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Rate Effects of Swine Manure Fermented with Sawdust on Efficiency of Nitrogen Utilization of Silage Corn and Soil Fertility

Wan Bang Yook, Dong Ho Choi* and Ki Chun Choi

Abstract

This study was carried out to examine the effects of animal manure on efficiency of the nitrogen utilization of silage corn *(Zea mays* L.) and soil fertility. The experiment was conducted on the field plot at Gongiam, Kwangju, Kyunggi-Do for 3 years, from 1996 to 1998, and arranged in split-plot design with three replications. The main plots were two kinds of composts such as swine manure fermented with sawdust (SMFWS) and swine manure fermented without sawdust (SMF). Subplots were the nitrogen fertilization rate (0, 100, 200, 300 and 400kgN/ha/year). The nitrogen (N) yield increased as the nitrogen fertilization rate increased up to a rate of 300 kg N/ha, but decreased at rate of 400 kg N/ha. Nitrogen yield in SMF treatments was higher than that of SMFWS treatments. But there were no significant differences between SMFWS and SMF treatments. Organic matter (OM) content of the soils in SMFWS was higher than that of SMF, and was not significantly different between SMFWS and SMF treatments. OM content increased with increasing the nitrogen fertilization rate. Total nitrogen (TN) content of the soils increased as the nitrogen fertilization rate increased. No difference of TN content was found between SMFWS and SMF treatments.
(**Key words** : Swine manure, Compost, Corn, Sawdust, Nutritive value)

I. Introduction

It is necessary for Korean livestock producers to increase their efforts of becoming self-supportive with herbages for livestock production. Currently, some livestock producers have biased concepts and feed imported forages such as pellet and cubes, but the rising costs of these materials make their usage unsustainable. In addition, Korean livestock producers have other burdens such as 45 million tons livestock wastes produced per year due to an increase in livestock numbers. Animal manure has many nutrients that can be utilized by plants fertilizer as well as organic matter that improves chemical and physical properties of soils (Gilley et al., 1999; Eghball and Power, 1994; Fraser et al., 1988, Campbell et al., 1986). These properties of animal manure encouraged an increase in manure utilization on fields of rice paddies and forage crops (Yook et al., 1999; Choi, 1999; Shin, 1999; Yook, 1997). Nutrient contents of animal manure, however, vary with animal species, age, feedings, feed stuffs, and processing types, so that excessive application of manure to soils can result in polluting the environment. Therefore, it is very important to match application rates with crop nutrient requirements and to manage manure systems as a system of nutrient recycling thereby utilizing natural

Dept. of Animal Sci., College of Agri., Konkuk Univ., Seoul 143-701, Korea.
* You Won Feed Co., LTD, Seoul 138-160, Korea.

resources and protecting the environment.

When animal manure is applied to agricultural lands, high levels of nitrogen in the manure can cause environmental. Inorganic nitrogen such as nitrate (NO_3^-) and ammonium N (NH_4^+-N) is taken up by plants and utilized for plant growth and development. Otherwise, nitrogen can be lost due to volatilization (Pain et al, 1990), denitrification (Stevens et al, 1987), leaching (Shin, 1999; Yook, 1999; Davies et al, 1996; Owens et al., 1995; Jemison, 1994), and runoff (Hall, 1986; Dam Kofoed, 1981). In particular, runoff and leaching of nitrogen and phosphorus resulting from high rainfall is regarded as a major non-point source of pollution of ground water, streams, lakes, and oceans as compared to volatilization and denitrification (Jarvis et al, 1987; Pye, 1983). Since Korea has a rainy season from June through August, organic and inorganic materials in the crop fields are very susceptible to runoff and leaching due to heavy rainfall. Therefore, it is necessary to evaluate and analyze the effectiveness of nitrogen recovery by forage crops and the level of nitrogen in the soil organic matter and the total nitrogen of soils in different types of manure fermentation. The objective of this study was to examine the effects of application rates of swine manure fermented with either sawdust or without sawdust on the efficiency of nitrogen utilization of silage corn and soil fertility.

II. Materials and Methods

1. Experimental place and soil characteristics

This experiment was carried out at the test pasture and forage crop fields of Livestock Technology Institute at Gongiam, Kwangju, Kyung-gi Province in South Korea and physical- and chemical characteristics of soil are shown in Table 1.

2. Materials and experimental design

Pioneer 3352, mid- and late maturity silage corn was used and experimental design was randomized complete block with split plot design with three replications. Main plot was two types of swine manure (swine manure fermented with sawdust: SMFWS and swine manure fermented without sawdust: SMF) and subplot was five different rates of nitrogen application (0, 100, 200, 300, and 400 kg N/ha/year). Plot size was 15 m^2 (3 m × 5 m). Swine manure fermented with sawdust had 0.46 % total nitrogen, 62% organic matter, 43% moisture content and was commercial compost which was fermented more than six months whereas swine manure fermented without sawdust had 1.07% total nitrogen, 2.3% organic matter, 98% moisture content and was completely fermented one.

3. Nitrogen yield and efficiency of N recovery

Nitrogen yield of silage corn by different manure types and application rates was calculated from dry matter yield and nitrogen content of silage corn. Efficiency of nitrogen recovery was calculated using a Westerman et al's method.

N recovery (%) = $(Wn+Cn-Wc+Cc)\times 100 / Fn$

Wn: dry matter yield of nitrogen applied treatment

Cn: total nitrogen content of nitrogen applied treatment

Wc: dry matter yield of control treatment

Table 1. Chemical properties of the soil used in this experiment

pH (1:5H_2O)	Total nitrogen (%)	Organic matter (%)	Available P_2O_5 (mg/kg)	Exchangeable Cations($cmol^+$/kg)				C.E.C ($cmol^+$/kg)
				Ca	K	Mg	Na	
5.1	0.14	2.22	212.2	4.25	0.68	1.98	0.20	14.3

Cc: total nitrogen content of control treatment
Fn: total amount of nitrogen applied per year

4. Total nitrogen content

Dried silage corn samples were ground through 2 mm mesh screen using a Wiley mill and kept in the desiccator, and analyzed using a Kjeldahl method (AOAC, 1990).

5. Organic matter and total nitrogen of soils

Soil samples for organic matter and total nitrogen content of soil were taken from the 10 cm depth and dried. Organic matter was analyzed using a Tyurin method and total nitrogen content of soil was analyzed using a Kjeldahl method (AOAC, 1990).

6. Statistical analysis

Data were analyzed statistically using a SPSS/PC+ to test the significance at the alpha level of 0.05.

III. Results and Discussion

1. Nitrogen yield and efficiency of nitrogen recovery

Nitrogen yield of silage corn applied with compost of swine manure fermented with either sawdust or without sawdust is shown in Table 2. There was no significant difference (p>0.05) in nitrogen yield although the SMF had higher nitrogen yield than the SMFWS by 11 kg N/ha. Nitrogen yield increased in both the SMFWS and the SMF with increasing application rates up to 300 kg N/ha and beyond that nitrogen yield decreased. At the 400 kg N/ha, the decreasing extent of nitrogen yield was much higher at the SMFWS than the SMF treatment. There was a nitrogen yield difference in different years and in the first and second production years nitrogen yield was decreased at the 400 kg N/ha in both the SMFWS and SMF. In the third production year, however, nitrogen yield rather increased at the 400 kg N/ha. This was most likely due to the increased mineralization rate of organic nitrogen in the third year.

Like the results mentioned above, the SMF had higher nitrogen yield than the SMFWS, this might be due to temporary immobilization resulting from high C : N ratio of sawdust itself. Kissel et al. (1976) reported that 20% of nitrogen applied became immobilized by soil microorganisms and these immobilization reduced nitrogen nutrient that can be utilized by crops and consequently reduced the utilization efficiency resulting from competition between crops and soil microorganisms (Inbar et al., 1990).

The SMF had a higher efficiency of nitrogen recovery than the SMFWS by 6% and efficiency of nitrogen recovery decreased with increasing nitrogen application rates (Table 3). The 100 kg N/ha treatment showed the highest efficiency of nitrogen recovery and the least at the 400 kg N/ha. In both the SMF and the SMFWS, efficiency of nitrogen recovery decreased with increasing nitrogen application rates and the highest efficiency of nitrogen recovery occurred at the 100 kg N/ha and the least at the 400 kg N/ha. These results were similar to Watson's report (1987) where perennial ryegrass had 31% of efficiency of nitrogen recovery per year with applying urea fertilizer. Efficiency of nitrogen recovery in crops is different because nitrogen applied to the soil can be varied with the degree of taking up nutrients by crops, resulting from different climates, crop species, types of fertilizers, and application rates (George et al., 1973; Lee et al., 1968; Kim et al., 1966).

2. Soil organic matter

To examine the improvement of soil quality with applying a compost swine manure, soil organic matter was measured (Table 4). Soil organic matter was 2.22 and 2.55% at the beginning and at the end of experiment, respectively indicating that soil

Table 2. Effects of type and nitrogen fertilization rate of composts injected on nitrogen yield of corn

Composts	N rate(kgN/ha)	N yield(kg/ha)			Mean
		1996	1997	1998	
SMFWS[1]	0	92±31.79[3]	87±12.17	85± 4.00	88±17.48
	100	152±30.73	98±13.32	117± 9.00	122±29.30
	200	159±29.82	105± 2.08	134±58.03	133±41.81
	300	175±19.08	124±14.15	145±20.55	148±27.45
	400	146±20.55	123±43.68	151±42.74	140±34.98
SMF[2]	0	94±23.52	86±0.58	86±13.05	89±14.23
	100	157±26.92	108±19.22	131±39.55	132±33.21
	200	160±31.80	131± 7.64	142± 9.07	144±21.01
	300	177±25.24	157±34.77	146±17.56	160±26.77
	400	171±21.39	141±35.59	170± 8.50	161±27.55
Mainplot					
SMFWS		145a	107a	126a	126a
SMF		152a	125a	135a	137a
Subplot (kgN/ha)					
0		93b	87b	86b	89b
100		155a	103ab	124ab	127a
200		159a	118a	138a	138a
300		176a	141a	145a	154a
400		159a	132a	161a	151a
Interaction effects Main plot × subplot plot		NS	NS	NS	NS

[1] SMFWS : compost of swine manure fermented with sawdust.
[2] SMF : compost of swine manure fermented without sawdust.
[3] Mean±SD
a and b: values with different letters in same column are significantly different at the 5% level.
NS: not significant.

Table 3. The efficiency of N recovery of corn by type and N levels of composts injected

Composts	Nitrogen fertilization rate(kgN/ha)				Mean
	100	200	300	400	
	....	....	%	....	....
SMFW[1]	34	22	20	13	22
SMF[2]	43	27	24	18	28
Mean	39	25	22	16	25

[1] SMFWS : compost of swine manure fermented with sawdust.
[2] SMF : compost of swine manure fermented without sawdust.

Table 4. Effects of type and nitrogen fertilization rate of composts injected on organic matter(OM) and total nitrogen(TN) contents of soil after the experiment finished

Composts	N rate (kgN/ha)	OM (%)	TN (%)			
		1998	1996	1997	1998	Mean
SMFWS[1)]	0	2.23±0.01	0.17±0.17	0.19±0.05	0.18±0.01	0.18±0.03
	100	2.48±0.05	0.18±0.01	0.20±0.02	0.18±0.01	0.19±0.01
	200	2.52±0.22	0.21±0.01	0.23±0.02	0.18±0.01	0.21±0.02
	300	2.69±0.40	0.23±0.04	0.25±0.01	0.20±0.02	0.23±0.03
	400	3.05±0.59	0.26±0.07	0.26±0.01	0.21±0.03	0.24±0.04
SMF[2)]	0	2.24±0.37	0.18±0.01	0.18±0.01	0.17±0.01	0.18±0.03
	100	2.33±0.10	0.19±0.01	0.20±0.01	0.18±0.03	0.19±0.03
	200	2.48±0.01	0.22±0.02	0.22±0.01	0.19±0.03	0.21±0.02
	300	2.65±0.25	0.26±0.04	0.23±0.01	0.19±0.01	0.23±0.03
	400	2.80±0.26	0.27±0.02	0.24±0.03	0.20±0.01	0.24±0.03
Main plot						
SMFWS		2.59a	0.21	0.23a	0.19a	0.21a
SMF		2.50a	0.22	0.21a	0.19a	0.21a
Subplot (kgN/ha)						
0		2.24b	0.17b	0.19c	0.18a	0.18b
100		2.41b	0.19b	0.20c	0.18a	0.19b
200		2.50ab	0.22ab	0.23b	0.19a	0.21ab
300		2.67a	0.25a	0.24ab	0.20a	0.23ab
400		2.93a	0.27a	0.25a	0.21a	0.24a
Interaction effects Main plot × subplot plot		NS	NS	NS	NS	NS

1) SMFWS : compost of swine manure fermented with sawdust.
2) SMF : compost of swine manure fermented without sawdust.
3) Mean ± SD
a and b; values with different letters in same column are significantly different at the 5% level.
NS: not significant.

organic matter increased by compost of swine manure. Soil organic matter contents at the SMFWS and SMF treatments were 2.59 and 2.50%, respectively, however, there was no significant difference between two manure treatments. As shown in Table 4, soil organic matter consistently increased with increasing nitrogen application rates up to 300 kg N/ha, but there was no significant difference. Soil organic matter at the 400 kg N/ha was significantly ($p<0.05$) higher than the control treatment. In the relationship between swine manure types and nitrogen application rates, soil organic matter contents in both the SMFWS and the SMF treatments increased with increasing nitrogen application rates. There was a significant difference ($p<0.05$) in organic matter when the SMFWS (0.82 %) was compared with the SMF treatment (0.56%). The facts that soil organic matter increased with increasing nitrogen application rates from swine manure were in agreement with reports from Sommerfeldt et al. (1988) and Gilley et al. (1999). Higher soil organic matter content at the SMFWS treatment than at the SMF treatment might be attributed to a higher organic matter at the SMFWS (62% organic matter) by adding sawdust than at the SMF (46% organic matter). Therefore, increasing application rates of swine manure fermented with sawdust increased soil organic matter content.

3. Soil nitrogen

Soil nitrogen at the silage corn field from swine manure types and application rates were shown in Table 4. Soil nitrogen content in both the SMFWS and the SMF was 0.21% when averaged over three years and there was no significant difference between two swine manure types. As application rate increased every 100 kg N/ha, soil nitrogen content increased by about 0.01%. Three years showed different trends in soil nitrogen; in 1996 the SMF had higher soil nitrogen than the SMFWS whereas it was opposite in 1997. There was no difference in soil nitrogen between the SMFWS and the SMF in 1998. Soil nitrogen at the 300 kg N/ha was significantly ($p<0.05$) higher than the control treatment. Although soil nitrogen increased very little with increasing nitrogen application rates, there was no significant difference. This was most likely due to surface runoff loss of manure resulting from very frequent heavy rainfall in 1998. Results of current study were similar to reports from Mathers et al. (1974), Mugwire (1979) and Cooper (1984) where total soil nitrogen increased with increasing nitrogen application rates from compost of swine manure fermented with either sawdust or without sawdust. In summary, total soil nitrogen increased with increasing nitrogen application rates up to 300 kg N/ha from fermented swine manure. However, a total soil nitrogen was not affected by swine manure types in silage corn production.

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