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To the Graduate Council:

I am submitting herewith a thesis written by Kenneth Laaker entitled "Forage Production of Orchardgrass (Dactylis glomerata L.) Under Several Cutting Management and Nitrogen Fertilization Regimes." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

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FORAGE PRODUCTION OF ORCHARDGRASS (DACTYLIS GLOMERATA L.)

UNDER SEVERAL CUTTING MANAGEMENT AND

NITROGEN FERTILIZATION REGIMES

A Thesis

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the Graduate Council of

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ABSTRACT

The relation of various nitrogen levels, stubble heights, and cutting frequencies to the dry matter production of orchardgrass (Dactylis glomerata L.) was studied at Knoxville, Tennessee. There were twelve combinations of these factors used in the experiment. The orchardgrass was harvested either four or eight times at 3.8-cm or 10.2-cm stubble heights, and with nitrogen fertilization rates of 224, 448, and 672 kg/ha applied in two equal parts. Regrowth stubble cores were taken at three-week intervals and stubble weights were sampled on June 5, July 25, and September 5, in 1967. During 1968, all plots received the same treatment of 224 kg/ha of nitrogen and 7.0-cm stubble height.

There was a significant difference in yield during 1967 with a range of 7.21 to 10.49 metric tons per hectare. The highest-producing treatment combination was 448 kg/ha of nitrogen, 3.8-cm stubble height, and 4-cutting frequency. Little difference in vigor was observed between treatments. This may have been due to lower-than-normal temperatures and higher-than-normal precipitation in July.

Differences in the yield of the first cutting of the residual year (1968) were small with nitrogen and cutting frequency effects not significant. The effect of cutting height was reversed from 1967, with the tall stubble significantly better in production in 1968.

The stubble weight samples, regrowth core weights, last-6-weeks yield of 1967, and 1967 total yield were used in a simple linear

correlation with the 1968 first-cutting forage yield. None of the factors correlated were significant.

The results indicate that intensive management is not extremely harmful to the capability of a first year orchardgrass stand to produce forage when cool and wet summer weather occurs. There was a lower yield from the orchardgrass fertilized with 672 kg/ha of nitrogen than with 448 kg/ha. Residual effects on the first cutting of the second year were small.

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CHAPTER I

INTRODUCTION

Management of pure grass stands for pasture and hay is becoming increasingly important in Tennessee because of unfavorable conditions for establishing and maintaining legumes and legume-grass mixtures. There have also been developments in recent years which allow grasses to be used on a more equal basis with legumes. Some of these developments are infestation of alfalfa by the alfalfa weevil, availability of better adapted grass varieties, lower nitrogen fertilizer prices, and the facts that the feeding value of grasses is higher when properly managed than previously thought, and that grasses require less involved management than legumes (14, 23). Some of the factors which have prevented certain grasses from replacing legumes have been a lack of persistence of stand and a failure to maintain yield at a high level when managed intensively.

Since orchardgrass (Dactylis glomerata L.) is, with tall fescue (Festuca arundinacea), one of the most important cool-season perennial grasses grown in Tennessee, it was thought that the effects of intensive management on yield and persistence should be studied. This project was undertaken to study the effect of high rates of nitrogen fertilization and different intensities of harvest management on the yield and regrowth potential of orchardgrass in the first harvest year and their effect on the yield of the following year.

CHAPTER II

LITERATURE REVIEW

Numerous investigations have shown increasing dry matter yield with increasing rates of nitrogen fertilization on orchardgrass (Dactylis glomerata L.). It has also been shown that orchardgrass will respond to higher rates of nitrogen fertilization than many other cool-season perennial grasses (8, 11, 12, 15, 19). However, it was reported by Schmidt and Tenpas (19) that slightly higher yields of dry matter were obtained with 500 lb/A of nitrogen fertilization than with 1,000 lb/A of nitrogen. This lack of response to applications of additional nitrogen was also found by Dotzenko (6) when he observed that orchardgrass responded little more to 320-lb and 640-lb nitrogen rates than to the 160-lb rate. Kresge and Younts (14) also observed that a 400-lb rate of nitrogen fertilization gave no greater response than a 200-lb rate. Even though suppression of yield has been reported for some high rates of nitrogen, it has been observed generally that orchardgrass reaches a higher yield level with application of nitrogen fertilizer than it does when the nitrogen is furnished by a legume (12, 19, 24, 25). Some of the other effects of nitrogen upon orchardgrass stands which have been found are: more tillering (1), lower carbohydrate reserves (18), larger aftermath yields (19, 23), and encroachment of weeds into thinned stands (6). It has been reported also that to obtain maximum yields from nitrogen fertilization intensive management must be practiced (4, 9, 10, 16, 17).

Drake (7) found a greater yield from a tall stubble than from a short stubble. Van Riper and Owen (20) reported a greater yield of forage with a 2-inch stubble than from a 5-inch stubble; however, it also has been reported that a short stubble leads to depletion of the stand (3). The first-year results of Griffith and Teel (10) agree with the above, since the 2-inch stubble produced a larger yield than the 4-inch stubble in their study, but the trend was reversed in the second year. They also found a loss of 57 percent of the stand under the 2-inch stubble treatment and that short stubble height and nitrogen were most closely associated with stand deterioration. Bryant and Blaser (3) have reported a significant decrease in stand under a 3/4-inch stubble compared to a 2 1/2-inch stubble. It has been found by Huokuna (13) that of three stubble heights, 3, 6, and 10 cm, the 3-cm stubble gave the greatest dry matter yield, and that a 4- to 6-cm stubble probably would be best for stand maintenance. Where low stubble has resulted in the highest-yielding treatment, generally there has been no time during the growing season when the supply of water was insufficient (2, 16).

Huokuna (13) maintains that the deleterious effect of a short stubble can be overcome by a less frequent cutting schedule. It has been reported by Colby (5) that short stubble and infrequent cutting led to the death of the center of the orchardgrass clumps when orchardgrass was subjected to high nitrogen treatments. Mitchell (16) states that more leaf sheaths, collars, and meristems were removed with the first cut at a 1-inch stubble than at a 3-inch stubble, so that regrowth

was slower from the 1-inch stubble. Ward and Blaser (22) have shown that the degree of defoliation affects the rate of regrowth in orchardgrass. They have shown that when two leaf blades were left on orchardgrass tillers, regrowth was faster than when complete removal of the leaf blades from the tillers took place. This would indicate that regrowth is a function of leaf area and carbohydrate reserves and that a tall stubble should favor fast recovery and regrowth. Wagner's (21) findings agree with those of Ward and Blaser; he stated that frequent cutting was less harmful to orchardgrass than a short stubble, because of the amount of defoliation under short stubble conditions.

Results are conflicting as to the residual effect that can be expected from previous year's treatments. Generally, cutting treatments have been found to have less influence on stand deterioration of orchardgrass than have nitrogen treatments. However, stand depletion has been most severe under intensive management where high rates of nitrogen had been applied.

CHAPTER III

EXPERIMENTAL PROCEDURE

Boone orchardgrass was seeded at the Plant Science Farm, Knoxville, Tennessee, with a cultipacker seeder on September 1, 1966. The soil was a Sequoyah silt loam with a pH of 6.2. The area seeded was divided into two sections. One section was used as a sampling area for regrowth cores and stubble weight, and the other section was harvested for yield. The same treatments were applied to each section of the experiment but each section was randomized independently of the other. Plot size was 1.7 x 7.3 meters in the sampling section and 1.8 x 7.3 meters in the yield section.

The experimental design was a split-plot factorial design with three replications of the whole plots. Whole plots within each replication were three nitrogen levels and the subplots were cutting management treatments. All four combinations of two cutting frequencies and two cutting heights were randomized within the whole plots.

The three nitrogen treatments were 224, 448, and 672 kg/ha of nitrogen, designated as N_1 , N_2 , and N_3 , respectively. These rates were applied in the form of ammonium nitrate in two equal parts. The nitrogen was applied on March 9 and June 20, 1967.

The two cutting frequencies were 8 cuttings (every 3 weeks) and 4 cuttings (every 6 weeks), designated by C_8 and C_4 , respectively. The cutting dates for the 3-week frequency were April 12, May 5, May 23,

June 12, July 3, July 25, August 14, and September 5. The dates of cutting for the 6-week frequency were May 5, June 12, July 25, and September 5. The cutting heights used in combination with the frequencies were 3.8 cm and 10.2 cm, designated as H_1 and H_2 , respectively. The treatment designations are listed in Table 1.

Forage yields were obtained by cutting a 1.06 x 7.92 m strip from the center of each plot. The forage was dried at 70° C and dry weight was used to calculate yield. The plots in the sampling section were harvested for each appropriate treatment and all forage was discarded with no yield data taken. Regrowth cores were taken from each of the sampling plots every three weeks following the harvest of the 8-cutting treatment. These cores were taken with a golf cup plugger and were 10.2 cm in diameter and 10.2 cm in depth. The cores were trimmed to the height specified in the treatment, then the cores were placed in tin cans for three weeks in a growth chamber which was maintained at 24-27° C and 16 hours daylength. They were then harvested by cutting the cores back to the specified height for each treatment with hand clippers. The regrowth harvested was dried at 70° C and the weight recorded.

The stubble weight samples were taken following the second, third, and fourth harvests of the 6-week cutting frequency in all plots of the sampling section of the experiment. A 0.14 m² quadrat was used for taking the sample in each plot. The plant material within the confines of the quadrat was dug and separated from the soil. The roots were removed and discarded. The samples were dried and the weight recorded

TABLE 1. Identification of treatments

Treatment name	Nitrogen levels kg/ha	Stubble height cm	Number of cuts
$N_1H_1C_8$	224	3.8	8
$N_1H_1C_4$	224	3.8	4
$N_1H_2C_8$	224	10.2	8
$N_1H_2C_4$	224	10.2	4
$N_2H_1C_8$	448	3.8	8
$N_2H_1C_4$	448	3.8	4
$N_2H_2C_8$	448	10.2	8
$N_2H_2C_4$	448	10.2	4
$N_3H_1C_8$	672	3.8	8
$N_3H_1C_4$	672	3.8	4
$N_3H_2C_8$	672	10.2	8
$N_3H_2C_4$	672	10.2	4

with no allowance made for a difference in height of stubble.

The treatments were imposed only during 1967. During 1968, nitrogen was applied at the rate of 22⁴ kg/ha on March 11 on all plots. All plots were cut at a uniform height of 7.0-cm on April 23, 1968. Yield data were taken from the yield section of the experiment and no samples were taken in the sampling section of the experiment. The same treatment was applied to all plots to determine the residual effect on yield of the previous year's treatments.

CHAPTER IV

RESULTS

I. WEATHER CONDITIONS

The climatological data taken during 1967 at the Plant Science Farm (Table 2) indicates that the season was characterized by higher-than-normal rainfall and lower-than-normal temperatures during the growing season. The weekly total precipitation was distributed evenly throughout the growing season, with only three periods from June 1 through September 1 when moisture might possibly have become limiting. These three periods were June 7 to June 20, July 12 to July 25, and August 2 to August 22. The first two periods were two weeks in length and the last one three weeks. The periods of low precipitation were apparently not long enough in duration to bring about a critical shortage of soil moisture. The average daily maximum temperature ranged slightly below normal in July and August. The month of July did not have a week in which the average daily maximum temperature reached the normal as compiled by the Weather Bureau on a monthly basis (26). This was also true of the average daily minimum temperature which was slightly lower than the normal. The month of August also had below-normal temperatures, but the differences were not as pronounced as in July.

Forage production for 1967 is shown in Table 3 for each harvest throughout the season. This distribution is unusual because of the

TABLE 2. Summary of average weekly minimum and maximum temperatures (°C) and weekly total precipitation (mm) for the period of March 1, 1967 to April 18, 1968*

Week of	Climatological week	Minimum temperatures	Maximum temperatures	Precipitation
March 1	1	0.6	15.0	84.8
March 8	2	3.9	19.4	19.6
March 15	3	1.1	15.6	10.2
March 22	4	3.3	21.6	0.0
March 29	5	6.1	25.0	9.4
April 5	6	9.4	26.1	7.9
April 12	7	8.9	26.7	0.0
April 19	8	6.1	22.8	20.8
April 26	9	6.7	20.0	24.6
May 3	10	6.7	19.4	55.1
May 10	11	8.3	23.9	74.7
May 17	12	10.0	21.7	11.4
May 24	13	12.2	28.3	10.9
May 31	14	13.9	23.9	56.9
June 7	15	15.0	28.9	3.1
June 14	16	16.7	31.7	1.8
June 21	17	17.2	30.0	49.0
June 28	18	17.8	27.8	32.3
July 5	19	15.6	26.1	123.7
July 12	20	15.0	26.7	4.3
July 19	21	16.7	29.4	7.4
July 26	22	18.3	28.3	98.6
August 2	23	17.8	30.0	1.8
August 9	24	15.0	27.8	1.8
August 16	25	18.3	29.4	8.1
August 23	26	17.2	26.7	64.5
August 30	27	12.8	25.6	2.3
Sept. 6	28	13.3	26.7	13.0
Sept. 13	29	12.2	26.7	0.0
Sept. 20	30	10.0	26.1	18.0
Sept. 27	31	6.7	23.9	50.0
Oct. 4	32	11.1	26.1	25.7
Oct. 11	33	6.1	22.8	0.0
Oct. 18	34	2.8	20.0	7.9
Oct. 25	35	0.0	18.3	31.2
Nov. 1	36	0.5	12.2	31.0
Nov. 8	37	-2.2	17.2	0.0
Nov. 15	38	-3.3	12.8	0.0

TABLE 2. (continued)

Week of	Climatological week	Minimum temperatures	Maximum temperatures	Precipitation
Nov. 22	39	0.5	13.3	49.0
Nov. 29	40	-3.8	8.9	46.5
Dec. 6	41	5.0	16.7	30.7
Dec. 13	42	0.0	12.8	52.3
Dec. 20	43	1.1	13.3	50.8
Dec. 27	44	-3.9	4.4	67.3
Jan. 3	45	-6.7	3.3	47.0
Jan. 10	46	-3.3	1.7	52.8
Jan. 17	47	-5.6	13.3	0.8
Jan. 24	48	-5.0	9.4	7.4
Jan. 31	49	-1.7	13.9	9.1
Feb. 7	50	-8.3	5.6	0.0
Feb. 14	51	-10.6	4.4	0.8
Feb. 21	52	-10.6	5.6	0.0
Feb. 28	53	-3.9	7.8	9.4
March 1	1	-6.1	9.4	1.3
March 8	2	0.0	17.2	59.2
March 15	3	0.6	18.8	18.3
March 22	4	0.6	17.8	24.9
March 29	5	7.8	21.6	44.2
April 5	6	6.7	18.8	32.3
April 12	7	5.0	22.2	22.1

*Data compiled by H. A. Fribourg, Agronomy Department, University of Tennessee, Knoxville, Tennessee.

TABLE 3. Dry matter yield (metric tons/ha) for individual harvests in 1967

Treat. name	Harvest date								Yearly total
	April 12	May 5	May 23	June 12	July 3	July 25	Aug. 14	Sept. 5	
$N_2H_1C_4$		4.54		2.75		1.99		1.21	10.49
$N_2H_1C_8$	1.97	1.60	0.88	1.39	0.81	1.60	0.87	0.65	9.77
$N_1H_1C_4$		3.40		2.33		3.05		0.98	9.68
$N_3H_1C_8$	1.51	1.72	0.90	1.62	0.65	1.41	0.97	0.74	9.52
$N_3H_1C_4$		3.41		2.81		1.66		1.43	9.31
$N_3H_2C_4$		2.31		3.23		1.97		1.71	9.22
$N_2H_2C_8$	0.97	0.89	1.28	1.44	0.78	2.06	0.98	0.69	9.09
$N_2H_2C_4$		2.00		2.50		2.46		1.81	8.78
$N_3H_2C_8$	0.94	0.81	1.42	1.58	0.59	1.54	1.04	0.73	8.65
$N_1H_2C_4$		2.44		2.22		2.39		1.13	8.18
$N_1H_1C_8$	1.92	1.52	0.70	0.86	0.99	1.24	0.51	0.38	8.12
$N_1H_2C_8$	1.08	1.41	0.68	0.86	0.86	1.39	0.59	0.34	7.21

great amount of forage produced in the latter part of the season. The reason for this may have been the higher-than-normal precipitation and the low temperatures that predominated in July. When comparing the first four dates with the second four dates in Table 3, it can be seen that there was a large amount produced in the second half as well as in the first half of this growing season.

II. FORAGE PRODUCTION

All three nitrogen levels were represented in the highest grouping in the 1967 total forage yield (Table 4). Production from short stubble was greater than from the tall stubble treatment, and the 4-cutting frequency was significantly better than the 8-cutting frequency. The N_2 treatment is shown in Table 5 to have been the highest-producing nitrogen level within each management level. The results of the managements within nitrogen levels are shown in Table 6. The H_1C_4 management treatment was the top forage-producing treatment at the N_1 and N_2 levels of fertilization; all managements were in the same group at N_3 . The short stubble treatment was the highest-producing stubble height for all nitrogen treatments. The tall stubble treatment was consistently the lowest-producing treatment.

The results of the 1968 first cutting yield for the residual effect of the previous year's treatments are presented in Table 7. No significance was found for the nitrogen effect in the 1968 first cutting, even though N_2 tended to be superior in 1967. There was very little difference among treatments. A significant effect of management

TABLE 6. Total forage dry matter yield (metric tons/ha) for 1967 with managements compared within nitrogen levels

Management levels	Nitrogen levels		
	N ₁	N ₂	N ₃
H ₁ C ₈	8.12 ^{a,b*}	9.74 ^{a,b}	9.52 ^a
H ₁ C ₄	9.68 ^a	10.49 ^a	9.31 ^a
H ₂ C ₈	7.21 ^b	9.09 ^{a,b}	8.65 ^a
H ₂ C ₄	8.18 ^{a,b}	8.77 ^b	9.22 ^a

*Values within each nitrogen level that are followed by the same letter are not significantly different at the .05 level of probability.

TABLE 7. Forage dry matter yield (metric tons/ha) for first cutting of 1968

Treatment name	Yield*
$N_3H_2C_8$	3.81 ^a
$N_1H_1C_4$	3.47 ^{a,b}
$N_1H_2C_4$	3.46 ^{a,b}
$N_3H_1C_8$	3.43 ^{a,b}
$N_2H_2C_4$	3.37 ^{a,b}
$N_1H_2C_8$	3.29 ^{a,b}
$N_2H_1C_4$	3.27 ^{a,b}
$N_3H_2C_4$	3.22 ^{a,b}
$N_2H_2C_8$	3.22 ^{a,b}
$N_3H_1C_4$	3.16 ^{a,b}
$N_2H_1C_8$	2.87 ^b
$N_1H_1C_8$	2.78 ^b

*Values followed by the same letter are not significantly different at the .05 level of probability.

levels was found. The tall stubble was significantly better than the short stubble. This was the reverse of the findings for 1967. No significant difference was found between cutting frequencies, while in 1967 there had been a significant difference between cutting frequencies. The results from the analysis of the management within nitrogen levels are presented in Table 8 and show that no treatment was consistently the highest-yielding management level.

III. REGROWTH POTENTIAL

The reason for using the core regrowth measurement as an indicator of regrowth potential is the impracticability of measuring regrowth by yield measurements in the field when frequency of cutting is one of the treatments imposed.

The regrowth sample yields for each harvest throughout the year are presented in Table 9. Significant effects were found in only the third, seventh, and eighth harvests. In two out of these three cases, only management was found to be significant. In the other case, only nitrogen was found to be significant.

In the third regrowth sample (Table 10) management effects were significant and nitrogen levels were not significant. Neither stubble height and neither cutting frequency had greater regrowth than the other.

In the seventh regrowth sample (Table 11), nitrogen effects were significant and management levels were not significant. The N_3 level generally produced the most regrowth and the N_1 generally produced the least regrowth.

TABLE 8. Forage dry matter yield (metric tons/ha) for first cutting 1968 with managements compared within nitrogen levels

Management levels	Nitrogen levels		
	N ₁	N ₂	N ₃
H ₁ C ₈	2.78 ^{b*}	2.87 ^b	3.43 ^b
H ₁ C ₄	3.47 ^a	3.27 ^a	3.16 ^b
H ₂ C ₈	3.29 ^a	3.22 ^{a,b}	3.81 ^a
H ₂ C ₄	3.46 ^a	3.37 ^a	3.22 ^b

*Values within each nitrogen level that are followed by the same letter are not significantly different at the .05 level of probability.

TABLE 9. Harvest number and dry matter yield (grams per core) of regrowth samples

Treatment name	Harvest number										
	1	2	3	4	5	6	7	8			
N ₁ H ₁ C ₈	.428	NS*	.621	NS	.372** ^{c,d}	.672	NS	.640	NS	.406 ^{b,c}	.191 ^{c,d}
N ₁ H ₁ C ₄	.679	.981	.413 ^{b,c,d}	.341	.654	.450	.396 ^c	.466 ^{a,b,c,d}	.103 ^d	.227 ^{b,c,d}	.388 ^{a,b,c,d}
N ₁ H ₂ C ₈	.521	1.023	.525 ^{a,b,c,d}	.540	.415	.382	.356 ^c	.577 ^{b,c}	.763 ^a	.206 ^{b,c,d}	.313 ^{b,c,d}
N ₁ H ₂ C ₄	.790	.982	.499 ^{b,c,d}	.692	.387	.679	.577 ^{b,c}	.680 ^{a,b,c}	.436 ^{a,b,c,d}	.642 ^{a,b}	.558 ^{a,b,c}
N ₂ H ₁ C ₈	.705	.924	.287 ^{c,d}	.650	.574	.582	.475 ^{b,c}	.705 ^{a,b,c}	.629 ^{a,b,c}	.589 ^{b,c}	.313 ^{b,c,d}
N ₂ H ₁ C ₄	.797	1.135	.480 ^{b,c,d}	.671	.808	.917	.705 ^{a,b,c}	.629 ^{a,b,c}	.436 ^{a,b,c,d}	.642 ^{a,b}	.558 ^{a,b,c}
N ₂ H ₂ C ₈	.669	.900	.519 ^{a,b,c,d}	.563	.484	.503	.629 ^{a,b,c}	.589 ^{b,c}	.436 ^{a,b,c,d}	.642 ^{a,b}	.558 ^{a,b,c}
N ₂ H ₂ C ₄	.972	1.404	.909 ^a	.892	.886	1.023	.589 ^{b,c}	.680 ^{a,b,c}	.436 ^{a,b,c,d}	.642 ^{a,b}	.558 ^{a,b,c}
N ₃ H ₁ C ₈	.456	1.031	.215 ^d	.605	.408	.737	.680 ^{a,b,c}	.884 ^{a,b}	.791 ^{a,b,c}	.422 ^{a,b,c,d}	.422 ^{a,b,c,d}
N ₃ H ₁ C ₄	.784	.829	.584 ^{a,b,c,d}	.699	.555	.395	.884 ^{a,b}	.791 ^{a,b,c}	.422 ^{a,b,c,d}	.422 ^{a,b,c,d}	.422 ^{a,b,c,d}
N ₃ H ₂ C ₈	.647	1.121	.663 ^{a,b,c}	.722	.734	.726	.791 ^{a,b,c}	.422 ^{a,b,c,d}	.422 ^{a,b,c,d}	.422 ^{a,b,c,d}	.422 ^{a,b,c,d}
N ₃ H ₂ C ₄	.596	1.160	.779 ^{a,b}	.861	.708	1.290	1.083 ^a	.422 ^{a,b,c,d}	.422 ^{a,b,c,d}	.422 ^{a,b,c,d}	.422 ^{a,b,c,d}

*In columns of values followed by NS, there are no significant differences within columns at the .05 level of probability.

**Values followed by the same letter within a column are not significantly different at the .05 level of probability.

TABLE 10. Dry matter yield (grams per core) for the third regrowth sample with managements compared within nitrogen levels

Management levels	Nitrogen levels		
	N ₁	N ₂	N ₃
H ₁ C ₈	.372 ^{a*}	.287 ^b	.215 ^b
H ₁ C ₄	.413 ^a	.480 ^b	.584 ^a
H ₂ C ₈	.525 ^a	.519 ^b	.663 ^a
H ₂ C ₄	.499 ^a	.909 ^a	.779 ^a

*Values that are followed by the same letter within each nitrogen level are not significantly different at the .05 level of probability.

TABLE 11. Dry matter yield (grams per core) for the seventh regrowth sample with nitrogen levels compared within management levels

Nitrogen levels	Management levels			
	H ₁ C ₈	H ₁ C ₄	H ₂ C ₈	H ₂ C ₄
N ₁	.406 ^{b*}	.396 ^b	.356 ^b	.577 ^b
N ₂	.475 ^b	.705 ^a	.629 ^a	.589 ^b
N ₃	.680 ^a	.884 ^a	.791 ^a	1.083 ^a

*Values that are followed by the same letter within each management level are not significantly different at the .05 level of probability.

Figure 1 shows one replication of the eighth regrowth sample as it appeared on September 27 after three weeks of regrowth in the growth chamber. Management effects were significant in the eighth regrowth sample results (Table 12). The 3.8-cm stubble height and the 4-cutting frequency produced the most regrowth.

The stubble weight measurement was used as an indicator of regrowth potential because of the impracticability of making percent stand cover estimates. The differences in cutting height made it exceedingly difficult to differentiate between different amounts of stand cover. Therefore, the stubble weight measurement gave a direct measurement of the amount of plant material within a given area.

The results of sampling the living stubble on June 5, 1967, are presented in Table 13. Management effects were significant and nitrogen levels were not significant. The results of the management effects within nitrogen levels are presented in Table 14. Neither stubble height and neither cutting frequency had a significantly greater stubble weight than the other.

The results of sampling the living stubble on July 25, 1967, are presented in Table 15. Management effects were significant and the nitrogen levels were not significant. The results of the management effects within nitrogen levels are presented in Table 16. The 10.2-cm stubble height and the 8-cutting frequency produced the most stubble weight.

The results of sampling the living stubble on September 5, 1967, are contained in Table 17 and the management levels were significant.



Figure 1. Regrowth cores from the 8th sample as they appeared on September 27, 1967, after 3 weeks in the growth chamber. From left to right: treatments $N_1H_1C_8$, $N_1H_2C_8$, $N_1H_1C_4$, $N_1H_2C_4$, $N_2H_2C_8$, $N_2H_2C_4$, $N_2H_1C_8$, $N_2H_1C_4$, $N_3H_1C_8$, $N_3H_1C_4$, $N_3H_2C_4$, $N_3H_2C_8$.

TABLE 12. Dry matter yield (grams per core) for the eighth regrowth sample with managements compared within nitrogen levels

Management levels	Nitrogen levels		
	N ₁	N ₂	N ₃
H ₁ C ₈	.191 ^{a,b*}	.388 ^b	.436 ^a
H ₁ C ₄	.466 ^a	.763 ^a	.642 ^a
H ₂ C ₈	.103 ^b	.206 ^b	.558 ^a
H ₂ C ₄	.227 ^{a,b}	.313 ^b	.422 ^a

*Values that are followed by the same letter within each nitrogen level are not significantly different at the .05 level of probability.

TABLE 13. Stubble weight (g/m^2) per treatment for June 5, 1967

Treatment name	Stubble weight*
$\text{N}_2\text{H}_2\text{C}_8$	299.52 ^a
$\text{N}_1\text{H}_2\text{C}_8$	287.32 ^a
$\text{N}_1\text{H}_2\text{C}_4$	280.43 ^{a,b}
$\text{N}_2\text{H}_2\text{C}_4$	275.84 ^{a,b,c}
$\text{N}_3\text{H}_2\text{C}_8$	271.32 ^{a,b,c}
$\text{N}_3\text{H}_2\text{C}_4$	182.27 ^{b,c}
$\text{N}_2\text{H}_1\text{C}_8$	181.41 ^{b,c}
$\text{N}_1\text{H}_1\text{C}_4$	171.79 ^c
$\text{N}_2\text{H}_1\text{C}_4$	171.43 ^c
$\text{N}_3\text{H}_1\text{C}_8$	165.62 ^c
$\text{N}_1\text{H}_1\text{C}_8$	164.11 ^c
$\text{N}_3\text{H}_1\text{C}_4$	159.16 ^c

*Values followed by the same letter are not significantly different at the .05 level of probability.

TABLE 14. Stubble weight (g/m^2) for managements within nitrogen levels for June 5, 1967

Management levels	Nitrogen levels		
	N ₁	N ₂	N ₃
H ₁ C ₈	164.11 ^{b*}	181.41 ^b	165.62 ^b
H ₁ C ₄	171.79 ^b	171.43 ^b	159.16 ^b
H ₂ C ₈	287.32 ^a	299.52 ^a	271.32 ^a
H ₂ C ₄	280.43 ^a	275.84 ^a	182.27 ^{a,b}

*Values that are followed by the same letter within each nitrogen level are not significantly different at the .05 level of probability.

TABLE 15. Stubble weight (g/m^2) per treatment for July 25, 1967

Treatment name	Stubble weight*
$\text{N}_1\text{H}_2\text{C}_4$	228.34 ^a
$\text{N}_1\text{H}_2\text{C}_8$	208.32 ^{a,b,c}
$\text{N}_2\text{H}_2\text{C}_8$	196.05 ^{a,b,c}
$\text{N}_3\text{H}_2\text{C}_4$	188.15 ^{a,b,c}
$\text{N}_3\text{H}_2\text{C}_8$	181.69 ^{a,b,c,d}
$\text{N}_2\text{H}_2\text{C}_4$	131.18 ^{b,c,d}
$\text{N}_1\text{H}_1\text{C}_8$	119.77 ^{c,d}
$\text{N}_1\text{H}_1\text{C}_4$	92.64 ^{c,d}
$\text{N}_2\text{H}_1\text{C}_8$	85.75 ^{c,d}
$\text{N}_3\text{H}_1\text{C}_8$	77.43 ^d
$\text{N}_2\text{H}_1\text{C}_4$	56.90 ^d
$\text{N}_3\text{H}_1\text{C}_4$	49.94 ^d

*Values followed by the same letter are not significantly different at the .05 level of probability.

TABLE 16. Stubble weight (g/m^2) for managements within nitrogen levels for July 25, 1967

Management levels	Nitrogen levels		
	N ₁	N ₂	N ₃
H ₁ C ₈	119.77 ^{b*}	85.75 ^c	77.43 ^b
H ₁ C ₄	92.64 ^b	56.90 ^c	49.94 ^b
H ₂ C ₈	208.32 ^a	196.05 ^a	181.69 ^a
H ₂ C ₄	288.34 ^a	131.18 ^b	188.15 ^a

*Values that are followed by the same letter within each nitrogen level are not significantly different at the .05 level of probability.

TABLE 17. Stubble weight (g/m^2) per treatment for September 5, 1967

Treatment name	Stubble weight*
$\text{N}_3\text{H}_2\text{C}_4$	267.95 ^a
$\text{N}_2\text{H}_2\text{C}_8$	259.34 ^a
$\text{N}_1\text{H}_2\text{C}_4$	237.95 ^a
$\text{N}_3\text{H}_2\text{C}_8$	233.65 ^a
$\text{N}_1\text{H}_2\text{C}_8$	214.99 ^{a,b}
$\text{N}_2\text{H}_2\text{C}_4$	193.82 ^{a,b,c}
$\text{N}_3\text{H}_1\text{C}_4$	150.77 ^{a,b,c}
$\text{N}_2\text{H}_1\text{C}_4$	111.94 ^{b,c}
$\text{N}_3\text{H}_1\text{C}_8$	108.43 ^{b,c}
$\text{N}_1\text{H}_1\text{C}_4$	106.28 ^{b,c}
$\text{N}_2\text{H}_1\text{C}_8$	84.39 ^c
$\text{N}_1\text{H}_1\text{C}_8$	74.20 ^c

*Values followed by the same letter are not significantly different at the .05 level of probability.

The results for the management within nitrogen levels are presented in Table 18. The 10.2-cm stubble height had a greater stubble weight than the 3.8 stubble height. There was no difference in the effect of the two frequencies upon stubble weight.

IV. PREDICTION OF PRODUCTION IN THE SECOND YEAR

Previous research in forages has shown the association of certain factors with yields in a subsequent year. Some of the factors which have been associated with yield potential are percent ground cover, etiolated regrowth, regrowth following defoliation, and segments of or the total of a previous year's yield (23). Therefore, simple correlation coefficients were computed, comparing several factors measured in 1967 with the 1968 first-cutting forage yield. The factors used for correlation were the core regrowth samples, stubble weights, forage yields in the last 6 weeks of the 1967 crop year, and total forage yields from 1967. These factors were selected because they were similar to factors associated with yield potential in previous work.

The correlation coefficients for these analyses are presented in Table 19. None of the factors correlated with the 1968 first-cutting forage yield were significant. The September 5 stubble weight sample and the third regrowth sample had the highest correlation coefficients, .48 and .47, respectively. None of the measurements taken in 1967 were suitable for predicting the 1968 yield ranking.

TABLE 18. Stubble weight (g/m^2) for managements within nitrogen levels for September 5, 1967

Management levels	Nitrogen levels		
	N ₁	N ₂	N ₃
H ₁ C ₈	74.20 ^{b*}	84.39 ^c	108.43 ^b
H ₁ C ₄	106.28 ^b	111.94 ^c	150.77 ^b
H ₂ C ₈	214.99 ^a	259.34 ^a	233.65 ^a
H ₂ C ₄	237.95 ^a	193.82 ^b	267.95 ^a

*Values that are followed by the same letter within each nitrogen level are not significantly different at the .05 level of probability.

TABLE 19. Correlation of indicators of regrowth potential with yield of first harvest in 1968

Indicator	Correlation coefficient
Yield during last 6 weeks of 1967 growing season	.29 NS
Yield during 1967 growing season	-.03 NS
June 5, 1967 stubble weight	.43 NS
July 25, 1967 stubble weight	.30 NS
September 5, 1967 stubble weight	.48 NS
Regrowth first sample	.05 NS
Regrowth second sample	.05 NS
Regrowth third sample	.47 NS
Regrowth fourth sample	-.12 NS
Regrowth fifth sample	.07 NS
Regrowth sixth sample	.04 NS
Regrowth seventh sample	.23 NS
Regrowth eighth sample	.12 NS

CHAPTER V

DISCUSSION

Increasing the rate of nitrogen fertilization did not bring about an increasing yield response for each additional application of nitrogen. The N_2 rate produced the highest yield, not the N_3 rate. These results are in agreement with those of Schmidt and Tenpas (19) who found nitrogen response to decrease at certain high rates. A greater yield was obtained with short stubble than with tall stubble. This response agrees with the findings of others (10, 20). The 4-cutting frequency was significantly better than the 8-cutting frequency in production of forage. The best treatment combination for 1967 yield was the 3.8 cm stubble height, 4-cutting frequency, and the 448 kg/ha nitrogen rate. This might be expected since these levels of factors were those found favorable by other research workers. However, no significant interaction of nitrogen x management was found in either 1967 or 1968 yields.

No drastic changes in production potential of the stands occurred throughout the season. This may have been caused by excessive precipitation and cool temperatures. It can be seen in Figure 2, taken on July 3, 1967, that differences in stand appeared to be developing midway in the growing season. Figure 3, taken on September 5, 1967, shows that the difference in the vigor of the two treatments is less by the end of the season. Figure 4, taken on April 16, 1968, shows

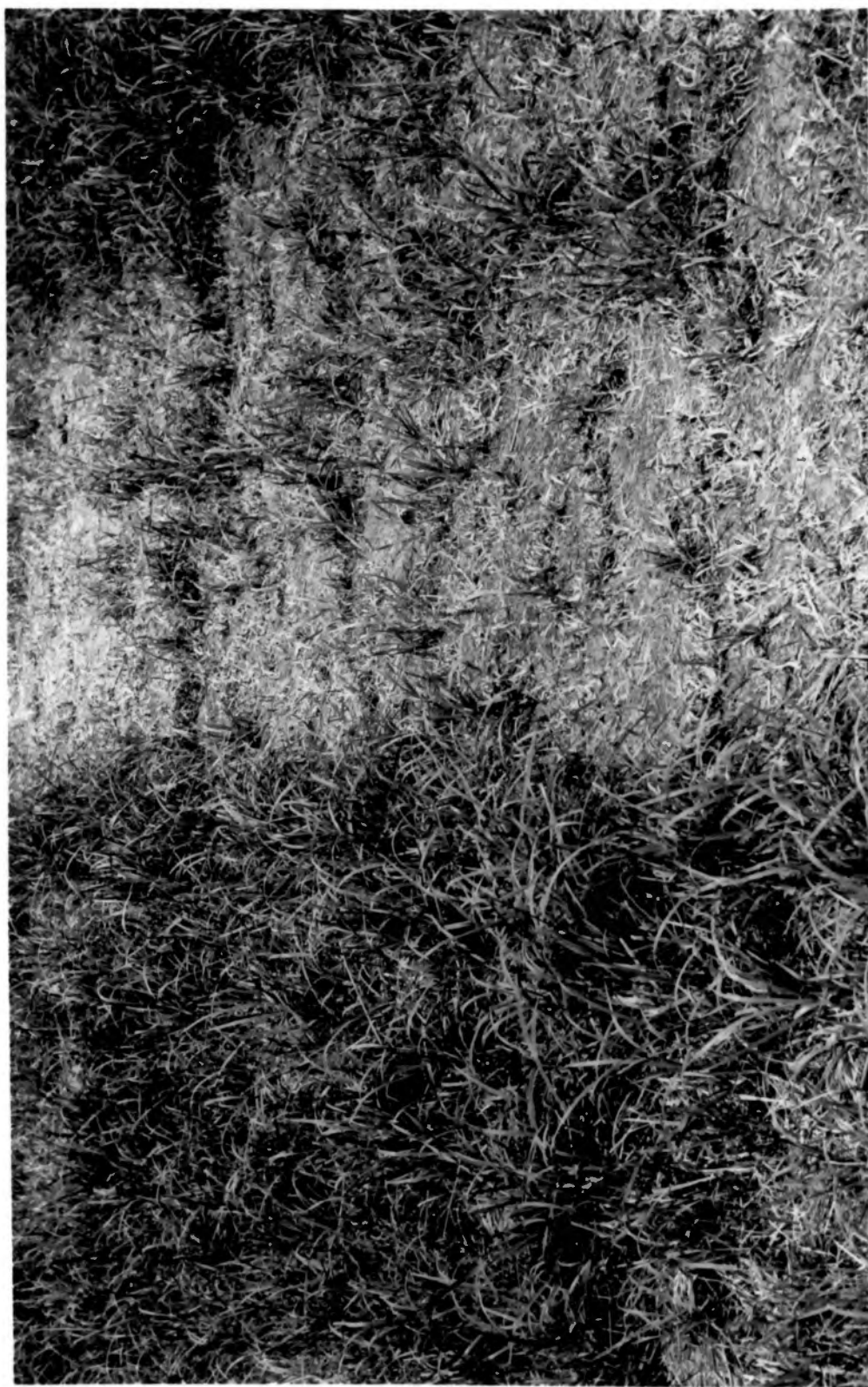


Figure 2. Orchardgrass stand as it appeared in the $\text{N}_3\text{H}_2\text{Cl}_4$ treatment (left) and the $\text{N}_3\text{H}_1\text{Cl}_4$ treatment (right) on July 3, 1967, showing apparent stand injury in the $\text{N}_3\text{H}_1\text{Cl}_4$ treatment.

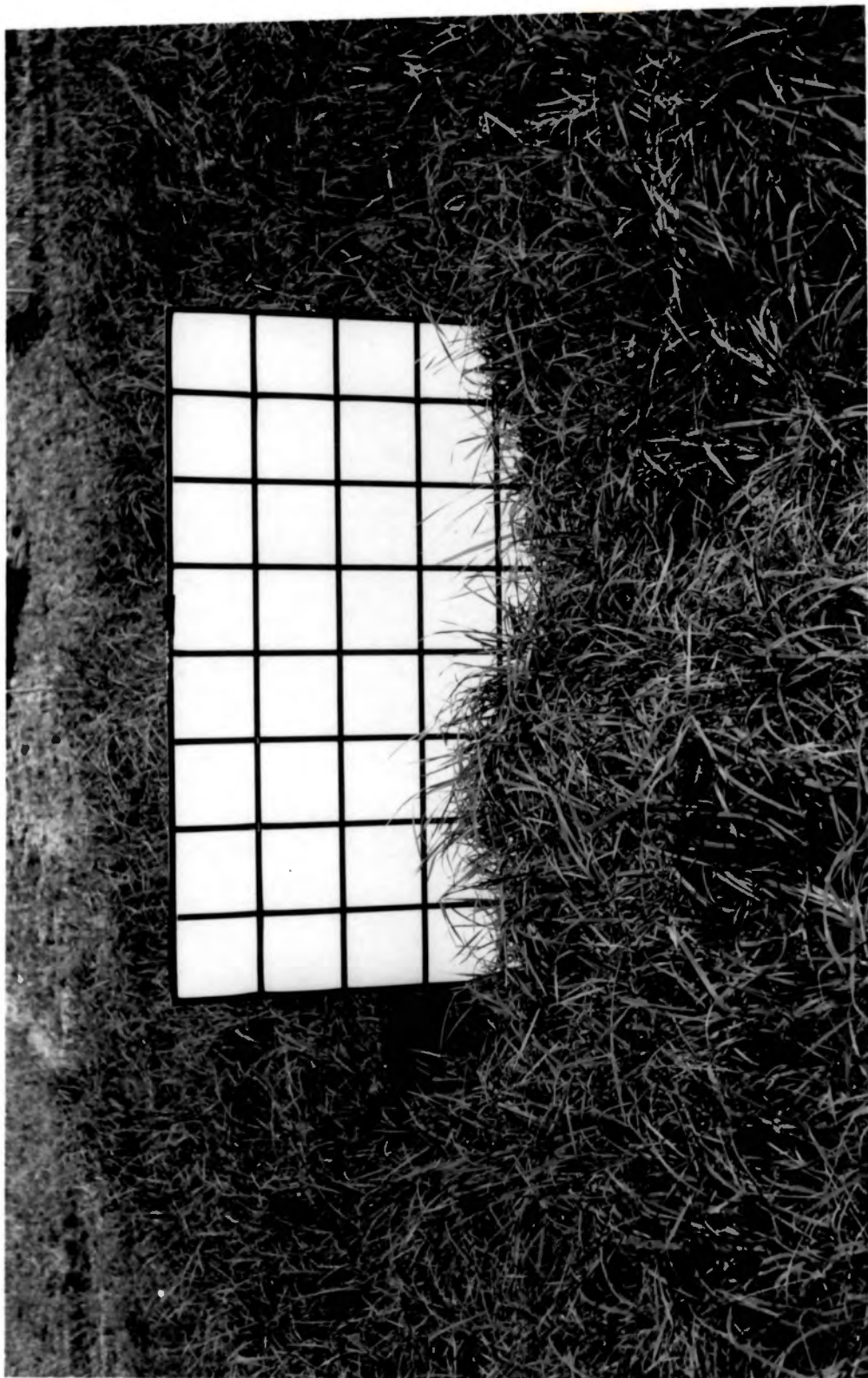


Figure 3. Orchardgrass stand as it appeared in the $N_3H_2Cl_4$ treatment (left) and the $N_3H_1Cl_4$ treatment (right) on September 6, 1967, showing good stand recovery.



Figure 4. Orchardgrass stand as it appeared in the $N_3H_2Cl_4$ treatment (left) and the $N_3H_1Cl_4$ treatment (right) on April 16, 1968, showing apparently equal vigor in the two treatments.

the recovery of the treatments by the next spring. At that time there was no apparent difference in vigor of the stands.

The 1968 first-cutting forage yield was not affected by the nitrogen rates applied the previous year. The residual effect of the stubble height was the reverse of the effect in the previous year. The tall stubble treatment became the most productive in the second year although the short stubble treatment was the most productive in the first year. Griffith and Teel (10) also found the same reversal in stubble heights for the first and second years of an orchardgrass stand. The residual effect of cutting frequency was not significant in 1968 as compared with 1967, when the 4-cutting frequency was found to be significantly better than the 8-cutting frequency.

The regrowth samples and stubble weight samples were taken for the purpose of evaluating regrowth potential and finding one or more predictors of the yield of the next year. The measurement of the core regrowth in the light is an alteration of a method used by Ward and Blaser (22) in studying potential regrowth under partial defoliation. There were no definite trends in the regrowth samples and stubble weight samples.

Throughout the sampling period, the tall stubble height treatment tended to be higher in stubble weight than the other treatments, whereas the infrequent cut predominated in the core regrowth samples. All of the measurements showed a nonsignificant correlation with the 1968 first-cutting forage yield. It would appear from these results

that either other factors should be sampled to find those factors that can be used to predict the yield of the next year, or that not enough change occurred in the first year to become evident in the measurements in this study.

CHAPTER VI

SUMMARY

The relationship of various nitrogen levels, stubble heights, and cutting frequencies to the dry matter production of orchardgrass (Dactylis glomerata L.) was studied at Knoxville, Tennessee. There were twelve combinations of these factors used in the experiment.

The orchardgrass was harvested either four or eight times at 3.8 or 10.2 cm stubble heights, and with nitrogen fertilization of 224, 448, and 672 kg/ha applied in two equal parts. Regrowth sample cores were taken at three-week intervals, and stubble weights were sampled on June 5, July 25, and September 5.

There was a significant difference in yield during 1967 with a range of 7.21 to 10.49 metric tons per hectare. The highest-producing treatment was 448 kg/ha of nitrogen, 3.8 cm stubble height, and 4-cutting frequency; the lowest-producing treatment was 224 kg/ha, 10.2 cm stubble height, and 8-cutting frequency in 1967. The vigor of the stand did not appear to be greatly different under any of the treatments used. This probably was due to the lower-than-normal temperatures and higher-than-normal precipitation during the month of July.

The differences between treatments in the residual year (1968) were very small. The effect of cutting height was reversed from 1967, with the tall stubble significantly better in production in 1968.

The effects of nitrogen and cutting frequency were significant in 1967 but not in 1968.

The stubble weight samples, regrowth core weights, last-6-weeks yield of 1967, and 1967 total yield were used in a simple linear correlation with the 1968 first-cutting forage yield. None of the correlation coefficients were significant. The highest correlation coefficients were found with the September 5 stubble weight and the third regrowth sample. It appears that to find the best predictor of the forage yield of the next year, other factors may have to be sampled. In a more normal year, the correlations might have been more meaningful and possibly would have been significant, but the abnormal weather conditions during 1967 may not have caused measurable changes to occur in the stands.

The results indicate that intensive management is not extremely harmful to the capability of a first-year orchardgrass stand to produce forage when cool and wet summer weather occurs. There was a lower yield from the orchardgrass fertilized with 672 kg/ha of nitrogen than with 448 kg/ha. Residual effects on the first cutting of the second year were small.

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APPENDIX

TABLE 20. Analyses of variance for 1967 forage yield, 1968 first-cutting forage yield, regrowth-sample yields for 8 sampling dates, and stubble weights for 3 sampling dates

Source of variation	Degrees of freedom	Mean squares	F-ratios
<u>1967 Total forage yield</u>			
Nitrogen	2	.9565	10.35*
Management	3	.7418	10.65**
N x M	6	.1552	2.23
<u>1968 First cutting yield</u>			
Nitrogen	2	.0320	.79
Management	3	.0567	6.30**
N x M	6	.0099	1.10
<u>First regrowth</u>			
Nitrogen	2	.0799	.37
Management	3	.1710	.92
N x M	6	.0845	.45
<u>Second regrowth</u>			
Nitrogen	2	.1752	.32
Management	3	.1802	1.46
N x M	6	.0815	.66
<u>Third regrowth</u>			
Nitrogen	2	.0421	1.02
Management	3	.2973	6.74**
N x M	6	.0502	1.14
<u>Fourth regrowth</u>			
Nitrogen	2	.1327	.89
Management	3	.0870	1.33
N x M	6	.0282	.43
<u>Fifth regrowth</u>			
Nitrogen	2	.0375	.45
Management	3	.0992	1.27
N x M	6	.1091	1.40

TABLE 20. (continued)

Source of variation	Degrees of freedom	Mean squares	F-ratios
<u>Sixth regrowth</u>			
Nitrogen	2	.2107	1.09
Management	3	.3103	4.14
N x M	6	.1767	2.36
<u>Seventh regrowth</u>			
Nitrogen	2	.5523	73.6**
Management	3	.0866	1.21
N x M	6	.0288	.40
<u>Eighth regrowth</u>			
Nitrogen	2	.2208	1.62
Management	3	.2167	7.20**
N x M	6	.0320	1.06
<u>June 5 stubble weight</u>			
Nitrogen	2	95.97	1.94
Management	3	624.87	10.75**
N x M	6	18.97	.33
<u>July 25 stubble weight</u>			
Nitrogen	2	137.78	1.75
Management	3	711.89	52.77**
N x M	6	21.38	1.58
<u>September 5 stubble weight</u>			
Nitrogen	2	70.09	2.15
Management	3	997.68	37.72*
N x M	6	30.65	1.15

*Significant at .05 level of probability.

**Significant at .01 level of probability.

VITA

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