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Effect of organic and inorganic fertilizers on growth, yield and nutrient content of bird chilli *(Capsicum frutescence)*

(Kesan baja organik dan tak organik terhadap pertumbuhan, hasil dan kandungan nutrien cili padi)

P. Vimala*, R. Melor**, O. Ahmad Shokri*** and P. Balasubramaniam*

Key words: bird chilli, organic fertilizer, processed poultry manure, nutrient content, nitrate content, heavy metal content, soil improvement

Abstract

Four rates (0, 20, 40, 60 t/ha) of organic fertilizer (processed poultry manure) and three rates of inorganic fertilizer (0, 2 and 3 t/ha) were evaluated on bird chilli grown on an upland clay soil.

Significant effects of processed poultry manure (PPM) and inorganic fertilizer (NPK) rates on yield were obtained. Interaction effects between PPM and NPK were not significant. Yield increased significantly from 6.46 t/ha at zero fertilizer to 15.49 t/ha at 20 t/ha PPM + 2 t/ha inorganic fertilizer ($N:P_2O_5:K_2O$: MgO = 12:12:17:2). Regression analysis showed a significant quadratic response to the inorganic fertilizer, represented by the equation $Y = 9.1455 + 5.0848x – 1.3292x^2$, where Y = yield in t/ha and x = fertilizer applied in t/ha. The optimum rate of inorganic fertilizer was 1.91 t/ha. Yield response to organic fertilizer as the sole nutrient source was quadratic, represented by the equation $Y = 6.0813 + 0.1861x – 0.0018x^2$, where Y = yield in t/ha and x = organic fertilizer in t/ha. The optimum rate of organic fertilizer was 52 t/ha.

Fertilizers had no significant effect on fruit weight, but had a significant effect on fruit length. Fruit weight ranged from 0.76–0.89 g and fruit length ranged from 3.8–4.5 cm.

Nutrient contents did not differ significantly, except for fruit Ca, Fe and Mn and leaf Mg and Mn. The mean fruit macronutrient contents were 2.38% N, 0.46% P, 5.22% K, 0.18% Ca and 0.24% Mg, and the mean fruit micronutrient contents were 27 mg/kg B, 13 mg/kg Cu, 76 mg/kg Fe, 8 mg/kg Mn and 27 mg/kg Zn. Mean leaf macronutrient content were 4.81% N, 0.36% P, 5.48% K, 1.62% Ca and 0.46% Mg, and mean leaf micronutrient contents were 44 mg/kg B, 17 mg/kg Cu, 284 mg/kg Fe, 17 mg/kg Mn and 47 mg/kg Zn. Most soil chemical properties improved with increasing rates of organic fertilizer.

*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 Purushothaman, Melor Rejab, Ahmad Shokri Othman and Balasubramaniam Pararajasingham

E-mail: vimala@mardi.my

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Introduction

Bird chilli *(Capsicum frutescens)*, locally known as *cili padi* or *cili api,* though popularly consumed, is presently not cultivated widely on a commercial scale in Malaysia. The total area under bird chilli cultivation is only 276 ha (DOA 2001). The import of bird chilli is more than 100 t/week (Wan Ibrahim Wan Daud, FAMA, pers. comm. 2003). With the increasing demand for bird chilli for fresh consumption as well as for processing and with its favourable prices, there is tremendous potential for growers to venture into bird chilli cultivation in Malaysia. Lack of technology for production is among the factors for the limited cultivation in the country currently.

MARDI recently identified high yielding varieties of bird chilli suitable for commercial cultivation (Melor 2003) with the accession CP 170 being recommended as the most suitable for large scale planting. There is, however, little information on the agronomic requirement of bird chilli, both locally and elsewhere. This paper presents the growth and yield responses of bird chilli to organic and inorganic fertilizers, with the objective of obtaining information on the fertilizer requirement for conventional as well as for organic production of bird chilli.

Materials and methods

Field details

The trial was conducted at the MARDI Headquarters experimental field on a clay soil (60% clay, 22% sand and 13% silt). The soil chemical properties are presented in *Table 1*. The experimental site was cleared, ploughed, rotor-tilled and 8 m x 1 m raised plots made at half meter apart. Treatments comprised four rates of processed poultry manure applied on the planted area at 0, 20, 40 and 60 t/ha and three rates of inorganic fertilizer (0, 2 and 3 t/ha). The experimental design was a 4 x 3 factorial arranged in a randomized complete block design with three replicates.

The nutrient contents of the processed poultry manure (PPM) are presented in *Table 2*. Half the PPM was applied on the plots as basal and worked into the soil for all the treatments. Five-week-old seedlings of bird chilli (variety CP 170) were transplanted one week after the basal application at a planting distance of 1.5 m x 1 m to give 8 plants/plot. The other half of the PPM was applied as top dressing around the plant at 13 weeks after transplanting for the lower rates (20 and 40 t/ha). For the highest rate of PPM (60 t/ha) the remaining half was split equally and applied at 13 weeks and at 20 weeks after transplanting. Inorganic fertilizer ($N:P_2O_5:K_2O:MgO$ = 12:12:17:2) was applied in six equal split applications, at monthly intervals.

Data recording

The height of two central plants/plot was measured at transplanting and then at monthly intervals until 24 weeks after

Table 1. Soil chemical properties

Soil properties	Values
N (%)	0.13
P (%)	0.06
CEC (cmol(+)/kg)	10.77
Total carbon (%)	1.55
Ex. Ca (cmol(+)/kg)	6.00
Ex. K (cmol(+)/kg)	0.63
Ex. Mg (cmol(+)/kg)	2.12
Conductivity (dS/m)	0.06
Base Saturation (%)	81.24

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

Nutrient	Content	Nutrients (kg) in 52 t/ha PPM
Macronutrient (%)		
N	3.2	1,664
P	2.9	1,508
K	4.2	2,184
Ca	14.3	7,436
Mg	1.1	572
Organic C	22.3	
pH	7.1	
Micronutrient content (mg/kg)		
Mn	581	30
Fe	946	49
Zn	667	35

transplanting (WAT). Harvesting was at weekly intervals, with the first harvest at 12 WAT and the last harvest at 47 WAT giving a harvesting period of about 8 months. Both fruit weight and fruit number/plot were recorded. Fruit length of 10 fruits picked randomly at mid-harvest from each treatment plot was measured.

Plant and soil sampling

Fruit samples were obtained from all the treatments for nutrient, heavy metal and nitrate analysis. Leaf samples were obtained from selected treatments for nutrient analysis. The samples were oven dried at 65 °C for about 48 h to constant weight and ground for chemical analysis. At the end of the experiment, soils from selected treatments were sampled and air dried for analysis. Chemical analysis was done at MARDI's Analytical and Quality Assurance Laboratory.

Data 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.

Results and discussion

Plant height

Plant height for the various treatment combinations is presented in *Table 3*.

Table 3. Plant height (cm) at the various rates of organic (PPM) and inorganic (NPK) fertilizers

Fertilizer treatments (t/ha)		Months from transplanting						
		1	2	3	4	5	6	7
PPM	NPK							
0	0	18.7	32.1	58.9d	74.3	79.5	84.9	89.5
0	2	20.4	39.5	71.2a	87.3	95.1	98.0	105.6
0	3	16.9	39.9	73.8a	82.1	88.0	92.6	95.9
20	0	20.0	42.3	69.1abc	80.8	88.8	96.1	99.6
20	2	18.8	35.6	65.9abcd	82.5	86.6	93.3	96.8
20	3	16.9	36.2	59.2cd	72.2	79.7	84.1	85.5
40	0	19.1	32.3	60.5bcd	75.5	78.8	83.3	87.8
40	2	19.3	41.4	70.4ab	85.4	91.2	96.5	104.8
40	3	19.0	40.2	64.2abcd	72.7	79.9	85.6	93.5
60	0	19.0	34.3	65.1abcd	83.2	86.0	92.3	93.0
60	2	20.9	40.4	60.7bcd	73.3	78.4	82.5	85.0
60	3	20.7	42.1	71.4a	87.3	93.9	99.8	105.3
Mean		19.1	38.0	65.8	79.5	85.5	90.8	95.2
Significance		ns	ns	*	ns	ns	ns	ns
CV%		13.1	13.2	9.0	8.8	9.0	9.6	11.7

PPM = Processed poultry manure; NPK = Inorganic fertilizer; ns = Not significant
*Significant at $p = 0.05$
Column means with the same letter(s) are not significantly different at $p = 0.05$

Table 4. ANOVA for yield/plot

Source	DF	Mean square	F value	Pr >F
Rep	2	15345889	2.31	0.1232ns
Organic fertilizer (PPM)	3	19430979	2.92	0.0567*
Inorganic fertilizer (NPK)	2	106038800	15.94	0.0001**
PPM x NPK	6	14271622	2.15	ns

ns = Not significant; *Significant at $p = 0.05$; **Significant at $p = 0.01$

Generally, fertilizers did not have a significant effect on height. Mean plant height increased from 19.1 cm at one month after transplanting to 95.2 cm at seven months after transplanting.

Yield

Plot yield The analysis of variance (ANOVA) for yield is presented in *Table 4*. Significant effects were obtained for both poultry manure (PPM) and inorganic fertilizer (NPK) applications. Interaction effects were not significant. Mean yields obtained are presented in *Table 5*.

Yield/plot increased significantly from 7.75 kg/plot at zero fertilizer to a maximum of 18.59 kg/plot at 20 t/ha PM + 2 t/ha NPK. Increasing rates of NPK increased yields significantly when no PPM was applied. When PPM was applied, the highest level of NPK invariably reduced yields indicating an excess of nutrients in the rooting zone causing adverse effects on yield due to ammonia or salt injury. A similar trend was obtained for cabbage in the highlands (Vimala et al. 2004).

Yield/plant The yield per plant increased significantly from 0.97 kg at zero fertilizer to 2.32 kg/plant with the application of 20 t/ha PPM + 2 t/ha NPK *(Table 5)*. The yields obtained in this study can be considered as very good yields compared to yields obtained in previous studies on peat soils which gave only about 0.8 kg/plant (Melor 2003). As in yield/plot, increasing rates of inorganic fertilizer had a detrimental effect on the yield/plant at all levels of organic fertilizer.

Fruit number/plant The fruit number per plant showed the same trend as yield/plant and increased significantly from 1,095 at zero fertilizer to 2,805 at 20 t/ha PPM + 2 t/ha inorganic fertilizer *(Table 5)*. Previous studies on peat soils reported 1,263 fruits/plant (Melor 2003).

Yield in t/ha Yield ranged from 6.5 t/ha at zero fertilizer application to 15.5 t/ha at 20 t/ha PPM + 2 t/ha NPK *(Table 5)*. Regression analysis showed a significant quadratic response to only the inorganic

Table 5. Bird chilli yields at various rates of organic and inorganic fertilizers

Fertilizer treatments (t/ha)		Yield		Yield (kg/plant)	Fruit no./plant
PPM	NPK	kg/plot	t/ha (Estimated)		
0	0	7.75d	6.46	0.97d	1095e
0	2	14.02abc	11.67	1.75abc	2273abcd
0	3	15.28ab	12.73	1.91ab	2351abc
20	0	9.50cd	7.92	1.19cd	1593de
20	2	18.59a	15.49	2.32a	2805a
20	3	14.25abc	11.88	1.78abc	2219abcd
40	0	14.17abc	11.81	1.77abc	2200abcd
40	2	16.68ab	13.91	2.08ab	2496abc
40	3	12.84bc	10.70	1.60bc	1969bcd
60	0	12.47bc	10.39	1.56bc	1771cde
60	2	17.94a	14.95	2.24a	2609ab
60	3	17.34ab	14.45	2.17ab	2457abc
Mean		14.23	11.86	1.78	2152
Significance		**		**	**
CV%		18.1		18.1	18.1

PPM = Processed poultry manure; NPK = Inorganic fertilizer; ns = Not significant
**Significant at $p = 0.01$
Column means with the same letter(s) are not significantly different at $p = 0.01$

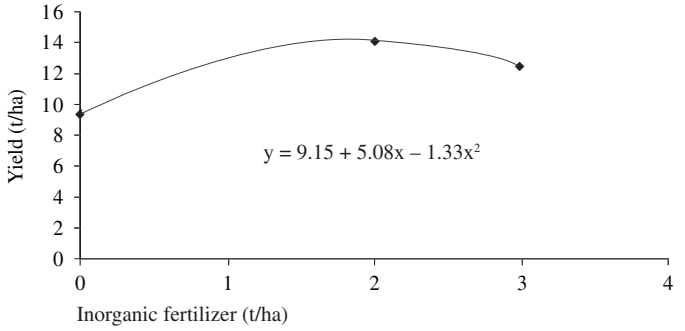

Figure 1. Effect of inorganic fertilizer on the yield of bird chilli

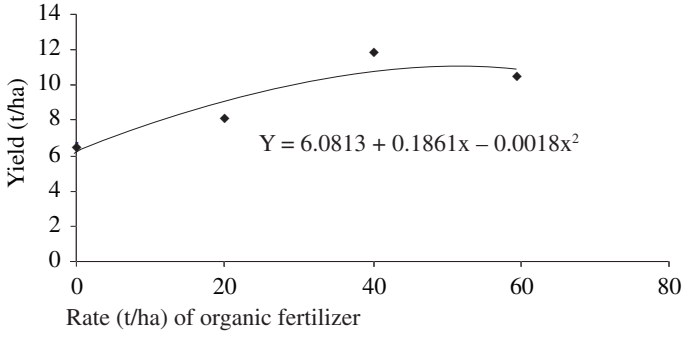

Figure 2. Yield vs. organic fertilizer as the sole nutrient source

fertilizer *(Figure 1).* The relationship between the rate of inorganic fertilizer applied and yield is represented by the equation $Y = 9.1455 + 5.0848x - 1.3292x^2$, where Y = yield in t/ha and x = inorganic fertilizer applied in t/ha. The optimum rate of inorganic fertilizer was found to be 1.91 t/ha.

Mean fruit weight Mean fruit weight was 0.83 g and did not differ significantly with treatments *(Table 6).* Fruit length ranged from 3.79 cm to 4.52 cm. Though there were significant effects, no trend was discernable.

Yield response to PPM as the sole nutrient source The yield response to PPM was quadratic *(Figure 2),* represented by the equation $Y = 6.0813 + 0.1861x - 0.0018x^2$, where Y= yield in t/ha and x = PPM applied in t/ha. The optimum rate of PPM was 52 t/ha. At this rate of organic fertilizer application, the nutrients present

Table 6. Effect of organic (PPM) and inorganic (NPK) fertilizers on fruit characteristics

Fertilizer treatments (t/ha)		Mean fruit wt. (g)	Mean fruit length (cm)
PPM	NPK		
0	0	0.88	4.02bcd
0	2	0.77	3.79d
0	3	0.81	3.99cd
20	0	0.76	4.09abcd
20	2	0.83	4.39abc
20	3	0.80	4.11abcd
40	0	0.81	3.81d
40	2	0.83	4.06bcd
40	3	0.81	4.34abc
60	0	0.89	4.47ab
60	2	0.86	4.52a
60	3	0.88	4.32abc
Mean		0.83	4.16
Significance		ns	*
CV%		7.2	18.34

PPM = Processed poultry manure;
NPK = Inorganic fertilizer; ns = Not significant
*Significant at $p = 0.05$
Column means with the same letter(s) are not significantly different at $p = 0.05$

are shown in *Table 2*. Though high levels of individual nutrients were present, at the optimum rate, neither the yield nor the quality of the crop was adversely affected.

The high organic nutrient rates are, in fact essential, due to the low availability of nutrients from organic sources. Generally, only 30% N, 20% P and 30–50% K is available from composts (Dierolf et al. 2001). Based on these availability figures, the organic nutrient source in this study would provide the bird chilli crop with 499 kg N, 302 kg P and 655 kg K/ha (assuming 30% K availability). As no deficiency nor toxicity symptoms (due to nutrient imbalances) were observed, in spite of the high K, it is probable that the availability of K from PPM could be lower than the 30–50% reported by Dierolf et al. (2001). The availability of Ca may possibly be much less, as even 10% availability would provide 744 kg Ca/ha.

Harvest pattern The yield/harvest for the highest yielding treatment i.e. 20 t/ha PPM + 2 t/ha NPK is presented in *Figure. 3.* The yields in t/ha are shown on the Y-axis and the yields in g/plant are written above each column. First harvest was at 83 days after transplanting (DAT) giving a yield of 0.05 t/ha (7.2 g/plant). Yields steadily increased to 0.79 t/ha (118.1 g/plant) at 125 DAT. The next peak harvest was at 166 DAT when a yield of 1.13 t/ha (169.2 g/plant) was obtained. Yields fluctuated between 0.2 t/ha (24.2 g/plant) and 0.7 t/ha (110.3 g/plant) till the next peak at 232 DAT, when a yield of 1.17 t/ha (174.7 g/plant) was obtained. The highest yield/harvest (1.49 t/ha or 222.6 kg/plant) was obtained at 238 DAT.

Essentially, the highest yielding period was between 232 and 252 DAT when the yield/harvest ranged between 0.62 t/ha (93.3 g/plant) and 1.49 t/ha (222.6 g/plant). Yields then declined to between 0.1 (15.5 g/plant) and 0.4 t/ha (59.2 g/plant) until the last harvest at 329 DAT, except at 287 DAT when a yield of 0.75 t/ha (112.4 g/plant) was obtained.

The harvest pattern presented can be used as a guide to estimate yields at each harvest, thus arming growers with information to determine labour required for the harvesting, sorting and packing of bird chilli. The yield pattern would also enable the grower to determine the size of his bird chilli farm for a predetermined weekly production level, as well as facilitate marketing plans. It is, however, pointed out that the yield pattern may vary, depending

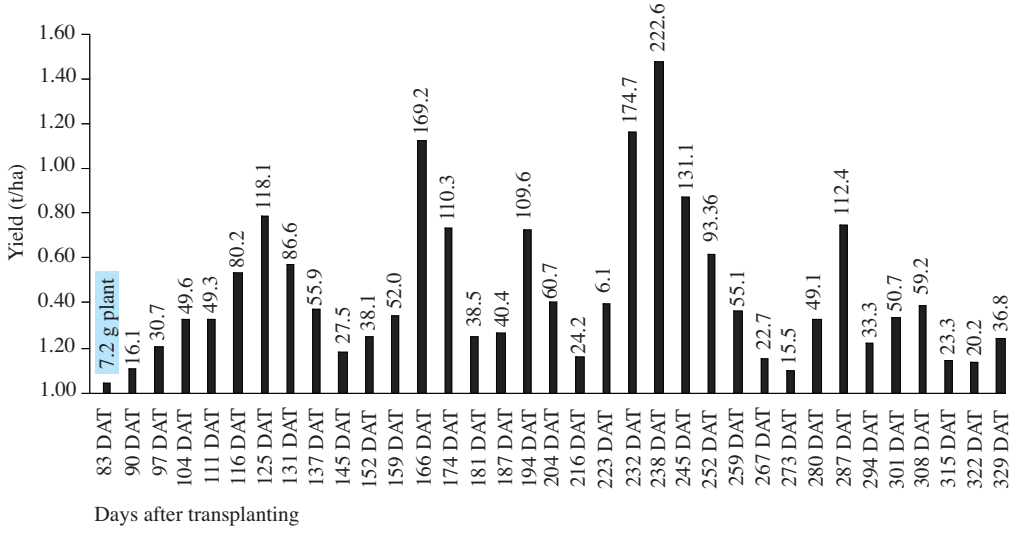

Figure 3. Yield per harvest

on environmental factors like weather, soil type and management practices.

Nutrient contents

Macronutrient Fertilizer had no significant effect on fruit macronutrient contents with the exception of Ca *(Table 7)*. Mean fruit N, P, K, Ca and Mg contents were 2.38%, 0.46%, 5.22%, 0.18% and 0.24% respectively. The P, Ca and Mg contents obtained are comparable to the fruit nutrient contents reported for chilli pepper *(Capsicum annuum)*. However, the K content of bird chilli fruit at 5.22% is much higher compared to the chilli pepper fruit K content of 3.16% (Vimala et al. 1997). The N content of bird chilli fruit at 2.38%, on the other hand, was lower than the N content of chilli pepper at 3.14%.

Fertilizers had no significant effect on leaf macronutrient contents either, except for Mg *(Table 8)*. Mean leaf N, P, K, Ca and Mg contents were 4.81%, 0.36%, 5.48%, 1.62% and 0.46% respectively. The leaf N content of bird chilli at 4.81% is comparable to the leaf N content of chilli pepper at 4.66% (Vimala et al. 1985).

The leaf K content at 5.48% in bird chilli is higher compared to the 4.55% K in chilli pepper leaf (Vimala et al. 1985). The high K content of bird chilli may be indicative of some degree of luxury consumption, though generally high K contents have been reported for vegetable crops (Adams 1985; Roberts and Smith 1988).

The mean leaf P concentration of bird chilli at 0.36% is comparable to the P concentration of 0.40% in chilli pepper leaf. Though the leaf P content was only just above the critical leaf nutrient concentration of 0.35% cited by Scaife and Turner (1983) for vegetables, no P deficiencies were observed. It is likely that the critical P concentration for bird chilli is less than 0.35%.

The mean leaf Ca concentration of 1.62% for bird chilli is comparable to the Ca concentration of 1.76% obtained for chilli pepper (Vimala et al. 1985).

Table 7. Macronutrient content (%) of fruit at the various fertilizer levels

Fertilizer treatments (t/ha)		N	P	K	Ca	Mg
PPM	NPK					
0	0	2.32	0.37	3.12	0.18abc	0.18
0	2	2.31	0.38	4.24	0.18abc	0.20
0	3	2.38	0.41	5.81	0.18abc	0.22
20	0	2.45	0.53	5.53	0.18abc	0.27
20	2	2.39	0.50	5.11	0.18abc	0.25
20	3	2.35	0.51	6.69	0.22a	0.30
40	0	2.28	0.52	6.87	0.19abc	0.28
40	2	2.34	0.51	5.15	0.16c	0.22
40	3	2.40	0.42	5.07	0.15c	0.20
60	0	2.40	0.45	4.05	0.18abc	0.22
60	2	2.37	0.47	4.96	0.190abc	0.24
60	3	2.44	0.45	5.13	0.20ab	0.27
Mean		2.38	0.46	5.22	0.18	0.24
Significance		ns	ns	ns	*	ns
CV%		4.8	19.8	29.6	12.1	25.2

PPM = Processed poultry manure; NPK = Inorganic fertilizer; ns = Not significant
*Significant at $p = 0.05$
Column means with the same letter(s) are not significantly different at $p = 0.05$

Table 8. Leaf macronutrient content (%) for selected treatments

Fertilizer treatments (t/ha)		N	P	K	Ca	Mg
PPM	NPK					
0	0	4.09	0.37	4.84	1.56ab	0.37bc
0	3	4.42	0.27	5.60	2.36a	0.58a
2	0	5.27	0.40	5.24	0.93b	0.33c
2	2	4.99	0.37	6.16	1.83ab	0.58a
4	0	5.11	0.37	5.20	1.55ab	0.40bc
Mean		4.81	0.36	5.48	1.62	0.46
Significance		ns	ns	ns	ns	*
CV%		11.9	13.6	11.33	36.8	19.3

PPM = Processed poultry manure; NPK = Inorganic fertilizer; ns = Not significant
*Significant at $p = 0.05$
Column means with the same letter(s) are not significantly different at $p = 0.05$

Table 9. Micronutrient content (mg/kg) of bird chilli fruit at the various fertilizer levels

Fertilizer treatments (t/ha)		B	Cu	Fe	Mn	Zn
PPM	NPK					
0	0	26	11	68bc	7de	28
0	2	26	10	76bc	8bcde	26
0	3	29	12	118ab	11abc	24
20	0	31	15	73bc	5de	28
20	2	24	13	70bc	7cde	25
20	3	32	16	63c	12ab	28
40	0	34	17	62c	6de	27
40	2	25	11	65c	7cde	25
40	3	23	11	71bc	9abcd	23
60	0	22	12	65c	7cde	33
60	2	24	12	63c	8cde	25
60	3	26	13	153a	13a	30
Mean		27	13	76	8	27
Significance		ns	ns	*	**	ns
CV%		26	37	36.30	27	22

PPM = Processed poultry manure; NPK = Inorganic fertilizer; ns = Not significant
*Significant at $p = 0.05$; **Significant at $p = 0.01$
Column means with the same letter(s) are not significantly different

The critical leaf concentrations of Ca for vegetables are reported to be very variable (Scaife and Turner 1983).

The mean leaf Mg concentration of 0.46% obtained for bird chilli in this study is slightly lower than the leaf Mg content of chilli pepper of 0.60% (Vimala et al. 1985). The critical Mg leaf concentration for vegetables in general is reported to be 0.2% (Maynard 1979; Scaife and Turner 1983).

Micronutrient Fruit micronutrient contents did not differ significantly with treatments except for Fe and Mn *(Table 9)*. Mean fruit micronutrient contents were 27 mg/kg B, 13 mg/kg Cu, 76 mg/kg Fe, 8 mg/kg Mn and 27 mg/kg Zn. The Fe, Cu and B contents are higher while the Mn and Zn are lower than that obtained for chillli pepper (Vimala et al. 1997). As obtained for the fruit, mean leaf micronutrient

Table 10. Leaf micronutrient content (mg/kg) for selected treatments

Fertilizer treatments (t/ha)		B	Cu	Fe	Mn	Zn
PPM	NPK					
0	0	45	19	261	15b	46
0	3	44	16	323	54a	49
20	0	39	16	304	7b	44
20	2	47	17	271	9b	45
40	0	45	17	272	8b	52
Mean		44	17	284	17	47
Significance		ns	ns	ns	*	ns
CV%		14	19	25	87	13

PPM = Processed poultry manure; NPK = Inorganic fertilizer; ns = Not significant
*Significant at $p = 0.05$
Column means with the same letter(s) are not significantly different at $p = 0.05$

contents too did not differ significantly with treatments, with the exception of Mn *(Table 10)*. Mean leaf micronutrient contents were 44 mg/kg B, 17 mg/kg Cu, 284 mg/kg Fe, 17 mg/kg Mn and 47 mg/kg Zn. Boron, Cu and Zn are comparable to that obtained for chilli pepper (Vimala et al. 1997).

Nitrate content

The nitrate contents of bird chilli fruits are presented in *Table 11*. An increase in inorganic fertilizer rates from 0 to 3 t/ha increased NO_3-N content significantly from 463 mg/kg to 684 mg/kg. All rates of PPM + NPK resulted in higher nitrate content than PPM only, though the differences were not significant. It is interesting to note that increasing organic fertilizer only, from 20 to 60 t/ha did not increase nitrate contents significantly. Higher $N0_3$-N contents in crops fertilized with inorganic fertilizers compared to organic fertilizers have been reported in previous studies (Leclerc et al 1991; Sang 1997; Vimala et al. 2004; Vimala et al. 2006). Thus, the high rates of organic fertilizers required for organic vegetable cultivation does not result in NO_3-N accumulation, rendering organic vegetables safe for consumption. The nitrate values obtained for all the treatments were below the safe limit (MAFF UK 1999).

Heavy metal content

Arsenic, cadmium and lead contents in bird chilli fruits are presented in *Table 12*. All the heavy metal contents were below the permissible limits of 1 mg/kg As, 1 mg/kg Cd, 2 mg/kg Pb (Legal Research Board 1997). There were no significant differences between treatments with the exception of Cd. However, no clear trend in Cd content with increasing fertilizer rates could be discerned. It is concluded that neither poultry manure nor inorganic fertilizers at the rates used in this study contributed to heavy metal accumulation to unsafe levels.

Soil chemical properties at the end of trial

Increasing rates of poultry manure increased CEC significantly from 9.12 at 0 PM to 11.05 at 40 t/ha PPM *(Table 13)*. It is interesting to note that application of 3 t/ha of inorganic fertilizer without any poultry manure did not improve CEC, indicating that chemical fertilizers, though applied in large quantities, do not result in soil improvement.

Soil N content showed the same trend as CEC. The N content increased significantly from 0.11% at 0 PPM to 0.15% at 40 t/ha PPM. Total P increased significantly from 0.04% at 0 PPM to 0.15% at 40 t/ha PPM. As obtained for CEC and N

Table 11. Nitrate content (mg/kg) of bird chilli fruit

Fertilizer treatments (t/ha)		NO_3-N
PPM	NPK	
0	0	463b
0	2	646ab
0	3	684a
20	0	592ab
20	2	709a
20	3	759a
40	0	579ab
40	2	672a
40	3	711a
60	0	576ab
60	2	752a
60	3	751a
Mean		659
Significance		*
CV%		16

PPM = Processed poultry manure;
NPK = Inorganic fertilizer
*Significant at $p = 0.05$
Column means with the same letter(s) are not significantly different at $p = 0.05$

Table 12. Heavy metal content (ppb) of bird chilli fruit

Fertilizer treatments (t/ha)		As	Cd	Pb
PPM	NPK			
0	0	47b	46c	164
0	2	28b	48bc	253
0	3	101ab	42c	215
20	0	6b	84a	192
20	2	30b	60abc	182
20	3	26b	79ab	181
40	0	62b	72abc	181
40	2	61b	66abc	202
40	3	47b	60abc	191
60	0	46b	64abc	213
60	2	19b	81a	191
60	3	173a	69abc	287
Mean		47	66	199
Significance		ns	*	ns
CV%		115	24	21

PPM = Processed poultry manure;
NPK = Inorganic fertilizer; ns = Not significant
Column means with the same letter(s) are not significantly different at $p = 0.05$

Table 13. Soil chemical properties after harvest

Fertilizer treatments (t/ha)		CEC (cmol (+) kg^{-1})	N (%)	P (%)	Ex. K (cmol (+) kg^{-1})	Ex. Ca (cmol (+) kg^{-1})	Ex. Mg (cmol (+) kg^{-1})	TC (%)
PPM	NPK							
0	0	9.12b	0.11c	0.04c	0.26c	0.11cd	0.04bc	1.30c
0	3	9.07b	0.11c	0.06bc	0.28c	0.04d	0.02c	1.27c
20	0	9.84ab.	0.13bc	0.08bc	0.38b	0.17cd	0.05ab	1.36bc
20	2	10.11ab	0.14b	0.10ab	0.35b	0.22bc	0.05ab	1.45ab
40	0	11.05a	0.15a	0.15a	0.44a	0.38a	0.07a	1.53a
Mean		9.83	0.13	0.09	0.34	0.18	0.05	1.38
Significance		*	**	*	**	**	**	**
CV%		7.5	5.7	30.9	8.3	41.1	20.7	4.9

PPM = Processed poultry manure; NPK = Inorganic fertilizer; ns = Not significant
*Significant at $p = 0.05$; **Significant at $p = 0.01$
Column means with the same letter(s) are not significantly different

content, inorganic fertilizer did not increase soil P content. Exchangeable K increased significantly from 0.26 cmol (+) kg^{-1} at 0 PPM to 0.38 cmol (+) kg^{-1} at 20 t/ha PPM and to 0.44 cmol (+) kg^{-1} at 40 t/ha PPM.

Again, it is interesting to note that there was no significant difference between the K content in the zero fertilizer plot and the plot receiving 3 t/ha of only inorganic fertilizer. There was also no significant difference between 20 t/ha PPM and 20 t/ha PPM + 2 t/ha inorganic fertilizer, emphasizing the fact that soil nutrient improvement is mainly through the application of organic fertilizers. Soil calcium and Mg too showed significant improvements with increasing rates of

Table 14. Soil chemical properties (mg/kg) after harvest

Fertilizer treatments (t/ha)		NO_3-N	Zn	Cu	Mn
PPM	NPK				
0		9.95bc	36.39bc	25.59b	86.62b
0	3	7.32c	32.41c	25.12b	76.68c
20	0	11.00bc	48.11b	26.84b	90.96b
20	2	11.29b	46.58b	25.91b	91.16b
40	0	15.47a	64.06a	28.73a	102.74a
Mean		11.00	45.5	26.43	89.6
Significance		*	**	*	**
CV%		17.5	15.3	3.8	4.5

PPM = Processed poultry manure; NPK = Inorganic fertilizer
*Significant at $p = 0.05$; **Significant at $p = 0.01$
Column means with the same letter(s) are not significantly different

PPM. Total carbon content (TC) increased significantly from 1.30% at 0 PPM to 1.53% at 40 t/ha PPM.

Nitrate, Zn, Cu and Mn contents are presented in *Table 14*. The $N0_3$-N content increased significantly from 9.95 mg/kg at 0 t/ha PPM to 15.47 at 40 t/ha PPM. Soil Zn content increased significantly from 36.39 mg/kg at 0 PPM to 64.06 mg/kg at 40 t/ha PPM. The Cu content increased significantly from 25.59 mg/kg to 28.73 mg/kg and the Mn content increased significantly from 86.62 mg/kg to 102.74 mg/kg when PPM was increased from 0 to 40 t/ha. Previous studies too have reported significant improvements in soil chemical properties with the addition of organic sources (Sang 1997; Illias and Vimala 2005; Vimala 2005; Vimala et al. 2006).

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Abstrak

Kajian ini menilai keberkesanan kadar baja organik (tahi ayam yang diproses) dan baja tak organik atau baja kimia untuk pertumbuhan, hasil dan kandungan nutrien cili padi. Tahi ayam proses (PPM) telah diuji pada kadar 0, 20, 40 dan 60 t/ha. Baja kimia (NPK) diguna pada kadar 0, 2 dan 3 t/ha.

Kesan PPM dan NPK terhadap hasil adalah signifikan. Kesan interaksi antara PPM dengan NPK didapati tidak signifikan. Hasil bertambah dengan signifikan daripada 6.46 t/ha (tanpa baja) kepada 15.49 t/ha pada kadar 20 t/ha PPM + 2 t/ha NPK. Perhubungan antara hasil cili padi dengan baja kimia adalah kuadratik, $Y = 9.1455 + 5.0848x - 1.3292x^2$ (Y = hasil dalam t/ha dan x = baja dalam t/ha). Kadar optimum baja kimia ialah 1.91 t/ha. Perhubungan antara hasil cili padi dengan baja organik sahaja adalah kuadratik, $Y= 6.0813 + 0.1861x - 0.0018x^2$ (Y = hasil dalam t/ha dan x = baja organik dalam t/ha). Kadar optimum baja organik ialah 52 t/ha.

Baja tidak memberi kesan signifikan terhadap berat buah tetapi memberi kesan signifikan terhadap panjang buah. Berat buah antara 0.76–0.89 g dan panjang buah antara 3.8–4.5 cm.

Kadar nutrien tidak berbeza dengan signifikan, kecuali kandungan Ca, Fe and Mn di dalam buah dan kandungan Mg and Mn di dalam daun. Makronutrien buah ialah 2.38% N, 0.46% P, 5.22% K, 0.18% Ca dan 0.24% Mg. Mikronutrien buah ialah 27 mg/kg B, 13 mg/kg Cu, 76 mg/kg Fe, 8 mg/kg Mn and 27 mg/kg Zn. Makronutrien daun ialah 4.81% N, 0.36% P, 5.48% K, 1.62% Ca and 0.46% Mg manakala mikronutrien daun ialah 44 mg/kg B, 17 mg/kg Cu, 284 mg/kg Fe, 17 mg/kg Mn dan 47 mg/kg Zn. Kebanyakan ciri-ciri kimia tanah bertambah apabila kadar baja organik bertambah.

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