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Effects of Animal Manure Application with Additional Nitrogen Fertilizer on Improvement of Forage Productivity and Soil Fertility in Mixed Grassland

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Abstract

Experiments were conducted on established grassland sward at Gongiam, Kwangju, and Kyung-gi in Korea from 1995 to 1997. The influence of mineral-N fertilizer or animal manure(AW) on herbage dry matter(DM) yield, N yield, the recovery of AM-N, and soil N and organic matter(OM) content in the mixed sward('potomac' orchardgrass, 'fawn' tall fescue, and 'kenblue' Kentuky bluegrass) was investigated. The treatments were replicated three times in a split plot block design. AM(the main plots) was applied at 200kg N ha^{-1} $year^{-1}$ on each plot. The types of AM were cattle feedlot manure(CFM), pig manure fermented with sawdust(PMFS) and Korea native cattle slurry(KNCS). Three levels of mineral-N fertilizer, as urea, ranging from 0 to 200kg N ha^{-1} $year^{-1}$ in 100kg increments, were superimposed on each plot. The fertilizers and AM were applied in two equal dressings(the end of March and middle of November).

AM and mineral fertilizer had significant effects($p<0.05$) on herbage DM and N yields. Herbage yields in KNCS were higher than those in CFM and PMFS($p<0.05$). The application of CFM and PMFS produced similar herbage yields which were lower and more variable than those with the mineral fetrlizers. KNCS on herbage yields had a higher effect than 200kg mineral N. The mean N contents of herbage ranged from 1.83% to 1.96%. N content of herbage increased by the application of AM and mineral N. The overall mean recovery of N from the CFM and PMFS treatments was reduced by 15% as compared to N recovery from the mineral fertilizer treatment which was similar to that from KNCS. The N recovery was the highest with KNCS and the lowest with PMFS. The mean N content of the soil ranged from 0.23% for control to 0.27% for PMFS. The N and OM contents in soil samples collected at the end of the experiment were remarkably higher than those in the beginning of the experiment, and increased by the AM and the mineral fertilizer application. The OM content of soil was more affected by the AM than the mineral fertilizer.

There were no significant interactions between mineral N and the AM treatments for herbage yields, and soil N and OM contents during the experimental period.

(**Key words** : Animal manure, Mineral fertilizer, Grassland, Herbage, Soil fertility)

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Ⅰ. Introduction

Animal waste is a valuable fertilizer and effective amender (Freeze and Sommerfeldt, 1985; Campbell et al., 1986; Eghball and Power, 1994), which can be attributted to improvement of the physical and chemical properties of the soil for plant growth and increase in the organic matter content of soil (Vitosh et al., 1973; Fraser et al., 1988; Gilley et al., 1999).

It is essential for the farmer to apply the additional chemical N fertilizer to improve the growth of plant, because the fertilizer value of N in animal waste is not sufficient, compared with the utilization efficiency of the chemical fertilizer. However, excess nitrogen above the needs of crop are known to be immobilized, denitrified, lost in surface runoff and leached from the soil into groundwater (De Datta, 1987; Jarvis et al., 1987; Bautista et al., 1999). Specially, nitrate leaching from agricultural ecosystems is one of the major environmental problems related to agricultural plant production, furthermore, the amount of nitrate leaching through natural soil is hardly predictd (Randall et al., 1994; Francis et al., 1995; Gilley et al., 1999). The Environmental Protection Agency has set a maximum contamination level of 10mg l^{-1} of NO_3-N to be safe for drinking water (WHO, 1978).

Therefore, efficient utilization of animal waste is very important in the aspect of reducing the amount of application of chemical fertilizer (Long and Gracey, 1990ab; Rees et al., 1993) and minimizing environmental pollution (Daliparthy et al., 1994).

Grassland is well suited for utilization of animal waste as plant nutrients, and its effective use is very important for improvement of grassland productivity and management (Daliparthy et al., 1994; Wightman et al., 1997). The main objective of this study was to investigate the effects of different sources of animal manure with urea applied at three levels on herbage yields, and an increase of soil fertility and to improve the utilization of animal manure in silt clay loam soil.

Ⅱ. Materials and Methods

1. Experimental site and soil

The field experiments were carried out from 1995 to 1997 on established grassland sward at Gongiam, Kwangju, Kyung-gi province in Korea. Soil type was classified as a silt clay loam. Topsoil (0~30cm) contained 29.5% clay, 57.4% silt and 13.1% sand and subsoil (30~60cm) contained 29.2% clay, 53.3% silt and 17.5% sand. Soil analysis indicated a pH of 5.1 and carbon, nitrogen, P_2O_5 and K_2O status of 2.22%, 0.14%, 212.2mg kg^{-1} and 81.6me $100g^{-1}$, respectively. The terrain of the experimental site is slightly sloped (<9%).

The field had been sown with a grasses mixture containing 'potomac' orchardgrass, 'fawn' tall fescue, and 'kenblue' Kentuky bluegrass. Seeding rates were 17, 13 and 5kg ha^{-1}, respectively. Most of the sown species were grown and survived well during the experimental period, but the sward were partly invaded by white clover and rough-staked grass.

Average annual rainfall was 1,500mm and temperature was 11℃ during the period. In the summer months (May-October), the mean monthly temperature was 27℃, and rainfall was 200mm (Table 1).

2. Types of animal manure (AM)

Cattle feedlot manure (CFM) was prepared by mixing feces and urine of cattle with rice straw in cattle feedlot for 6 months.

Pig manure fermented with sawdust (PMFS) was manufactured by the fermentation for 2 months in natural condition after mixing with pig slurry and sawdust at the ratio of one to two by weight. Pig slurry used in PMFS was collected from a building where pigs were housed for fattening on a commercial pellet diet.

The cattle slurry (KNCS) was produced by Korean native cattle fed grass silage and rice straw.

Table 1. Meteriological data over the experimental periods in 1995 to 1997

Month	Precipitation (mm)			Temperature (℃)		
	1995	1996	1997	1995	1996	1997
Jar.	2.4	15.5	16.8	-3.4	-3.5	-5.1
Feb.	4.5	3.0	31.5	-0.7	-3.1	-1.2
Mar.	59.0	85.0	33.0	6.1	4.8	4.8
Apr.	43.0	40.5	39.5	12.2	10.7	11.2
May	65.1	18.0	248.2	15.4	16.2	15.7
June	58.1	275.7	89.0	20.0	21.3	21.1
July	441.5	30.7	287.5	24.0	24.2	24.6
Aug.	925.0	96.0	274.0	25.6	25.1	24.9
Sep.	22.0	10.0	1087.0	18.5	19.8	17.8
Oct.	30.0	45.0	21.5	13.5	12.8	11.0
Nov.	27.8	59.5	68.5	4.4	4.4	6.5
Dec.	5.8	14.5	39.5	-2.5	-0.9	-0.2

3. The experimental design

The experiment was designed as a randomized complete block with a split plot blocks arrangement. Each treatment was replicated three times. Each subplot was allocated to the area of 4 × 3m.

The main plots consisted of three kinds of AM (CFM, PMFS and KNCS). Subplots were mineral N applications of 0, 100 and 200kg N ha^{-1} $year^{-1}$ by use of urea.

The amount of all AM were applied at 200kg N ha^{-1} $year^{-1}$, which was spread evenly over the soil surface two times; first in the autumn (end of November) and second in the spring (middle of March). Urea was applied by hand after cutting in all treatments.

4. Herbage harvest

The herbage sward was cut four times each year at approximately the middle of May and June, early in August and the middle of October. The sward from each plot was cut at a height of 10cm using an Agria type 505 motor-mower and weighed in the field immediately after the cutting to determine total dry matter yield. Samples of approximately 300g were dried at 70℃ for 3 days and weighted to determine the dry matter content. Samples were ground to pass through a 1mm sieve prior to analysis of total nitrogen by Kjeldahl digestion (AOAC, 1990).

5. Soil N and organic matter (OM) analysis

To examine the soil properties, soils were sampled randomly from the plots at the depth of 0 to 20cm before application of AM or urea. After the end of the experiments in 1998, the samples were taken randomly within the plots to study the soil N and OM content and air-dried by spreading soil in thin layers(<1cm) in a shadow place using forced air at ambient temperature. After drying, the samples were ground to pass through at 1mm sieve. The OM content was analysized by the method of Nelson and Sommers (1982). Total N content was determined by the method of Kjeldahl digestion (AOAC, 1990).

6. Statistical analysis

Duncan's multiple range test was used to determine the effects of application of mineral fertilizer and AM on herbage yield and soil N and OM contents (SPSS/PC+ package). Tests were run at the 5% probability level.

Ⅲ. Results and Discussion

1. Herbage yield response to AM and urea

The effects of AM and urea on DM yield are shown in Table 2. Mean DM yields for AM treatments for 3 years were increased significantly

Table 2. Effects of applications of animal manure and mineral fertilizer on herbage DM yields in 1995 to 1997

Treatment		DM yield			Mean
Manure type (200 kg N ha⁻¹)	Fertilizer N rate[g] (kgN ha⁻¹)	1995	1996	1997	
Control	0	4.73±0.68	6.51±0.46	7.39±0.47	6.21±1.27
	100	8.10±0.54	8.35±1.09	9.34±0.58	8.60±0.88
	200	9.60±1.54	9.74±2.31	11.40±1.72	10.25±1.85
CFM[d]	0	7.46±2.08	8.12±0.95	10.35±1.48	8.65±1.89
	100	9.57±0.16	9.72±1.22	10.99±0.86	10.09±1.01
	200	10.47±1.42	10.59±1.53	13.79±0.96	11.62±2.00
PMFS[e]	0	8.13±1.72	8.41±1.05	10.25±1.63	8.93±1.64
	100	9.49±1.55	9.99±0.52	12.07±0.69	10.52±1.48
	200	10.80±1.36	10.88±0.11	13.67±0.75	11.78±1.62
KNCS[f]	0	9.39±0.58	9.44±0.30	12.35±0.75	10.39±1.55
	100	10.51±0.78	11.01±0.47	13.25±0.67	11.59±1.38
	200	11.26±0.26	12.37±0.53	14.56±1.21	12.73±1.60
Main plot(200 kg N ha⁻¹)					
Control		7.48±2.34[b]	8.20±1.91[c]	9.38±1.98[c]	8.35±2.15[c]
CFM		9.16±1.84[ab]	9.48±1.54[bc]	11.71±1.87[b]	10.12±2.04[b]
PMFS		9.47±1.77[a]	9.76±1.23[ab]	12.00±1.77[ab]	10.41±1.93[b]
KNCS		10.39±0.96[a]	10.94±1.33[a]	13.39±1.24[a]	11.57±1.75[a]
Subplot(kg N ha⁻¹)					
0		7.43±2.16[b]	8.12±1.27[b]	10.09±2.11[b]	8.55±2.16[c]
100		9.42±1.19[a]	9.77±1.25[a]	11.41±1.62[b]	10.19±1.59[b]
200		10.53±1.25[a]	10.89±1.56[a]	13.36±1.61[a]	11.60±1.92[a]
Interaction Main plot × Subplot		NS	NS	NS	NS

Each value represents Mean ± SD.
[a,b,c] Values with different letters in same column are significantly different at the 5% level.
[d] Cattle feedlot manure.
[e] Compost of pig manure fermented with sawdust.
[f] Korean native cattle slurry.
[g] Mineral fertilizer(Urea).
NS : Non-significant.

compared to that for the control. Among the AM treatments, the response to KNCS treatment was higher significantly than those to CFM and PMFS treatments and there was no significant difference between CFM and PMFS.

Mean DM yields were increased significantly with increasing mineral N application rate, however, there was no significant interaction between mineral N and AM treatment for 3 years. DM yields in AM treatments were lower in 1995 and 1996 than in 1997 due to the low precipitation during the experimental period. Long and Gracey (1990a) reported that the mean yields of herbage significantly increased by fertilizer N application at all years and that no interaction were recorded between cattle slurry and fertilizer N in terms of DM yields Long and Gracey (1990b) reported that the response of cattle slurry treatment to DM yields was higher compared to untreated control and that injection of slurry could be an effective means of utilizing slurry N.

2. Herbage N uptake by the applications of mineral N and AM

A. N yield response

Table 3 shows herbage N yields by the application of AM and mineral N. N yields in AM treatments with mineral N were greater than those of the non-AM treatment without mineral N or with 100kg mineral N in the 3 years. N yields in 200kg mineral N were higher than those of AM treatments without mineral N. N yields showed the positive effects, as increasing the level of mineral N in AM treatments with mineral N.

Statistical analysis revealed that the N yields from non-AM(control) and AM treatments were significantly different($p<0.05$). The N yields were greater with KNCA than with CFM and PMFS($p<0.05$), and the highest N yields among AM were produced by KNCA in the 3 yr period. CFM and PMFS were similar in the herbage N yields.

Mineral-N treatment resulted in higher N yields than the zero-N treatment($p<0.05$) in the 3 years. The N yields in 100kg ha^{-1} and 200kg ha^{-1} N were improved 73 and 42 kg ha^{-1} above the value in zero-N treatment, respectively, whose differences were statistically significant($p<0.05$).

B. Total N content response in herbage

Herbage N contents are shown in Table 4. Total N contents in AM treatments with mineral N were increased, compared with the no-AM treatment without mineral N or AM treatment without mineral N. N contents in AM treatments without mineral N were higher than those of zero-N, but showed trends similar to those of mineral N treatments.

N content was significantly higher with KNCS than with CFM and PMFS, and was lower in 1995 and 1996 than in 1997. N content in KNCS treatment was greater than the no-AM treatment ($p<0.05$). N content from CFM and PMFS was not significantly different. Herbage N contents with mineral N fertilizer were higher than that of the zero-N treatment($p<0.05$) and increased with increasing mineral N rate. N content of herbage showed positive effects as the rate of the mineral N increased and the AM was applied. There was no significant interaction between mineral N and AM treatment for N content of herbage in the 3 years. Rees et al.(1993) reported that N contents of herbage from plots treated with pig slurry of 86 ton ha^{-1} were higher than from those receiving mineral N, from 60 to 300kg N ha^{-1}. The results of this study showed positive correlation between herbage N content and the application rate of mineral N.

Daliparthy et al.(1994) reported that the soil mineralization rate in June was greater than in May, due to higher soil temperature. Environmental conditions for N mineralization are very important during the period of growth of the sward. In this study, an increase in DM and N yields by AM application in 1997 was detected, compared with those in 1995 and 1996. Presumably, this is due to

Table 3. Effects of applications of animal manure and mineral fertilizer on herbage N yields in 1995 to 1997

Manure type (200 kg N ha⁻¹)	Fertilizer N rate[g] (kgN ha⁻¹)	N yields 1995	1996	1997	Mean
Control	0	76.42±12.15	123.88±14.47	139.00±22.33	113.10±31.84
	100	139.05± 7.42	167.22±24.18	157.51±18.80	154.59±20.04
	200	175.92±29.50	214.72±49.52	192.41±37.93	194.35±38.40
CFM[d]	0	123.65±33.62	169.34±28.28	198.60±49.02	163.86±46.41
	100	165.77± 9.85	213.81±31.19	219.04±22.58	199.54±32.27
	200	196.47±35.05	225.94±39.03	243.82±23.40	222.07±35.40
PMFS[e]	0	138.02±32.42	166.15±29.74	175.09±48.85	159.76±36.89
	100	166.95±25.66	202.81± 9.02	220.22±23.38	196.66±29.58
	200	197.05±26.62	237.04±10.61	237.87±15.40	223.99±25.94
KNCS[f]	0	170.96±10.38	193.36±11.61	216.97±46.70	193.76±31.67
	100	206.03±27.67	232.61±23.64	225.06±20.67	221.23±24.05
	200	231.20±10.96	285.10±11.69	281.94±26.28	266.08±30.38
Main plot(200 kg N ha⁻¹)					
Control		130.46±46.54[b]	168.61±48.58[b]	162.97±33.53[b]	154.01±45.08[c]
CFM		161.96±40.20[b]	203.03±38.60[ab]	220.48±35.34[a]	195.16±44.33[b]
PMFS		167.34±35.47[ab]	202.00±34.82[ab]	211.06±39.73[a]	193.47±40.18[b]
KNCS		202.73±30.58[a]	237.02±42.38[a]	241.32±42.01[a]	227.02±41.15[a]
Subplot(kg N ha⁻¹)					
0		127.26±41.28[c]	163.18±32.42[c]	182.41±47.79[b]	157.62±46.06[c]
100		169.45±30.15[b]	204.11±31.91[b]	205.46±34.28[ab]	193.00±35.51[b]
200		200.16±31.01[a]	240.70±39.40[a]	239.01±40.39[a]	226.62±40.79[a]
Interaction Main plot × Subplot		NS	NS	NS	NS

Each value represents Mean ± SD.
[a,b,c] Values with different letters in same column are significantly different at the 5% level.
[d] Cattle feedlot manure.
[e] Compost of pig manure fermented with sawdust.
[f] Korean native cattle slurry.
[g] Mineral fertilizer(Urea).
NS : Non-significant.

the mineralization of organic N, because of the repeated application of AM for 3 years. Also, Long and Gracey(1990b) suggested that the significant correlation between the amount of rainfall within a 72 hour period of slurry application and DM response indicating that the rainfall pattern after surface application of slurry could have a strong influence on subsequent N-use efficiency.

Table 4. Effects of applications of animal manure and mineral fertilizer on herbage N content in 1995 to 1997

Treatment		N content			Mean
Manure type (200 kg N ha⁻¹)	Fertilizer N rate[g] (kgN ha⁻¹)	1995	1996	1997	
Control	0	1.62±0.03	1.90±0.15	1.65±0.11	1.80±0.18
	100	1.72±0.04	2.00±0.05	1.68±0.09	1.80±0.16
	200	1.83±0.07	2.21±0.07	1.87±0.19	1.91±0.24
CFM[d]	0	1.66±0.01	2.09±0.12	1.77±0.06	1.88±0.26
	100	1.73±0.07	2.20±0.12	1.91±0.15	1.97±0.22
	200	1.88±0.09	2.13±0.06	1.99±0.05	1.92±0.17
PMFS[e]	0	1.70±0.05	1.98±0.12	1.69±0.11	1.78±0.18
	100	1.76±0.05	2.03±0.01	1.74±0.03	1.87±0.17
	200	1.83±0.04	2.18±0.09	1.83±0.12	1.91±0.21
KNCS[f]	0	1.82±0.01	2.05±0.13	1.70±0.07	1.87±0.21
	100	1.95±0.14	2.11±0.13	1.75±0.13	1.92±0.21
	200	2.05±0.06	2.24±0.06	1.94±0.02	2.10±0.17
Main plot(200 kg N ha⁻¹)					
Control		1.74 ± 0.10^{b}	2.04 ± 0.16^{a}	1.75 ± 0.15^{a}	1.83 ± 0.20^{b}
CFM		1.77 ± 0.11^{b}	2.13 ± 0.11^{a}	1.89 ± 0.20^{a}	1.93 ± 0.21^{ab}
PMFS		1.77 ± 0.07^{b}	2.06 ± 0.12^{a}	1.75 ± 0.16^{a}	1.86 ± 0.19^{ab}
KNCS		1.94 ± 0.13^{a}	2.15 ± 0.15^{a}	1.79 ± 0.19^{a}	1.96 ± 0.21^{a}
Subplot(kg N ha⁻¹)					
0		1.71 ± 0.08^{c}	2.00 ± 0.13^{b}	1.80 ± 0.25^{a}	1.83 ± 0.21^{b}
100		1.79 ± 0.12^{b}	2.08 ± 0.11^{ab}	1.80 ± 0.17^{a}	1.89 ± 0.19^{ab}
200		1.90 ± 0.11^{a}	2.20 ± 0.09^{a}	1.78 ± 0.11^{a}	1.96 ± 0.21^{a}
Interaction Main plot × Subplot		NS	NS	NS	NS

Each value represents Mean ± SD.

[a,b,c] Values with different letters in same column are significantly different at the 5% level.

[d] Cattle feedlot manure.

[e] Compost of pig manure fermented with sawdust.

[f] Korean native cattle slurry.

[g] Mineral fertilizer(Urea).

NS : Non-significant.

In Korea, annual rainfall ranges from 700 to 1,500mm. This rainfall is poor on forage growth because most of the rain is concentrated from May to September. The amount of organic and inorganic nutrients in the soil is affected by the high rainfall in this period. Variability in fertilizer N value of AM and mineral fertilizer during the experimental period can be largely attributed to the erosion and runoff by high rainfall after the application of fertilizer N source. Long and Gracey(1990b) found that the relationship between rainfall and slurry N-use efficiency was important and the high rainfall condition should reduce the N-use efficiency of mineral fertilizer relative to that under low rainfall conditions.

3. The N recovery of AM-N in herbage

The recovery of N in herbage was shown in Table 5. The recovery of the total N content of AM was calculated by subtracting the N uptake by herbage on plots receiving AM-N from that of the no-AM treatment and expressed as a percentage of the total AM-N applied. The N recovery with KNCS was higher than those with CFM and PMFS and lower with CFM than that with PMFS. The recoveries from applied CFM and PMFS were greater in 1997 than in 1995 and 1996. However, those from applied KNCS were similiar for the 3 yrs.

The results of this study are similar to those of Pain and Sanders(1980) and Pain et al.(1986). Long and Gracey(1990a) reported the mean apparent recovery of cattle slurry total N in herbage was 40% in 1986 and 27% in 1987.

Generally, the recovery of fertilizer N averages only 50 to 60%, and the relative efficiency of cattle slurry N is low and variable compared with fertilizer N (Pain and Sanders, 1980; Pain et al., 1986).

This study clearly shows that N recovery was severely affected by the type of AM and the rates of mineral fertilizer, and KNCS among AM had the highest recovery of N.

4. Total N and organic matter(OM) contents in the soil by the applications of mineral N and animal manure

Total N and OM contents in soils after 3 years of mineral N and AM applications are shown in Table 6. N content of the soils by mineral N application with AM ranged from 0.23%(non-AM treatment without mineral N) to 0.28%(PMFS treatment with mineral 100kg N ha^{-1}) and OM content ranged from 3.28%(non-AM treatment without mineral N) to 4.69%(CFM treatment with mineral 200kgN ha^{-1}). Pasture soil prior to ploughing had a total N content of 0.12% and an OM content of 2.22%.

Table 5. N recoveries of animal manure in herbage for 3 years

Treatment	N yields			Mean
	1995	1996	1997	
Animal manure(200 kg N ha^{-1})				
CFM[a]	15.8	17.2	28.8	20.6
PMFS[b]	18.4	16.9	24.1	19.8
KNCS[c]	36.4	34.2	36.5	35.6
Fertilizer N rate[d](kg N ha^{-1})				
100	42.2	40.9	23.5	35.4
200	36.5	38.8	28.3	34.5

[a] Cattle feedlot manure.
[b] Compost of Pig manure fermented with sawdust.
[c] Korean native cattle slurry.
[d] Mineral fertilizer(Urea).

Table 6. Effects of applications of animal manure and mineral fertilizer on N and OM contents of the soils at the end of experiment

Treatment		Content in the soils	
Manure type (200 kg N ha $^{-1}$)	Fertilizer N rate[f] (kgN ha $^{-1}$)	N	OM
Control	0	0.23±0.02	3.28±0.38
	100	0.23±0.02	3.58±0.20
	200	0.24±0.01	3.59±0.32
CFM[c]	0	0.24±0.06	4.26±1.03
	100	0.27±0.02	4.29±0.38
	200	0.27±0.02	4.69±0.79
PMFS[d]	0	0.26±0.03	4.24±0.65
	100	0.28±0.01	4.48±0.55
	200	0.27±0.02	4.52±0.52
KNCS[e]	0	0.25±0.04	3.64±0.31
	100	0.26±0.03	3.73±0.09
	200	0.26±0.03	3.76±0.37
Main plot(200 kg N ha $^{-1}$)			
Control		0.23±0.02[b]	3.48±0.30[b]
CFM		0.26±0.03[ab]	4.41±0.73[a]
PMFS		0.27±0.02[a]	4.41±0.57[a]
KNCS		0.26±0.03[ab]	3.71±0.20[b]
Subplot(kg N ha $^{-1}$)			
0		0.24±0.04[a]	3.85±0.59[a]
100		0.26±0.02[a]	4.02±0.31[a]
200		0.26±0.02[a]	4.04±0.50[a]
Interaction Main plot × Subplot		NS	NS

Each value represents Mean ± SD.
[a,b] Values with different letters in same column are significantly different at the 5% level.
[c] Cattle feedlot manure.
[d] Compost of pig manure fermented with sawdust.
[e] Korean native cattle slurry.
[f] Mineral fertilizer(Urea).
NS : Non-significant.

Total N and OM contents in AM treatments with mineral N were higher than those of the non-AM treatment without mineral N, 100kg and 200kg ha $^{-1}$ N rates or AM treatment without mineral N. The N and OM contents increased with increasing level of mineral N fertilizer as AM applied.

The total N content was greater on the plots with AM application significantly($p<0.05$). N content increased progressively with the increasing amounts of mineral-N fertilizer. but was not significantly different between mineral 100 kg ha^{-1} and 200 kg ha^{-1} rates. Compared with zero-N treatment, N content increased by 0.1 and 1.5% at 100 and 200 kg ha^{-1} N rates, respectively.

OM content was lower in KNCS treatment than in CFM and PMFS treatments. OM content after the end of experiment increased by approximately 2.0%, compared to that of beginning. OM content tended to increase by applications of mineral N, compared with zero-N treatment, which were not significantly different. AM application resulted in significantly higher OM content in soils($p<0.05$).

Gilley et al.(1999) found that OM content was greater on the plots where manure of 27 ton ha^{-1} was applied than that of zero manure. However, the increase in OM was not significantly different. OM content was also similar between fertilizer treatments. Vitosh et al.(1973) and Fraser et al.(1988) reported that the OM content of some soils increased by the addition of beef cattle manure. Manure improves the chemical and physical properties of soils and increases the organic matter content of the soils(Freeze and Sommerfeldt, 1985; Campbell et al., 1986; Sommerfeldt et al., 1988; Eghball and Power, 1994). However, McCalla(1970) reported that excess amount of N, P, and soluble salts in manure could pollute the soil and water. Therefore. Gilley et al.(1999) suggested that since manure was applied annually at the approximate rate required to meet plant N requirements, there does not appear to have been a large accumulation of OM within the sandy loam soil. Similar results were obtained in the current experiment. and also, OM content varied considerably with the type and environment of the soils.

The natural recycling process can be completed by application of manure in the grassland on which pasture plants were produced, because it is used to obtain an optimum productivity of pasture plants while conserving natural resources and decreasing mineral fertilizer

This study was conducted to determine the effects of AM application with additional N fertilizer on improvement of forage productivity and soil property. The soil used in this study had received AM(200kgN ha^{-1} yr^{-1} of mineral N) and two levels of mineral N fertilizer(100kg and 200kg N ha^{-1} yr^{-1} of mineral N) for 3 years. The application of AM and/or mineral fertilizer did significantly affect the growth of grass, and N and OM of the soil. KNCS had a greater effect than the corresponding amount of mineral N fertilizer, and was more efficiently utilized than CFM and PMFS.

The growth of swards was influenced more by environmental factors than the sward cultivation and management, and affected by type of AM rather than by mineral fertilizer rates. The results support that the use of mineral fertilizer in combination with AM improves the herbage productivity and the property of soil. We conclude that AM can be applied to grasses at rates of 200kg N ha^{-1} without any negative effects on DM production and the property of soil. Therefore, the pasture of Korea can be better utilized by applying AM with mineral fertilizer to the mixed sward.

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