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Rate Effects of Swine Manure Fermented with Sawdust on Productivity and Nutritive Value of Silage Corn

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Abstract

This study was carried out to determine a fertilization rate for productivity and nutritive value improvement of silage corn, using two kinds of composts, and to examine the potential possibility of utilization as an organic fertilizer. 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 rates (0, 100, 200, 300 and 400kgN/ha/year). The dry matter (DM) 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. Dry matter yield in SMFWS treatment was higher than that of SMF treatment, but there was no significant difference between SMFWS and SMF treatments. Net energy for lactation (NE_l) and total digestible nutrients (TDN) in corn increased as the fertilization rate of SMFWS and SMF increased, and crude protein (CP) content increased by the fertilization of SMFWS and SMF. No difference of CP, NE_l and TDN was found between SMFWS and SMF treatments.
(Key words : Swine manure, Compost, Corn, Net energy, TDN)

I. Introduction

Although consumption of livestock products increased with the increase in people's income due to economic development, rising imports of agricultural and livestock products encouraged by the WTO system along with the recent IMF financial crisis created hard times for Korean agricultural and livestock producers. An increase in the size of animal operating systems resulting from the intensifying, grouping, and transferring trends of livestock feeding made situations worse by producing more than 45 million ton per year of animal manure. These situations made government as well as livestock producers recognize the importance of developing effective treatments and allocating funds for the utilization of animal manure to help reduce the environmental impacts of excess manure. Unlike industrial wastes, however, animal wastes have plant nutrients and can be utilized as a bio-fertilizer for growing crops. By developing methods to increase the effectiveness of animal manure, crop production as well as physical and chemical properties of soils can be improved. Consequently, livestock producers could increase their income and sustainable agriculture could be achieved by substituting animal manure for chemical fertilizer.

Composting, one of the representative methods in making a valuable resource from animal manure, can

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minimize water pollution from animal production, increase the ease handling manure, and become a safe biological method for humans to use. When farmers use animal manure to fertilize crops, soil quality will also benefit by the increase in organic matter. The protection from soil microorganisms will increase the water hold capacity and porosity of the will improve (Campbell et al., 1986; Fraser et al., 1988; Eghball and Power, 1994; Gilley et al., 1999).

Based on the facts mentioned above, this study was conducted to determine the optimum application rate to produce high yield and nutritive values of silage corn using composts of swine manure fermented with either sawdust or without sawdust as a moisture controller used in animal manure.

II. Materials and Methods

1. Experimental Period and Location

This experiment was conducted at the test pasture and forage crop fields of Kyung-gi Provincial Livestock Institute in Gongiam, Kwangju, Kyung-gi Do, South Korea from April, 1996 to August, 1998. Soil physical and chemical properties of test field are shown in Table 1.

2. Crop species and Planting method

Crop species used in this experiment was mid- and late maturity silage corn, Pioneer 3352 and planting dates were April 27, 1996, April 28, 1997, and April 25, 1998. Two corn seeds were band-seeded with 60 cm row spacing and 20 cm plant spacing having two rows and after emergence one good condition corn plant was utilized for the experiment.

3. Experimental design and Materials

The experimental design was randomized complete block with split plot design having three replications. Whole plots were two types of commercial composts such as compost of swine manure fermented with sawdust (SMFWS) and without sawdust (SMF), and sub-plots were five nitrogen application rates such as 0, 100, 200, 300, and 400 kg N/ha. Plot size was 15 m^2 (3 m × 5 m). The SMFWS had 1.1% total nitrogen, 62% organic matter, 30:0 Carbon: Nitrogen ratio, and 43% moisture content and was fermented more than six months. The SMF had 2.1% total nitrogen, 46% organic matter, 22:0 Carbon: Nitrogen ratio, and 38% moisture and was fermented more than four months.

4. Dry matter yield

Silage corn was harvested on August 14, 1996, August 14, 1997, and August 13, 1998, respectively and fresh yield was measured after separating ears and stalk. Dry matter yields of two ears and stalks were measured by drying at 80℃ for 96 hours and converted to dry matter yield per hectare.

5. Nutritive values

Dried samples were ground using a 2 mm mesh screen of Wiley mill and kept in desiccator. Nitrogen was analyzed by a Kjeldahl method (AOAC, 1990) and net energy for lactation (NE_l) and total digestible nutrients (TDN) was calculated by modifying Jurgens's method (1998).

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

P_2O_5 (mg/kg)	OM (%)	C.E.C ($cmol^+$/kg)	Exchangeable Cations($cmol^+$/kg)				pH
			Ca	K	Mg	Na	(1:5H_2O)
212.2	2.22	14.3	4.25	0.68	1.98	0.20	5.06

6. Statistical analysis

Data were analyzed using a SPSS/PC+ statistical package and significance was tested at the alpha level of 0.05.

III. Results and Discussion

1. Dry matter yield

Dry matter yield of silage corn from types and application rates of swine manure is shown in Table 2. Although the SMF had 0.62 ton/ha higher dry matter yield than SMFWS, there was no significant difference (p>0.05). Both the SMFWS and the SMF increased their herbage yields (13.14 and 14.35 ton/ha, respectively) up to 300 kg N/ha and after that there was a tendency of decreasing yields (12.81 and 13.43 ton/ha, respectively). This finding

Table 2. Effects of type and nitrogen fertilization rate of compost on dry matter yield of corn

Composts	N rate (kgN/ha)	Dry matter yield(ton/ha)			Mean
		1996	1997	1998	
SMFWS[1]	0	9.01	9.31	9.29	9.20
	100	12.60	10.75	11.34	11.56
	200	12.93	11.06	12.68	11.20
	300	14.25	11.91	13.25	13.14
	400	13.01	11.40	14.03	12.81
	0	9.03	9.23	9.49	9.24
SMF[2]	100	12.60	11.53	11.56	11.90
	200	13.20	13.31	12.78	13.10
	300	14.22	15.32	13.52	14.35
	400	13.23	12.76	14.30	13.43
Main plot					
SMFWS		12.36a	10.88a	12.12a	11.78a
SMF		12.46a	12.43a	12.33a	12.40a
Subplot (kgN/ha)					
0		9.02b	9.27b	9.39b	9.23b
100		12.60a	11.14ab	11.45ab	11.73ab
200		13.07a	12.19a	12.73a	12.66a
300		14.24a	13.62a	13.39a	13.75a
400		13.12a	12.08a	14.17a	13.12a
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.
a and b; values with different letters in same column are significantly different at the 5% level.
NS : not significant.

was different from Yook's (1997) report where highest yield of rye was achieved at the 100 and 200 kg N/ha. These differences might attribute to possible following reasons; firstly, no chemical fertilizer was utilized; secondly, slurry manure had faster N utilization by crops than composts; and thirdly, silage corn normally has higher nutrient requirement for its growth and development than rye. There was no significant (p>0.05) interaction between manure fermentation types and application rates.

In 1996 and 1997, herbage dry matter yields of silage corn from N application rates in both swine manure types increased up to 300 kg N/ha and decreased at the 400 kg N/ha. Herbage dry matter yields in 1998, however, increased consistently with increasing application rates in both SMFWS and SMF. This is possibly due to the differences of nitrogen metabolism rates of silage corn resulting from manure losses from a heavy rainfall and El

Table 3. Effects of type and nitrogen fertilization rate of compost on crude protein content of corn

Composts	N rate (kgN/ha)	Crude protein(%)			Mean
		1996	1997	1998	
SMFWS[1]	0	6.38	5.84	5.72	5.98
	100	7.54	5.70	6.45	6.56
	200	7.69	5.93	6.62	6.75
	300	7.68	6.51	6.84	7.01
	400	7.01	6.74	6.73	6.83
SMF[2]	0	6.51	5.83	5.66	6.00
	100	7.79	5.86	7.08	6.91
	200	7.58	6.15	6.94	6.89
	300	7.78	6.41	6.75	6.98
	400	8.08	6.91	7.43	7.47
Main plot					
SMFWS		7.26a	6.14a	6.47a	6.63a
SMF		7.55a	6.23a	6.77a	6.85a
Subplot(kgN/ha)					
0		6.45b	5.84b	5.69b	5.99b
100		7.67a	5.78ab	6.77a	6.74ab
200		7.64a	6.04ab	6.78a	6.82ab
300		7.73a	6.46ab	6.80a	7.00a
400		7.55a	6.82a	7.08a	7.15a
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.
a and b; values with different letters in same column are significantly different at the 5% level.
NS : not significant.

Nino phenomenon.

Based on these results, average dry matter yields of silage corn was about 12 ton/ha that was much lower than average yields of Pioneer's silage corn. This is most likely due to lack of nitrogen support to have an optimum silage corn growth resulting from slow nitrogen mineralization of composts and nitrogen losses by surface runoff from a heavy rainfall during the rainy season. Several researches showed that additional application of chemical fertilizer at the proper time was necessary to increase crop yields (Pain, 1986; Van der Meer et al., 1987; Long and Gracey, 1990) and even in this study it appears that combining a swine manure with a chemical fertilizer might increase herbage yields of silage corn.

Therefore, it is believed that it is necessary to increase herbage yield by applying additional

Table 4. Effects of type and nitrogen fertilization rate of compost on net energy for lactation(NE_l) of corn

Composts	N rate (kgN/ha)	NE_l(Mkcal) 1996	1997	1998	Mean
SMFWS[1]	0	1.33	1.45	1.41	1.40
	100	1.36	1.48	1.39	1.41
	200	1.22	1.46	1.56	1.41
	300	1.32	1.53	1.43	1.42
	400	1.34	1.52	1.49	1.45
SMF[2]	0	1.31	1.50	1.40	1.40
	100	1.41	1.52	1.46	1.46
	200	1.32	1.57	1.44	1.45
	300	1.31	1.49	1.40	1.40
	400	1.39	1.54	1.47	1.46
Main plot					
SMFWS		1.31a	1.48a	1.45a	1.42a
SMF		1.34a	1.52a	1.43a	1.43a
Subplot(kgN/ha)					
0		1.32ab	1.48a	1.41b	1.40b
100		1.39a	1.50a	1.43ab	1.44ab
200		1.27ab	1.52a	1.50a	1.43ab
300		1.32ab	1.51a	1.42ab	1.41ab
400		1.37a	1.53a	1.48a	1.46a
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.
a and b; values with different letters in same column are significantly different at the 5% level.
NS : not significant.

chemical nitrogen fertilizer when silage corn is grown with compost from swine manure. It appears that applying 300 kg N/ha would be an optimum to have a maximum yield of silage corn when compost of swine manure is the only nutrient source.

2. Nutritive values

Crude protein (CP), net energy for lactation (NE_l), and total digestible nutrients (TDN) from types of swine manure and application rates are shown in Tables 3, 4 and 5. There was no significant

Table 5. Effects of type and nitrogen fertilization rate of compost on total digestible nutrients(TDN) in corn

Composts	N rate (kgN/ha)	TDN (%)			Mean
		1996	1997	1998	
SMFWS[1)]	0	57.21	61.95	60.51	59.89
	100	58.65	63.18	59.68	60.50
	200	52.94	62.17	66.42	60.67
	300	56.89	65.31	61.11	61.11
	400	57.54	64.88	63.63	62.02
SMF[2)]	0	56.33	63.99	60.16	60.16
	100	60.31	64.93	62.59	62.61
	200	56.91	67.08	61.83	61.94
	300	56.51	63.78	59.95	60.08
	400	59.67	65.64	62.77	62.69
Main plot					
SMFWS		56.64a	63.60a	62.26a	60.84a
SMF		57.94a	65.08a	61.46a	61.49a
Subplot(kgN/ha)					
0		56.77a	62.97a	60.34b	60.02b
100		59.48a	64.06ab	61.14ab	61.56ab
200		54.93a	64.63ab	64.13a	61.31ab
300		56.70a	64.55ab	60.53ab	61.60ab
400		58.61a	65.26a	63.20a	62.36a
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.
a and b; values with different letters in same column are significantly different at the 5% level.
NS : not significant.

difference ($p>0.05$) in crude protein although the SMF had 0.22% higher CP than SMFWS over the three years. There was a difference in NE_l and TDN when compared three years, however, no significant difference was shown when averaged over three years.

There was a increasing tendency of CP, NE_l, and TDN with increasing application rates of both SMFWS and SMF, and only at the 400 kg N/ha significant difference ($p<0.05$) was shown. The SMF showed a little more increase in CP, NE_l, and TDN compared to the SMFWS. There was no significant difference in interaction between manure types and application rates ($p>0.05$) in CP, NE_l, and TDN. The facts that CP was increased with increasing N application rates of swine manure were similar to other reports (Roth, 1970 and Wiernga, 1978). Holland et al. (1970) reported that silage corn had CP 6~17%, TDN 55~78%, NE_l 1.31~1.67 Mcal/kg, and Kim (1999) also showed that P3353, one of Korean government's recommended silage corn varieties had CP 7.5~7.6%, TDN 65.4~67.8%, NE_l 1.53~1.59 Mcal/kg although these values were varied with planting dates. The reason why current study showed smaller decrease in CP, NE_l, and TDN when compared to Kim's results might attribute to differences in types of fertilizers and testing locations. Like Hunt's reports (1992), nutritive values of silage corn could be changed by planting- and harvesting dates in CP, NE_l, and TDN.

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