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Yield responses of vegetables to organic fertilizers

(Penghasilan sayur-sayuran dengan baja organik)

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Key words: tomato, cabbage, brinjal, *Amaranthus*, lettuce, poultry manure, composts

Abstrak

Matlamat utama kajian ini adalah untuk memperoleh syor pembajaan bagi penanaman sayur-sayuran secara organik. Sebanyak tiga percubaan telah dijalankan untuk mengkaji kesan pembajaan organik terhadap hasil sayur.

Percubaan pertama menggunakan tahi ayam (PM) pada kadar 0, 13.3, 26.7, 39.9, 53.2 dan 66.5 t/ha pada tomato *(Lycopersicon esculentum)*, kubis *(Brassica oleracea* var. *capitata)* dan terung *(Solanum melongena)* di tanah gambut. Baja tak organik ($N:P_2O_5:K_2O:MgO$ =12:12:17:2) diguna pada kadar 2 t/ha sebagai rawatan kawalan. Hasil tomato bertambah daripada 4 t/ha kepada 31 t/ha apabila kadar PM ditambah daripada 0 kepada 66.5 t/ha. Perhubungan linear, Y = 9.70 + 0.35 PM telah diperoleh untuk tomato. Apabila menggunakan baja tak organik pada kadar 2 t/ha, hasil tomato yang diperoleh ialah 24 t/ha. Untuk mendapatkan hasil sebanyak ini, 40 t/ha tahi ayam perlu digunakan. Hasil kubis bertambah daripada 6 t/ha kepada 25 t/ha apabila tahi ayam ditambah daripada 0 kepada 53.2 t/ha. Perhubungan antara hasil kubis dengan kadar tahi ayam adalah kuadratik, $Y = 6.02 + 0.61\ PM - 0.01\ PM^2$. Baja tak organik pada kadar 2 t/ha memberi hasil terung 28 t/ha. Hasil terung bertambah daripada 3 t/ha kepada 46 t/ha apabila tahi ayam ditambah daripada 0 kepada 66.5 t/ha. Perhubungan antara hasil terung dengan kadar tahi ayam adalah linear, Y = 8.95 + 0.58 PM. Hasil terung daripada baja tak organik pada kadar 2 t/ha ialah 37 t/ha. Untuk mendapat hasil terung yang sama, petani sayur organik perlu membubuh baja tahi ayam sebanyak 48 t/ha.

Percubaan kedua membandingkan tahi ayam yang sudah diproses dengan tahi ayam biasa pada kadar 6.7, 13.4 dan 20.1 t/ha terhadap tanaman bayam di tanah gambut. Tiada perbezaan yang ketara antara kedua-dua jenis baja organik ini. Perhubungan hasil bayam dengan kadar tahi ayam ialah linear. Pada kadar 20.1 t/ha tahi ayam, hasil bayam yang diperoleh ialah 20 t/ha. Tanaman bayam kedua daripada baki baja memberi hasil 14 t/ha.

Percubaan ketiga membandingkan jenis-jenis baja organik terhadap tanaman salad yang ditanam di tanah lom tanah liat di Cameron Highlands. Tahi ayam memberi hasil tinggi, berbanding dengan tiga baja organik lain iaitu kompos cacing, kompos tahi ayam + serbuk kayu, dan kompos serbuk kayu + tahi ayam + sekam padi.

Sebagai kesimpulan, tahi ayam sama ada diproses atau tidak ialah baja organik yang paling sesuai digunakan untuk tanaman sayur pada masa ini. Kadar yang disyorkan lebih kurang 40–50 t/ha untuk tomato, kubis dan terung di tanah

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gambut manakala 20 t/ha untuk bayam di tanah gambut dan 20 t/ha untuk salad di tanah lom tanah liat, Cameron Highlands.

Abstract

The main objective of the paper is to obtain yield response data to organic sources and rates and subsequently to provide guidelines for organic vegetable cultivation in Malaysia. Three experiments were conducted to investigate the effect of organic fertilizers on vegetables.

In the first experiment, poultry manure (PM) at 0, 13.3, 26.7, 39.9, 53.2 and 66.5 t/ha were applied to tomato (*Lycopersicon esculentum*), cabbage (*Brassica oleracea* var. *capitata*) and brinjal (*Solanum melongena*) grown on peat. Inorganic fertilizer ($N:P_2O_5:K_2O:MgO$ =12:12:17:2) at 2 t/ha was used as control. Tomato yield increased from 4 t/ha to 31 t/ha when PM was increased from 0 to 66.5 t/ha. A linear yield response to PM was obtained, represented by the equation, Y= 9.70 + 0.35 PM where Y=yield and PM=poultry manure in t/ha. Applying 2 t/ha inorganic fertilizer gave tomato yield of 24 t/ha. To get this yield under organic farming, 40 t/ha of PM need to be applied. For cabbage, yields increased from 6 t/ha to 25 t/ha when PM was increased from 0 to 53.2 t/ha. The yield response was quadratic represented by the equation, Y= 6.02 + 0.61 PM - 0.01 PM^2. Applying inorganic fertilizer at 2 t/ha gave cabbage yield of 28 t/ha. Brinjal yields increased from 3 t/ha at 0 PM to 46 t/ha at 66.5 t/ha PM. A linear yield response represented by the equation, Y = 8.95 + 0.58 PM was obtained. Yields obtained with inorganic fertilizer at 2 t/ha, was 37 t/ha. To get yields equivalent to the inorganic application, the organic grower has to apply 48 t/ha PM.

In the second experiment comparing processed (PPM) and unprocessed poultry manure (PM) at 6.7, 13.4 and 20.1 t/ha on *Amaranthus* (bayam) grown on peat, no significant yield difference was obtained between PM and PPM. A linear yield response to rate of organic fertilizer applied was obtained. Yields obtained at 20.1 t/ha PM was 20 t/ha for the first crop and 14 t/ha for the residual crop.

In the third experiment, on lettuce grown in Cameron Highlands on clay loam soil, PM was superior to three other compost evaluated, namely wormcompost, PM + sawdust compost, and PM + sawdust + rice husk compost.

It is concluded that PM whether processed or unprocessed is the most suitable organic fertilizer presently available for organic vegetable cultivation. Recommendations would be about 40–50 t/ha for tomato, cabbage and brinjal on peat soil, 20 t/ha for *Amaranthus* on peat soil and 20 t/ha for lettuce in Cameron Highlands on clay loam soil.

Introduction

Vegetables are nutrient demanding crops, removing 60 kg/ha to over 300 kg/ha each of N and K and lesser amounts of the other nutrients (Vimala and Joseph 1977; Vimala et al. 1980; Vimala and Cheah 1980; Vimala et al. 1990; Vimala et al. 1996a, b). Inorganic fertilizers ($N:P_2O_5:K_2O:MgO$ = 12:12:17:2) applied at 1–3 t/ha, or organic plus inorganic fertilizers applied on the less fertile soil fulfill the nutrient requirement for the most demanding vegetable crops (Vimala, Zaharah et al. 1990; Vimala and Zaharah 1992; Vimala and Chan 1997). In the highlands, large amounts of organic and inorganic fertilizers are used (Vimala 1976).

In organic vegetable cultivation, which is gaining popularity in Malaysia, inorganic

fertilizers are not used. The organic grower has to depend purely on organic fertilizer sources which are not fortified. These organic sources are invariably low in nutrient contents. Inevitably, large quantities need to be applied to provide all the nutrients required for the growth and yield of vegetables. The organic grower, if he does not produce his own compost, has to depend on the few organic sources available in the market. Some of the organic sources can be of dubious or low quality as organic fertilizers (Vimala et al. 1999; Vimala, Mah, Roff, Wan Rubiah et al. 2000; Vimala, Mah, Roff, Ong et al. 2000). The optimum rates and types of organic fertilizers for organic vegetable cultivation have yet to be documented in Malaysia.

This paper presents the yield responses of vegetables to poultry manure (PM) and a few other organic sources. Information obtained is intended to serve as a guide to the fertilizer requirement of vegetable crops under organic farming.

Materials and methods

Experiment 1. Response of cabbage, tomato and brinjal to poultry manure

In this experiment on peat at MARDI Jalan Kebun, poultry manure (PM) was tested on cabbage, tomato and brinjal at the rates of 13.3, 26.7, 39.9, 53.2 and 66.5 t/ha. Half of the PM was applied as basal, the other half was applied in between the plants at 1 month after transplanting and worked carefully into the soil. Plot size, inclusive of walking space, was 4 m x 1.5 m. The actual rates of PM applied per plot were 0, 8, 16, 24, 32 and 40 kg/plot applied on the planted area (1 m x 4 m). For the inorganic treatment, inorganic fertilizer ($N:P_2O_5:K_2O:MgO$ = 12:12:17:2) at 1 200 g/plot or 2 t/ha was applied in 3 split applications i.e. as basal, 4 weeks and 7 weeks after transplanting. A control treatment without any organic or inorganic fertilizer was also included.

One-month-old seedlings of tomato (MT 11), and cabbage (EIYU) were transplanted at a distance of 0.6 m x 0.5 m to give 12 plants/plot. Brinjal (Mte 1) was planted in triangular planting to give 9 plants/plot. Poultry manure (20–25% moisture) was applied for each crop at the same rates. All the crops were grown on the same plot successively in the order of tomato, cabbage, brinjal. Routine agronomic practices for disease and pest control were followed.

Experiment 2. Response of Amaranthus **(bayam)** *to processed poultry manure (PPM) and unprocessed poultry manure (PM)*

In this experiment, also on peat, raw dry PM and PPM were compared at 6.7, 13.4, 20.1 t/ha, together with inorganic fertilizer ($N:P_2O_5:K_2O:MgO$ = 12:12:17:2) at 0, 166.7, 333.3 kg/ha in a 2 x 3 x 3 factorial, on *Amaranthus* (bayam) grown on peat. Plot size used was 2 m x 1.5 m inclusive of walking space. The actual fertilizers applied were 2, 4 and 6 kg PM and 0, 50, 100 g inorganic fertilizer on the planting area of 2 m x 1 m. The organic sources were broadcast on the plots and worked into the top 15 cm of soil. *Amaranthus* (pointed leaf cultivar) seeds were sown at 20 cm x 10 cm to give 80 plants/plot, after thinning. Inorganic fertilizer was applied in between the planting rows at 16 days from sowing. The plants were harvested at 30 days from sowing. A second crop was grown without further addition of organic or inorganic fertilizers.

Experiment 3. Response of lettuce to various organic fertilizers

In the third experiment conducted in Cameron Highlands, several organic sources, namely wormcompost, a commercially prepared compost (poultry manure + sawdust + bacterial sprays) and another compost (poultry manure + sawdust + rice husk) were compared at 26.7, 53.4, 80.1 and 106.8 t/ha. Poultry manure was used on the control plot.

The organic nutrient sources were applied at 20, 40, 60 and 80 kg/plot (5 m x 1.5 m), with and without inorganic fertilizer ($N:P_2O_5:K_2O:MgO$ = 12:12:17:2) at 1.5 t/ha. The organic sources were applied as basal and the inorganic fertilizer was applied in 2 split applications. One-month-old lettuce seedlings were transplanted 5 days after the application of poultry manure. Harvesting was done at 60 days from transplanting.

All the three experiments were arranged in a Randomized Complete Block Design with 3 replications.

Some chemical properties of the experimental site is given in *Appendix 1.* Nutrient contents of the organic sources are presented in *Appendix 2.* Details of the 3 experiments are summarized in *Table 1* for easy reference.

Results and discussion

Experiment 1. Yield response of tomato, cabbage and brinjal on peat to poultry manure (PM)

All the fertilized plots gave significantly higher yields than the unfertilized plots for the three vegetables. The inorganic fertilizer plots yielded 14.2 kg (23.7 t/ha), 16.7 kg (27.8 t/ha) and 22.2 kg (37.0 t/ha) for tomato, cabbage and brinjal, respectively.

Tomato yields increased significantly by 350% from 2.4 kg/plot (4 t/ha) at 0 PM to 10.9 kg/plot (18.2 t/ha) at 13.3 t/ha PM *(Table 2)*. Yields reached 18.4 kg/plot (30.7 t/ha) at the highest level of PM, but was not significant beyond 39.9 t/ha PM. Stoffella and Graetz (1966) reported tomato yield increase of 455% from 2.2 t/ha at 0 compost to 12.2 t/ha when sugarcane filter cake was applied at 224 t/ha. Yield/plant and yield/plot showed the same trend of increase with higher PM applications. The fruit number per plant increased significantly from 7.9 at 0 PM to 43.8 at 66.5 t/ha PM. There was no significant effect of increasing PM on average fruit weight, though fertilized plots gave bigger fruits than the control plot. The yield response was linear, represented by the equation Y = 9.70 + 0.35 PM, where Y = yield in t/ha and PM = poultry manure in t/ha *(Figure 1).* To obtain yields comparable to inorganic fertilizer application, 40 t/ha PM is required.

Increasing levels of PM increased the yields of cabbage significantly from 3.8 kg/plot (6.3 t/ha) at 0 PM to 11.9 kg/plot (19.8 t/ha) at 26.6 t/ha PM *(Table 3)*. Further

Table 1. Summary of experiments

Experiment	Soil type	Crop	Organic fertilizer tested	Organic fertilizer rate (t/ha)	Inorganic fertilizer rate
1	Peat	a) Cabbage b) Tomato c) Brinjal	a) Poultry manure	0, 13.3, 26.7, 39.9, 53.2 and 66.5	2 t/ha
2	Peat	*Amaranthus*	a) Poultry manure b) Processed poultry manure	6.7, 13.4 and 20.1	0, 166.7 and 333.3 kg/ha
3	Clay loam	Lettuce	a) Wormcompost b) Poultry manure + sawdust + bacterial spray compost c) Poultry manure + sawdust + rice husk compost d) Poultry manure	26.7, 53.4 80.1 and 106.8	a) 0 t/ha b) 1.5 t/ha

Table 2. Yield of tomato at various rates of poultry manure

Poultry manure (t/ha)	Yield (kg/plot) (4 m x 1.5 m)	Yield increase (%)	Yield (kg/plant)	Fruit no./plant	Avg. fruit wt. (g)
0	2.42d	–	0.24d	7.86c	30.55
13.3	10.90c	350	1.01c	31.27b	33.41
26.6	12.93bc	434	1.14bc	31.71ab	35.92
39.9	16.49ab	581	1.54ab	36.77ab	42.10
53.2	15.73ab	550	1.39bc	36.28ab	38.52
66.5	18.40a	660	1.87a	43.83a	41.94
NPK	14.20bc	487	1.34bc	33.43ab	39.67
Mean	13.01		1.22	31.59	37.44
CV (%)	16.86		19.17	15.39	12.99
Significance	**		**	**	ns

Values with different letters are significantly different
** = Significant at 1%
ns = Not significant

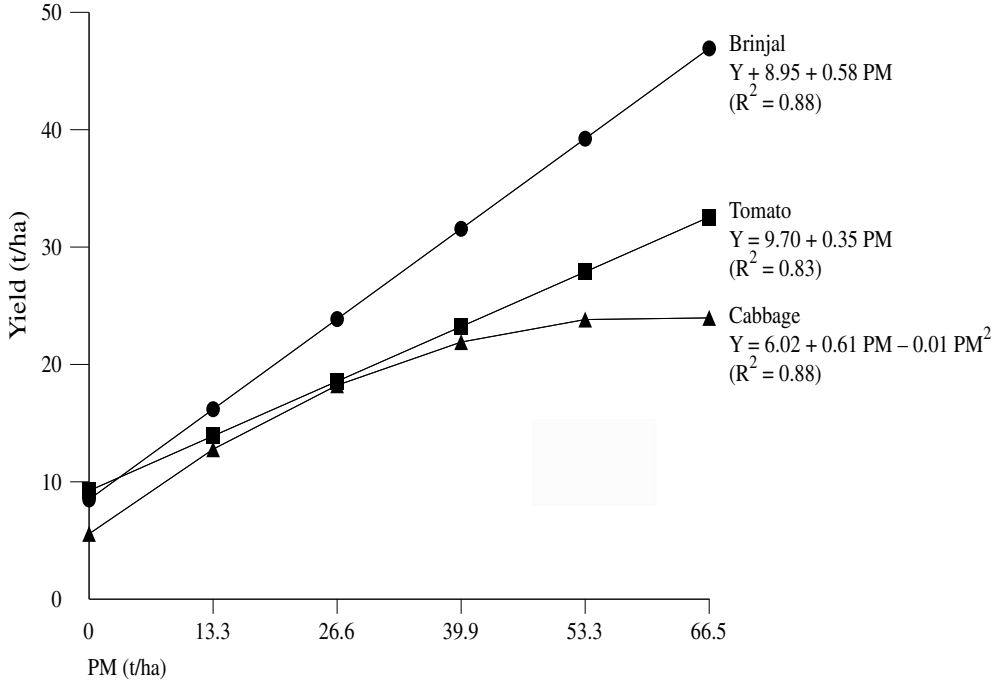

Figure 1. Yield of tomato, cabbage and brinjal at various rates of poultry manure (PM)

increase in yield, with higher PM applications was insignificant. The yield (t/ha) response to PM (t/ha) was quadratic represented by the equation $Y = 6.02 + 0.61 PM - 0.01 PM^2$ *(Figure 1).* The average head weight increased significantly from 0.32 kg at 0 PM to 1.20 kg at 39.9 t/ha PM *(Table 3).*

Brinjal yields increased significantly from 1.6 kg/plot (2.7 t/ha) at 0 PM to 27.3 kg (45.5 t/ha) at 66.5 t/ha PM *(Table 4).* The average yield/plant increased significantly from 0.18 kg/plant at 0 PM to 3.3 kg/plant

Table 3. Yield of cabbage at various rates of poultry manure

Poultry manure (t/ha)	Yield (kg/plot) (4 m x 1.5 m)	Yield increase (%)	Avg. head wt. (kg)
0	3.83b	–	0.32c
13.3	7.32b	91	0.76b
26.6	11.88a	210	1.01ab
39.9	12.93a	238	1.20a
53.2	14.92a	290	1.24a
66.5	14.52a	279	1.18a
NPK	16.72a	336	1.35a
Mean	11.73		1.01
CV (%)	21.4		18.3
Significance	**		**

Values with different letters are significantly different
** = Significant at 1%

Table 4. Yield of brinjal at various rates of poultry manure

Poultry manure (t/ha)	Yield (kg/plot) (4 m x 1.5 m)	Yield increase (%)	Yield (kg/plant)	Fruit no./plant	Avg. fruit wt. (g)
0	1.60c	–	0.18d	3.22c	54.50c
13.3	10.82bc	576	1.20c	21.48b	55.92bc
26.6	19.87ab	1142	2.21b	36.07a	61.21bc
39.9	20.13ab	1158	2.24b	34.82a	64.08ab
53.2	21.64ab	1253	2.65ab	41.34a	63.54ab
66.5	27.33a	1608	3.26a	45.70a	71.24a
NPK	22.20ab	1288	2.53ab	40.24a	62.38bc
Mean	17.66		2.04	31.8	61.84
CV (%)	35.49		24.75	19.1	7.19
Significance	*		**	*	*

Values with different letters are significantly different
* = Significant at 5%
** = Significant at 1%

at 66.5 t/ha PM. No significant increase in fruit number/plant after the 26.6 t/ha PM level was obtained, indicating that the significant yield increase per plant at higher rates of PM is due to increase in fruit weight. The average fruit weight increased from 54.5 g at 0 PM to 71.2 g at 66.5 t/ha PM *(Table 4).*

The yield in t/ha *(Figure 1)* shows a linear response to PM (t/ha) represented by the equation Y = 8.95 + 0.58 PM. Stoffella et al. (1996) reported bell pepper (same family as brinjal) yield increase of 53% from 19.8 t/ha at 0 compost to 30.3 t/ha when sewage sludge/yard-trimming compost was applied at 134 t/ha, while Roe et al. (1997) reported bell-pepper yield increase of 88% from 13.9 t/ha at 0 compost to 26.1 t/ha at 134 t/ha compost. From *Figure 1,* 48 t/ha of PM is required for yields (37 t/ha) comparable to inorganic fertilizer application.

Two tonnes of the inorganic compound fertilizer would cost the grower RM2 400, while 48 t PM at a price of RM100/t would cost the grower RM4 800 or more, if the additional labour cost incurred in the organic application is considered. The organic grower therefore, must of necessity, sell his produce at a higher price to stay in business.

Experiment 2. Yield response of Amaranthus on peat to processed and unprocessed PM

There was no significant difference between processed and unprocessed PM *(Table 5)*. Both the main crop and the residual crop showed response to only organic rate. The significant linear yield response obtained, indicate that with higher rates of organic fertilizer, higher yields are possible.

The mean yield was 5.98 kg/plot (19.9 t/ha) and the mean yield obtained with the residual crop was 4.34 kg/plot (14.47 t/ha) *(Table 6).* Plant height showed a significantly higher yield with unprocessed poultry manure in the first crop but not in

Table 5. ANOVA and contrast for effect of processed poultry manure and unprocessed poultry manure on the yield of *Amaranthus* - 1st crop and residual crop

Source of variation	DF	Mean square	F-value	Significance
1st Crop				
Organic rate (OR)	2	54.90	22.11	**
Organic source (OS)	1	0.31	0.13	ns
NPK rate	2	4.81	1.94	ns
OR x NPK rate	2	0.42	0.17	ns
OS x NPK rate	2	3.77	1.52	ns
OR x OS x NPK rate	4	3.76	1.51	ns
Contrast				
OR linear	1	105.75	42.60	**
OR quadratic	1	4.04	1.63	ns
Residual crop				
Organic rate (OR)	2	53.05	39.46	**
Organic source (OS)	1	3.84	2.86	ns
NPK rate	2	4.03	3.00	ns
OR x OS	2	0.33	0.25NS	
OR x NPK rate	4	4.26	3.17	*
OS x NPK rate	2	0.77	0.58	ns
OR x OS x NPK rate	4	0.69	0.51	ns
Contrast				
OR linear	1	106.09	78.91	**
OR quadratic	1	0.01	0.01	ns

* = Significant at 5% level
** = Significant at 1% level
ns = Not significant

Table 6. Growth and yield of *Amaranthus* with processed and unprocessed poultry manure

Types of poultry manure	Yield (kg/plot 2 m x 1.5 m)		Yield reduction of 2nd crop (%)	Height (cm)	
	1st crop	2nd crop (residual)		1st crop	2nd crop
Unprocessed	6.06	4.61	24	58.57	50.65
Processed	5.90	4.08	31	53.46	48.31
Mean	5.98	4.34	–	56.02	49.48
CV (%)	26.35	26.68	–	13.92	13.01
Significance	ns	ns	–	*	ns

* = Significant at 5%
ns = Not significant

the second crop. This is, however, inconsequential as it is yield that counts for economical and practical purposes. The yield reduction in the residual crop, grown without further addition of organic or inorganic fertilizer was 24–31% *(Table 6).* Yields obtained, suggests that with 20 t/ha PM, two crops of *Amaranthus* may be possible, with about 24% reduction in the yield of the second crop. Perhaps a smaller quantum of PM can be applied for the second crop to sustain yields. The actual rates for the second and subsequent crops need to be investigated in subsequent studies to provide answers for sustainable organic vegetable cultivation.

Yields obtained in earlier studies, also using the pointed leaf cultivar ranged from 13–20 t/ha (Vimala et al. 1993). Recent studies with the round leaf cultivar gave mean yields of about 41 t/ha and 21 t/ha for the main crop and residual crop respectively (Vimala et al. 1999). *Amaranthus* is reportedly among the highest yielding of the 1500 species of edible leaves in the tropic. Yields quoted ranged from 10–60 t/ha (Ruberte 1984).

Thus, either processed or unprocessed PM can be used. Unprocessed PM is, of course, the cheaper of the two. Processed PM, however, has the advantage of more pleasant handling as it is odourless and does not attract flies. Though a linear response to rate of PM was obtained, 20 t/ha PM would suffice, as good yields were obtained at this rate.

Experiment 3. Yield response of lettuce on clay loam soil to several organic fertilizers

Organic fertilizers were highly significant but the rate of organic fertilizer was not significant indicating that 20 kg/plot or 26.7 t/ha PM was sufficient for lettuce in Cameron Highlands on clay loam soil *(Table 7)*. No interaction effects were obtained between PM and inorganic compound fertilizer. Poultry manure without NPK gave significantly higher yields than the other organic fertilizers without NPK. This indicates the superior nutrient supplying capacity of PM to the nutrient demanding vegetable crops, compared to other organic sources for organic vegetable cultivation in Malaysia. Yield reduction without NPK was only 4.8% with PM compared to 28-48% with the other organic sources *(Table 8)*.

Studies elsewhere too have shown higher yields with PM compared to other organic sources (Rice et al. 1993; Maynard 1994; Maraiker et al. 1996) Other local studies also showed the superiority of PM over several organic sources available in the country (Vimala et al. 1999; Vimala, Aziz et al. 2000; Vimala, Mah, Roff, Wan Rubiah et al. 2000; Vimala, Mah, Roff, Ong et al. 2000). The extremely low yields obtained with the PM + sawdust + rice husk compost is attributed to N immobilisation because of its high CN ratio *(Appendix 1).* According to Morris and Ma (1996) the critical CN ratio for short-term crops is probably less than 15. Results obtained in this study seem to

Table 7. Analysis of variance for yield of lettuce in Cameron Highlands with and without inorganic fertilizer

Source of variation	DF	Mean square	F-value	Significance
Organic fertilizer	3	126.73	16.09	**
Rate of organic fertilizer	3	0.84	0.11	ns
NPK	1	251.55	31.93	**
Rate of organic fertilizer x NPK	3	6.64	0.84	ns
Organic fertilizer x NPK	3	19.42	2.46	ns
Organic fertilizer x rate x NPK	9	2.17	0.28	ns

** = Significant at 1%
ns = Not significant

Table 8. Yield of lettuce with and without NPK

Fertilizer	Yield (kg/plot)	Yield reduction with only organic fertilizer (%)
Poultry manure	12.96a	4.8
Poultry manure + NPK	13.61a	–
Wormcompost	8.94b	28.4
Wormcompost + NPK	12.48a	–
PM + sawdust compost	8.47b	32.0
PM + sawdust compost + NPK	12.45a	–
PM + sawdust + rice husk compost	5.28c	47.5
PM + sawdust + rice husk compost + NPK	10.05b	–

Values with the same letter are not significantly different at 1%

indicate a requirement for CN ratios of less than 12 for short-term crops like vegetables.

Conclusion

Poultry manure at about 40–50 t/ha is required for organic cultivation of tomato, cabbage and brinjal on peat. No significant difference between processed and unprocessed poultry manure was obtained. Thus, either can be used depending on grower preference. Processed animal wastes are generally preferred by organic growers. Poultry manure was superior to several other organic sources evaluated for lettuce in Cameron Highlands. Poultry manure at 20 t/ha is sufficient for lettuce in Cameron Highlands. It is concluded that poultry manure, whether raw or processed is at present the most suitable organic fertilizer for organic vegetable cultivation in Malaysia.

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Appendix 1. Soil characteristics of experimental plots

Characteristic	1st trial	2nd trial	3rd trial
	Tomato/cabbage brinjal (peat)	*Amaranthus* (peat)	Lettuce (clay loam)
pH	4.9	5.4	–
Soluble P (ppm)	41.9	53.0	260.0
Organic carbon (%)	26.7	28.2	0.16
Nitrogen (%)	1.30	1.34	0.23
CEC (meq %)	110.0	134.1	–
Ex. K (meq %)	1.09	0.51	0.54
Ex. Na (meq %)	0.51	0.41	–
Ex. Ca (meq %)	94.4	46.2	402.0
Ex. Mg (meq %)	19.1	11.4	0.71

Appendix 2. Nutrient content of some organic fertilizers

Organic fertilizer	%						ppm				CN ratio
	N	P	K	Ca	Mg	Mn	Fe	Cu	Zn	B	
Poultry manure	2.59	2.93	3.39	7.97	1.07	475	2505	76	506	39	8.3
Processed poultry manure	1.93	2.09	2.21	13.8	0.90	467	7656	58	631	38	11.5
PM + sawdust compost	2.01	1.32	1.79	4.70	0.52	278	1088	76	328	71	14.9
Wormcompost	0.92	1.95	0.38	9.73	0.64	4.76	3007	69	459	49	21.6
PM + sawdust + rice husk compost	0.59	0.23	0.29	0.85	0.09	–	–	–	–	–	59.0