

Effects of manure on soil chemical properties, yields, and chemical compositions of Chinese kale grown in alluvial and sandy paddy soils of Northeast Thailand.

I. Soil chemical properties and yields of Chinese kale.

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ABSTRACT

A pot experiment was conducted to study the effects of cow manure on chemical properties and yields of Chinese kale grown in soils with different fertility status. One soil was a high - fertility market garden soil (Ratburi), the other was low - fertility, coarse-textured paddy soil (Roi Et). Five rates of cow manure were used, 0, 1, 2, 3, 4, and 5% on a soil dry weight basis (0, 20, 40, 60, 80, and 100 ton/ha). Cow manure increased pH of the soils significantly. It did not increase organic matter content of Ratburi soil at higher rates of application, unlike the significant increase in organic matter content in Roi Et soil. Nutrient contents in Ratburi soil after plant harvest did not increase with rates of manure applied unlike those of Roi Et soil. Higher yields and higher yield response to cow manure were found in Ratburi soil than Roi Et soil.

INTRODUCTION

Buffalo and cow manure is used by farmers for their intensive market garden practice in Khon Kaen province of Northeast Thailand. The market garden area situated on the outskirts of the city of Khon Kaen is on irrigated area and has young alluvial soils of medium to clayey texture. The soil is more fertile and has better texture for market garden crops than the sandy soils which are more typical soils of the Northeast. As differs from the market garden soils, the paddy soils receive some small quantity of animal manure once a year around February before the rainy season. This is because rice culture is not as intensive as market gardening and there is not enough manure for heavy applications in paddy rice.

Animal manure applied to soils help improve their chemical and physical properties. It was demonstrated that annual applications of cattle manure decreased particle and bulk densities, and modulus rupture of soil cores, increased diameter of water-stable aggregates, and hydraulic conductivity (Tiarks *et al.*, 1974), and water intake

rate (Meek *et al.*, 1982). Chemical properties of soils were improved through increasing organic carbon content (Tiarks *et al.*, 1974), P availability (Meek *et al.*, 1982), and soil pH (Long *et al.*, 1975). However, continuous application of animal manure at high rates can be harmful due to accumulations of salts and nitrate in soils and plants (Mathers and Stewart, 1974; Long *et al.*, 1975; Magiwa, 1976).

The objective of this study was to investigate the effect of animal manure commonly used in this region on some chemical properties, and yields of Chinese kale grown in two soils with different fertility status.

MATERIALS AND METHODS

A pot experiment was conducted on two soils, i.e. an alluvial soil, Ratburi series (Rb) - a Tropaquept which was a market garden Soil and an Aeric Paleaquult (Roi Et series - Re) which was a common paddy soil. Four kilograms of top soil (0 - 20 cm depth) per pot was used. The soil was ground to pass a 2 - mm sieve. The pots were clay pot with top diameter of 19.3 cm, and

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bottom diameter of 14.4 cm, and they were 20.0 cm in height. The pot had a round hole approximately 2 cm in diameter at the bottom end for drainage. A clay tray was placed beneath each pot to trap any water leached out of the pot. Basal fertilizers of N, P, and K were applied to all experimental units at the rate of 50 kg elements per hectare in the forms of urea (46%N), superphosphate (40% P_2O_5), and muriate of potash (60% K_2O).

Dried, powdered cattle manure was mixed with the soil thoroughly before the mixture was potted. Six rates of the manure were used 0, 1, 2, 3, 4, and 5% of soil dry weights which correspond to 0, 20, 40, 60, 80, and 100 tons per hectare, or 0, 3.2, 6.4, 9.6, 12.8, and 16.0 tons per rai, respectively.

The experiment was of factorial arrangement with two soils, and six manure rates. The experimental design was randomized complete block with four replications. There were all together 48 pots.

Five seeds of Chinese kale were sown in each pot after which the seedlings were thinned to three seedlings per pot. Watering was done daily to 70% of the water holding capacities of the soils. Weeding was done regularly.

Harvesting was done 53 days after seeding. The plants were at their marketable stage. It was done by cutting the tops at ground level. The roots were extracted out of the soils. The plant materials were dried at 70°C for several days, and dry weights determined. The oven-dried materials were ground ready for chemical analyses.

A composite soil sample from each pot was analysed chemically after plant harvest. Total N was done by micro-Kjeldahl technique which did not include nitrate-nitrogen. Exchangeable Ca, Mg, K, and Na were extracted by 1 N NH_4OAc at pH 7, and Ca and Mg were determined by atomic absorption spectrophotometry, while K and Na were determined by flame photometry. Exchangeable Al was extracted with 1 N KCl, and was determined by NaF complexation-titration method. Soil P was extracted by Bray II solution and determined colorimetrically by molybdenum blue method. Organic matter

was determined by Walkley and Black method (Page, 1982). Particle size distribution was determined by pipet method (Black, 1965).

RESULTS

1. Soil chemical and physical properties before the application of cow manure.

In general, Ratburi soil was of higher soil fertility, and had heavier texture than Roi Et soil. The most marked difference between the two soils were available P level (Table 1). Both available P and exchangeable K in both soils were low.

2. Some chemical properties of cow manure.

Cow manure had remarkably high pH (Table 2). Total N content was not high, while organic carbon was high which resulted in relatively wide C/N ratio. Cow manure was especially high in K and Mg contents (Table 2).

3. Chemical properties of soils after harvesting.

All chemical properties of the two soils were significantly different (Figure 1a-1g), and with an exception of pH Roi Et soil had significantly lower levels of various chemical and fertility parameters than Ratburi soil.

pH

pH increased in both soils with increasing rates of cow manure, however, the increase was highly significant only in Roi Et soil (Figure 1a).

Organic matter

Soil organic matter increased with increasing rates of applied cow manure. At higher manure rates the organic matter levels of Ratburi soil tapered off while those of Roi Et soil still increased significantly (Figure 1b).

Total N

Total N contents of both soils significantly increased with increasing rates of cow manure applied. In Ratburi soil, there was a significant decrease in total N level at the second highest rate of the manure applied (Figure 1c).

Available P

Extractable P in both soils increased significantly with increasing rate of cow manure applied, except for the highest rate of cow manure in Ratburi soil where there was no increase in soil extractable P (Figure 1d).

Table 1. Some properties of Ratburi and Roi Et soils.

Soil properties	Ratburi	Roi Et
pH (soil:water = 1:2)	4.8	5.0
Organic matter (%)	1.7	1.0
Total N (%)	0.09	0.06
Available P (ppm)	13.0	4.0
Exchangeable K (me/100 g)	0.62	0.20
Exchangeable Ca (me/100 g)	0.69	0.45
Exchangeable Mg (me/100 g)	0.45	0.22
Exchangeable Na (me/100 g)	0.27	0.07
Exchangeable Al (me/100 g)	0.37	0.23
ECEC ¹ (me/100 g)	2.40	1.17
Sand content (%)	16.1	67.0
Silt content (%)	53.2	20.0
Clay content (%)	30.7	13.0
Texture	silty clay loam	sandy loam

¹ ECEC = Effective cation exchange capacity which is the sum in me/100 g of Ca, Mg, K, Na, and Al contents.

Exchangeable bases

In Ratburi soil, K, and Mg levels did not increase significantly at higher rates of manure, while those in Roi Et soil did. Calcium level in both soils did not give significant response to increasing rates of cow manure applied with an exception of Ca level in Roi Et soil at the highest rate of the manure (Figure 1e, f, and g).

4. Yields

Top yields of Chinese kale grown in Ratburi soil were significantly higher than those grown in Roi Et soil (Figure 2a). Significant increase in top yields with increasing rates of cow manure was found in those grown in Ratburi soil, but in Roi Et soil the significant increase was only found at the highest rate of manure applied (Figure 2a). Root yields only increased significantly at the highest rate of manure applied in Ratburi soil (Figure 2b).

DISCUSSION

Ratburi soil is of higher fertility than Roi Et soil (Table 1) because the former is of recent alluvium in origin and it has been used for market

garden crops, therefore, has been receiving heavier application of organic and inorganic fertilizers relative to Roi Et soil which is rice paddy soil of old alluvium in origin with coarser texture.

Cow manure had high C/N ratio (Table 2) relative to chicken manure (C/N ratio 4.5) (Vityakon, P., and S. Seripong, unpublished). According to Stevenson (1986) and Masayna (1987), C/N ratio of soil organic matter or humus is 10 - 12. This is the equilibrium level by which the added organic residues with wider ratio will become after they are decomposed by microbial population. The cow manure would need vigorous microbial activities to be decomposed and various nutrients mineralized.

Cow manure had liming effect on soils as shown by significant pH increases with increasing rates of the manure (Figure 1a). This is considered an important beneficial effect of manure on acid soils frequently encountered in the tropics. More pH responses to manure in Roi Et soil than in Ratburi soil (Figure 1a) was likely due to the low buffering capacity of the coarse-

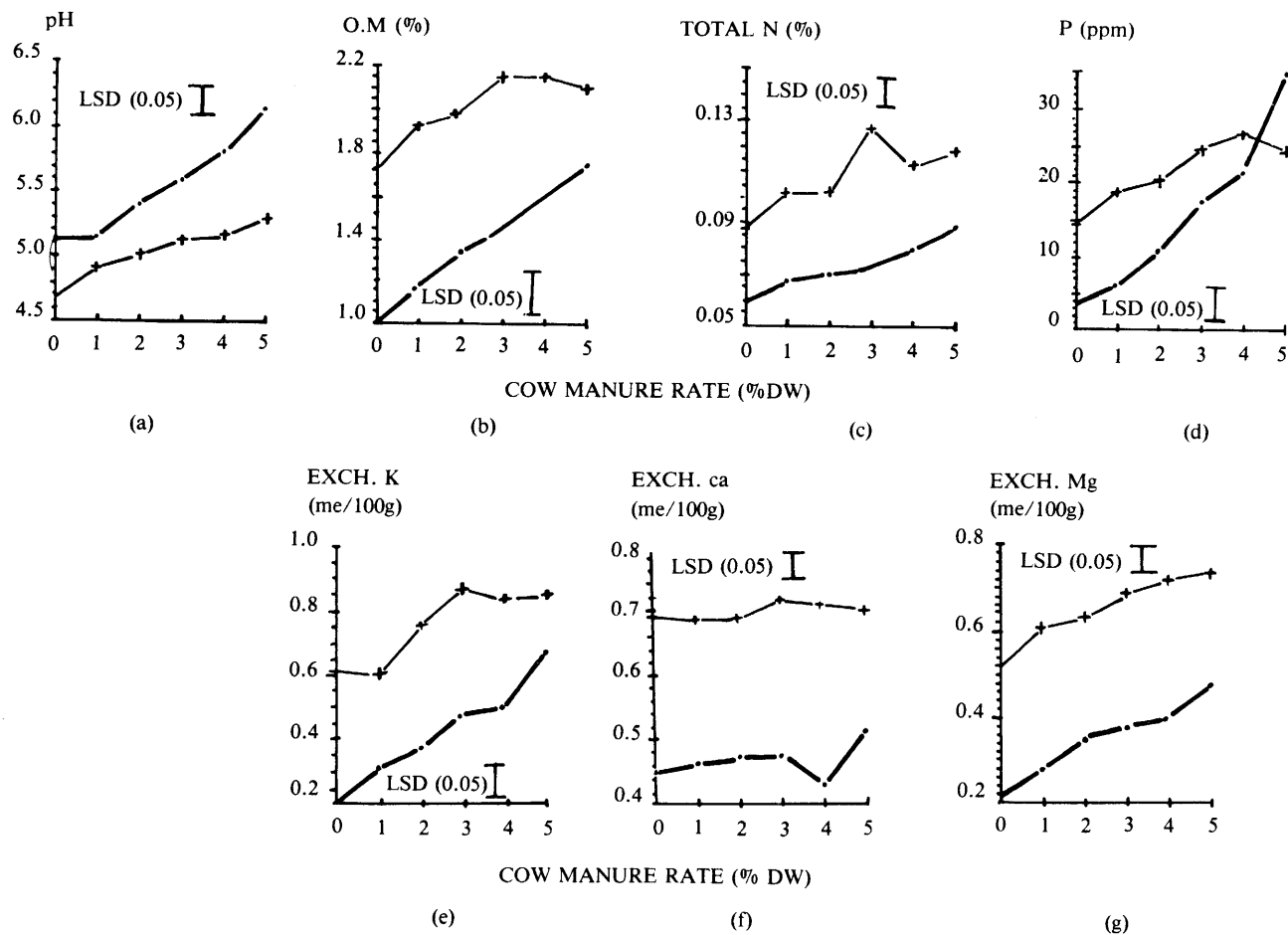


Figure 1 Effects of different rates of cow manure on some chemical properties and nutrient status of Roi Et soil (.....) and Ratburi soil (++). a) pH; b) organic mater (D.M.); c) total N; d) extractable P; e) exchangeable K; f) exchangeable Ca; g) exchangeable Mg.

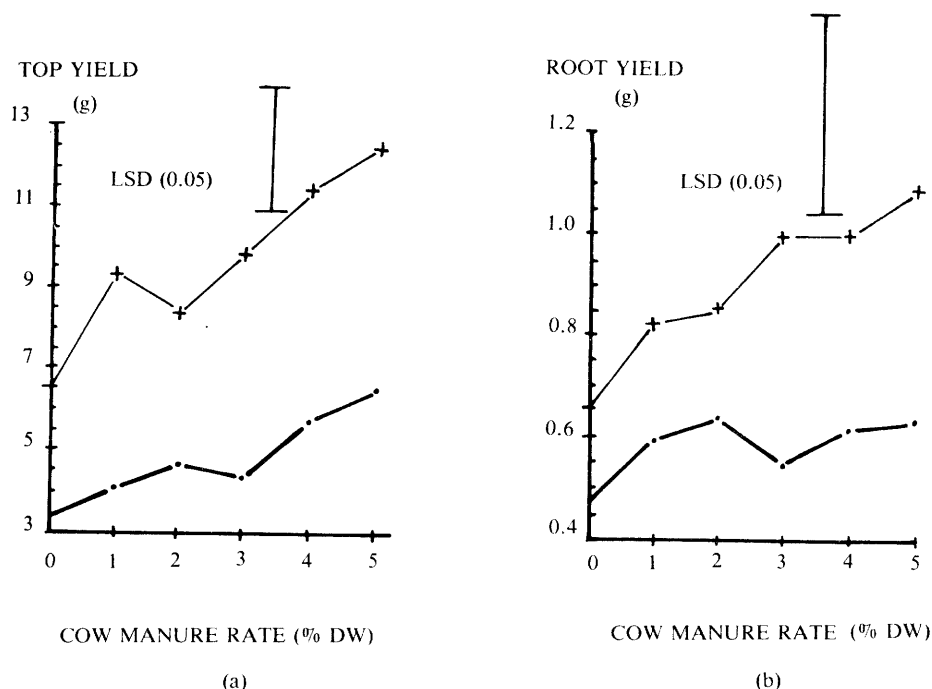


Figure 2. Effects of different rates of cow manure on a) top yield; and b) root yield of Chinese kale grown in Roi Et soil (.....), and Rathburi soil (+ +)

Table 2. Some chemical properties of cow manure used in the study.

Chemical properties	Values
pH	8.80
Total N (%)	0.60
P (%)	0.48
K (%)	2.83
Ca (%)	0.49
Mg (%)	8.05
Organic C (%)	16.9
C/N ratio	28.1

textured, and low organic matter Roi Et soil. On the other hand, Rathburi soil had higher buffering capacity because it had higher clay and organic matter content which resulted in low pH fluctuations.

At lower rates of cow manure application in Rathburi soil, soil organic matter significantly increased. This was likely because Rathburi soil has high clay content (Table 1) which can form complexes with organic substances and render them less susceptible to biodegradation. At higher rates of cow manure applied no increase in soil organic was formed. This was likely because at higher rates cow manure added was no longer adsorbed and protected by the clay, and hence, was in soil solution. Those in soil solution was decomposed rapidly.

Significant increase in soil organic matter content in Roi Et at all rates of cow manure application was likely due to low microbial activities of the soil. It has been documented that clay minerals can stimulate microbial growth and activities (Haynes, 1986). In this case Roi Et soil should have lower microbial activities than Rathburi soil because it had lower clay content

(Table 1).

The trend of levels of nutrients in Ratburi soil not to increase significantly at higher rate of manure (Figure 1c - h) was likely due to increasing nutrient absorption by the plants, as the yields increased significantly at higher rates of cattle manure applied (Figure 2a). In Roi Et soil yields were significantly lower due to lower levels of soil nutrient contents. The uptake of nutrients was not as high as that in Ratburi soil (Vityakon, P., and S. Seripong, the second paper in this series), therefore, more nutrients were still in the soil in increasing levels corresponding to increasing rates of applied cow manure. Since the cow manure had low Ca content relative to other bases (K, and Mg), it did not significantly increase the levels of Ca in both soils (Figure 1f).

The significant top and root yield increases with increasing rates of manure in Ratburi soil indicated the beneficial effects of manure in this soil from improving chemical properties, i.e. nutrient status and pH increase, point of view. On the other hand, plants grown in Roi Et soil only gave significant top yield increase at the highest rates of manure. This is likely because a lot of manure added was not decomposed immediately due to the soil low microbial activities. Moreover, the soil had extremely low nutrient status even when the manure was applied. This did not support vigorous growth.

CONCLUSION

Addition of organic matter to soils have beneficial effects due to improving soil chemical properties. The degree by which the beneficial effects are realized is due to soil properties including soil fertility status and texture. Soil with high fertility status and higher clay content usually sustain vigorous microbial activities which will decompose added organic residue rapidly resulting in beneficial effect to plant growth soon after the organic matter was added. On the contrary, soil with low microbial activities (low fertility status) will accumulate the added organic matter for some time until its microbial activities

can be built up so that more rapid decomposition rate results.

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