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Application of chicken manure on lowland cabbage (*Brassica oleracea* var. Capitata) grown on peat soil under rainshelter

(Pemberian baja tahi ayam pada kubis (*Brassica oleracea* var. Capitata) tanah rendah di tanah gambut di bawah struktur pelindung hujan)

M.K. Illias* and P. Vimala**

Key words: cabbage, chicken manure, rainshelter, peat

Abstract

A study was conducted to determine the effects of chicken manure on lowland cabbage grown on peat soil under rainshelter. Chicken manure at 20, 30 and 40 t/ha were applied all as basal or split into two equal applications as basal and at 4 weeks after transplanting. The plant canopy, fresh weight of outer leaves and yield of plants treated with chicken manure at 20–40 t/ha were similar to those from plants treated with inorganic fertilizer. Soil and leaf nutrient analyses also indicated that chicken manure as the sole source of nutrients could improve soil fertility and provide enough nutrients for good growth and yield. Crops fertilized with chicken manure alone gave yields between 20.77–24.67 t/ha, similar to the inorganic fertilizer. For cabbage grown on peat under the rainshelter, chicken manure at 20 t/ha applied all as basal is recommended.

Introduction

The use of organic fertilizers is one of the ways to reduce excessive use of chemical fertilizers and over-dependency on them. Application of organic fertilizers, either alone or in combination with inorganic fertilizers, may result in better yields than crops fertilized with inorganic fertilizers alone. Organic together with inorganic fertilizers are, thus, widely used in the lowlands and the highlands of Malaysia to fulfill the nutrient requirements of most vegetables. One of the popularly used organic fertilizers is unprocessed or raw chicken manure, which is easily available compared to other animal manures. High rates of chicken manure applied as the sole nutrient sources give high yields of lettuce (Vimala et al. 2000a) and spinach (Vimala et al. 2000b) on peat soil, while on a tin-tailing soil, tomato, french bean and cucumber responded to increasing levels of chicken manure applied together with inorganic fertilizers (Vimala et al. 1997).

Cabbage is one of the temperate vegetables that can be successfully cultivated in the lowlands when grown under rainshelters. The fertilizer recommendation for cabbage under rainshelters using inorganic fertilizers on different soil types is available (Illias and Ramli 1994). In view of increasing interests in the use of organic fertilizers and organic farming, it is appropriate that organic fertilizers be used in the cultivation of cabbage in the lowlands under rainshelters.

*Horticulture Research Centre, MARDI Headquarters, Serdang, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia
**Strategic Resources Research Centre, MARDI Headquarters, Serdang,
P.O. Box 12301, 50774 Kuala Lumpur, Malaysia
Authors' full names: Illias Mohd Khir and Vimala Purushothaman
E-mail: illias@mardi.my

An experiment was conducted to determine the effects of unprocessed chicken manure at different rates and application times on lowland cabbage grown on peat under the rainshelter.

Materials and methods

The experiment was conducted on peat soil under a netting-sided tunnel type rainshelter at MARDI Station, Jalan Kebun, Klang, Selangor. Soil samples were collected to determine soil characteristics (nutrient status) before the start of the experiment. The soil chemical characteristics of the experimental site are shown in *Table 1*.

Chicken manure treatments consisted of three rates at two application frequencies. Rates tested were 20, 30 and 40 t/ha and application frequencies were either all as basal or two equal split applications at basal and at 4 weeks after transplanting (w.a.t). The chicken manure used had a chemical composition of 2.6% N, 2.9% P, 3.4% K, 7.9% Ca, 1.1% Mg and a C/N ratio of 8.3.

Control treatments were 1.5 t/ha of compound fertilizer 12:12:17:2 applied in two split applications at 2 and 5 w.a.t., and the zero fertilizer plot, giving altogether 8 treatments as follows: 20 t/ha chicken manure applied all as basal (Treatment 1); 20 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t. (Treatment 2); 30 t/ha chicken manure applied all as basal (Treatment 3); 30 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t. (Treatment 4); 40 t/ha chicken manure applied all as basal (Treatment 5); 40 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t. (Treatment 6); inorganic fertilizer 12:12:17:2 at 1.5 t/ha applied 2 & 5 w.a.t. (Treatment 7); and no fertilizer (Treatment 8).

Table 1. Soil chemical characteristics before the start of the experiment

Characteristic	Value
pH	6.69
Total N	1.24%
NO_3-N	0.19%
Soluble P	1,429 mg/kg
Exchangeable K	5.62 cmol(+)/kg
Exchangeable Ca	79.27 cmol(+)/kg
Exchangeable Mg	53.66 cmol(+)/kg

Seedlings of the cabbage cultivar KK Cross were raised in germination trays containing peat soil in an insect proof nursery. Raised soil beds were made under the rainshelter, each bed measuring 1.5 m wide and 9 m long. Experimental plots were arranged in a randomized complete block design with three replications. In treatments receiving basal application of chicken manure, the manure was broadcasted on the bed and raked into the soil 4 days before transplanting. Four-week-old cabbage seedlings, about 10–12 cm in height and with three pairs of leaves, were then transplanted on the beds at spacing of 50 cm x 60 cm, with each experimental plot consisting of 28 plants. For the next application of chicken manure, which was 4 weeks after transplanting, the manure was applied in between cabbage rows and incorporated into the soil. Plants were watered daily using the drip irrigation system.

Growth and yield measurements made were on plant canopy, fresh weight of outer leaves, head diameter and head weight. Plant canopy was measured just before first harvest (10 w.a.t) while outer leaf fresh weight was recorded during harvest. Yield in t/ha was calculated. Leaf samples were collected during the harvesting period and soil samples taken at the end of the experiment for analysis. All chemical analyses were done at the Agricultural Chemical and Quality Assurance Laboratory at MARDI Headquarters using in-hose methods. Leaf nitrogen was determined by the micro-Kjeldahl method using an auto-analyser. The nutrients P, K, Ca, Mg and Cu were determined using the ICP emission spectrophotometer. Data were analysed using the Analysis of Variance (ANOVA) and the differences between treatment means were compared by the Duncan Multiple Range Test method.

Results and discussion

Canopy diameter and fresh weight of outer leaves

There were no differences in plant canopy diameter among chicken manure treatments (Treatments 1, 2, 3, 4, 5 and 6) and between the manure treated plants and plants treated with inorganic fertilizer *(Table 2)*, but they were all significantly higher than plants from the no fertilizer treatment (Treatment 8). The same trend was observed with fresh weight of outer leaves. At various combinations of rates and application frequencies of chicken manure, fresh weight of outer leaves ranged from 624.0 – 725.3 g, which were similar to plants receiving inorganic fertilizer (662.7 g), but significantly higher than the no fertilizer treatment. The results indicated that cabbage plants grew just as well whether chicken manure was applied at 20, 30 or 40 t/ha and either applied all basal or split into two equal applications. Growth of manure treated plants was also as good as those fertilized with inorganic fertilizer.

Head weight and head diameter

Chicken manure treated plants did not show any difference in head weight, ranging from 1.08 – 1.29 kg *(Table 3)*. Although Treatment 4 (30 t/ha chicken manure applied 1/2 basal + 1/2 at 4 w.a.t.) had a significantly smaller head weight than the inorganic fertilizer treatment, head weight was in general similar among chicken manure and inorganic fertilizer treatments. Head weight was significantly lowest in the unfertilized plot. Head diameter in Treatment 3 was

Table 2. Effects of chicken manure on plant canopy and fresh weight of outer leaves of cabbage

Treatment no.	Treatment	Canopy diameter (cm)	Fresh weight of outer leaves (g)
1	20 t/ha chicken manure applied all basal	63.8a	663.3a
2	20 t/ha chicken manure applied 1/2 basal + 1/2 at 4 w.a.t.	61.7a	644.7a
3	30 t/ha chicken manure applied all as basal	63.0a	725.3a
4	30 t/ha chicken manure applied 1/2 basal + 1/2 at 4 w.a.t.	58.8a	624.0a
5	40 t/ha chicken manure applied all as basal	60.4a	658.0a
6	40 t/ha chicken manure applied 1/2 basal + 1/2 at 4 w.a.t.	60.8a	638.0a
7	1.5 t/ha inorganic fertilizer 12:12:17:2 applied 2 and 5 w.a.t.	61.3a	662.7a
8	No fertilizer	49.7b	472.7b

Values in a column with the same letter are not significantly different at $p < 0.05$ according to the DMRT
w.a.t. = weeks after transplanting

Table 3. Effects of chicken manure on head weight, head diameter and yield of cabbage

Treatment no.	Treatment	Head weight (kg)	Head diameter (cm)	Yield (t/ha)
1	20 t/ha chicken manure applied all as basal	1.16ab	17.6ab	22.30ab
2	20 t/ha chicken manure applied 1/2 basal + 1/2 at 4 w.a.t.	1.18ab	16.8ab	22.71ab
3	30 t/ha chicken manure applied all as basal	1.29ab	18.1a	24.67ab
4	30 t/ha chicken manure applied 1/2 basal + 1/2 at 4 w.a.t.	1.08b	16.9ab	20.77b
5	40 t/ha chicken manure applied all as basal	1.12ab	16.7b	21.41ab
6	40 t/ha chicken manure applied 1/2 basal + 1/2 at 4 w.a.t.	1.11ab	17.1ab	21.22ab
7	1.5 t/ha inorganic fertilizer 12:12:17:2 applied 2 and 5 w.a.t.	1.31a	17.6ab	25.13a
8	No fertilizer	0.62c	14.0c	13.30c

Values in a column with the same letter are not significantly different at $p < 0.05$ according to the DMRT
w.a.t. = weeks after transplanting

Table 4. Soil analysis at harvest (pH, Total N, NO_3-N and soluble P)

Treatment no.	Treatment	PH	Total N (%)	NO_3-N (%)	Soluble P (mg/kg)
1	20 t/ha chicken manure applied all basal.	6.13a	1.67bc	0.50ab	3,332b
2	20 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t.	6.09a	2.05b	0.80ab	5,485a
3	30 t/ha chicken manure applied all basal.	6.33a	1.99b	0.58ab	3,364b
4	30 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t.	6.27a	2.14b	0.72ab	5,821a
5	40 t/ha chicken manure applied all basal.	6.33a	2.12b	0.38b	6,388a
6	40 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t.	6.63a	2.90a	1.05a	7,236a
7	1.5 t/ha inorganic fertilizer 12:12:17:2 applied 2 & 5 w.a.t.	6.11a	1.46c	0.44ab	2,762b
8	No fertilizer	6.55a	1.43c	0.37b	1,105b

Values in a column with the same letter are not significantly different at $p < 0.05$ according to the DMRT
w.a.t. = weeks after transplanting

significantly higher than that in Treatment 5 but not significantly different from the rest of the manure treatments. The no fertilizer treatment also gave the smallest head diameter. The results seemed to show that higher rates of chicken manure did not result in bigger or heavier cabbage heads. This indicated that lower manure rates were enough to improve soil fertility and support cabbage growth.

Yield

Yields were similar from plants treated with chicken manure at all levels and applied either all as basal or in two split applications, ranging from 20.77–24.67 t/ha. Except for Treatment 4 (30 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t.) all manure treatments gave yields similar to the yield from the inorganic fertilizer treatment (13.30 t/ha). As expected, a very low yield was obtained from plants without any fertilizer. An almost similar yield trend was obtained in a previous study on the effects of chicken manure application on lowland cauliflower grown under the rainshelter on peat (Illias and Vimala 2002). As with head weight and head diameter, increasing rates of chicken manure did not result in higher yields. It seemed that 20 t/ha of chicken manure was enough to give a good yield of cabbage grown on peat soil.

Soil analysis

There were no differences in soil pH between all treatments, which ranged from 6.09 to 6.63 *(Table 4)*. Soil pH values in all treatment plots at the end of the experiment were also lower than the pH before experiment. It seemed that pH values in the manure treated soil were more conducive for plant growth than the pH in the no fertilizer treatment as indicated by higher yields in Treatments 1, 2, 3, 4, 5 and 6.

Applications of chicken manure resulted in increases in soil N. Soil total N in T2–T6 ranged from 2.05–2.90%, significantly higher than that in the inorganic fertilizer and no fertilizer treatments which had 1.46% and 1.43% total N, respectively. However, soil total N in T1 (20 t/ha chicken manure applied all as basal) was significantly lower than T6 and not significantly different from the rest of the treatments. This could be due to the manure being applied all as basal and much of the N being taken up by the plant. It was also observed that soil total N in T6 was significantly higher than that in T5 even though the rate of chicken manure applied in these treatments was the same, that was, 40 t/ha. This could be due to T6 had the manure split applied at basal and at 4 weeks after transplanting. Nitrate-N values generally did not show differences among treatments except between T5 and T6 where soil NO_3-N in T6 (1.05%) was significantly higher than that in T5 (0.38%), even though

Table 5. Soil analysis at harvest (exchangeable K, Ca and Mg)

Treatment no.	Treatment	Exc. K (cmol(+)/kg)	Exc. Ca (cmol(+)/kg)	Exc. Mg (cmol(+)/kg)
1	20 t/ha chicken manure applied all as basal.	8.48ab	75.90ab	51.64a
2	20 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t.	15.81a	72.98ab	61.03a
3	30 t/ha chicken manure applied all as basal.	8.67ab	72.83ab	51.23a
4	30 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t.	14.14ab	74.18ab	57.21a
5	40 t/ha chicken manure applied all as basal.	7.44ab	61.04b	42.39a
6	40 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t.	8.04ab	72.82ab	64.74a
7	1.5 t/ha inorganic fertilizer 12:12:17:2 applied 2 & 5 w.a.t.	12.28ab	90.53a	56.47a
8	No fertilizer	6.44b	85.26a	64.26a

Values in a column with the same letter are not significantly different at $p < 0.05$ according to the DMRT
w.a.t. = weeks after transplanting

both these treatments had the same chicken manure rate of 40 t/ha. As with the values for total N, the lower soil NO_3-N content in T5 could be due to the manure being applied all as basal.

Soluble P was very much increased, from 1,429 mg/kg before experiment to 3,332–7,236 mg/kg with chicken manure application. Among the chicken manure treatments, it was observed that soluble P was higher when the manure was split applied, as seen between T1 and T2, and T3 and T4. Treatment 5 and T6 also showed a difference although not significant. The no fertilizer and inorganic fertilizer treatments had significantly lower soluble P values (1,105–2,762 mg/kg) than all chicken manure treatments except T1 and T3. In general, it is seen that higher soil soluble P and total N with chicken manure applications are reflected by higher yields compared to inorganic fertilizer and no fertilizer applications.

All treatments had increased exchangeable K values compared to the value before experiment *(Table 5)*. Although not significantly different among treatments, exchangeable K values of 7.44–15.81 cmol(+)/kg in chicken manure treatments seemed higher than that in the no fertilizer plot which was 6.44 cmol(+)/kg. Exchangeable Ca showed an apparent decrease in values in chicken manure treatments which had values of 61.04–75.90 cmol(+)/kg, compared to a value of 79.27 cmol(+)/kg before experiment. The inorganic fertilizer and no fertilizer treatments had higher values but these were not significantly different from those in T1–T6 except T5. Although values of exchangeable Ca were lower in chicken manure treated plots, the high yields obtained in these plots indicated that the exchangeable Ca content in the soil was at sufficient level for crop growth. There were not much differences in soil exchangeable Mg before and after experimentation, while values among all treatments were not significantly different. However, whether the exchangeable Mg was lower or higher compared to the state before experimentation, the high yields obtained still indicated that the amount of Mg in the soil was sufficient for crop growth. Exchangeable Mg values of >10 meq/100 g soil indicates the soil is sufficient in Mg for crop growth (Kanapathy 1976).

Leaf analysis

There were no differences in foliar nutrient contents among all treatments. Nitrogen content ranged from 3.190–4.583% among the chicken manure treatments and 3.903% in the inorganic fertilizer plot *(Table 6)*. Even the plants from the no fertilizer treatment had similar N level (3.943%). These levels were lower than the critical N levels of 5.2–6.0% reported by Munro et al. (1978) for broccoli, another brassica crop. However, the high yields obtained in manure

Table 6. Foliar nutrient content of cabbage (N, P and K)

Treatment no.	Treatment	N (%)	P (%)	K (%)
1	20 t/ha chicken manure applied all as basal.	3.877a	0.917a	5.967a
2	20 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t.	3.190a	0.833a	5.537a
3	30 t/ha chicken manure applied all as basal.	4.583a	0.780a	5.077a
4	30 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t.	4.223a	0.853a	5.560a
5	40 t/ha chicken manure applied all as basal.	4.313a	0.777a	4.987a
6	40 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t.	3.617a	0.963a	6.070a
7	1.5 t/ha inorganic fertilizer 12:12:17:2 applied 2 & 5 w.a.t.	3.903a	0.920a	5.533a
8	No fertilizer	3.943a	0.907a	5.947a

Values in a column with the same letter are not significantly different at $p < 0.05$ according to the DMRT
w.a.t. = weeks after transplanting

Table 7. Foliar nutrient contents of cabbage (Ca, Mg and Cu)

Treatment no.	Treatment	Ca (%)	Mg (%)	Cu (ppm)
1	20 t/ha chicken manure applied all as basal.	1.250a	0.617a	3.627a
2	20 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t.	1.197a	0.560a	3.577a
3	30 t/ha chicken manure applied all as basal.	1.003a	0.507a	3.500a
4	30 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t.	1.307a	0.607a	3.737a
5	40 t/ha chicken manure applied all as basal.	0.897a	0.453a	3.983a
6	40 t/ha chicken manure applied ½ basal + ½ at 4 w.a.t.	1.193a	0.573a	4.640a
7	1.5 t/ha inorganic fertilizer 12:12:17:2 applied 2 & 5 w.a.t.	1.230a	0.587a	4.423a
8	No fertilizer	1.217a	0.627a	3.397a

Values in a column with the same letter are not significantly different at $p < 0.05$ according to the DMRT
w.a.t. = weeks after transplanting

treated plots indicated that N supplied by chicken manure was enough for the crop. Foliar P ranged from 0.777–0.963% in all treatments, which was comparable to P levels in broccoli as reported by Munro et al. (1978). Contents of other nutrients for all treatments were 4.987–6.070% for K, 0.897–1.307% for Ca, 0.453–0.627% for Mg and 3.397–4.640 mg/kg for Cu *(Table 7)*.

Although foliar nutrient contents were similar among all treatments, even between manure treatments and the no fertilizer plot, the significantly higher yields from manure treated plants indicated various beneficial effects of chicken manure application. Plants from the no fertilizer plot might have similar leaf nutrient contents as manure and NPK fertilizer treated plots but the low yield would most likely be due to the absence of the beneficial effects of chicken manure in the soil. These include improvements in soil physical structure, nutrient availability and water holding capacity.

No analysis was done to determine heavy metal contents in the leaf. However, in a study on the effects of chrysanthemum residue compost and poultry manure on cabbage grown on a sandy loam soil in MARDI Station, Cameron Highlands, it was found that cadmium, lead and arsenic contents in the leaf of poultry manure treated plants were below the permissible limits of 1 ppm Cd, 2 ppm Pb and 1 ppm As (Vimala et al. 2004). This indicates that poultry manure does not contribute to any heavy metal accumulation to unsafe levels.

In general, chicken manure at 20–40 t/ha applied either all as basal or in two applications at ½ basal + ½ at 4 weeks after transplanting would give cabbage yields as good as the yield from plants fertilized with inorganic fertilizers alone. The overall improvement in soil fertility when chicken manure was used indicated the benefits of using organic fertilizers besides the goal of reducing dependence on inorganic fertilizers. A total of 20 t/ha of chicken manure is recommended as basal application instead of in two split applications since there will be some cost savings in terms of labour requirement in fertilizer application.

In terms of cost, it will cost more when 20 t/ha of chicken manure is used compared to conventional application of 1.5 t/ha of inorganic NPK fertilizer. Based on a cost of RM200 per tonne, 20 t of chicken manure will cost RM4,000 while 1.5 t of the inorganic fertilizer costs RM1,890 (at RM1,260/t). It seems that using organic fertilizers is costly, but there are many benefits of using organic fertilizers such as improvement of soil physical characteristics and fertility, environmental friendly and production of chemical free and safe produce for consumption. This is especially when organic fertilizers such as chicken manure are used in organic farming. Furthermore, organically produced products are normally sold at premium prices, thereby making organic production of crops profitable.

Conclusion

Chicken manure can be the sole source of nutrients for vegetable crops. In adequate amounts and without additional inorganic NPK fertilizers, organic fertilizers such as chicken manure improve soil fertility, producing high cabbage yields. For cabbage, 20 t/ha of an unprocessed chicken manure all applied as basal will give a yield comparable to that obtained with inorganic fertilizers.

Although involving high cost due to large amounts needed to meet the nutritional requirement of the crop, the use of organic fertilizers and organic farming are still favoured and encouraged. The use of organic fertilizers will reduce over-dependence on chemicals and inorganic fertilizers, leading to more environment-friendly production systems such as organic farming. Produce from organic farming or from production systems using organic fertilizers are free from chemicals and safe for consumption. Chicken manure also does not contribute to any accumulation of heavy metals to unsafe levels in the leaf. Furthermore, organically produced vegetables usually command premium price, making the production system economically viable. With increasing interest in organic farming, organic fertilizers such as chicken manure at appropriate rates will be major fertilizer sources in the vegetable industry.

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Abstrak

Kesan baja tahi ayam telah dikaji pada kubis yang ditanam di tanah gambut di bawah struktur pelindung hujan. Baja tahi ayam pada kadar 20, 30 dan 40 t/ha diberi sama ada semua sebelum menanam atau diberi dua kali pada kadar yang sama iaitu sebelum menanam dan pada 4 minggu lepas menanam. Kanopi pokok, berat basah daun luar dan hasil pokok yang dibaja dengan 20–40 t/ha tahi ayam adalah sama dengan pokok yang diberi baja tak organik. Analisis tanah dan daun juga menunjukkan baja tahi ayam sebagai sumber tunggal pembajaan dapat meningkatkan kesuburan tanah serta memberi nutrien yang cukup untuk pertumbuhan dan penghasilan kubis yang memuaskan. Tanaman yang dibaja dengan tahi ayam sahaja boleh mengeluarkan hasil antara 20.77–24.67 t/ha, sama dengan baja tak organik. Untuk tanaman kubis yang ditanam di tanah gambut di bawah struktur pelindung hujan, baja tahi ayam pada kadar 20 t/ha dan diberi kesemuanya sebelum menanam adalah disyorkan.

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