# Effect of Hog Dung Compost on the Growth and Nitrogen Composition of Cabbage

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## ABSTRACT

The experiment was carried out in the Agricultural Research Farm of the National Taiwan University during the winter of 1997. There were four kinds of treatments in total including a conventional chemical fertilizer control and three rates (30, 60 and 120 Mg ha$^{-1}$) of compost-treated plots. The cabbage (*Brassica oleracea* L. Capitata Group, cultivar early spring) was harvested after 94 days of transplanting. After being washed, the plants were divided into the root, the wrapper leaf petioles, the wrapper leaf blades, and the head (the marketable portion). The dry weight and the concentrations of the total nitrogen (N), phosphorus (P), potassium (K), nitrate N ($NO_3$-N), ammonium N ($NH_4$-N) and insoluble N in various parts of the plants were determined. The results showed that there were no significant differences in the growth of various treatments. However, the productivity of the head of 120 Mg ha$^{-1}$ compost- and chemical fertilizer-treated plots were higher than those of the 30 Mg ha$^{-1}$ and 60 Mg ha$^{-1}$ compost-treated plots. The total N and K concentrations of various parts of the plants were not significantly different for the treatments. However, the P concentrations in the chemical fertilizer-treated plants were lower and those in compost-treated plants increased with increasing the compost rate. The

$NO_3$-N concentrations in the whole plant, the wrapper leaf blades, and the head of the chemical fertilizer-treated plants were the lowest among all treatments and there were no significant differences in the $NO_3$-N concentrations of the head among the compost treated-plots. There were no significant differences in the concentrations of $NH_4$-N, soluble organic N, and insoluble N in various parts of the plants among the treatments. In conclusion, even though with the application of 120 Mg $ha^{-1}$ of compost, there was no disadvantageous effect on the growth of cabbage, on the other hand, a good yield was obtained.

Key words: Cabbage, mamure, N uptake, P uptake, K uptake, N composition.

## Introduction

Nitrogen is a principal constituent of plants and accounts for at least one-half of the total number of ions absorbed. However, as the level of N supplied to a plant exceeds that normally needed to sustain growth, the growth is affected and the soluble form of N, such as $NO_3$-N, soluble organic compounds, begin to accumulate in the tissues (Mills and Jones, 1979). Nitrogen supply is the most important nutritional controlling factor that affects the $NO_3$-N levels in plants (Goh and Haynes,1986). Although $NO_3$-N is essential to life, it is a nuisance and possibly a hazard in the wrong place or at the wrong time (Addiscott et al., 1991). The accumulation of $NO_3$-N in plants, to a certain extent, is a natural and necessary process. Since vegetables provide a major portion of our dietary intake of $NO_3$-N, it is important that its concentration should be maintained at a level as low as possible.

Organic matter affects crop growth and yield either directly by supplying nutrients, or indirectly by modifying soil physical properties that can improve the root environment and stimulate plant growth (Avnimelech, 1986). Crop production based on the use of organic manures rather than agricultural chemicals is assumed to be a more sustainable type of agriculture, and produces nutritious food. Therefore, organic farming has received great attention from environmentalists, agriculturists and consumers in recent years. Application of animal manure to agricultural lands has also been increasing steadily in recent years. An abundant source of organic matter in Taiwan is animal manure (particularly hog dung manure) from intensive animal husbandry facilities. Therefore, more information is needed on the application rate and the effect of organic matter on crop production. Furthermore, little information is available regarding the effect of fertilization on the N composition of cabbage.

The purpose of this study is to assess the effect of high application rates of hog dung compost on the growth, accumulation of N, P, and K and N composition of cabbage in a field experiment.

## MATERIALS AND METHODS

### Experimental Design and Cultivation of Cabbage

The experiment was conducted in the Agricultural Research Farm of the National Taiwan University during the winter of 1997. The soil was loamy in texture (sand, 315 g $kg^{-1}$; silt, 509 g $kg^{-1}$; clay, 176 g $kg^{-1}$), a pH of 4.2 in water (1:1 w/w soil: water ratio), an organic carbon content (Walkley and Black method, Nelson and Sommer, 1982) of 12.1 g $kg^{-1}$, a total N of 2.16 g $kg^{-1}$, and Bray No. 1 extractable P of 15 g $kg^{-1}$. A randomized complete block design consisting of three rates of hog dung compost and a conventional chemical fertilizer was used. The pH of the compost was 7.2 in water (1:5 w/w compost water ratio), electric conductivity of 7.1 dS $m^{-1}$ in water (1:5 w/w compost water ratio), Total carbon of 378 g $kg^{-1}$, total N of 24.1 g $kg^{-1}$, total P of 4.5 g $kg^{-1}$, total K of 16.9 g $kg^{-1}$, total calcium of 26.1 g $kg^{-1}$, total magnesium of 4.5 g $kg^{-1}$, total iron of 10.4 g $kg^{-1}$, total aluminum of 3.7 g $kg^{-1}$, total manganese of 1170 g $kg^{-1}$, total copper of 240 mg $kg^{-1}$, total zinc of 430 mg $kg^{-1}$,$NH_4$-N of 1.8 g $kg^{-1}$, insoluble N of 8.6 g $kg^{-1}$, and trace amount of $NO_3$-N was also detected. The experiment was conducted with four replications. The size of each plot was 6.5 x 6.0 $m^2$. The three application rates of hog dung compost were 30, 60, and 120 Mg $ha^{-1}$ (32% moisture). These rates are equal to the N rates of 492, 984, and 1968 kg $ha^{-1}$, respectively; the P rates of 92, 184, and 368 kg $ha^{-1}$, respectively; the K rates of 345, 690, and 1380 kg $ha^{-1}$, respectively; upon adjusting for the moisture, N, P, and K from each treatment. The chemical fertilizer application rate of the control was 147-72-126 (N-$P_2O_5$- $K_2O$ ) kg $ha^{-1}$. The chemical fertilizers applied were in the form of ammonium sulfate, superphosphate, and potassium chloride for N, P, and K, respectively. The organic manure was manually applied on the soil surface and basal dressing of chemical fertilizers were placed in row by hand and mixed immediately with soil by a hoe one day prior to transplanting.

Cabbage (*Brassica oleracea* L. Capitata Group, cultivar early spring) used for this study was transplanted on November 7, 1997 with a 0.50-m row spacing and a 0.60-m plant spacing. In chemical fertilizer-treated plots, 63 kg N $ha^{-1}$, all P and all K were used as basal dressing and 42 kg N $ha^{-1}$ was side-dressed for each of another two by hand on the soil surface after 22 and 42 days of planting. Appropriate pesticides were applied after 23 and 39 days, respectively, of planting for controlled insects. Weed was removed by hand.

**Plant Sampling and Analysis**

Three whole plant samples per plot were collected randomly from all plots after 94 days of transplanting. The plant sample was washed, then separated into the head, the wrapper leaf blades, the wrapper leaf petioles (including the lower stem and midrib), and the root, respectively. The washed plant material was oven dried at 65°C to a constant weight, weighed, and then ground to pass through a 40 mesh screen. Total N, P, and K were determined after digestion of the plant material with a mixture of salicylic acid, and sulfuric acid plus sodium thiosulfate to include nitrate and nitrite. (Bremner and Mulvaney, 1982). Nitrate N (including nitrite-N) and $NH_4$-N were extracted with 1.0 N hydrochloric acid (HCl) solution (Blacquiere et al.,1987) and was reduced by zinc powder (Broaddus et al., 1965) and then determined the reduced nitrite by Ilovsay-Griess method ( Keeney and Nelson, 1982a). Ammonium N was determined by steam distillation of the extract with magnesium oxide and collected in boric acid (Keeney and Nelson, 1982b). The N in the residue after 1.0 N HCl extraction was determined by the Kjeldahl method. Then, the soluble organic N was calculated by substrating $NO_3$-N, $NH_4$-N and insoluble residue N from total N.

Potassium was determined using flame photometer. Phosphorus was measured colorimetrically by Murphy and Riley method (Murphy and Riley, 1962).

## RESULTS AND DISCUSSION

### Growth and Dry Matter Distribution

There was no significant difference in the total dry weight between treatments, but the higher rate of compost that has been received by the plants tended to produce more dry matter (Table 1). Treated with 30 and 60 Mg $ha^{-1}$ of compost the yields of heads were lower than those treated with 120 Mg $ha^{-1}$ of compost and chemical fertilizer, but not significant in statistics. The dry weight of the wrapper leaf blades, which were generally green and hence the main site of photosynthesis, was greater in compost-treated plants, so were the wrapper leaf petioles, which were associated with the former. The greater growth of 120 Mg ha$^{-1}$ compost-treated plants was attributable to more available N with the higher application rate of compost. Even though the N applied with 120 Mg ha$^{-1}$ compost rate was almost equal to 2,000 kg ha$^{-1}$, the growth of the plant did not seem to be suffering from the disadvantageous effect caused by the high rate of compost. Therefore the whole N in the compost was not mineralized and available to the plants during the growth of the cabbage. The distribution of dry matter in various plant parts was according to the following order: The head > the wrapper leaf blades > the wrapper leaf petioles > the root.

**Accumulation of N, P and K**

The total N concentrations of the different plant parts in various treatments were not significantly different except that of wrapper leaf blades. The wrapper leaf petioles and wrapper leaf blades almost had the same concentration of N, and they were higher than those in the heads and the roots. The N concentration of the root was the lowest, compared with the other plant parts (Table 2). The considerable higher concentration of total N in the wrapper leaf petioles was different from that observed in other plants, where the total N in the petioles was lower than that of the other plant parts (Kirkby and Mengel, 1967; Osaki et al., 1995; Peck et al., 1971). This result might be due to the fact that the wrapper leaf petioles were the important storage organs of cabbage for N compounds. The amount of N accumulation of compost-treated plants increased with raising the compost rate, although there was no significant difference among treatments ( table 1). On the other hand, the amount of N accumulation in the control plant was the same as that in the 30 Mg ha$^{-1}$ compost-treated plants. Only a small fraction of N in the compost was absorbed by the cabbage, assuming that all the N accumulated in the cabbage was from the compost. The N partitioning in various organs followed the same trends as observed with the dry matter partitioning.

Although it was not significantly different in every instance, plants receiving higher rate of compost tended to have higher P concentration. The P concentration of the chemical fertilizer-treated plants was the lowest (Table 3). Among various parts, the P concentration in the wrapper leaf petioles was the highest and that in the wrapper leaf blades was the lowest. This situation does not agree with the general occurrence for the plants, in which, the reverse is true. From the fact that the dry matter yield of chemical fertilizer-treated plants was the same as that of the 60 Mg ha$^{-1}$ compost-treated plants, a luxury consumption of P in the compost-treated plants can be existed. This result is attributed to the large amount of available P was associated with the compost.

The plants treated with compost had a greater P accumulation than that of chemical fertilizer treated plants. Phosphorus partitioning in various parts of the plants followed a similar pattern to that of dry matter partitioning except a lower proportion of P was observed in the wrapper leaf blades. The accumulation of P in compost-treated plants was increased by raising the compost rate. Only a little amount of applied P accumulated in the cabbage, assuming that all P accumulated by the plants was from the fertilizer.

The concentration and accumulation of K in plants of various treatments did not differ significantly, however, there was a tendency that accumulation of K increased with raising the compost rate (Table 4). The concentration of K in the wrapper leaf petioles was the highest and that in the root was the lowest among various plant parts. There were almost the same concentration of K in the wrapper leaf blades and the heads. The much higher concentration of K in the petioles than those in the other organs was generally observed in the higher plants (Geraldson and Tyler, 1990; Hue et al., 1978; Jones, 1970; Kirkby and Mengel, 1967). Most of the K accumulated was distributed in the head, followed by the wrapper leaf petioles and lowest in the root. This was different from those of N and P, probably due to the higher concentration of K in the wrapper leaf petioles than that in the other parts of the plant. Only a little amount of applied K was accumulated by the cabbage, assuming that all K accumulated by the plants was from the fertilizer.

### Nitrogen Composition

#### Nitrate N

The concentration of $NO_3$-N in the shoot of the compost-treated plants was significantly higher than that of the chemical fertilizer-treated plants, but there were no significant differences among the compost-treated ones. Cabbage is a relatively $NO_3$-N loving plant (Huffaker and Rains, 1978; Maynard et al., 1976; Mills and Jones, 1979), therefore high concentration of $NO_3$-N was accumulated in its tissues. Table 5 shows that, in average, about one-tenth of total N was in the form of $NO_3$-N. High $NO_3$-N/total N ratio also existed in other $NO_3$-N loving plants (Chung et al., 1999; Vieira et al., 1998). No consistent relationship existed between application rate of compost and $NO_3$-N concentrations in various parts of plants. The concentration $NO_3$-N in the wrapper leaf blades was increased with increasing the application rate of compost, but this situation did not occur in the roots, the head, and the wrapper leaf petioles. The higher $NO_3$-N concentrations in the compost-treated plants than in the chemical fertilizer-treated plants were due to the large amount of N which was with the applied compost. The $NO_3$-N concentration in the wrapper leaf petioles was the highest among various plant parts, although not all N was available in the compost. The $NO_3$-N concentration in wrapper leaf blades was about one-third of that in the wrapper leaf petioles. However, the $NO_3$-N concentration in wrapper leaf blades was much higher than that in the head. Similar results were reported in the other plants (Barker et al.,1971; Homenauth et al., 1986; Maynard and

Barker, 1972; Mills et al., 1976a, 1976b; Minotti et al., 1989; Olday et *al*., 1976a, 1976b; Peck et al., 1971). Rubeiz et al.(1993) showed that the $NO_3$-N concentration of the midrib of the cabbage was 2.7-7.2 g $kg^{-1}$ under different fertilizer treatments. The $NO_3$-N/ total N ratio was similar in the root and the wrapper leaf blades. In the head, the $NO_3$-N/ total N ratio was low. This result indicates that only small amount of N in the head was in the form of $NO_3$-N. However, some of the $NO_3$-N translocated into the head was probably due to excess amount of $NO_3$-N accumulation.

**Ammonium N**

Plant can absorb $NH_4$-N and metabolize it quickly (Reisenauer, 1978; Marschner, 1995). Ammonium N absorbed by the roots will be transformed into glutamine in the roots by glutamine synthetase, and then transformed into amino acids or amides (Miflin and Lea, 1976; Givan, 1979). Small amounts of $NH_4$-N may be transported to shoots, and then metabolized (Givan, 1979). When plant organs are senescent, proteins degrade and produce amides, amino acids and $NH_4$-N (Givan, 1979; Vierstra; 1993). In general, the concentration of $NH_4$-N in the plant tissues are rather low because the high concentration of $NH_4$-N induces ammonium toxicity, resulting in chlorosis of leaves, restricted growth, and even death in some cases (Barker et al., 1966; Bennet et al., 1964; Mills and Jones, 1979; Puritch and Barker, 1967; Wallace and Ashcroft, 1966; Wander and Sites, 1956; Weir et al., 1972). The concentration of $NH_4$-N in the whole plant of various treatments was low and there was no significant difference among treatments except the 30 Mg $ha^{-1}$ treated-plants, which was significantly lower (Table 5). The $NH_4$-N/ total N ratios in various parts of cabbage were low. There was no consistent relationship between treatments and $NH_4$-N concentrations in various parts of plants. The $NH_4$-N concentration in the roots was the lowest among different plant parts, which can be explained by considering the fact that most of $NO_3$-N reduction did not take place in the root. The higher concentration of $NH_4$-N in the head than the roots can not be explained correctly, however, it can be the product of protein degradation.

**Soluble Organic N**

Soluble organic N contains amino acids, amides, small peptides, and other small molecular N containing-compounds. A high concentration of soluble organic N in plant organs is probably due to excess N nutrition, especially under the excess nutrition of ammonium (Allen and Smith, 1986; Harada et al., 1968). However, the soluble organic N concentration also depends on the changes in the physiological status of plant, such as initiation of flower increases its concentration (Kafkafi and Ganmove-Neumann, 1997; Sagee and Lovatt, 1991). There were few differences in soluble organic N concentration in various parts of plants from the different treatments (Table 5). The concentration of soluble organic N in the head was the highest of all plant parts and that in the roots was the lowest. More than half of total N in the head was in the soluble organic N form suggested that soluble organic N accumulated in the head and this might be one of the causes of its sweetness. However, there was considerably high amount of soluble organic N in the other parts of plants (about one-third of total N).

**Insoluble N**

Insoluble N in plant organs is large molecule containing compounds, including proteins, nucleic acids, etc. (Barker et al., 1966). There were no significant differences in insoluble N concentrations in various parts of plants due to the different treatments except in the wrapper leaf blade (Table 5). Among different plant parts, insoluble N concentrations in the wrapper leaf blades was the highest. Most of the metabolism occurred in the wrapper leaf blades, and hence there were more proteins, nucleic acids etc. than in other plant parts. The insoluble N/ total N ratio of wrapper leaf blades was higher than that of the other plant parts.

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Table 1. Effect of application rate of hog dung compost on the dry weight yield of cabbage.

| Treatment | Root | Wrapper leaf petiole | Wrapper leaf blade | Head | The whole plant |
|---|---|---|---|---|---|
| kg ha$^{-1}$ | | | | | |
| 30 Mg ha$^{-1}$ | 162 a* ( 5)# | 436 ab (12) | 571 a (16) | 2418 a (67) | 3587 a (100) |
| 60 Mg ha$^{-1}$ | 202 a ( 5) | 509 ab (13) | 786 a (21) | 2312 a (61) | 3809 a (100) |
| 120 Mg ha$^{-1}$ | 149 a ( 4) | 558 a (14) | 720 a (18) | 2682 a (65) | 4109 a (100) |
| Control | 182 a ( 5) | 373 b (10) | 542 a (15) | 2616 a (70) | 3713 a (100) |

* Averages followed by the same letters in each column are not significantly different by Duncan's Multiple Range Test (p = 0.05).

# The number in parenthesis is the partition ratio in percentage.

Table 2. Effect of application rate of hog dung compost on the concentration and accumulation of total N in cabbage.

| Treatment | Root | Wrapper leaf petiole | Wrapper leaf blade | Head | The whole plant |
|---|---|---|---|---|---|
| Concentration, g kg$^{-1}$ | | | | | |
| 30 Mg ha$^{-1}$ | 17.3 a* | 37.4 a | 38.7 ab | 33.4 a | 33.9 a |
| 60 Mg ha$^{-1}$ | 19.1 a | 40.4 a | 37.3 b | 33.7 a | 34.4 a |
| 120 Mg ha$^{-1}$ | 18.9 a | 39.0 a | 40.9 a | 33.2 a | 34.7 a |
| Control | 18.0 a | 36.7 a | 37.7 b | 32.9 a | 33.4 a |
| Accumulation, kg ha$^{-1}$ | | | | | |
| 30 Mg ha$^{-1}$ | 2.7 a( 2)# | 16.3 ab (13) | 22.1 a (18) | 80.5 a (66) | 121.6 a (100) |
| 60 Mg ha$^{-1}$ | 3.8 a( 3) | 20.6 ab (16) | 29.1 a (22) | 76.9 a (59) | 130.4 a (100) |
| 120 Mg ha$^{-1}$ | 2.8 a( 2) | 21.7 a (15) | 29.4 a (21) | 88.5 a (62) | 142.4 a (100) |
| Control | 3.3 a( 3) | 13.9 b (11) | 20.9 a (17) | 85.6 a (69) | 124.0 a (100) |

* Averages followed by the same letters in each column are not significantly different by Duncan's Multiple Range Test (p = 0.05).

# The number in parenthesis is partition ratio in percentage.

Table 3. Effect of application rate of hog dung compost on the P concentration and accumulation of P in cabbage.

| Treatment | Root | Wrapper leaf petiole | Wrapper leaf blade | Head | The whole plant |
|---|---|---|---|---|---|
| Concentration, g kg$^{-1}$ | | | | | |
| 30 Mg ha$^{-1}$ | 4.2 b* | 4.6 b | 3.6 b | 4.4 a | 4.3 b |
| 60 Mg ha$^{-1}$ | 4.7 b | 5.1 b | 3.4 b | 4.8 a | 4.5 ab |
| 120 Mg ha$^{-1}$ | 5.5 a | 5.7 a | 4.2 a | 4.7 a | 4.8 a |
| Control | 2.2 c | 3.3 c | 2.6 c | 3.7 b | 3.4 c |
| Accumulation, kg ha$^{-1}$ | | | | | |
| 30 Mg ha$^{-1}$ | 0.7 ab ( 5) | 2.0 bc (13) | 2.0 ab (13) | 10.7 b (69)# | 15.4 bc (100) |
| 60 Mg ha$^{-1}$ | 0.9 a ( 5) | 2.6 ab (15) | 2.7 ab (16) | 10.8 b (64) | 17.0 ab (100) |
| 120 Mg ha$^{-1}$ | 0.8 a ( 4) | 3.2 a (16) | 3.0 a (15) | 12.6 a (64) | 19.6 a (100) |
| Control | 0.4 b ( 3) | 1.3 d (10) | 1.4 b (11) | 9.6 b (76) | 12.7 c (100) |

* Averages followed by the same letters in each column are not significantly different by Duncan's Multiple Range Test ($p = 0.05$).

# The number in parenthesis is partition ratio in percentage.

Table 4. Effect of application rate of hog dung compost on the concentration and accumulation of K in cabbage.

| Treatment | Root | Wrapper leaf petiole | Wrapper leaf blade | Head | The whole plant |
|---|---|---|---|---|---|
| Concentration, g kg$^{-1}$ | | | | | |
| 30 Mg ha$^{-1}$ | 20.8 a | 56.1 a | 35.7 a | 36.6 a | 38.0 a |
| 60 Mg ha$^{-1}$ | 21.0 a | 55.6 a | 34.5 a | 36.9 a | 37.9 a |
| 120 Mg ha$^{-1}$ | 21.9 a | 53.4 a | 34.2 a | 34.5 a | 36.7 a |
| Control | 19.8 a | 50.4 a | 36.5 a | 35.5 a | 36.4 a |
| Accumulation, kg ha$^{-1}$ | | | | | |
| 30 Mg ha$^{-1}$ | 3.3 a ( 2) | 24.4 a (18) | 20.5 a (15) | 88.0 a (65) | 136.2 a (100) |
| 60 Mg ha$^{-1}$ | 4.2 a ( 3) | 28.3 a (20) | 27.4 a (19) | 53.6 a (58) | 143.5 a (100) |
| 120 Mg ha$^{-1}$ | 3.2 a ( 2) | 29.4 a (20) | 25.2 a (17) | 91.9 a (61) | 149.7 a (100) |
| Control | 3.6 a ( 3) | 19.1 a (14) | 20.3 a (15) | 92.4 a (68) | 135.4 a (100) |

* Averages followed by the same letters in each column are not significantly different by Duncan's Multiple Range Test ($p = 0.05$).

# The number in parenthesis is partition ratio in percentage.

Table 5. Effect of application rate of hog dung compost on the N composition of cabbage (g kg$^{-1}$).

| Treatment | Root | Wrapper leaf petiole | Wrapper leaf blade | Head | The whole plant |
|---|---|---|---|---|---|
| $NO_3^-$-N, g kg$^{-1}$ | | | | | |
| 30 Mg ha$^{-1}$ | 2.9 a (0.17) | 13.1 a (0.35) | 4.3 ab (0.11) | 1.5 ab (0.04) | 3.4 a* (0.1)$ |
| 60 Mg ha$^{-1}$ | 2.9 a (0.15) | 14.7 a (0.36) | 5.2 ab (0.14) | 1.6 a (0.05) | 4.2 a (0.12) |
| 120 Mg ha$^{-1}$ | 3.0 a (0.16) | 16.8 a (0.43) | 5.6 a (0.14) | 1.4 ab (0.04) | 4.2 a (0.12) |
| Control | 3.0 a (0.16) | 13.8 a (0.37) | 3.6 b (0.09) | 1.0 b (0.03) | 2.9 b (0.09) |
| $NH_4^+$-N, g kg$^{-1}$ | | | | | |
| 30 Mg ha$^{-1}$ | 0.4 ab (0.02) | 1.2 b (0.03) | 1.1 a (0.03) | 1.0 b (0.03) | 1.0 b *(0.03)$ |
| 60 Mg ha$^{-1}$ | 0.5 ab (0.02) | 1.4 ab (0.03) | 0.9 a (0.03) | 1.5 a (0.04) | 1.3 a (0.04) |
| 120 Mg ha$^{-1}$ | 0.4 b (0.02) | 1.4 ab (0.04) | 1.1 a (0.03) | 1.3 ab (0.04) | 1.3 a (0.04) |
| Control | 0.5 a (0.03) | 1.6 a (0.04) | 0.8 a (0.02) | 1.5 a (0.04) | 1.4 a (0.04) |
| soluble organic N, g kg$^{-1}$ | | | | | |
| 30 Mg ha$^{-1}$ | 5.8 a (0.33) | 11.9 a (0.32) | 9.7 a (0.25) | 18.8 a (0.56) | 15.9 a* (0.47)$ |
| 60 Mg ha$^{-1}$ | 7.7 a (0.40) | 13.0 a (0.32) | 9.7 a (0.26) | 18.5 a (0.55) | 15.4 a (0.45) |
| 120 Mg ha$^{-1}$ | 7.0 a (0.37) | 10.3 a (0.26) | 10.5 a (0.26) | 17.9 a (0.54) | 15.2 a (0.44) |
| Control | 6.7 a (0.37) | 10.2 a (0.28) | 9.9 a (0.26) | 18.7 a (0.57) | 16.0 a (0.48) |
| Insoluble N, g kg$^{-1}$ | | | | | |
| 30 Mg ha$^{-1}$ | 8.2 a (0.48) | 11.3 a (0.30) | 23.5 a (0.61) | 12.2 a (0.36) | 13.7 a (0.40)$ |
| 60 Mg ha$^{-1}$ | 8.0 a (0.42) | 11.4 a (0.28) | 21.5 a (0.58) | 12.1 a (0.36) | 13.6 a (0.41) |
| 120 Mg ha$^{-1}$ | 8.6 a (0.45) | 10.5 b (0.27) | 23.6 a (0.58) | 12.6 a (0.38) | 14.0 a (0.40) |
| Control | 7.8 a (0.44) | 11.1 ab (0.30) | 23.5 a (0.62) | 11.7 a (0.36) | 13.1 a (0.39) |

* Averages followed by the same letters in each column are not significantly different by Duncan's Multiple Range Test ($p = 0.05$).

$ The number in parenthesis is insoluble N/ total N.

# The number in parenthesis is partition ratio in percentage.

# 豬糞堆肥對甘藍生長與氮磷鉀吸收之影響

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本研究之目的在探討不同量之豬糞堆肥對甘藍生長、氮、磷與鉀吸收及氮素組成分之影響，試驗在國立台灣大學農業試驗場進行。堆肥處理爲每公頃 30、60 與 120 公噸三種，以施用化學肥料之處理爲對照。甘藍於移植後 94 天採收，以水洗淨後，分成根、外葉葉片、外葉葉柄及球四部分，經烘乾後分析氮、磷、鉀、硝酸態氮、銨態氮與不溶解性氮濃度。結果顯示各種不同處理之不同部位之氮與鉀濃度無顯著差異，但是化學肥料處理之磷濃度顯著低於堆肥處理者，堆肥處理之磷濃度則隨堆肥施用量增加而增加；化學肥料處理之整株植物、外葉葉片及球之硝酸態氮濃度爲各處理中之最低者，而堆肥處理間球之硝酸態氮濃度則無顯著差異；各處理不同部位之銨態氮、溶解性有機態氮及不溶性氮無顯著差異。整體而言，豬糞堆肥之用量高達每公頃 120 公噸，在第一年之結果裡對甘藍之生長顯出無不良之影響。

關鍵詞：甘藍、堆肥、氮素吸收、磷素吸收、鉀素吸收、氮素組成。