EFFECTS OF CUTTING FREQUENCY AND NITROGEN FERTILIZATION ON DRY MATTER YIELD OF REED CANARYGRASS (*Phalaris arundinacea* L.) IN UNCULTIVATED RICE PADDY

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Summary

Dry matter yield of reed canarygrass was investigated in uncultivated rice paddy in Korea, and an attempt was made to estimate the most economic and efficient cutting frequency and rates of nitrogen (N) fertilization, for increased production of reed canarygrass. Total dry matter yields of reed canarygrass per year were 7.4-15.7, 8.5-16.1, and 7.5-13.4 tons/ha in 3, 4, and 5 cutting frequencies, respectively, and over the N treatments of 0-120 kg N/ha/cut. When cut 3 or 5 times annually, the 2nd cut produced the highest proportion of total yield at 38.4 and 33.0%, respectively, when cut 4 times the 3rd cut was highest (38.3%).

The ranges of economic N level, limiting N level and efficiency of dry matter production were 243.3-293.0, 387.2, and 14.6kg DM/kg N, respectively. These indicators were particularly low for the 5 cutting frequency possibly because of the unusually high temperature in the summer season. The best cutting frequency for the dry matter production of reed canarygrass in 1994 was 3 per year because of the higher efficiency of dry matter production.

(**Key Words:** Reed Canarygrass, Cutting Frequency, Relative Yield, Economic N level, Efficiency of Dry Matter Production)

Introduction

In Korea, the area of uncultivated rice paddy has increased due mainly to the lack of rural labour. It has been predicted by Lee et al. (1994) that in 10 years, 500-600 thousand hectares of arable land in Korea will be under-utilized causing a serious lack of forage supply for ruminants. In order to efficiently utilize this land, perennial grasses could be introduced because of their adaptability to the poor conditions and less requirement of labour.

Reed canarygrass is a perennial grass which has the desired characteristics of high dry matter yield and nutritional value as a roughage. Reed canarygrass promotes soil conservation (Klappe, 1983; Lee et al., 1993), and is well adapted to the poor environmental conditions (Schmid et al., 1979). Although the digestibility of reed canarygrass is low (Frame and Morrison, 1991) and its palatability is adversely affected by the presence of an alkaloid (Marten et al., 1976), its usage is expected to increase with the introduction of a new cultivar containing lower alkaloid levels (Kalton et al., 1989). In this study, the dry matter production of reed canarygrass was investigated in response to the cutting frequency and N fertilization.

Materials and Methods

Reed canarygrass (var. Venture) was used for the experiment. It was grown on Migum farm, Namyangju-si, Kyunggi-do, Korea from April to October in 1994. The trial site had been used for rice production by 1991 and afterwards, it was drained and reed canarygrass has been established. Soil type was clay loam. The experiment was

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a split plot design with main treatments (cutting frequencies of 3, 4 or 5 occasions) randomly arranged in 3 replicate blocks. Each main plot was split into 5 subplots (each 2 m × 2 m), representing rates of 0, 30, 60, 90 and 120 kgN/ha/cut and the N was fertilized in the form of urea. 200 kg/ha of phosphorus and 240 kg/ha of potassium were applied in early April as a basal fertilizer dressing.

Cutting time for each cutting frequency was May 20th (1st cut), August 3rd (2nd cut), and October 14th (3rd cut) in 3 cutting frequency, May 6th (1st cut), July 1st (2nd cut), August 26th (3rd cut) and October 14th (4th cut) in 4 cutting frequency, and April 29th (1st cut), June 19th (2nd cut), July 29th (3rd cut), September 9th (4th cut) and October 14th (5th cut) in 5 cutting frequency, respectively. All plots were cut at a cutting height of 5 cm using a rotary mower.

Dry matter yield was determined by placing 500 g of randomly collected fresh reed canarygrass at forced air

drying oven (80°C) for 48 hours. Response equation of dry matter yield to N fertilization levels were used to estimate the economical border, economic N level, marginal DM yield, limiting N level and maximum N level in each cut. The equation was obtained through the application of input-output curve determined by tertiary regression of the form ($Y = a \pm bx \pm cx^2 \pm dx^3$) and these were based on the calculations of economical borders of 12-16, 10-12, and 8-10 kgDM/kgN at 3, 4, and 5 annual cuts, respectively, which were suggested by Jo (1989).

Table 1 shows the meteorological data during the growth period in 1994 and the averages for 30 years.

Mean temperature between April and October in 1994 was higher than the 30-year averages (1961-1990), especially in July (+4°C) and August (+2°C). June, July and September were dry, with rainfall below the 30-year averages but in October it was 4 times higher than the 30-year averages as 214.5 mm.

TABLE 1. METEOROLOGICAL DATA DURING THE GROWTH PERIOD IN 1994 AND THE AVERAGES FOR 30 YEARS

Growth period		Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.
1994	Mean temperature (°C)	4.0	15.2	17.9	22.8	28.5	27.6	21.0	15.2
	Rainfall (mm)	31.7	44.9	152.4	85.0	139.5	232.7	60.7	214.5
1961-1990	Mean temperature (°C)	4.5	11.8	17.4	21.5	24.6	25.4	20.6	14.3
	Rainfall (mm)	46.7	93.7	92.0	133.8	369.1	293.9	168.9	49.4

Results

1. Dry matter yield

Table 2 shows the dry matter yield of reed canarygrass in response to the cutting frequency and N fertilization levels.

2. Cutting frequency :

Dry matter of reed canarygrass was significantly ($p < 0.05$) increased at the 1st cut for every increment of N fertilizer (table 2). Average over the N treatments was 2.92 tons/ha or 24.3% of the total annual dry matter yield. The trends in yield response to N at the 2nd and 3rd cuts were similar with smaller responses to N fertilizer, especially at the 3rd cut. Average over the N treatments, the 2nd and 3rd cuts represented 38.4 and 37.3% of the total yield, respectively.

3. Cutting frequency :

Dry matter yield was not significantly different at the 1st cut with 60-120 kgN/ha/cut. However, the 2nd cut

with 90-120 kgN/ha/cut showed significantly ($p < 0.05$) higher dry matter yield compared to other levels of N fertilization. The 2nd cut represented 28.4% of the total annual dry matter. Average over the N treatments, the 3rd and 4th cuts represented 38.3 and 19.9%, respectively. The highest dry matter yield of 16.1 ton/ha was obtained at 480 kgN/ha.

4. Cutting frequency :

Annual dry matter yields with cut 5 times were the lowest at all cutting systems. Dry matter yield was not significantly different at the 1st and 2nd cuts with 60-120 kgN/ha/cut. However, dry matter yield of the 2nd cut was highest representing 33.0% of the total annual dry matter. Average over the N treatment, the 3rd and 4th cuts represented 27.0 and 22.0%, respectively, however the 5th cut showed only 8.0%. Total dry matter yield when cut 5 times was 10.9-13.4 tons/ha at the levels of 150-600 kgN/ha, however no significant difference was recorded between various N fertilization levels.

TABLE 2. DRY MATTER YIELD OF REED CANARYGRASS AT DIFFERENT N LEVEL AND CUTTING FREQUENCY

Cutting frequency	N level (kg/ha/cut)	Dry matter yield (t/ha)					
		1st cut	2nd cut	3rd cut	4th cut	5th cut	Total
3	0 kg	1.31 ^e	2.74 ^c	3.34 ^b			7.39 ^d
	30 kg	2.22 ^d	3.79 ^{bc}	4.24 ^{ab}			10.25 ^c
	60 kg	3.04 ^c	4.67 ^b	4.67 ^a			12.38 ^b
	90 kg	3.62 ^b	5.82 ^a	4.92 ^a			14.35 ^{ab}
	120 kg	4.42 ^a	6.06 ^a	5.22 ^a			15.70 ^a
	Mean	2.92 ^b	4.62 ^a	4.48 ^a			
4	0 kg	0.84 ^c	1.90 ^d	4.17 ^b	1.55 ^b		8.45 ^c
	30 kg	1.40 ^{bc}	2.64 ^{cd}	3.94 ^b	1.98 ^b		9.96 ^c
	60 kg	1.85 ^{ab}	3.53 ^{bc}	4.62 ^{ab}	2.83 ^a		12.84 ^b
	90 kg	1.86 ^{ab}	4.28 ^{ab}	5.30 ^a	2.75 ^a		14.19 ^{ab}
	120 kg	2.29 ^a	5.14 ^a	5.52 ^a	3.16 ^a		16.11 ^a
	Mean	1.65 ^d	3.50 ^b	4.71 ^a	2.45 ^c		
5	0 kg	0.52 ^c	1.71 ^c	2.49 ^a	2.32 ^a	0.49 ^b	7.53 ^b
	30 kg	0.94 ^{bc}	3.15 ^b	3.23 ^a	2.72 ^a	0.87 ^{ab}	10.91 ^a
	60 kg	1.31 ^{ab}	4.14 ^a	2.93 ^a	2.25 ^a	0.91 ^a	11.54 ^a
	90 kg	1.44 ^a	4.77 ^a	3.31 ^a	2.64 ^a	1.19 ^a	13.36 ^a
	120 kg	1.43 ^a	4.92 ^a	3.33 ^a	2.50 ^a	1.09 ^a	13.28 ^a
	Mean	1.13 ^c	3.74 ^a	3.06 ^{ab}	2.49 ^b	0.91 ^c	

Note. Means separated within a column by Multiple Range Test, 5% level.
The same letters show non-significant difference at the 5% level.

5. Economic N level

Input-output curve of dry matter yield according to cutting frequency and N fertilization is presented in table 3.

The response of dry matter yield to the various levels of N fertilization appeared as tertiary equation and correlation coefficients were significantly ($p < 0.05$) different between all cutting frequencies.

TABLE 3. INPUT-OUTPUT CURVES ACCORDING TO VARIOUS CUTTING FREQUENCIES IN REED CANARYGRASS

Cuttings	r^2	Input-Output curve
3	0.9984*	$y = 7,105.57 + 33.93x - 0.035x^2 + 0.000012574x^3$
4	0.9610*	$y = 8,467.29 + 12.09x + 0.028x^2 - 0.000042921x^3$
5	0.9984*	$y = 7,630.43 + 24.28x - 0.037x^2 + 0.000020988x^3$

Table 4 shows that the estimated economic N levels were 306.9-399.1, 436.5-469.5, and 243.3-293.0 kg/ha in 3, 4, and 5 cutting frequencies, respectively. Marginal dry matter yields were also estimated as 14.6-15.9, 15.5-15.9, and 11.6-12.1 tons/ha in 3, 4, and 5 cutting frequencies, respectively, indicating the lowest marginal dry matter yield in 5 cutting frequency. Limiting N levels were 731.3, 593.2, and 387.2 kg/ha in 3, 4, and 5 cutting frequencies, respectively and maximum dry matter yields were 18.1, 16.5, and 12.7 tons/ha in 3, 4 and 5 cutting frequencies, respectively. It shows that the higher cutting

frequency, the lowest limiting N level and maximum dry matter yield.

6. Efficiency of dry matter production

Efficiency of dry matter production (kg DM/kg N) is indicated in table 5.

The higher N fertilization resulted in the decreased efficiency of dry matter production. With 5 annual cuts, the lowest efficiency of dry matter production (9.6 kg) occurred at the level of 120 kg/ha/cut. Mean efficiencies of dry matter production were highest in 3 annual cuts.

TABLE 4. ECONOMICAL BORDER, ECONOMIC N LEVEL, MARGINAL DRY MATTER YIELD, LIMITING N LEVEL AND MAXIMUM DRY MATTER YIELD IN EACH CUTTING

Cuttings	Economical border (kg DM/kg N)	Economic N level (N econ. kg/ha)	Marginal DM yield (Y mar. ton/ha)	Limiting N level (N max. kg/ha)	Maximum DM yield (Y max. ton/ha)
3	dy/dx = 16~12	306.9~399.1	14.6~15.9	731.3	18.1
4	dy/dx = 12~10	436.5~469.5	15.5~15.9	593.2	16.5
5	dy/dx = 10~ 8	243.3~293.0	11.6~12.1	387.2	12.7

Economical border : Ranges of economical dry matter production per N (kg DM/kg N).

Economic N level : Ranges of N level obtained at Economical border.

Marginal DM yield : Dry matter yield obtained at Economic N level.

Limiting N level : N level to obtain Maximum dry matter yield.

Maximum DM yield : Dry matter obtained at Limiting N level.

TABLE 5. EFFICIENCIES OF DRY MATTER PRODUCTION (Kg DM/Kg N) TO NITROGEN FERTILIZATION LEVELS IN EACH CUTTING

N level (ha /cut)	kg DM /kg N		
	3 cuttings	4 cuttings	5 cuttings
30 kg	31.8	12.6	22.5
60 kg	27.7	18.3	13.4
90 kg	25.8	16.0	13.0
120 kg	23.1	16.0	9.6
Mean	27.1	15.7	14.6

Discussion

Dry matter yield of grass in general is influenced by the levels of N fertilization and the efficiency of N utilization (Lee and Abe, 1984). Therefore, when forage is evaluated in view of dry matter yield, it is helpful to estimate economic N level and limiting N level and also to investigate the adequate cutting frequency and levels of N fertilization (Jo, 1989; Lee et al., 1994). The maximum yield of dry matter for hay-type management pastures in general was obtained at 300-400 kg N/ha (Garwood, 1988; Lee and Abe, 1984; Lee, 1982).

Cutting frequency also influences dry matter yield with more frequent cutting leading to a higher economic N level and limiting N level but lower efficiency of dry matter production (Lee et al., 1994; Reid, 1986). Optimum efficiencies of dry matter production in relation to cutting frequency were 16-12 kg at 3 cutting frequency, 12-10 kg at 4 cutting frequency and 10-8 kg at 5 cutting frequency (Jo, 1989).

In this study, both economic N level and limiting N level were lowest at 5 cutting frequency (243.3-297.0 and

387.3 kg/ha, respectively) (table 4) and the efficiency of dry matter production was also lowest (table 5), in particular at the 120 kg/ha/cut level. The unusually warm summer in 1994 combined with too short regrowth period in the 5 cut system could have contributed to this result.

In order to increase dry matter yield, it is essential to maintain the adequate growth period as grass plants need enough time to absorb and utilize nitrogen fertilizer (Lee and Abe, 1984). Plants also require adequate temperature and radiation (Lee and Kusutani, 1981) and high efficiency of nitrogen utilization in soil (Garwood, 1988). However, in this study, we suggest the growth period in 5 cutting frequency was too short to allow sufficient absorption and utilization of nitrogen fertilizer. Furthermore, it is likely high temperatures in summer caused increased plant respiration and consequently poor regrowth (Norris and Thomas, 1982). Volatilization losses of nitrogen during the period (Pain and Thompson, 1989) may have contributed to the low efficiency of nitrogen utilization at 5 cutting frequency.

For the production of reed canarygrass in uncultivated rice paddy, the climate was a critical factor. Under climatic condition suitable for growth, more frequent cutting with adequate mineral N fertilization may increase dry matter yield. However, under the poor climatic condition like 1994, in Korea, the levels of mineral N fertilization is recommended are between 270-360 kg/ha/year (table 2). In this study, cutting 3 times annually increased efficiency of dry matter production since it allowed enough time between cuts for reed canarygrass to absorb and utilize fertilizer nitrogen.

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