertilizer applied and yield for each cultivar was investigated separately.

For the first cultivar (V1), a quadratic relationship represented by the equation $Y= -0.0088x^2 + 0.6887x + 1.241$ ($p = 0.01$) was obtained (*Figure 1a*), where Y = yield in t/ha and x = fertilizer applied in t/ha. The optimum rate of organic fertilizer was 39.1 t/ha. Yield obtained at this rate was 14.72 t/ha. Nutrients present at the optimum fertilizer far exceeds crop requirement as shown in *Table 2*, for 40 t/ha PPM. Dierolf et al. (2001) reported an availability of 20–50% from organic fertilizers. Studies on the availability to the crop from commonly used organic fertilizers under Malaysian conditions are suggested.

The second cultivar (V2) also showed a quadratic relationship represented by the equation, $Y= -0.0028x^2 + 0.2859x + 0.699$ ($p = 0.01$), where Y= yield (t/ha) and x = fertilizer applied (t/ha), as shown in *Figure 1b*. The optimum rate of organic fertilizer was 51.1 t/ha. The yield, however, was only 8.0 t/ha compared to the other two cultivars which gave higher yields at lower optimum organic rates *(Figure 1)*. The highest rate of fertilizer used i.e. 45 t/ha contains a tremendous amount of nutrients i.e. 1,440 kg N, 1,305 kg P, 1,890 kg K, 6,435 kg Ca and 495 kg Mg *(Table 2),* which should be more than sufficient for a short-term crop like leaf-mustard. Cultivar 2 (V2) thus appear to be less efficient in

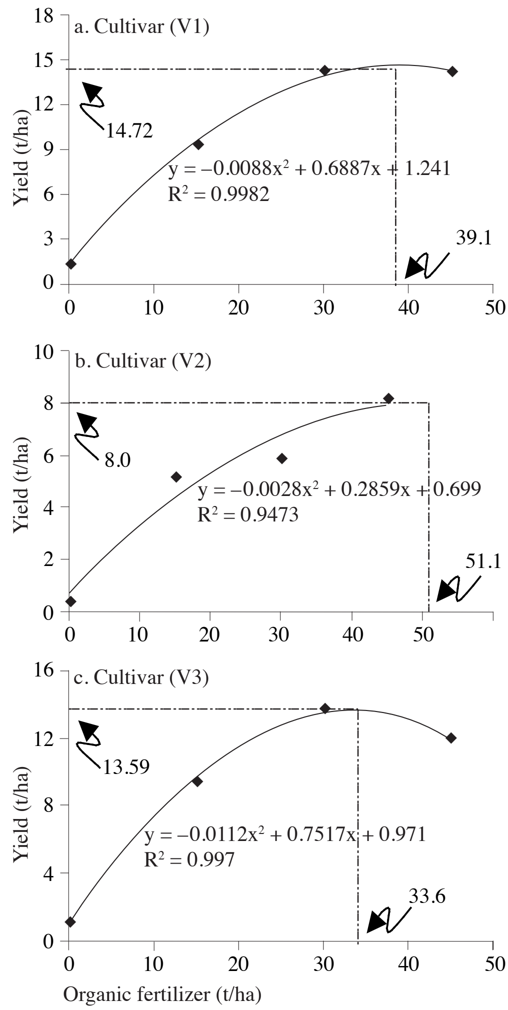

Figure 1. Effect of organic fertilizer rates on yield of leaf-mustard

Table 4. Macronutrient content of leaf-mustard

Fertilizer rates	Macronutrient content (%)				
	N	P	K	Ca	Mg
0	0.92a	0.16b	1.47b	3.21a	1.43a
15	1.34a	0.32b	2.17ab	2.08a	0.67a
30	1.54a	0.63a	3.15a	3.41a	1.06a
45	1.43a	0.57a	2.53ab	3.19a	0.95a
Mean	1.31	0.42	2.33	2.97	1.03
Significance	ns	**	*	ns	ns
Trend	–	Quadratic	Quadratic	–	–

nutrient absorption and growth, compared to cultivars 1 and 3 (*Figure 1*). Studies on the nutrient availability from organic fertilizers under Malaysian conditions and studies on the root structure of cultivar 2 may provide some answers to its slow response to increasing organic fertilizer rates.

With cultivar 3 (V3), a quadratic relationship represented by the equation, $Y = -0.0112x^2 + 0.7517x + 0.971$ ($p = 0.01$), where Y= yield (t/ha) and x = fertilizer applied (t/ha), was obtained, as shown in *Figure 1c*. The optimum rate of organic fertilizer was 33.6 t/ha and the yield at this rate was 13.59 t/ha.

Macronutrient content Nitrogen content increased from 0.92% to 1.54% when organic fertilizer increased from 0 to 30 t/ha but the increase was not significant (*Table 4*). Earlier studies on cabbage and bird-chilli, also did not show significant increase in N content with increasing rates of organic fertilizer (Vimala et al. 2006; 2007). The optimum rate of fertilizer i.e. 39.1 t/ha would theoretically contain 1,251 kg N/ha (3.2% N in PPM). Nitrogen mineralized from manures has been reported to vary from 30% of N from applied manure (Dierolf et al. 2001) to 61% (Hayami 1985).

In the absence of data on mineralization of poultry manure under local conditions, it is not possible to conclude on the quantity of N available to the crop of leaf-mustard. Fresh poultry manure decomposes rapidly and heavy applications can be detrimental to crops due to the production of organic acids or phenolic compounds (Matsuzaki 1977; Shiga 1997) but composted manure is reported to decompose slowly (Ushio et al. 1997). It is likely that the processed poultry manure used in this study provided N at a rate commensurate with crop demand as there was no significant increase in N content at the higher levels of application. Also no toxicity symptoms were seen at the highest level of application.

The P content showed a significant quadratic trend with increasing rates of organic fertilizer (*Table 4*). Phosphorus increased significantly from 0.16% at the zero fertilizer level to 0.63% at 30 t/ha PPM. Similar increase in P content from 0.34% to 0.59% was obtained when PPM application increased from 0 to 45 t/ha for cabbage outer-leaves (Vimala et al. 2006). The P content at 0 and 15 t/ha was below the critical leaf concentration of 0.35% cited by Scaife and Turner (1983).

The K content too showed a significant quadratic trend with increasing rates of organic fertilizer (*Table 4*). Potassium content increased significantly from 1.47% to 3.15% when PPM increased from 0 to 30 t/ha. Increasing PPM to 45 t/ha did not further increase the K content, indicating that there was no luxury consumption of K by leaf-mustard. Results obtained were contrary to the K accumulation reported for other vegetables (Maraikar et al. 1996; Vimala et al. 2006). For all rates from 15 t/ha PPM and higher, the K contents were above the critical leaf

Table 5. Micronutrient content of leaf-mustard

Organic fertilizer rates	Micronutrient content (ppm)			
	Mn	B	Cu	Zn
0	52.3c	5.4b	16.4b	74.9b
15	67.7bc	7.7b	18.4ab	89.0b
30	105.0a	12.6a	22.7a	150.3a
45	98.0ab	9.3ab	20.8ab	145.9a
Mean	80.7	8.7	19.5	115.0
Significance	**	*	*	**
Trend	Quadratic	Quadratic	Quadratic	Quadratic

concentration of 2.0% (Scaife and Turner 1983).

Calcium content ranged from 2.08% to 3.41% and did not differ significantly with treatments. A similar trend was observed for the outer-leaves of lowland cabbage grown under shelter (Vimala et al. 2006). Critical Ca concentrations have been reported to be very variable (Scaife and Turner 1983).

Like Ca, Mg content too did not differ significantly with increasing rates of organic fertilizer and ranged from 0.67% to 1.43%. Scaife and Turner (1983) and Maynard (1994) cited 0.2% Mg as critical leaf concentration for vegetables in general.

Micronutrient content Significant quadratic trends between rates of organic fertilizers applied and plant micronutrient contents were obtained (*Table 5*).

Manganese content increased significantly from 52.3 ppm to 105.0 ppm when PPM was increased from zero to 30 t/ha (*Table 5*). The Mn contents in this study were above the critical leaf concentration of 20.0 ppm for vegetables reported by Scaife and Turner (1983) and comparable to that obtained in previous studies (Vimala et al. 1999; 2006). As no Mn deficiency symptoms were observed, the concentrations obtained are deemed to be sufficient. Askew and Smith (1995) reported adequate Mn for cabbage as being between 15 and 100 ppm.

The B concentrations obtained were comparable to B concentrations obtained for other vegetables (Vimala et al. 1997; 1999; 2006) and are deemed to be in the sufficient range as no nutrient deficiency or toxicity symptoms were observed. According to Gupta and Cutcliffe (1984), B concentration up to 132 ppm was not toxic and deficiency symptoms were not evident at 16 ppm for cabbage. In this study, deficiency symptoms were not evident at even 5.4 ppm.

Copper content increased significantly from 16.4 ppm at zero fertilizer to 22.7 ppm at 30 t/ha organic fertilizer. Results obtained were comparable to leaf Cu contents reported for chilli and egg plant in earlier studies (Vimala et al. 1997). Scaife and Turner (1983) reported 5 ppm as the critical leaf concentration for vegetables, while Askew and Smith (1995) cited 4–100 ppm Cu as adequate for cabbage.

Zinc concentration increased significantly from 74.9 ppm to 150.3 ppm when PPM increased from zero to 30 t/ha and are comparable to results reported for other vegetables (Vimala et al. 1997).

Second crop

The analysis of variance for yield of the second crop is presented in *Table 6*. Significant effects of treatments and added fertilizer were obtained. Interaction effects for cultivar x treatment and treatment x fertilizer added were also significant. The significant interaction effects obtained could be due to varying nutrient uptake abilities of the three cultivars.

Yields obtained from the residual fertilizer plots and plots with added fertilizer are presented in *Figure 2*. It is interesting to note that yield in the residual fertilizer

Table 6. ANOVA for second crop yield of leaf-mustard

Source of variation	DF	Mean square	F-value	Significance
Replicate	2	1063238	4.10	*
Cultivar	2	545298	2.10	ns
Treatments	3	36064050	138.16	**
Fertilizer added	1	17789618	68.55	**
Cultivar x treatment	6	802643	3.09	*
Cultivar x fertilizer added	2	451237	1.74	ns
Treatment x fertilizer added	3	2241121	8.64	**
Cultivar x treatment x fertilizer added	6	287663	1.11	ns

Table 7. Cost of unit N from urea and poultry manure

Fertilizer	% N	Fertilizer cost (RM/t)	kg N/t	Unit cost of N (RM/kg N)
Urea	46	800	460	1.74
Processed poultry manure	3.2	500	32	15.63

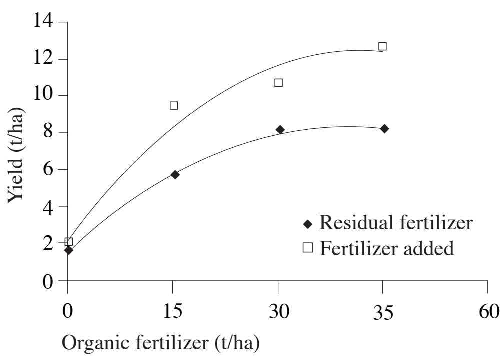

Figure 2. Effect of residual and added organic fertilizer on the yield of leaf-mustard

plots were 60–70% of yields obtained from fertilizer added plots, indicating the possibility of substantially reducing organic fertilizer input for successive short-term vegetables like leaf-mustard. Earlier studies showed varying yield reductions from residual fertilizers depending on source of organic fertilizer and soil type (Vimala et al. 2000; 2001; 2002). However, how much should the rate of organic fertilizer be reduced for successive crops, without compromising yield and quality, is presently a matter of conjecture. Answers need to be obtained for organic farming through long term research on successive crops grown on various soil types. As organic fertilizers are expensive per unit nutrient *(Table 7)* compared to inorganic fertilizer (RM15.63 vs RM1.74/kg N), the cost savings to the organic grower can be tremendous if he can apply reduced amounts of organic fertilizer for successive crops, and yet sustain yields.

Conclusion

The optimum rate of fertilizer for organic cultivation of leaf-mustard ranged from 34 to 51 t/ha processed poultry manure depending on the cultivar used. Yields obtained ranged from 8 to 15 t/ha. For the second crop, residual fertilizer gave 60–70% of the yield of fertilizer applied plots, indicating the possibility of reducing the rate of organic fertilizer for subsequent crops. Long term studies on the organic fertilizer requirement of successive crops need to be conducted to determine the quantum of reduction for successive crops.

Acknowledgement

The authors thank Ms Rubiah and Mr Fadzerun for field assistance.

References

Anon. (2001). Monitoring of pesticide residue in some highland and lowland vegetables in Sabah. Annual Research Progress Reports 2001. Department Agriculture Sabah, Malaysia

Askew, D.J. and Smith, I.E. (1995). Leaf nutrient norms and crop removal figures for cabbage in the Umlaas River Valley, Kwa Zulu-Natal. *J. of the S. African Soc. for Hort. Sc.* 5(2): 91–95

Dierolf, T., Fairhurst, T. and Mutert, E. (2001). Soil Fertility Kit. *A toolkit for acid, upland soil fertility management in Southeast Asia*. 149 p. Food and Agriculture Organisation: PT Jasa Katom; Potash and Phosphate Institute (PPI) and Potash and Phosphate Institute of Canada (PPIC)

DOA (2006). *Crop hectarage statistics, P. Malaysia*. Kuala Lumpur: Dept. of Agric. Malaysia

Gupta, U.C. and Cutcliffe, J.A. (1984). Effects of applied and residual boron on the nutrition of cabbage and field beans. *Can. J. Soil Sci. 64:* 571–576

Hayami, K. (1985). Characteristics regarding decomposition of organic materials. Research report (No. 166) of Secretariat of Agriculture, Forestry and Fisheries Research Council, p. 20–24

Ho, T.H. (1965). The life history and control of diamondback moth in Malaysia. *Bulletin No. 118:* 26 p., Kuala Lumpur: Ministry of Agriculture Malaysia

Maraikar, S. Wijewardena, J.D.H. and Amarasiri, S.L. (1996). Improving productivity of vegetable cultivation in Ultisols of Sri Lanka. Managing soil fertility for intensive vegetable production systems in Asia. *Proceedings of International Conference,* 4–10 Nov. 1996. Tainan, (Morris, R.A., ed.), p. 270–282. AVRDC/FFTC

Matsuzaki, T. (1977). Studies on the utilization of animal waste in agriculture. *Bull. Agricultural Research Institute of Kanagawa Prefecture* 118: 1–38

Maynard, A.A. (1994). Protecting ground water while recycling nutrients. *Biocycle* 35(5): 40

NPHL (2005). National Public Health Laboratory Report, Ministry of Health, Malaysia

Ong, S.H. (1990). Degradation of endosulfan and permethrin on sawi, *Brassica rapa* (L.) – implications on insect management. *Proc. 3rd. International Conf. on Plt. Prot. in the Tropics,* 20–23 Mar. 1990, Genting Highlands, p. 55–61. Kuala Lumpur: MPPS

Ramasamy, S. and Nursiah, M.T.A. (1988). A survey of pesticide use and associated incidence of poisoning in Peninsular Malaysia. *J. Pl. Prot. in the Tropics* 5: 1–9

Scaife, A. and Turner, M. (1983). Diagnosis of mineral disorders in plants. In: *Vegetables*, Vol. 2, (Robinson, J.B.D. ed.). London: HMSO

Shiga, H. (1997). The decomposition of fresh and composted organic materials in soil. *Extension Bulletin* 447: 1–14

Ushio, S., Suzuki, N. and Nakajima, N. (1997). Evaluation of quality of livestock manure compost for efficient utilization (4). *Abstract of the Annual meeting of Japanese Society of Soil Science and Plant Nutrition* 43: 359

Vimala, P., Aziz, B., Ong, H.K., Salbiah, H. and Ibrahim, B. (2002). Sustaining acid sulphate soils for vegetable production. *Proc. International symposium on sustainable land management,* (Theme: Paradigms for the new millennium), 8–10 Aug. 2000, Kuala Lumpur, (Shamsuddin, J., Hamdan, J. and Samsuri, A.W., eds.), p. 173–184. Kuala Lumpur: MSSS

Vimala, P., Illias, M.K., and Salbiah, H. (2006). Effects of rates of organic fertilizer on growth, yield and nutrient content of cabbage (*Brassica oleracea* var. *capitata*) grown under shelter. *J. Trop. Agric. and Fd. Sc.* 34(1): 17–25

Vimala, P., Illias, M.K., Yeong, N.H. and Salbiah, H. (1997). Nutrient uptake studies on broccoli (*Brassica oleracea* var. *italica*) grown on peat. *J. Trop. Agric. and Fd. Sc.* 25(1): 9–14

Vimala, P., Mah, S.Y., Roff, M.N., Wan Rubiah, W.A. and Salbiah, H. (2000). Yield and growth performance of organically grown bayam (*Amaranthus* sp.) *Transactions of the Malaysian Soc. of Plt. Physio.* 9: 273–276

Vimala, P., Melor, R., Ahmad Shokri, O. and Balasubramaniam, P. (2007). Effect of organic and inorganic fertilizers on growth, yield and nutrient content of bird chilli (*Capsicum frutescence*). *J. Trop. Agric. and Fd. Sc.* 35(1): 29–40

Vimala, P., Salbiah, H. and Zahrah, T. (1999). Micronutrient content and uptake by vegetables in Malaysia. *Proc. of the International Workshop on Micronutrients in Crop Production,* 8–13 Nov. 1999. Taipei: FFTC

Vimala P., Salbiah, H., Zahrah, T. and Ruwaida, M. (2001). Yield responses of fertilizers to organic fertilizers. *J. Trop. Agric. and Fd. Sc.* 29(1): 17–27

Vimala, P., Yeong, N.H. and Salbiah, H. (1997). Nutrient content and uptake by some fruit vegetables in Malaysia. *Proc. of International Conference*, (Theme: Managing soil fertility for intensive vegetable production systems in Asia), 4–10 Nov. 1996, Tainan, Taiwan (Morris, R.A., ed.), p. 47–57. Tainan: AVRDC/FFTC

Abstrak
Baja organik telah diuji pada kadar 0, 15, 30 dan 45 t/ha terhadap hasil tiga kultivar sawi yang ditanam secara organik di bawah perlindungan hujan. Bagi kultivar pertama (V1), perhubungan antara hasil dengan kadar baja organik adalah kuadratik, $Y = -0.0088x^2 + 0.6887x + 1.241$ (Y = hasil dalam t/ha dan x = baja organik dalam t/ha). Kadar baja organik optimum ialah 39.1 t/ha. Hasil pada kadar ini ialah 14.7 t/ha. Bagi kultivar 2, perhubungan antara hasil dengan kadar baja organik ialah, $Y = -0.0028x^2 + 0.2859x + 0.699$. Kadar baja organik optimum ialah 51.1 t/ha. Hasil pada kadar ini ialah 8.0 t/ha. Bagi kultivar 3, perhubungan antara hasil dan kadar baja organik adalah kuadratik, $Y = -0.0112x^2 + 0.7517x + 0.971$. Kadar baja organik optimum ialah 33.6 t/ha dengan hasil pada kadar ini ialah 13.6 t/ha. Kadar baja organik menunjukkan kesan signifikan untuk kandungan P, K, Mn, B, Cu dan Zn. Tanaman musim kedua ke atas plot mengandungi baja sisa memberi hasil antara 60% hingga 76% daripada hasil yang diperoleh dari plot berbaja tambahan.

Accepted for publication on 25 August 2010