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Effects of Manure on Soil Chemical Properties, Yields, and Chemical Compositions of Chinese Kale Grown in Alluvial and Sandy Paddy Soils of Northeast Thailand. II. Nutrient Contents and Relationships with Yields

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ABSTRACT

A pot experiment was conducted to study the effects of cow manure on nutrient concentration and uptake of Chinese kale and the relationships between nutrient concentrations and plant yield in plants grown in two different soils. Five rates of cow manure were used, 0, 1, 2, 3, 4 and 5% on a dry weight basis (0, 20, 40, 60, 80 and 100 ton/ha). Cow manure significantly increased the uptake of P and K but not N and Ca. Soil Bray II extractable P, P concentration in plant and yields produced significant positive correlation with soil pH in both soils, but the soil with higher original soil P fertility gave lower correlation coefficients than the lower fertility soil. The relationships between nutrient concentrations and yields showed that the critical nutrient concentration was close for plants grown in two different soils with an exception of K. The critical concentration for N found was 2.0 - 2.5% and that for P was 0.22%.

INTRODUCTION

Soil analysis presented in the first paper of this series (Vityakon *et al.,* 1988) was useful to the extent that the information regarding changes occurred in the soils after cow manure application was acquired. However, in order to obtain information on changes pertaining to nutrient status occurred in plants as a result of cow manure application, plant analysis is required. Plant analysis can be used as a tool to predict crop yields, diagnose nutrient deficiencies, adequacies, toxicities, or imbalances, establish fertilizer recommendation, and estimate the overall nutritional status of soils. When plant analysis is employed, the usual parameters measured are nutrient concentration and plant yield from which nutrient uptake can be calculated. In addition, the relationship between yield and nutrient concentration can lead to much useful interpretation regarding nutrient status in the plants (Reuter and Robinson, 1986). This study was conducted with the objectives of investigating the effects of cow manure rates on nutrient concentration and uptake of Chinese kale grown in two soil different in original soil fertility, and investigating the relationships of nutrient concentration and plant yield.

MATERIALS AND METHODS

A pot experiment was conducted on two soils, i.e. an alluvial soil, Ratburi siries (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

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soil was ground to pass a 2 - mm sieve. The pots were clay pots with top diameter of 19.3 cm, and 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 (0, 20, 40, 60, 80 and 100 kg/ha).

The experiment was of factorial arrangement with two soils, and six manure rates. The experimental design was randomized complete block with four replications.

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 water holding capacities of the soils.

Harvesting was done 53 days after seedling. The plants were at their marketable stage. It was done by cutting the tops at ground level. Fresh weights were determined before the plant materials were dried at 70°C for several days, and dry weights determined.

A composite soil sample from each pot was analyzed chemically after plant harvest. pH was determined in 1 : 2 of soil to water suspension employing a pH meter. Soil P was extracted by Bray II solution and determined colorimetrically by molybdenum blue method.

Plant analysis was performed on oven-dried, ground plant materials from whole plant tops. Total N was determined by micro Kjeldahl method (Bremner and Mulvaney, 1982). Plant material was digested by concentrated H_2SO_4 with catalyst ($CuSO_4 : K_2SO_4$: Se = 10 : 100 : 1).

Phosphorus and bases were analyzed in plant materials digested with nitric - perchloric acids. Phosphorus was determined by vanado-molybdophosphoric yellow color method (Jackson, 1973). Potassium was determined by flame emission spectrophotometry. Calcium and magnesium were determined by atomic absorption spectrophotometry.

Nutrient uptake was the product of nutrient concentration and yield. Relative yield was the ratio in per cent of actual yield and maximum yield.

RESULTS

1. Nutrient concentration and uptake

Phosphorus concentration and uptake in plants grown in both Ratburi and Roi Et soils increased significantly with increasing rates of cow manure (Figures 1b, and 2b). Nutrient concentration other than that of P did not change significantly with increasing rates of cow manure with exceptions of K and Mg contents in Roi Et soil grown plants received higher rates of cow manure which was significantly higher than the controls (Figures 1 c, e). Uptake of other nutrients exhibited increasing trend but only significant at higher rates of cow manure applied (Figures 2a, c, d, e).

In general, nutrient concentration in plants grown in Roi Et soil was higher than that of plants grown in Ratburi soil (Figures 1 a - e). On the other hand, nutrient uptake in Ratburi soil was higher than that of Roi Et soil (Figures 2 a - e).

Potassium was the nutrient taken up in highest quantity (Figure 2c). Nitrogen and K concentrations in plants were of the same magnitude and they were the two highest nutrient concentration in plants.

2. Relationships between nutrient concentration and yield

The relationships between nutrient concentrations and yields are shown in Figures 3 and 4 a - c. At low N and P concentrations, yields increased markedly with little or no change in N and P concentrations (Figures 3 a-b and 4 a-b). This zone of the curve is called 'deficiency' zone where the relationship derived was steep. In addition, deficiency zone of the relationship derived for N in Ratburi grown plant was sigmoid (Figure 3a). The abrupt change in slope of the curve derived for P indicated the adequate zone where P concentration increased with little or no effect on yield. The abrupt slope change enabled the determination of P critical level to be 0.22% for both Ratburi and Roi Et soil grown plants.

The relationship derived for N did not exhibit distinct 'adequate' range (Figures 3a, 4a). Beyond the critical N level of 2.5% in Ratburi soil grown plant, and 2.0% in Roi Et soil grown plant, increasing tissue N concentrations accompanied yield decrease. This zone is generally termed 'toxicity' zone.

The relationship derived for K were different for plants grown in two different soils (Figures 3c, 4c). At deficiency zone of Ratburi soil grown plants, yield increased was accompanied by marked decrease in K concentration. Abrupt change in slope indicated the adequate K range where increase in K concentration was associated with little yield change, and the critical K concentration could be determined to be 3.0%. Toxicity range was also shown in Figure 3c where yield started to decrease at K concentration more than 3.4%. The relationship derived for K in Roi Et soil grown plant (Figure 4c) showed that yield kept increasing with increasing tissue K concentration. Only deficiency range was exhibited even at 4.0% K.

The critical nutrient concentrations for plants grown in both soils were closed with an exception for that of K.

3. Relationships of soil pH with yield, plant P, and soil P

The increase in soil pH, due to the cow manure application, produced significant positive correlation coefficients with yields, plant P concentration, and soil extractable P in both soils, with an exception of the correlation coefficient between pH and plant P concentration in Ratburi soil (Figures 5 a, b). The correlation coefficients of these relationships are higher in Roi Et soil than in Ratburi soil.

DISCUSSION

Significant increase in P concentration and uptake by Chinese kale could be due to increased P availability resulting from manure application. Meek *et al.* (1982) found that application of high rates of manure greatly increased soil $NaHCO_3$ extractable P in calcareous soil. Some work led to the suggestion that manure enhanced the availability of soil P through increased soil microbial activity, resulting in greater solubility and mobility of native soil P (Abbott and Tucker, 1973). The fact that cow manure increased soil pH significantly (Vityakon *et al.,* 1988) could lead to greater solubility of soil P both through increased microbial activity and solubility of Al phosphate and Fe phosphate at high pH with the consequence of higher P concentration in plant tissue (Figure 5 a, b). The fact that Ratburi soil is more fertile than Roi Et soil with respect to original soil P level (Vityakon *et al.,* 1988) led to the lower correlation between soil pH with soil P, plant P, and yield in Ratburi soil relative to Roi Et soil. This indicates that Ratburi soil was not as responsive to cow manure as Roi Et soil.

Increased uptake of K and Mg was likely due to the high amount of these two elements contained in the manure itself (Vityakon *et al.,* 1988). On the other hand, the manure had rela-

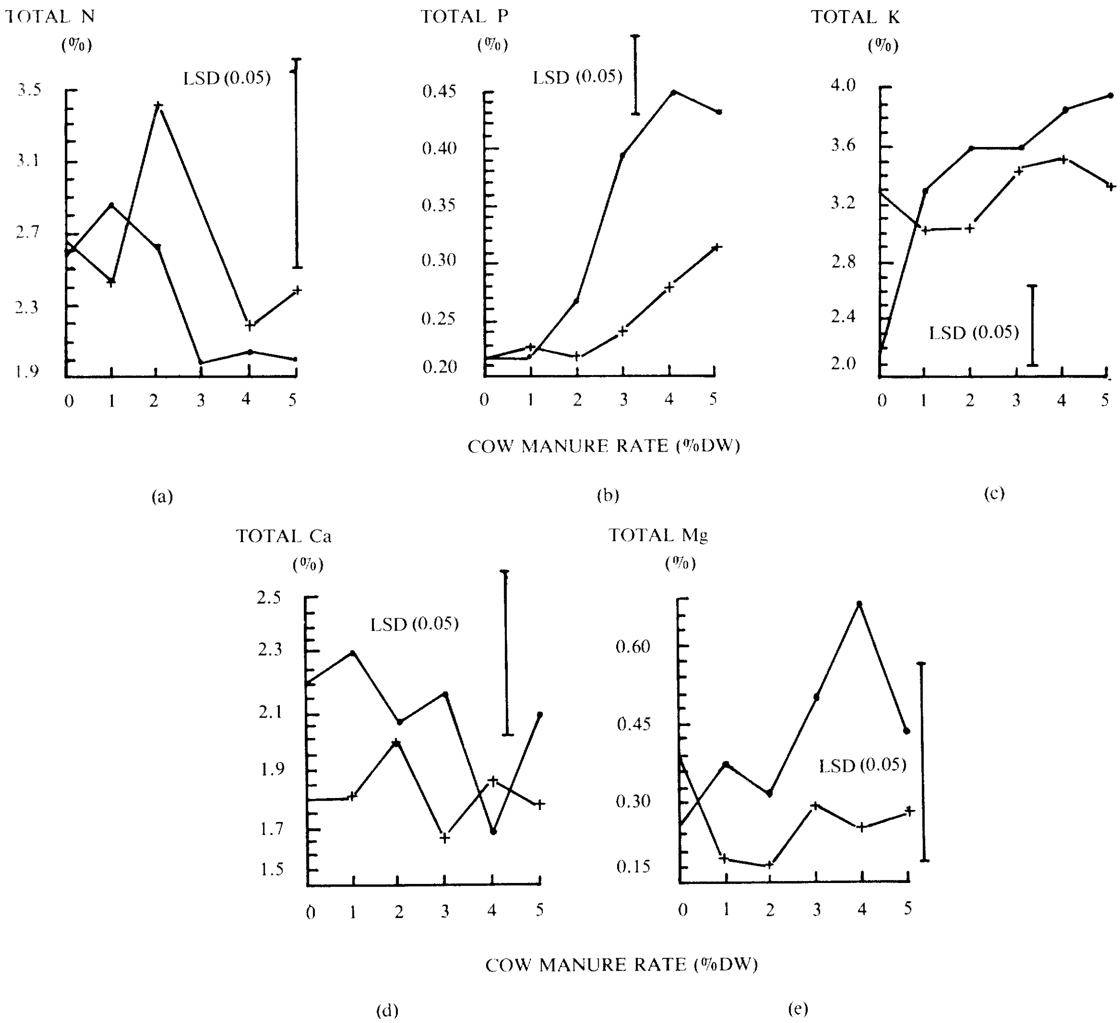

Figure 1 Effects of cow manure rates on nutrient concentration in Chinese kale: (a) N;(b) P;(c) K;(d) Ca; and (e) Mg, Ratburi soil (+ ——— +), Roi Et soil (. ——— .)

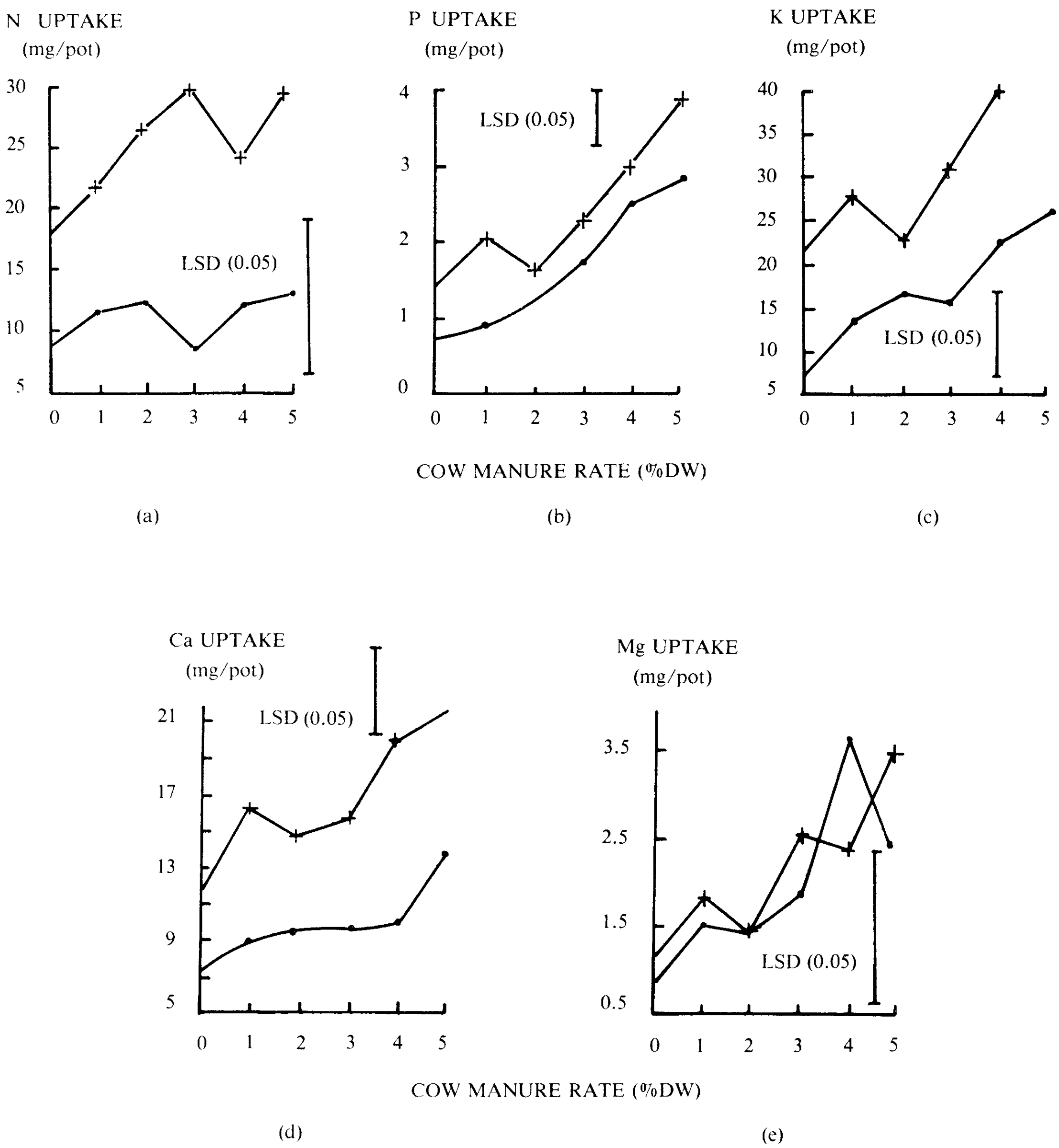

Figure 2 Effects of cow manure rates on nutrient uptake by Chinese kale: (a) N; (b) P; (c) K; (d) Ca; and (e) Mg, Ratburi soil (+ ———— +), Roi Et soil (. ———— .)

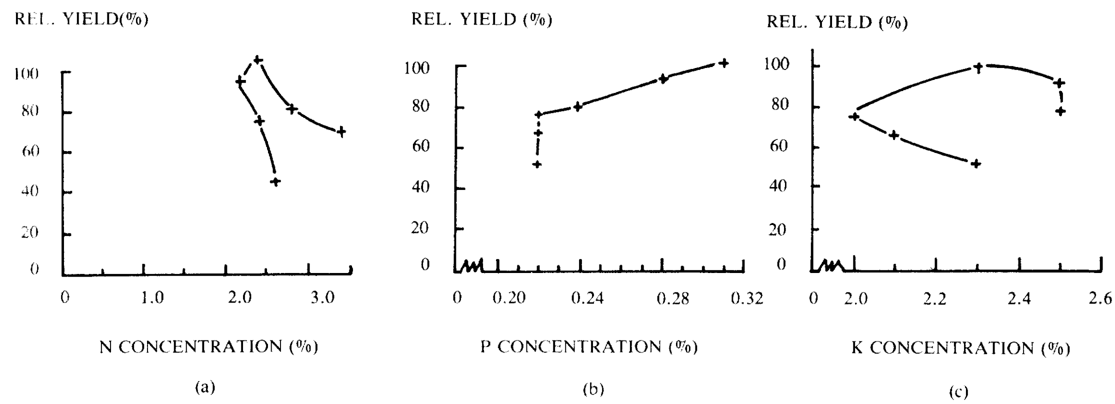

Figure 3 **Relationships between nutrient concentration and yields in Ratburi soil grown Chinese kale: (a) N; (b) P; (c) K**

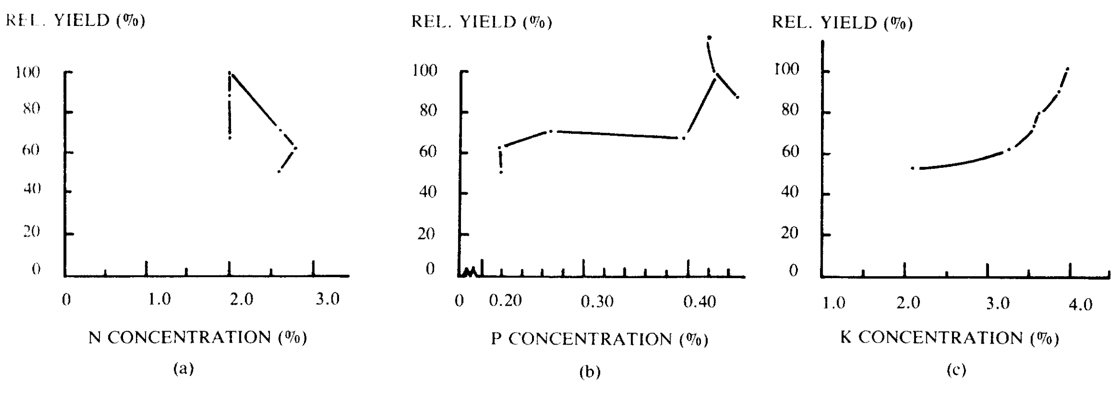

Figure 4 **Relationships between nutrient concentration and yields in Roi Et soil grown Chinese kale: (a) N; (b) p; (c) K**

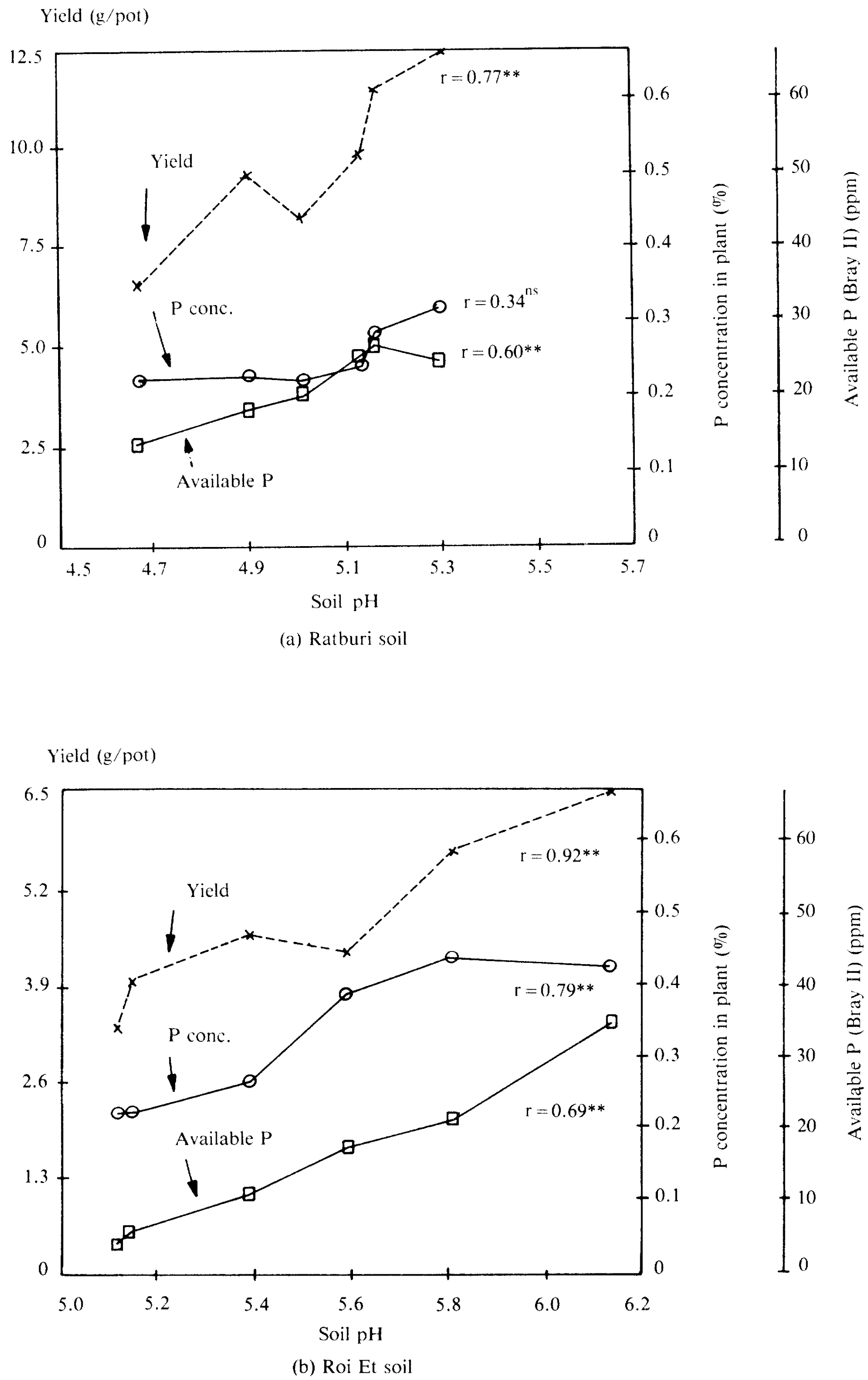

Figure 5 Relationships of soil pH as affected by cow manure application with yield, plant P and soil P.

tively little N and Ca contents (Vityakon *et al.*, 1988) which led to non-significant increase of N and Ca uptake with increasing rates of cow manure (Figures 2a, d).

The low nutrient concentration in plants grown in Ratburi soil was due to dilution effect because the plant growth rate was more rapid than nutrient accumulation rate (Jarrell and Beverly, 1981).

The high concentration and uptake of K in Chinese kale confirmed the fact that K is the most important cation in plant physiology (Mengel and Kirkby, 1982). In other leafy vegetables such as spinach (Vityakon, 1979), and broccoli (Reuter and Robinson, 1986), K concentration and uptake were also the highest comparing with other cations.

Nutrient uptake in plants grown in Ratburi soil was higher than those in Roi Et soil because the former had higher "nutrient demand" due to higher growth (Nye and Tinker, 1969 as cited by Raper, Jr., *et al.,* 1977). The high nutrient uptake may have been the reason for the no increase in soil nutrient levels in Ratburi soil found earlier (Vityakon *et al.,* 1988).

In general, critical nutrient concentration for each kind of plants fall within a narrow range (Reuter and Robinson, 1986). The results obtained in this study were so for N and P but not for K. Nutrient concentrations in plant can be affected by many factors including environmental factors, and nutrient interactions (Bates, 1971). The different fertility of the two soils under study may have been the cause of the difference in K critical level in plants grown in the two soils.

The relationship between P concentration and yield derived was similar to those obtained in pasture species (Smith, 1975).

The deficiency zone obtained in relationships derived for N, P and K indicated that the soils did not supply adequate nutrients for good plant growth and by applying cow manure at various rates, the manure had supplied those lacking nutrients to plants which enable rapid vegetative growth. When growth rate is high, the nutrient accumulation rate can lag behind which resulted in apparent dilution effect and the consequent no increase in nutrient concentrations (Raper, Jr., *et al.,* 1977, Jarrell and Beverly, 1981).

When plant growth was approaching its limit which was determined by nutrient availability, various other environmental factors, and genetic factor, growth rate was slow down, nutrient uptake rate at this point could exceed growth rate which resulted in nutrient accumulation as shown in the adequate zone of the curve relating yield and nutrient concentration.

Cow manure at third to fourth rates appeared to be able to supply nutrient enough for critical requirements of plants.

CONCLUSIONS

Results of plant analysis showed that P and K were the nutrients with significant increase in uptake due to cow manure application. Consider the very low P content of the two soils studied and significant positive P uptake response to increased cow manure rate, it can be put forward that increased available P was the most important changes brought about by cow manure application. Acid soils usually have low available P and bases, from this standpoint application of manure is highly benificial through increasing availability of these nutrients for plant growth.

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