No. B-5 1.2.8 CH_4 and N_2O Emissions Control from Grassland and Animal Waste Management

Contact Person Takeshi Shibuya Researcher
Department of Environment, National Grassland Research Institute,
Ministry of Agriculture, Forestry & Fisheries.
768 Senbonmatsu, Nishinasuno, Tochigi, 329-2793 Japan
Phone +81-287-36-0111(Ext.7558), FAX +81-287-36-6629
E-mail: mirage@ngri.affrc.go.jp

Total Budget for FY1998 4,381,000 Yen

Abstract So far, we measured methane(CH_4) and nitrous oxide(N_2O) fluxes at the grassland in 91, 95, 96, 97, in 98. Moreover, it measured CH_4 and N_2O fluxes at the slurry applications with several times. Based on these data, we made the emission factor index for CH_4 and N_2O from grassland and animal waste. This emission factor index is the revise of the index which was made in 94(B-2.4.2 Emission of Trace Gases Contributing Greenhouse Effect from Grassland by GERF). Besides, we made the emission factor indexes of slurry application methods and nitrogen fertilizers.

We have proposing the management that N_2O emission could be effectively reduced by the change in the kind with nitrogen fertilizer(B-16.3 Studies of Control and Activities of Greenhouse Trace Gases in Grassland by GERF). As for the way of the fertilization management, it computed a cost. As a result, the effective way of the fertilization management to reduce N_2O emission had increased a fertilizer charge by 17-51% compared with the conventional management. The highest cost way of the fertilization management was the way of the fertilization management to have used CDU.

Key Words Grassland, Nitrous oxide, Methane, Animal waste, Nitrogen fertilizer

1. Introduction

In November, 97, The 3rd Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change(UNFCC/COP3) was held in Kyoto, Japan. That the reduction objects added Methane(CH_4), Nitrous oxide(N_2O), Hydrofluorocarbons(HFCs), Perfluorocarbons(PFCs), Sulphur hexafluoride(SF6) in the conference was decided with Carbon dioxide(CO_2). The reduction goal of these gases does 5 (2008-2012) years with the goal period and it sets them to it. To make the action plan to have paid to this reduction goal achievement, the estimation of high precision of these gases emissions and sinks is demanded.

The greenhouse gases which occurs much in the grassland animal husbandry system is CH_4 and N_2O. As for the sources of these gases, the CH_4 and N_2O emissions from animal waste and N_2O emission from the nitrogen fertilizer is high. Therefore, to restrain the emissions of these gases from these parts is important.

2. Research Objective

And then, based on the accumulating data, we planned to revise in CH_4, N_2O emission factor

index at grassland which was experimentally made in 94. Besides, it made emission factor indexes every kind with slurry applications and nitrogen fertilizers.
Also, it investigated about the cost of the effective way of the fertilization management to restrain N_2O emission.

3. Research Method

(1) The revision of the emission factor index relating to grassland and animal waste

At the grassland, it measured the CH_4, N_2O gas fluxes in 91, 95, 97, in 98. Also, it measured several times, CH_4, N_2O gas fluxes at the time of slurry application. Based on their data, it examined the revision of the emission factor index in 94 (B-2.4.2 Emission of Trace Gases Contributing Greenhouse Effect from Grassland by GERF).

(2) The planning of the emission factor index according to the kind with slurry application ways and nitrogen fertilizers

As for the reduction technique of CH_4, N_2O emissions to have examined so far (B-2.4.2 Emission of Trace Gases Contributing Greenhouse Effect from Grassland, B-16.3 Studies of Control and Activities of Greenhouse Trace Gases in Grassland by GERF), it examined the planning of a emission factor index about the kind with slurry application ways and nitrogen fertilizers.

(3) The cost investigation about N_2O degradation from grassland by change of the applied nitrogen fertilizer

It did cost investigation about the effective way of the fertilization management for the emission reduction in fertilization to have planned to do in 97(B-16.3 Studies of Control and Activities of Greenhouse Trace Gases in Grassland by GERF).

4. Result and Discussion

(1) The revision of the emission factor index relating to grassland and animal waste

In the index which was made in 94, it showed emission factor in addition to the examination in the standard error. After that, there are some factors with increased measurement experiments. Therefore, we examined to revise emission factor added gas flux data by statistic processing(Table 1).

The revised emission factor index have higher precision about the part with the measurements times than before it. However, there is one which the median and the standard deviation leave to the average in the factor. By the application time and the treatments applied to field of fertilizer and animal waste, CH_4, N_2O emissions are gravely influenced. Because it wasn't arranging for those conditions strictly at experiments, it was never high precision factor value. Therefore, the measurement example must be more piled with the future. Especially, as for the factor which is related with animal waste, because there is little measurement number of times, to increase experiments is important.

The emission factor which was shown here was gotten in Nasu area, Tochigi, Japan where is National Grassland Research Institute. Therefore, to apply to all Japan, it is necessary to examine. To settle on the emission factor which corresponded to all Japan, the investigation inside Hokkaidou which has about 60 % of grassland in Japan and in Kyushu area which is doing many animal waste application is necessary.

Table 1. The emission factor index relating to grassland and animal waste

N_2O emission factor	n	median	average	standard deviation	range	unit
Grassland	5	44.0	43.8	2.5	40.6-47.4	N_2O-N mg / m^2 / yr
Nitrogen fertilizer*1	20	2.3	1.0	0.9	0.1-4.4	N_2O-N % / applid N amount
Feces of grazing cattle*2	7	0.07	0.05	0.04	0.02-0.11	N_2O-N % / T-N
Urine of grazing cattle	7	0.37	0.27	0.18	0.12-0.61	N_2O-N % / T-N
Cow slurry	7	0.16	0.12	0.07	0.06-0.26	N_2O-N % / T-N
Excreta of grazing cattle*3	--	0.32	--	--	0.09-0.55	N_2O-N g / cattle / day
Forest floor	1	--	45.9	--	--	N_2O-N mg / m^2 / yr
CH_4 emission factor	**n**	**median**	**average**	**standard deviation**	**range**	**unit**
Grassland	5	-126.5	-129.9	18.8	-106.8- -146.2	CH_4-C mg / m^2 / yr
Feces of grazing cattle	7	0.19	0.18	0.06	0.10-0.28	CH_4-C % / T-C
Cow slurry	7	0.31	0.25	0.17	0.06-0.55	CH_4-C % / T-C
Excreta of grazing cattle*3	--	2.75	--	--	0.85-4.65	CH_4-C g / cattle / day
Forest floor	1	--	-449.5	--	--	CH_4-C mg /m2 / yr

*1: T-N ratio is NH_4-N: 47% and urea-N: 53%.
*2:In Early Spring and continuous drying condition after defecation, N_2O emission do not occur every times.
*3:This data is simulation output of grazing cattle growth model.(Preliminary Study of a Model Describing the Growth of Grazing Cattle. M. Tsuiki et al., Bull. Natl. Grassl. Res. Inst. 43,1-11(1990))

(2) The planning of the emission factor index according to the kind with slurry application ways and nitrogen fertilizers

(2)-1 The making of the emission factor index of CH_4, N_2O relating to cow slurry

We aimed to reduce CH_4, N_2O emissions by changing the slurry application methods. And then, it gathered their emission factors to Table 2.

The examination of the degraded technique for CH_4, N_2O emissions at slurry application time was assumed in the use of the machine which often exists. Also, there were methods with little measurement times. As for these methods, it should increase the measurement times and improve precision more. After that, the effectiveness of the application techniques should be confirmed. The application methods which was comparatively much examined in the past were surface application and soil injection. When comparing these application methods, it finds that the trade-off relation occurs between the emissions of CH_4 and N_2O. Therefore, it added nitrification inhibitor immediately to slurry application. By doing the slurry for soil injection, it planed the reduction of CH_4, N_2O emissions. Here, nitrification inhibitor was using thio urea.
When using the other nitrification inhibitor, N_2O emission changes. Therefore, it is necessary to examine about the other nitrification inhibitor.

Table 2. the emission factor index of CH_4, N_2O relating to cow slurry

N_2O emission factor	n	median	average	standard deviation	range	unit
Slurry						
Surface application	7	0.16	0.12	0.07	0.06-0.26	N_2O-N % / T-N
added N.I.*	1	--	0.07	--	--	N_2O-N % / T-N
Soil injection	4	0.49	0.47	0.19	0.29--0.68	N_2O-N % / T-N
added N.I.*	1	--	0.20	--	--	N_2O-N % / T-N
Soil mixed application	1	--	0.15	--	--	N_2O-N % / T-N
Tine injection	1	--	0.18	--	--	N_2O-N % / T-N
Slurry tank	1	--	4.27	--	--	N_2O-N g / cattle / yr
CH_4 emission factor	n	median	average	standard deviation	range	unit
Slurry						CH_4-C % / T-C
Surface application	7	0.31	0.25	0.17	0.06-0.55	CH_4-C % / T-C
Soil injection	4	0.06	0.06	0.03	0.02-0.10	CH_4-C % / T-C
Soil mixed application	1	--	0.09	--	--	CH_4-C % / T-C
Tine injection	1	--	0.18	--	--	CH_4-C % / T-C
Slurry tank	1	--	23.0	--	--	CH_4-C g / cattle / yr

*: N.I. is nitrification inhibitor. This case is thio urea, added 0.5 weihgt % Slurry T-N.

(2)-2. The making of the emission factor index of N_2O relating to nitrogen fertilizers

To apply nitrogen fertilizer at grassland, N_2O occurs at the time. Therefore, it did the examination to make N_2O emission reduce in changing nitrogen fertilizer. Every characteristic things of nitrogen fertilizers to have used this time was shown in Table 3.

Table 3. The character of experimental nitrogen fertilizers

Fertilizer	Call name	Character
High analysis mixed fertilizer	17ALL	N-P_2O_5-K_2O=17-17-17% T-N ratio is NH_4-N: 47% and urea-N: 53%
Slow-N release fertilizer		
Chemical synthesized type	CDU	CDU－Urea
Coated urea(fast type)	LP30	30 days in solution
Coated urea(slow type)	LP70	70 days in solution
Coated calcium nitrate	Long40	40 days in solution
Added nitrification inhibitor		
added DCD	DCD	N-P_2O_5-K_2O=15-15-15% Added nitrification inhibitor is dicyanodiamide.
added AM	AM	N-P_2O_5-K_2O=15-15-15% Added nitrification inhibitor is 2-amino-4-chloro-6-methylpirimidine.
Calcium nitrate	Ca-N	High deliquescence

In each fertilizer experiments, superphosphate was used as P_2O_5 and potassium chloride was used as K_2O , except for 17ALL, DCD, AM.

The fertilization at grassland applies nitrogen fertilizer on grassland surface. Because soil injection of fertilizer influences grass yield at grassland, it doesn't do generally. And then, the result which applied examined nitrogen fertilizer to grassland surface were shown in Table 4.

Table 4. The emission factor index of N_2O relating to nitrogen fertilizers

	n	median	average	standard deviation	range	unit
17ALL	20	2.3	1.0	0.9	0.1-4.4	N_2O-N % / applid N amount
CDU	12	0.5	0.4	0.3	0.0-1.0	//
LP30	8	0.4	0.3	0.2	0.1-0.7	//
LP70	12	0.3	0.2	0.2	0.0-0.6	//
Long40	8	0.4	0.4	0.2	0.1-0.6	//
DCD	12	0.4	0.3	0.2	0.0-0.8	//
AM	12	0.4	0.4	0.2	0.1-0.7	//
Ca-N	12	0.4	0.2	0.2	0.0-0.8	//

Like Table 1, the any results of N_2O emissions of experimental nitrogen fertilizers have different average from median and standard deviation. Because it wain't arranging for those conditions strictly at experiments, it was never high precision factor value. Thus, the measurement example must be more piled with the future. Therefore, it is difficult to build N_2O emission management plan only at the emission factor index which is shown here. The examination which included application time, area and yield, is necessary to N_2O emission management plan.

(3) The cost investigation about N_2O degradation from grassland by change of the applied nitrogen fertilizer

We planned effective fertilization in N_2O discharge depression in question with a little in procurement and easiness of handling, yield and calculated the diminution factor as a test (Table 6), in 97(B-16.3 Studies of Control and Activities of Greenhouse Trace Gases in Grassland by GERF). And then, as for this fertilization management, we did cost investigation.

As a result, the fertilizer cost increased by about 17-51% compared with the case to have used conventional practice fertilizer as shown in Table 6. The way of cost's becoming the highest was the plan which used CDU.

Table 5. Fertilizer application management for N_2O emission to degrade

Fertilizer application management	Rate of N_2O emission to degrade
All fertilizer application time, use of chemical fertilizer added nitrification inhibiter(DCD, AM)	43～57%
All fertilizer application time, use of slow-N release fertilizer (CDU), except for spring time, by high analysis mixed fertilizer(17ALL)	47%

Every fertilizer application time for grassland, N-P_2O_5-K_2O=5-5-5kg/10a

Table 6.The cost investigation about N_2O degradation from grassland by change of the applied nitrogen fertilizer

	Annual cost per 10a	The difference between conventional and N_2O degradation plan
All splits application of fertilizer by 17ALL (conventional practice fertilizer)	¥ 10,588	--
All splits application of fertilizer by AM	¥14,452	¥3,864
All splits application of fertilizer by DCD	¥12,388	¥1,800
Early spring splits application of fertilizer by17ALL, and other times by CDU	¥15,993	¥5,405

Every fertilizer application time for grassland, $N\text{-}P_2O_5\text{-}K_2O$=5-5-5kg/10a

CDU application cost include with superphosphate and potassium chloride cost. Fertilizer cost calculate at December, 98.

With custom method is simple and easy because put it, and put a change with the principal objective, did not do that changed NPK amounts of fertilizer in every fertilization. Generally, slow-release fertilizer is high fertilizer efficiency. Therefore, it is possible for the application rate of fertilizer to decrease by using slow-release fertilizer. If it is possible for the application rate of fertilizer to decrease, the fertilizer cost and N_2O emission are degraded. Then, the use of slow-release fertilizer will become effective option. The cost and to decrease application rate of fertilizer are necessary the examination.