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Yield and N Accumulation of Meadow Forage Fertilized at Advancing Maturity with N[1]

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ABSTRACT

These experiments were conducted to compare the efficiency of utilization of N applied early in the spring with that applied at increasingly later stages of herbage maturation and to determine if the N concentration of mature herbage could be increased by delayed applications of N fertilizer. Herbage growth and N accumulation were measured at regular intervals from meadows unfertilized and fertilized with N at increasingly later stages of herbage maturation. Nitrogen increased herbage production, but yields declined as the date of application was delayed. Yields from plots fertilized in June or July were lower by about 10 and 23%, respectively, than yields from plots fertilized in mid-May. Nitrogen was rapidly accumulated in herbage soon after application, but the maximum accumulated concentrations decreased from more than 3 to less than 2% as the date of fertilization was delayed from May until July.

Additional index words: **Forage maturation, Delayed fertilization.**

COOPER (1956) reported that fall and spring applications of N fertilizer were equally effective in increasing yields of meadow hay. Spring application referred to the 2- to 4-week period between snow melt and the flood-irrigating season, which begins in early April and precedes the beginning of active herbage growth by 3 to 4 weeks (Rumburg, Wallace, and Raleigh, 1964). In the past, fertilization of meadows after the beginning of irrigation has been nearly impossible. However, this difficulty has been largely eliminated with the advent of applicators mounted on flotation tires.

Meadow hay cut prior to or soon after maximum dry matter production (mid-July in Oregon) supplies the N required for wintering pregnant cows and heifers. But meadow hay alone will not provide sufficient N for growing calves. Protein supplements are necessary to achieve recommended gains of .60 to .72 kg/day on calves during the winter. Nitrogen fertilizer, at rates up to 269 kg/ha, will not increase the N concentration of hay harvested after late June (Rumburg et al., 1964). An exception to this statement is that anhydrous ammonia applied in spring usually increases N concentration in hay but is expensive to apply (Rumburg, 1969).

The objectives of the following experiments were: (i) to compare the efficiency of utilization of N applied early in the spring with that applied at increasingly later stages of herbage maturation; (ii) to determine how late in the season N fertilizer could be applied and still produce an economical yield response; and (iii) to determine if the N concentration of mature herbage could be increased by delayed applications of N fertilizer.

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METHODS AND MATERIALS

Rush (*Juncus* spp.) and sedge (*Carex* spp.) comprised 70 to 80% of the vegetation on the experimental meadows, with grasses comprising most of the remaining 20 to 30%. Dominant species on the experimental meadows were 70 to 80% rushes and sedges and 20 to 30% grasses: meadow barley (*Hordeum brachyanterum* Nevski.), beardless wild-rye (*Elymus triticoides* Buck.), and Nevada bluegrass (*Poa nevadensis* Vasey ex Schribn.).

Phenological development at any calendar date depends upon the species under consideration. Rushes and sedges mature ahead of the grasses, most of which bloom in late June.

Meadows were flood-irrigated for 6 to 12 weeks in the spring, depending on water supply. All fertilizer was broadcast directly onto the water when the application date occurred after flooding.

Yields were sampled by harvesting a strip of forage through the center of each plot with a sickle bar mower. Herbage was weighed fresh and a subsample removed for dry weight. Drying was accomplished in a forced air oven at 70 C. Dried samples were ground, stored in glass jars, and analyzed by standard Kjeldahl procedures to determine N concentration. The three experiments were conducted in three separate locations in 2 different years.

Experiment 1. One hundred and twelve kg of N/ha, applied as $(NH_4)_2SO_4$ were broadcast on 1.8- by 30.5-m plots on May 22, June 5, June 19, or July 3. Each date of application was randomly assigned to one of the four plots, but dates were not replicated. Five samples 30.5 cm^2 were clipped by hand from within each plot at each date of sampling. Dates of sampling were immediately before and after fertilization (which was always on Wednesday); the following Friday; and then each Monday, Wednesday, and Friday for 3 weeks; Monday and Wednesday for 2 weeks; and then each Monday until termination. Sampling terminated on August 19 on plots fertilized June 19 or July 3.

Experiment 2. Nitrogen (112 kg/ha) was applied broadcast as NH_4NO_3 on May 19, June 16, or July 14 to 1.2- by 4.6-m plots. Yields were sampled at weekly intervals from May 19 until September 1. The experimental design was a two-way whole plot variation of the split plot design employing four replications.

Experiment 3. Nitrogen (224 kg/ha) was applied broadcast as NH_4NO_3 on May 21, June 11, or July 2 to 0.91- by 9.1-m plots. Yields were sampled at weekly intervals from May 21 to July 23 and then every other week until September 2. The experimental design combined three dates of N application with 13 dates of harvest in factorial combination in a randomized block design with four replications.

RESULTS AND DISCUSSION

In the first experiment the application of N to meadows resulted in an increase of 0.22% N (averaged for all application dates) in herbage when sampled immediately after application. This increase was probably due to ammonium sulfate adhering to the herbage. The accumulation of N in herbage was detected 2 days after fertilization, and reached maximum concentration in herbage about 1 week later (Fig. 1). A maximum concentration of 3.2% N occurred in herbage fertilized May 22, compared to a maximum concentration of only 2% when fertilized on July 3. There was always the same pattern of rapid absorption soon after fertilization at all application dates (Fig. 1).

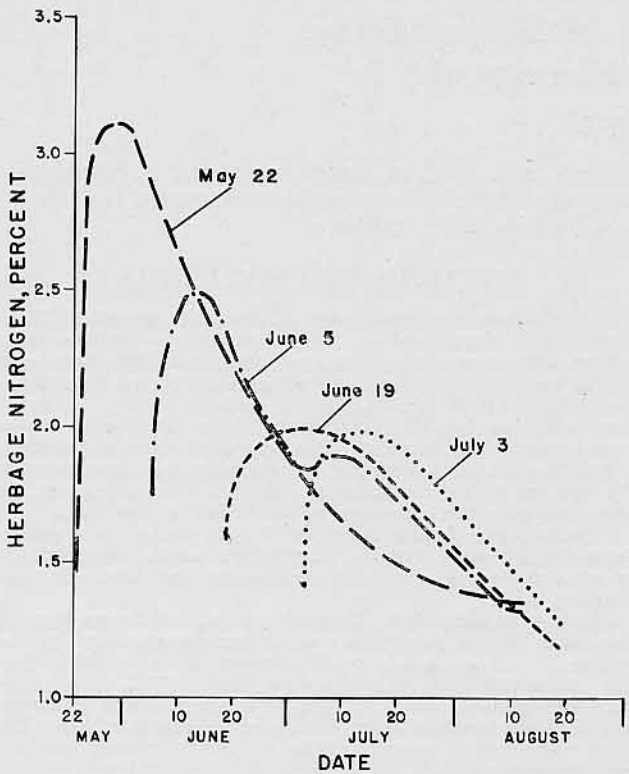

Fig. 1. Nitrogen concentration in herbage prior to and after fertilization with 112 kg N/ha on May 22, June 5, and June 19, or July 3.

In the second experiment none and 112 kg N/ha applied May 19, June 16, and July 14 produced yields of 2,750, 3,500, 3,300, and 2,880 kg/ha, respectively, when averaged for all dates of harvest (Table 1). Variation introduced by fertilizer dates was significant at $P \leqslant 0.01$; however, the difference (130 kg/ha) between none and 112 kg N/ha on July 14 was significant at $P \leqslant 0.85$. The date of harvest by date of fertilization interaction was not significant.

Yield of N – at the point of maximum N yield – from unfertilized plots was 44 kg/ha. Plots fertilized on May 19, June 16, or July 14 yielded 61, 63, and 53 kg N/ha, respectively. Nitrogen recovery from the fertilized treatments was 11, 15, and 12%, respectively, of the 112 kg applied.

In the third experiment plots fertilized with 224 kg/ha on May 21, June 11, and July 12 yielded 5,190, 4,440 and 3,740 kg/ha, respectively, when averaged for all harvest dates (Table 2). Yields from plots fertilized June 11 or July 2 were 86 and 72% respectively, of yields from plots fertilized May 21. Date of harvest, date of fertilization, and the interaction were all significant at $P \leqslant 0.01$.

Yield of N, at the point of maximum N yield, from plots fertilized on May 21, June 11 and July 2 was 112, 122, and 138 kg/ha, respectively.

Dry matter yields were increased by applying N fertilizer to meadows even when the fertilizer was applied near herbage maturity; however, loss of efficiency accompanied each delay in fertilizer application. Delaying fertilization up to mid-June could be recommended in years with abundant irrigation water. In one experiment delaying fertilization from May 19 until June 16 resulted in a reduction in dry matter yields of only 6%. In the other experiment delaying fertilization from May 21 until June 11 resulted in

Table 1. Dry matter yields in kg/ha from meadows throughout the growing season when fertilized with 112 kg N/ha at increasingly later stages of herbage maturation.

	Date of N fertilization			
Date of harvest	None	May 19	June 16	July 14
May 19	920	850	850	950
May 26	1520	1460	1470	1400
June 2	2100	2020	2130	1830
June 9	2260	2500	2380	2220
June 16	2700	3400	3070	2970
June 23	2970	3770	3140	2950
June 30	2990	3800	3400	3120
July 7	2880	4110	3900	3280
July 14	2750	3900	3570	3170
July 21	3330	4230	4120	3310
July 28	3450	4320	4120	3310
Aug. 4	3410	4470	4380	3790
Aug. 11	3410	4590	4470	3550
Aug. 18	3390	4520	4180	3600
Sept. 1	3230	4520	4360	3830
Mean	2750	3500	3300	2880

$S_{\bar{x}}$ for date of N fertilization within a harvest date = 303; n = 4.
$S_{\bar{x}}$ for date of harvest within a date of N fertilization = 131; n = 4.

Table 2. Dry matter yields in kg/ha from meadows throughout the growing season when fertilized with 225 kg N/ha at increasingly later stages of maturation.

	Date of fertilization		
Date of harvest	May 21	June 11	July 2
May 21	650	570	620
May 28	960	930	980
June 4	2020	1120	1220
June 11	3320	2070	1850
June 18	4670	3280	2870
June 25	5190	3910	3480
July 2	5780	4960	3860
July 9	7550	6720	4160
July 16	7850	6500	4810
July 23	7990	7014	6430
Aug. 6	7970	6840	6430
Aug. 20	7520	7120	5950
Sept. 3	5950	6760	5980
Mean	5190	4440	3740

$S_{\bar{x}}$ for individual observation = 343; n = 4.

Table 3. Percent of N in herbage throughout the growing season when fertilized with 112 kg N/ha at increasingly later stages of herbage maturation.

	Date of fertilization			
Date of harvest	None	May 19	June 16	July 14
May 19	2.06	2.08	2.11	2.07
May 26	1.96	2.24	1.97	1.94
June 2	1.78	2.22	1.82	1.86
June 9	1.66	1.89	1.64	1.65
June 16	1.60	1.66	1.64	1.64
June 23	1.49	1.59	1.76	1.46
June 30	1.37	1.42	1.58	1.48
July 7	1.40	1.49	1.62	1.42
July 14	1.40	1.38	1.52	1.43
July 21	1.29	1.32	1.50	1.47
July 28	1.25	1.25	1.42	1.50
Aug. 4	1.23	1.22	1.34	1.41
Aug. 11	1.24	1.20	1.35	1.41
Aug. 18	1.23	1.15	1.28	1.36
Sept. 1	1.08	1.06	1.16	1.23

$S_{\bar{x}}$ for individual observations = .05; n = 4.

Table 4. Percent N in herbage throughout the growing season when fertilized with 224 kg N/ha at increasingly later stages of maturation.

	Date of fertilization		
Date of harvest	May 21	June 11	July 2
May 21	2.04	2.15	2.13
May 28	2.59	1.98	1.92
June 4	2.76	2.02	1.73
June 11	2.17	1.91	2.48
June 18	2.00	2.30	1.67
June 25	1.67	2.41	1.64
July 2	1.50	1.95	1.38
July 9	1.50	1.82	2.26
July 16	1.37	1.75	2.10
July 23	1.41	1.60	2.15
Aug. 6	1.15	1.34	1.68
Aug. 20	1.22	1.16	1.66
Sept. 3	1.03	1.17	1.39

$S_{\bar{x}}$ for individual observations = .09; n = 3.

a reduction of dry matter yields of 14%. However, the forage from plots fertilized in June averaged from 0.2 to 0.3% higher in N concentration than forage from plots fertilized in May (Tables 3 and 4).

Nitrogen concentration in herbage initially increased in response to applied N. In general, the N concentration at or near terminal harvest was inversely related to dry matter yields. Herbage from plots fertilized in July was an exception (Tables 1 and 3) because these plots yielded slightly more herbage with higher N concentrations than unfertilized plots. The recovery of fertilizer in N applied to meadows averages about 20% (Rumburg, 1969). With such low recovery of N, economical increase in dry matter production must accompany increases in N concentration. Otherwise, the producer could buy protein or non-protein-nitrogen supplements and feed the supplements directly to livestock, which would be the same as increasing recovery to 100%.

Herbage showed maximum response in N concentration 1 to 2 weeks after N fertilization. However, changes in rate of herbage dry matter production were not evident until 3 to 4 weeks after fertilization. A delay of 3 to 4 weeks suggests that N stimulated production of new shoots from basal buds.

CONCLUSIONS

Environmental conditions in meadows were favorable for rapid dissolution of N salts and growth of rushes, sedges, and grasses. Nitrogen applied as ammonium sulfate or ammonium nitrate was rapidly accumulated in herbage, even when applied near herbage maturation. Herbage N reached peak concentrations 1 to 2 weeks after fertilization and then declined. Concentrations of N accumulated in herbage decreased from 2 to 3% when fertilized early in the season to 1 to 2% when fertilized near herbage maturity.

The highest herbage production was attained by fertilization in May, but delaying fertilization until early or mid-June resulted in only slight yield reductions. Nitrogen concentration in herbage initially increased in response to applied N. Dry matter production continually diluted internal N concentrations. The final N concentration was inversely related to dry matter yields except that of herbage from plots fertilized in June and July. These yielded more herbage of higher N concentration than unfertilized plots.

LITERATURE CITED

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