山形大学紀要（農学）第12巻　第1号：15-22. 平成6年1月
Bull. Yamagata Univ., Agr. Sci., 12(1) : 15-22. Jan. 1994

Effects of High Fertilization of Sheep Waste in Cultivation of Rice Plant and Urea Supplement into Whole Crop Silage on the Nutritive Yield

Toshiyoshi TAKAHASHI, Yayoi GOTO* and Takeo KAYABA
Section of Agricultural Production, Faculty of Agriculture,
Yamagata University, Tsuruoka 997, Japan.
*Present address ; Shonai Agricutural High School, Fujishima 999-76, Japan
(Received September 1, 1993)

Summary

Cultivation trial of rice plants fertilized with sheep waste and digestion trial of whole crop silage of rice plants (WCSRP) supplemented urea were carried out to improve the nutritive yield and to establish as a stable forage. Three experimental plots were set up according to nitrogen fertilization ; i. e. equivalent, one and half, twice with that of the conventional amount used in Yamagata Prefecture (8.5kg／10a). At earlier stage, the more fertilizer was applied, the higher the dry matter yield. Although crude protein content decreased with growth stage in all experimental plots, it has the tendency to increase depending on the amount of nitrogen fertilizer. At milk-ripe stage, dry matter digestibility of WCSRP *in vitro* is superior in plots applied with high fertilizer and supplemented with 2 % urea. However, it is not affected by the application of high fertilizer and urea supplement at the stages after dough-ripe. Although the palatability of ration in sheep was improved in WCSRP cultivated with high fertilizer, TDN yield was not affected by high application of waste due to low crude fiber digestibility. Nutritive yield, however, remarkably increased by urea supplement. Especially, experimental plot supplemented with urea had DCP yield that was 4.24 times more than that of control plot.

Introduction

Recently, whole crop silage of rice plant (WCSRP) has been considered as a well-balanced roughage with high energy for beef and dairy cattle fodder. Whole crop of rice plant (WCRP) was classified as a specific crop from 1984 in the countermeasure of recognization on paddy field use in Japan. Especially in granary along the Japan Sea, WCRP is thought to have a high potential as a crop which has stable yield and can resist injury caused by continuous cropping. The major weaknesses of WCRP, however, might be lower yield and lesser nitrogen content than other forages, especially corn.

The present authors reported that WCRP which was resistant against lodging with V-type leaves contained high nitrogen and improved nutritive value and yield by surplus application of nitrogen fertilizer[1]. Furthermore, supplement of urea to WCSRP was effective for the improvement of the nitrogen utilization ; i. e. crude protein digestibility and nitrogen retention[7,8].

On the other hand, livestock waste has become a very serious problem with a tendency to more headed number of housing livestock animals. Reuse of livestock waste such as fertilizer for crop and as methane gas for energy[3] is expected for the conservation of environment.

The present experiment was carried out to examine the step-up in production of nutritive yield by the application of livestock waste and the supplement of urea into WCSRP.

Materials and Methods

1. Cultivated trial by fertilizing sheep waste and making of silage in WCRP

Cultivated trial was conducted from June 8 to October

4, 1992 in the University Farm of Yamagata University. Four hundred square meter paddy field was used for the cultivated trial of WCRP. Rice seeds (*Oriza sativa* L., cv. *Ootori*) were broadcasted at a seedling rate of 6.25 kg/10a under submergence. The experimental plots were designed to three plots ; i. e. equivalent (8.5kg), one and half (12.75kg) and twice (17kg) of the conventional amount (8.5kg / 10a) of nitrogen used in Yamagata Prefecture[9]. Twenty eight point six percent feces and 71.4% urine on fresh matter basis of sheep waste, which was the same ratio of feces and urine of sheep excreted in our laboratory, were used at the nitrogen level of three-quarters for basal application of fertilizer. Only urine of sheep was used at the level of one-quarter for additional fertilizer. The experiment was desighed with 3 * 3 Latin square method.

WCRP was harvested at random from 1 m^2 area of each plot at four stages, i. e. milk-ripe, dough-ripe, yellow-ripe and full-ripe stages. WCRP cut at the length of 0.5 cm was ensiled at about 5 kg per bag made of polyethylene. After 3 weeks, WCSRP was used to examine dry matter digestibility *in vitro*. At the yellow-ripe stage, WCSP was harvested, cut at a length of 3-4 cm and ensiled at about 90 kg in a drum can to examine its nutritive value.

2. Digestion trial *in vitro* and *in vivo* in WCSRP

These trials were carried out by using four WCSRPs, namely ; three WCSRPs cultivated at three levels of nitrogen fertilizer and 2 % urea supplemented (on dry matter basis) WCSRP cultivated twice nitrogen fertilizer, in order to improve its nutritive value.

WCSRP was cultivated for 48 hours at 39 ℃ under carbon dioxide flow with McDougall's artificial saliva and rumen juice of goat filtered through two layers of

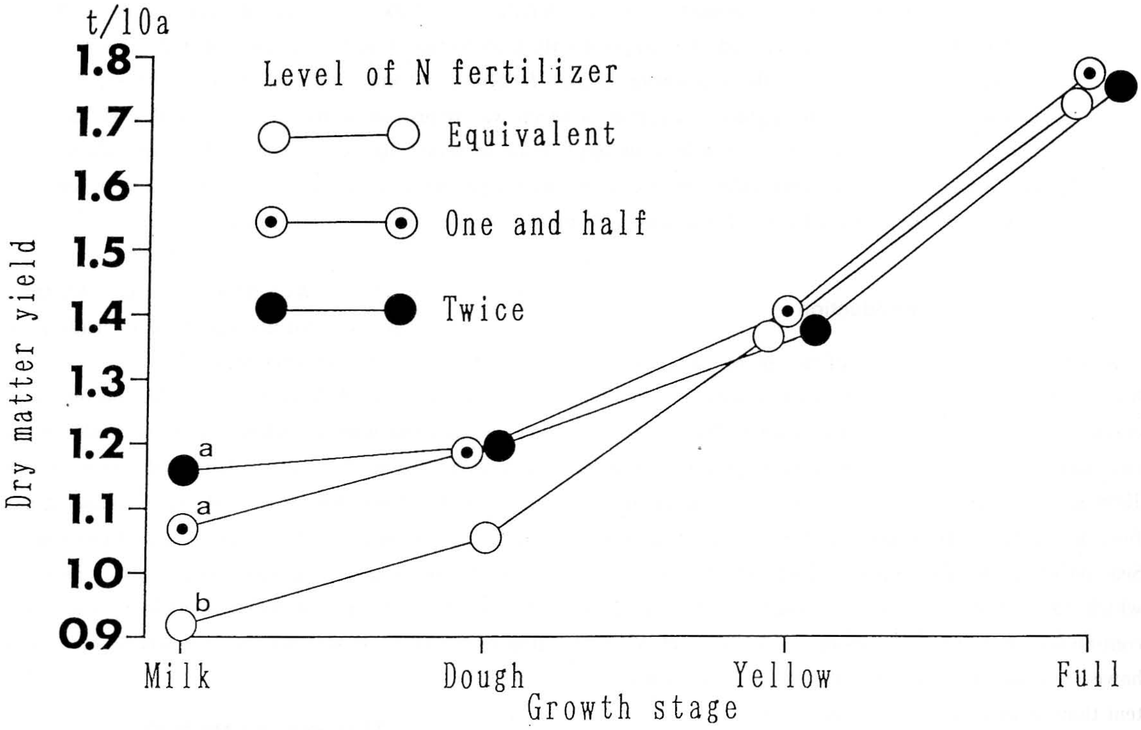

Fig. 1. Changes in dry matter yield of whole crop silage of rice plant with growth stage. Sheep waste was fertilized at the three nitrogen levels of equivalent, one and half, and twice with that of the conventional amount (8.5kg/10a) used in Yamagata Prefecture. Means with different superscripts are significantly different at the 0.05 probability level.

cheese cloth[5]. After cultivating, dry matter digestibility (DMD) was determined.

Four sheep (43 kg in average body weight) were used as experimental animals for digestion trial *in vivo*. All rations were supplied once a day so as to remain approximately one-tenth amount on the next day. Trials of digestion and nitrogen balance were conducted by daily collection of feces and urine for a total of 5 consecutive days after 7 preliminary days. The experiment was designed with 4＊4 Latin square method.

The chemical composition of WCSRP, feces and urine were analysed by the coventional method[5]. Volatile fatty acid was sream-distilled and measured by the gaschromatography. Ammonium-N in WCSRP and rumen liquor by microdiffusion method of CONWAY[5] and urea-N in blood plasma by urea-N Test (Wako Junyaku Kogyo Co., LTD.) were determined.

The significances of difference were evaluated by analysis of DUNCAN's multiple range test[6].

Results and Discussions

The changes in dry matter yield and nitrogen content of WCSRP are presented in Figures 1 and 2, respectively. Dry matter yield increased with growth stage in all experimental plots. At earlier ripening stage of rice plant, the more nitrogen fertilizer was applied, the more dry matter yield was obtained. Especially at milk-ripe stage, there was a significant difference ($p<0.05$) among the three experimental plots. It was thought that dry matter production at high level of nitrogen fertilizer increased because nitrogen of additional urine fertilizer might be immediately absorbed by rice plant and affect the yield at milk-ripe stage. Nitrogen content had the tendency to decrease with growth stage in all experimental plots and to be higher in case of high nitrogen fertilizer than equivalent one at all growth stages. When WCRP is harvested at an early stage such as milk-ripe, it is understood that there are three advantages that high

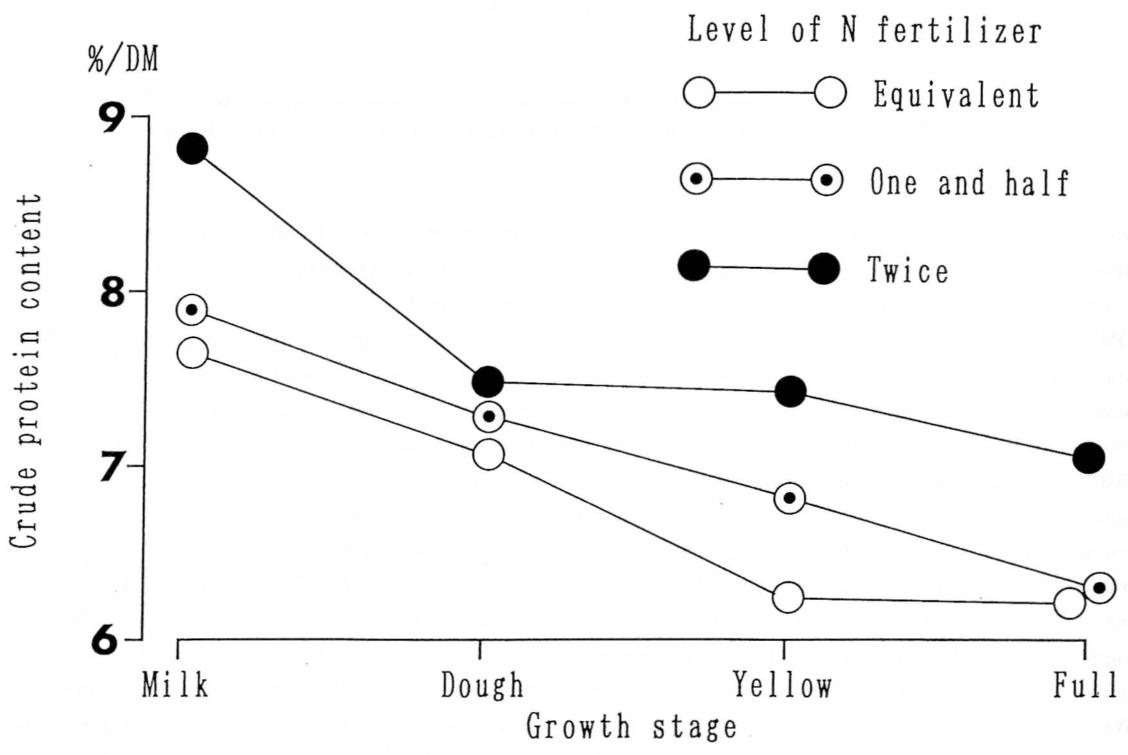

Fig. 2. Changes in crude protein content of whole crop silage of rice plant with growth stage.

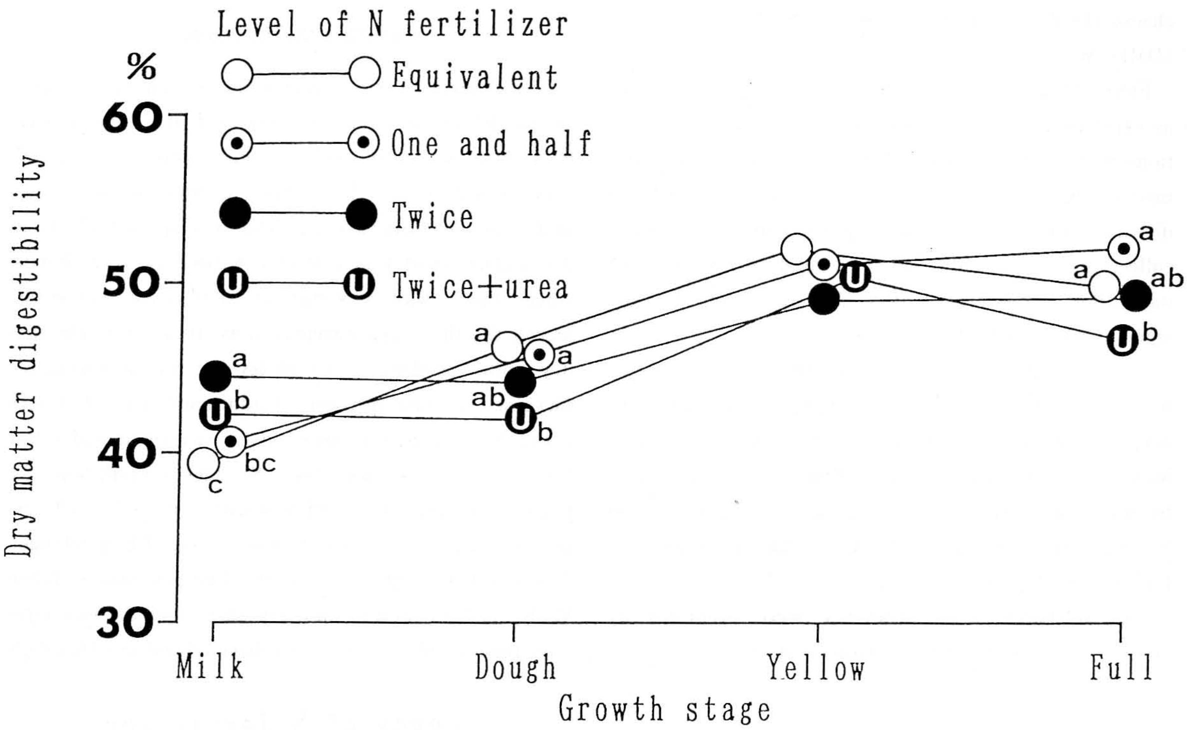

Fig. 3. Changes in *in vitro* dry matter digestibility of whole crop silage of rice plant (WCSRP) with growth stage. Two percent urea was supplemented into WCSRP on dry matter basis. Means with different superscripts are significantly different at the 0.05 probability level.

yield of dry matter, high content of crude protein and short cultivation period were obtained at the same time.

Changes in DMD of WCSRP are given in Figure 3. DMD had the tendency to increase until yellow-ripe stage and to be equal or to decrease during full-ripe stage at all experimental plots. At milk-ripe stage, twice nitrogen fertilizer and urea supplement caused DMD to increase significantly. However at the three-ripe stages after dough-ripe stage, DMD is lower in high nitrogen fertilizer and urea supplement than in equivalent nitrogen fertilizer. It is recognized that DMD of WCSRP was increased in high nitrogen content[1] and urea supplement[7,8]. The reason why high DMD was obtained might be that ammonium nitrogen decomposed from WCSRP or urea was synthesized into microbes protein and so the activity of digestion was accelerated. The cause that DMD of WCSRP was not improved by urea supplement at periods after dough stage was unclear, though the interrelation among other constituents was contemplated.

Chemical composition and properties of WCSRP are shown in Tables 1-1 and 1-2, respectively. Crude protein contents was slightly higher in high fertilizer than in equivalent one. There was no obvious difference in other chemical compositions among three rations. VBN／TN (%) was significantly higher in twice fertilizer than in equivalent fertilizer.

Dry matter intake (DMI), apparent digestibility and nitrogen retention are presented in Table 2. DMI was significantly higher in WCSRP cultivated by twice nitrogen fertilizer than in WCSRP cultivated by equivalent nitrogen fertilizer. In case of WCSRP containing high nitrogen, DMI might increase because rumen load would be relieved by accerelated activity of microbes synthesized

Table 1-1. Chemical composition of whole crop silage of rice plant used in digestion trial.

Level of N fertilizer[1)]	Moisture	% on dry matter basis						
		C. protein	C. fat	NFE[2)]	C. fiber	C. ash	NDF[3)]	SS[4)]
Equivalent	64.6	5.9	2.6	57.1	25.5	8.9	47.4	35.2
One and half	64.2	6.4	2.7	55.3	26.5	9.1	48.9	32.9
Twice	66.7	6.6	2.8	56.7	25.0	8.9	46.8	34.9

1) ; Sheep waste was fertilized at the three nitrogen levels of equivalent, one and half, and twice with that of conventional amount (8.5 kg/10a) used in Yamagata Prefecture.
2) ; Nitrogen free extract.
3) ; Neutral detergent fiber.
4) ; Soluble sugar=100−(C. protein+C. fat+NDF+C. ash).

Table 1-2. pH, organic acids composition, VBN[1)]/TN[2)] and Flieg's score in whole crop silage of rice plant used in digestion trial.

Level of N fertilizer	pH	Organic acids composition (% on fresh matter basis)				VBN/TN (%)	Flieg's score
		Lactic acid	Acetic acid	Propionic acid	Butyric acid		
Equivalent	5.1	0.15	0.22	0.03	0.44	$27.6^{b3)}$	9.0
One and half	5.1	0.24	0.17	0.03	0.38	29.2^{ab}	5.0
Twice	5.1	0.23	0.18	0.03	0.39	31.6^{a}	6.0

1) ; Volatile basic nitrogen.
2) ; Total nitrogen.
3) ; Means with different superscripts are significantly different at the 0.05 probability level.

Table 2. Dry matter intake, apparent digestibility of nutrients and N retention in whole crop silage of rice plant.

Level of N fertilizer or urea supplement	Dry matter intake (g/BW[1)] (kg)$^{0.75}$/day)	Apparent digestibility (%)					N retention (g/BW (kg)$^{0.75}$/day)
		C. protein	C. fat	NFE[2)]	C. fiber	NDF[3)]	
Equivalent	$39.6^{b4)}$	39.1^{b}	59.2	62.3	39.1	35.1	-5.0^{b}
One and half	44.9^{ab}	42.7^{b}	64.6	63.3	41.2	39.5	2.0^{b}
Twice	45.9^{a}	41.3^{b}	63.6	61.1	33.3	30.5	1.3^{b}
Twice+urea supplement[5)]	45.5^{a}	71.5^{a}	65.3	62.1	33.6	31.5	502.5^{a}

1) ; Body weight.
2), 3), 4) ; See notes to Table 1-1 and Table 1-2.
5) ; 2 % urea was supplemented to whole crop silage of rice plant on dry matter basis.

from surplus nitrogen. Crude protein digestibility and nitrogen retention were improved by urea supplement. Assuming that c. protein digestibility of WCSRP supplemented urea was the same as that of non-supplemented WCSRP, almost nitrogen originated from urea was absorbed in theory. It becomes a problem, however, that nitrogen retention of WCSRP was extremely low and utilization of nitrogen in fodder fell behind when taking notice of 146 * Body Weight (kg) $^{0.72}$ in endogeneous urinary nitrogen (mg／day)[2)]. Crude fiber digestibility had the tendency to decrease according to high nitrogen fertilizer or urea supplement. Maybe the pass speed of the ration across the rumen increased because of high DMI.

Both NH_3-N in rumen liquor and urea-N in blood plasma were significantly higher in twice fertilizer than equivalent fertilizer at 4 hours after feeding (Table 3). Urea supplement into WCSRP caused NH_3-N in rumen liquor and urea-N in blood plasma to increase remarkably. It is supported that NH_3-N decomposed from urea and high NH_3-N of WCSRP was immediately absorbed from rumen into circulating blood plasma. There was no obvious difference in rumen volatile fatty acids concentration amoung four experiments at both feeding times.

Table 4 showed the comparison of dry matter yield and digestible nutrients between WCSRP in present experiment and corn silage in Yamagata Prefecture. The value of dry matter yield in corn silage was calculated from the averages during the past five years[4]. Dry matter yield of WCSRP in all experiments increased from 15 to 18 % more than that of corn silage. One and half nitrogen fertilizer significantly increased yield of digestible crude protein to 24 % of the equivalent fertilizer. Yield of total digestible nutrients by the application of high fertilizer did not increase due to low c. fiber digestibility. Both TDN and DCP of digestible nutrient yields were lesser in WCSRP than in corn silage. By urea supplementation. TDN yield of WCSRP was the same as in corn silage. Furthermore, DCP yield of WCSRP supplemented urea was 2.35 times more than that of corn sil-

Table 3. NH_3-N and VFA[1)] concentrations in rumen liquor and urea-N in blood plasma before feeding and at 4 hours after feeding.

Level of N fertilizer or urea supplement	Rumen NH_3-N (mg/dl)	Blood plasma Urea-N (mg/dl)	Rumen VFA concentretion (mol %)		
			Acetic acid	Propionic acid	Butyric acid
Before feeding					
Equivalent	30.3[b2)]	12.7[c]	61.9	19.1	19.0
One and half	29.4[b]	13.8[bc]	60.2	23.6	16.3
Twice	28.1[b]	17.1[b]	58.4	24.4	17.3
Twice+urea supplement	222.0[a]	32.5[a]	59.8	19.0	21.2
At 4 hours after feeding					
Equivalent	33.6[c]	11.9[c]	64.7	21.8	13.5
One and half	39.7[bc]	13.7[bc]	61.1	24.4	14.6
Twice	44.0[b]	17.3[b]	58.9	25.2	16.0
Twice+urea supplement	78.1[a]	27.2[a]	61.4	23.3	15.4

1) ; Volatile fatty acids.
2) ; See note to Table 1-2.

Table 4. Comparison of yields of dry matter and digestible nutrients between whole crop silage of rice plant and corn silage.

Level of N fertilizer, or urea supplement and forage	Dry matter yield (kg/10a)	Digestible nutrient (% on dry matter basis)		Digestible nutrient yield (kg/10a)	
		DCP[1)]	TDN[2)]	DCP	TDN
Equivalent	1,372 (115)[3)]	2.3[b4)]	51.3	31.7[c] (56)[3)]	704[bc] (88)[3)]
One and half	1,402 (118)	2.8[b]	52.6	39.3[b] (68)	737[b] (92)
Twice	1,383 (116)	2.7[b]	49.7	37.3[bc] (65)	688[c] (86)
Twice+urea supplement	1,384 (116)	9.7[b]	57.5	134.3[a] (235)	796[a] (99)
Corn silage	1,189[5)] (100)	4.8[6)]	67.6[6)]	57.1[7)] (100)	804[7)] (100)

1) ; Digestible crude protein.
2) ; Total digestible nutrients.
3) ; Figures are index comparing with corn silage 100.
4) ; See to note of Table 1-2.
5) ; Average during past five years in Yamagata Prefecture.
6) ; Figures quoted from pp. 44-45 in "Standard Tables of Feed Composition in Japan (1987)" edited by Agriculture, Forestry and Fisheries Research Council Secretariat, Ministry of Agriculture, Forestry and Fisheries.
7) ; Figures calculated from dry matter yield and percents of digestible nutrients.

age and 4.24 times more than that of WCSRP cultivated by equivalent fertilizer.

From the results described above, it indicates that it is almost possible to increase dry matter yield of WCSRP as much as corn silage by application of livestock fertilizer. In addition, urea supplementation into WCSRP remarkably accelerated the DCP yield.

Acknowledgement

The authors are grateful to Prof. Hiroshi IKARASHI of University Farm and Prof. Ho ANDO of Section of Agricultural Production for their precious advices and to technical officials of University Farm for their helpful assistances to this cultivating trial of WCRP.

References

1) HORIGUCHI, K., T. TAKAHASHI, T. KAYABA and T. SASAHARA (1992) Comparison of nutritive value among whole crop silage of rice plant with V－type leaves and other forages. *J. Japan. Grassl. Sci.* **38**, 242—245.*

2) KAMETAKA, M., M. HORIGUCHI, T. ISHIBASHI and O. FURUYA (1984) Feed and Feeding of Domestic Animals. Yokendo. Tokyo. pp.123.*

3) KIYOMORI, H. (1976) Use of livestock waste for energy, especially the production and use of methane. *Anim. Husbandry* **30**, 222—226.*

4) Livestock Industry in Yamagata Prefecture (1992) Animal Husbandry Division of Yamagata Prefectural Government. Yamagata. pp.46—47.*

5) MORIMOTO, H. (Ed.) (1971) Method of Nutritional Experiment for Animals. Yokendo. Tokyo. pp.280—431.*

6) SAS institute Inc. (1985) SAS User's Guide. Statistics. Ver. 5th. SAS Institute Inc. Cary. pp.443—506.

7) TAKAHASHI, T., K. HORIGUCHI and T. KAYABA (1992) The effect of urea supplementation on the improvement of nutritive value with feeding of different concentrate-roughage ratios in whole crop silage of rice plant. *The Tohoku J. Anim. Sci. Technol. Abstracts of 42th Annual Meeting,* 60.*

8) TAKAHASHI, T., K. HORIGUCHI, T. KAYABA and H. ANDO (1993) The effect of urea supplementation on the improvement of the feeding value in whole crop silage of rice plant. *J. Japan. Grassl. Sci.* **39**, 387—390.

9) Thesaurus in Agriculture (1987) Agriculture Technology Division of Yamagata Prefectural Government. Yamagata. pp.12—13.*

* : In Japanese only. Translated title by present authors.

水稲の栽培時におけるメン羊糞尿の多肥とホールクロップサイレージへの尿素添加が栄養収量に及ぼす影響

高橋敏能・後藤弥生*・萱場猛夫
（山形大学農学部農業生産学講座・*現在：山形県立庄内農業高等学校）

摘　　要

家畜糞尿の多肥条件下で水稲の栽培試験とホールクロップサイレージに調製後，尿素を添加給与する消化試験を実施して，水稲ホールクロップサイレージ（WCSRP）の栄養収量の増大化を検討した．メン羊の糞尿を窒素成分において山形県で慣行法として実施している施肥量（8.5kg/10a）と等量，その1.5倍及び2倍量の試験区を設定した．乾物収量は，生育ステージが早い時期において施肥量に応じて多くなった．粗蛋白質含量はいずれの試験区も生育が進むに伴い減少したが，施肥量に応じて高く推移する傾向だった．*In vitro* における WCSRP の乾物消化率は，乳熟期において多肥と2倍区の WCSRP に尿素を乾物当たり2％添加すると高くなったが，糊熟期以降はそれらの効果がなかった．メン羊における飼料の嗜好性は，糞尿を多肥して栽培した WCSRP は改善されたが，粗繊維の消化率が低かったため TDN 収量の増大は認められなかった．しかし，2倍区の WCSRP に尿素を2％添加することにより栄養収量が著しく増加した．特に，DCP 収量は尿素添加により等量区の4.24倍の効果があった．