# Manures Made of Livestock Excreta, and Their Application to the Nursery

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Livestock excreta is very difficult to be applied directly to nurseries, because of their bad smell and dampness, to say nothing of growth troubles of plants caused by undecomposed organic matters. But, we can use it as liquid barnyard manures, or as solid ones when mixed with materials that absorb water, so long as they are well decomposed.

In the present study, a method to utilize livestock excreta as barnyard manure by promoting decomposition and maturing by mixing with highly water-absorbent sawdust was examined. Experiments to determine the reasonable rate of application and substitutability for chemical fertilizer of the manure produced from cattle excreta and hog excreta (hereafter referred to cattle manure and hog manure) were carried out, by using Sugi seedlings (*Cryptomeria japonica*) as test plants. This study was carried out under the special research project, "Studies on the technical treatment of livestock excreta"[1].

## Changes of chemical properties in the process of manure production

### 1) *Cattle manure*

Cattle excreta mixed with sawdust at the ratio of 1:1 by volume were loosely piled in order to keep good aeration, which promotes calorification and fermentation, at the moisture content of about 70%, which is regarded as adequate for manure production. After 120 days, well-matured cattle manure was obtained. The change in the amount of inorganic nitrogen occurred during that period is given in Table 1. Organic nitrogen was mineralized, that is, $NH_4$-N was formed through calorification and fermentation in the first stage. Then, $NO_3$-N was formed from the $NH_4$-N in the next stage. Finaly, the amount of $NH_4$-N decreased relatively, whereas that of $NO_3$-N increased.

**Table 1. Changes of the inorganic nitrogen content during the pilling period**

(ppm on dry matter basis)

| Nitrogen form | Days after the start of piling | | | |
|---|---|---|---|---|
| | 12 | 26 | 61 | 97 |
| $NH_4$-N | 303.6 | 138.6 | 175.1 | 4.4 |
| $NO_3$-N | 8.6 | 19.6 | 969.0 | 20.4 |
| $NH_4$-N | (Yellow | 757.6 | | |
| $NO_3$-N | part) | 17.3 | | |

Using cattle excreta mixed with sawdust at 1:4, a compost production test by Automatic Ventilation Mixer was made in the Institute of Agricultural Machinery. The well-matured manure was produced in only about 60 days[2]. This means that the fermentation speed was accelerated about 2 times by the ventilation.

The comparison of chemical properties between 2 kinds of cattle manure produced with and without ventilation are given in Table 2. They are nearly the same in regard to nitrogen mineralization, although there might be some differences between them, regarding quality of cattle excreta and sawdust, and mixing ratio. In other words, under the natural condition of piling $NH_4$-N was gradually formed through ammonification and the amount of $NO_3$-N increased through nitrification during a period of 120 days, while with the forced

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Table 2. Changes of chemical composition of barnyard manure made of cattle excreta and sawdust (dry matter basis)

| Piling method and period | | pH | E C (m mho/cm) | Water soluble C (mg/100 g) | Alkali soluble humus (%) | C (%) | N (%) |
|---|---|---|---|---|---|---|---|
| Piling with ventilation | 20 days | 7.12 | 3.32 | 962 | 32.9 | 46.7 | 1.80 |
| | 60 days | 7.08 | 3.68 | 670 | 35.2 | 44.7 | 2.32 |
| Piling under natural condition | 1 month | 7.10 | 2.30 | 592 | 32.0 | 39.9 | 1.37 |
| | 2 months | 7.10 | 2.60 | 615 | 34.0 | 41.6 | 1.82 |
| | 3 months | 7.20 | 2.42 | 937 | 34.9 | 40.9 | 1.75 |
| | 4 months | 6.58 | 2.90 | 709 | 40.3 | 37.4 | 2.12 |

| Piling method and period | | $NH_4$-N (ppm) | $NO_3$-N (ppm) | $P_2O_5$ (%) | $K_2O$ (%) | CaO (%) | MgO (%) |
|---|---|---|---|---|---|---|---|
| Piling with ventilation | 20 days | 39.1 | 9.9 | 1.87 | 1.95 | 1.34 | 1.94 |
| | 60 days | 20.2 | 347.5 | 1.89 | 2.60 | 1.73 | 2.62 |
| Piling under natural condition | 1 month | 30.2 | 206.9 | 1.72 | 2.09 | 2.28 | 2.98 |
| | 2 months | 559.6 | 375.9 | 1.85 | 2.69 | 2.87 | 3.48 |
| | 3 months | 239.0 | 111.6 | 1.91 | 2.60 | 2.81 | 3.43 |
| | 4 months | 269.8 | 576.5 | 1.75 | 3.25 | 2.81 | 3.43 |

Table 3. Various kinds of changes of cattle excreta in the process of barnyard manure production

| | Cattle excreta | Barnyard manure |
|---|---|---|
| Color | yellow → yellowish brown dark brown → | dark brown |
| Moisture | 70% → 70% with water → | 50–40% |
| Smell | stink → stink partly (ammonia butyrate) → | stink sugarily |
| Intensity of smell* | 4 → 4–3 → | 2–1 |
| Texture | blocky → | granular or massive |

*1: faint, 2: not strong, 3: strong, 4: stronger, 5: strongest

ventilation the same phenomena finished only after 60 days. It is supposed that humification also well progressed with ventilation, because no difference was found in the amount of alkali soluble humus between two different conditions.

The changes of color, moisture, smell, etc. in the piling period are given in Table 3. With the progress of maturity, the smell changed from ammoniac or butylic acid like to sugary, and the color of organic matter from yellow to dark brown.

### *2) Hog manure*

Sawdust was spread in pighouses to mix with hog excreta at the ratio of 1:1 by volume. The mixture was taken out and piled provisionally. Then, the mixture was piled up every about 2 $m^3$ after its moisture content was adjusted to 70% by spraying water, as the mixture had already calorified and fermented a little during the period of provisional piling.

The changes of chemical properties in the process of manure production are given in Table 4. With the progress of maturity, the amount of water soluble carbon and $NH_4$-N decreased, and that of alkali soluble humus and $NO_3$-N increased.

The changes of color, moisture, smell, etc. in the piling period are given in Table 5.

**Table 4. Changes of chemical composition of barnyard manure made of hog excreta and sawdust (dry matter basis)**

| Piling period | pH | E C (m mho/cm) | Water soluble C (mg/100 g) | Alkali soluble humus (%) | C (%) | N (%) | $NH_4$-N (ppm) | $NO_3$-N (ppm) | $P_2O_5$ (%) | $K_2O$ (%) | CaO (%) | MgO (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 month | 7.08 | 5.30 | 1641 | 39.32 | 42.7 | 2.76 | 53.8 | 28.4 | 3.84 | 6.38 | 2.55 | 4.46 |
| 2 months | 7.08 | 5.18 | 1103 | 44.95 | 38.9 | 3.09 | 930.1 | 627.6 | 3.86 | 5.92 | 2.69 | 6.27 |
| 3 months | 7.00 | 5.42 | 1170 | 45.75 | 41.6 | 3.08 | 663.9 | 451.9 | 3.80 | 6.31 | 2.49 | 5.22 |
| 4 months | 6.00 | 7.42 | 689 | 55.20 | 40.0 | 3.40 | 382.6 | 2039.9 | 3.87 | 6.21 | 3.02 | 6.04 |

**Table 5. Various kinds of changes of hog excreta in the process of barnyard manure production**

| | Hog excreta | | Barnyard manure |
|---|---|---|---|
| Color | brown black → | dark brown → | dark grey |
| Moisture | 60–70% → | covered with white mould → | 50–40% |
| Smell | stink* → | stink** → | stink aciduously |
| Intensity of smell | 5 → | 4 → | 3–2 |
| Texture | blocky → | | fine massive |

* Methyl-merga-butane or hydrogensulfide
** Methyl-merga-butane or ammonia
About intensity of smell, see the legend of Table 3.

**Table 6. Nutrient absorption of Sugi seedlings grown in the nursery where chicken manure was used for the past 3 years** ($g/m^2$)

| | Dry weight of seedlings ($g/m^2$) | N | $P_2O_5$ | $K_2O$ | CaO | MgO |
|---|---|---|---|---|---|---|
| Chicken manure | 735.8 | 6.01 | 1.23 | 6.63 | 5.88 | 0.81 |
| Chemical fertilizer | 513.1 | 4.01 | 1.10 | 4.74 | 4.72 | 0.56 |
| Control | 324.0 | 2.98 | 0.68 | 2.14 | 4.03 | 0.40 |

## Fertilizing effect of manures produced from chicken droppings or livestock excreta

### *1) Chicken manure*

Application tests were carried out by using transplanted seedlings for continuous 3 years. Judging from the dry matter production of the seedlings, the chicken manure was as effective as or more effective than chemical fertilizer. The seedlings absorbed more nitrogen, phosphorus and potassium in the manure plot than in the chemical fertilizer plot (Table 6).

It must be emphasized that the most nitrogen in the chicken manure was easily decomposable urea which acts effectively on plant growth and the rest was protein which decomposed gradually, supplying slowly available nitrogen to plants[3].

### *2) Cattle manure and hog manure*

Application tests were carried out by using Sugi seedlings for continuous 2 years, and dry matter production is given in Tables 7 and 8. The cattle manure was applied to each plot at the rate of 2.3t/10a, 5t/10a, 10t/10a or 20t/10a, and the hog manure at the rate of 1.5t/10a, 5t/10a, 10t/10a or 20t/10a. For reference, a plot of chemical fertilizer was set up. It was observed with the cattle manure that the higher the rate of application, the

**Table 7. Dry matter production of Sugi seedlings supplied with cattle manure** (g/m²)

| Year | Rate of cattle manure application (t/10 a) | | | | Chemical fertilizer | Control |
|---|---|---|---|---|---|---|
| | 2.3 | 5 | 10 | 20 | | |
| 1st year | 355.7<br>( 72) | 499.3<br>(101) | 632.2<br>(128) | 838.8<br>(170) | 492.8<br>(100) | 326.4<br>( 66) |
| 2nd year | 492.3<br>( 99) | 590.6<br>(119) | 827.6<br>(166) | 842.3<br>(169) | 497.1<br>(100) | 298.8<br>( 60) |

**Table 8. Dry matter production of Sugi seedlings supplied with hog manure** (g/m²)

| Year | Rate of hog manure application (t/10 a) | | | | Chemical fertilizer | Control |
|---|---|---|---|---|---|---|
| | 1.5 | 5 | 10 | 20 | | |
| 1st year | 373.9<br>( 60) | 336.2<br>( 54) | 670.9<br>(108) | 724.1<br>(116) | 623.1<br>(100) | 324.0<br>( 52) |
| 2nd year | 398.1<br>( 89) | 487.7<br>(109) | 670.2<br>(150) | 501.0<br>(112) | 447.9<br>(100) | 331.8<br>( 74) |

more the dry matter production and nutrient absorption of the seedlings in the first year. The dry matter production in the 2nd year was greater than that in the first year in every plot. On the other hand, with the hog manure, dry matter production and nutrient absorption increased with the increase of application rate in the 1st year. However, in the 2nd year, the dry matter production was greatest in the 10t/10a plot, showing decreased production beyond that rate.

These manures can be substitutes for chemical fertilizer, because their effect was the same as that of chemical fertilizer at the rate of at least 5t/10a of both manures. However, for continuously repeated use of manures for a long period, the application rate of 2t/10a/yr seems to be reasonable because they contain plenty of many kinds of mineral salts, such as K, Ca, Mg, etc..

## Mineralization of nitrogen in the soil to which livestock excreta were applied

As above mentioned, the livestock manure is highly effective and able to substitute for chemical fertilizer. From the view point of soil fertility, mineralization of nitrogen in the soil which received livestock excreta was examined.

### *1) Nitrogen supplying capacity of the nursery soil*

The amount of inorganic nitrogen in the nursery soil which received cattle excreta at the rate of 750–1,000 kg/10 a/yr continuously for 10 years was measured. Contents of $NH_4$-N and $NO_3$-N in two soil layers (0–5 cm and 15–20 cm in depth) were measured once a month during a period from May to November, 1976. The results are shown in Fig. 1. During the growing period (May to Nov.) of seedlings, the content of $NH_4$-N was about 10 ppm and that of $NO_3$-N was 45 to 60 ppm in the soil. Needless to say, the amount of inorganic nitrogen during the vegetative season is an important factor of soil fertility. These values obtained show that mineralization of nitrogen proceeded at a rather high speed in those nursery soils.

Chemical fertilizer has not been used in the nursery where this measurement was done. However, Sugi seedlings grown in the nursery have been highly evaluated in the Kanto District[4].

### *2) Potentiality of nitrogen mineralization in manured nursery soil*

The amount of mineralized nitrogen was measured by the incubation experiment using the soil to which the manure of chicken droppings had been spread for consecutive 3 years, and the soil which received cattle excreta for 2 years. The

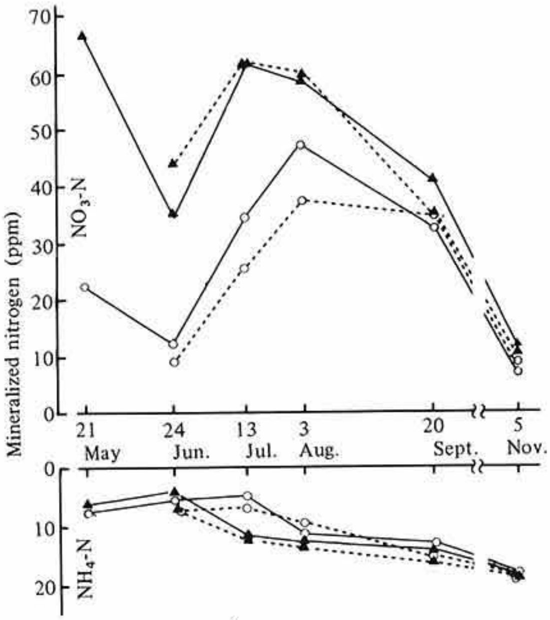


Fig. 1. Monthly variation in the content of mineralized nitrogen

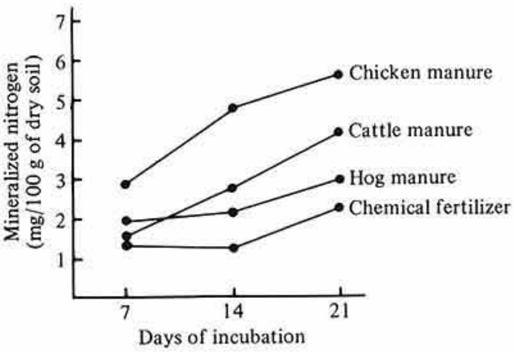


Fig. 2. The amount of mineralized nitrogen in the nursery to which manures were applied in the past time

results are shown in Fig. 2. In both soils, the amount of mineralized nitrogen was rich in comparison with that of the soil which received chemical fertilizer only.

*3) Nitrogen supply as a factor of soil fertility*

The nitrogen of basal fertilizer changes rapidly into $NO_3$-N after application, in other words, only 1–2 mg/100 g of dry soil remains in the soil after July[5]. For this reason, it has been said that top dressing is necessary. However, it was definitely demonstrated by this research that the large amount of mineralized inorganic nitrogen is continuously supplied to the soil from the cattle manure even after July. That is, the manure of livestock excreta as an organic material plays a role not only to increase nitrogenous soil fertility but also to supply many kinds of nutrients to seedlings.

However, here remains a problem about woody materials such as sawdust, chipped bark, etc.. They are usually used as materials to regulate the moisture level in the process of compost production. But it is not easy for them to be decomposed along with livestock excreta, because cellulose or hemicellulose are generally decomposed under low temperature condition (30–45°C) rather than under high temperature condition[6]. Then, the study will be necessary about the decomposition of woody materials in manures.

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