Special Report 1043
September 2002

Nitrogen, Phosphorus, and Potassium Uptake in Perennial Grasses Fertilized with Dairy Manure

OREGON STATE UNIVERSITY
EXTENSION SERVICE

For additional copies of this publication, write:

Troy Downing
Oregon State University Extension Service
Tillamook County office
2204 Fourth St.
Tillamook, OR 97141-2491

Nitrogen, Phosphorus, and Potassium Uptake in Perennial Grasses Fertilized with Dairy Manure

T. Downing

Forage grass production is a major part of profitable dairying in western Oregon. Grazing forage grasses with both milk cows and heifers is a well-established practice. In recent years, intensive mechanical harvests of grasses for both hay and silage have occurred. This increase in intensity of crop management, combined with new developments in waste management practices, has led to many questions about nutrient uptake in these intensive systems, including the best varieties of grasses to plant.

For years, it was thought that forage grasses utilize only about 200 lb of nitrogen (N) per acre annually (up to 300 lb for the highest nitrogen-consuming grasses such as orchardgrasses). One 1995 trial in the Willamette Valley, Oregon, showed that some grass varieties treated with 300 lb N/acre removed more than 400 lb N/acre in plant growth in a season. With a treatment equivalent to 450 lb N/acre, plant removal rates were nearly 500 lb N/acre (Gamroth and Moore, 1996). This 1-year study showed high removal rates of nitrogen; however, it did not address phosphorus or potassium utilization throughout the growing season. No data have been reported along the Oregon coast.

Materials and methods

In the fall of 1999, 11 ryegrasses, 4 orchardgrasses, 5 fescues, 1 festuolium, and 1 prairie grass variety were planted in randomized field plots. Each grass variety was planted in three 4' x 25' plots, for a total of 66 plots. Seed from five companies was included in the trial.

The first fall, soil testing was used to establish fertilizer and lime requirements. During establishment, plots were fertilized only with commercial fertilizer to avoid damage from manure application equipment.

In the spring of 2000, plots began receiving manure applications via honey wagon spreader. Manure was applied at a rate of 500 lb N/acre annually, divided into five applications the first year. Plots were mechanically harvested and samples weighed eight times throughout the season, starting in March and ending in November. At each cutting, replicates of each variety were pooled and analyzed for nitrogen, phosphorus, and potassium.

Treatment the second year (2001) was similar to year 1 with some exceptions. Harvesting started in March and occurred eight times, ending in October. After the second cutting, the fescue varieties were eliminated from the trial because of their lack of survival. Less than 50 percent of the plots' forage production was fescue.

Troy Downing, Extension dairy agent, Tillamook County, Oregon State University

Results and discussion

Table 1 shows yield data for year 1. Values in all tables are averages of the three replicates (lb of dry matter per acre-equivalent). First-year yields ranged between 6.5 and 7.5 tons of dry matter/acre.

Table 2 shows the nitrogen removal of the same cuttings. Crude protein is approximately 16 percent nitrogen. For example, forage that is 30 percent protein contains 4.8 percent N. Nitrogen removed ranged from 539 to 676 lb/acre. These values are higher than some felt were possible, but confirmed the expectations of many farmers in Tillamook County.

Figure 1 illustrates the percentage of nitrogen and phosphorus removed in each cutting in 2000. That year, more than half the nitrogen removed was removed by May, with more than 75 percent removed by July. This finding illustrates the importance of fertilizing early enough in the season to achieve a high level of utilization.

Table 1.—Yield data, 2000 (lb dry matter/acre).

	20 Mar	17 Apr	15 May	16 Jun	14 Jul	18 Aug	27 Sep	16 Nov	Total
Fescue									
Barolex	807	2,446	2,825	2,316	1,603	1,234	901	1,503	13,635
Barcarella	605	2,424	2,696	2,413	1,528	1,275	959	1,384	13,284
Fuego	777	2,245	2,572	2,715	1,692	1,168	816	1,517	13,502
AU Triumph	934	2,496	2,253	2,274	1,814	1,430	711	1,697	13,609
Seine	714	2,729	2,260	1,810	1,789	1,438	888	1,505	13,133
Orchardgrass									
Cambria	1,038	2,292	2,390	2,331	2,017	1,487	1,269	1,280	14,104
Pizza	470	2,698	2,401	2,412	1,845	1,324	1,168	1,225	13,543
Orion	536	2,808	2,782	2,249	1,826	1,278	1,092	1,192	13,763
Baridana	1,361	2,698	2,376	2,189	1,801	1,169	941	1,052	13,587
Ryegrass									
Tonga	1,428	1,938	2,292	2,546	1,618	1,106	875	1,088	12,891
Elgon	1,307	2,357	2,539	2,814	1,745	1,215	913	1,029	13,919
Herbie	917	2,393	2,925	2,248	2,081	1,392	886	933	13,775
Glenn	1,672	2,680	2,891	2,300	2,196	1,409	819	1,077	15,044

Table 2.—Nitrogen uptake, 2000 (lb N/acre).

	20 Mar	17 Apr	15 May	16 Jun	14 Jul	18 Aug	27 Sep	16 Nov	Total
Fescue									
Barolex	24.8	94.7	138.1	84.0	65.7	37.3	32.3	62.5	539
Barcarella	37.6	123.4	132.1	86.4	48.9	42.2	34.1	55.8	561
Fuego	32.9	113.6	126.0	96.9	57.5	41.0	29.0	54.9	552
AU Triumph	43.6	135.3	107.9	85.0	63.9	47.7	25.5	65.2	574
Seine	44.4	144.9	135.6	85.4	60.1	44.0	32.0	62.6	609
Orchardgrass									
Cambria	64.1	124.7	112.8	82.0	70.0	43.0	46.0	55.7	598
Pizza	30.4	145.4	127.5	144.7	87.1	44.5	37.5	37.5	655
Orion	34.4	151.3	147.7	80.5	65.4	58.1	39.9	50.3	628
Baridana	73.5	140.3	118.1	71.1	63.8	40.8	34.3	40.2	582
Ryegrass									
Tonga	87.7	106.6	91.0	90.4	64.4	29.6	29.9	45.3	545
Elgon	67.3	140.7	127.2	90.9	61.4	42.2	30.3	32.7	593
Herbie	51.9	133.3	145.6	103.6	80.3	42.7	31.7	38.3	627
Glenn	98.6	144.4	110.1	72.9	94.2	43.3	29.3	44.2	637
Barfort	80.5	138.4	133.9	102.4	63.8	40.7	26.6	36.7	623
Bronsyn	103.6	119.8	161.9	109.2	69.7	41.3	28.8	42.1	676
Bellramo	54.3	126.6	121.4	79.8	68.6	43.4	35.1	32.1	561
BG-34	77.9	128.4	161.5	96.6	81.1	49.0	32.7	48.3	676
Intermediate ryegrass									
Bison	95.5	120.6	99.6	106.7	60.3	44.8	37.0	47.6	612
Tetralite	89.3	124.0	137.7	85.8	38.8	37.8	34.0	29.2	577
Italian ryegrass									
Flanker	91.5	121.3	139.0	92.5	34.0	28.1	25.8	36.6	569
Festuolium									
Barfest	80.8	144.0	146.1	117.5	59.3	47.6	32.0	39.1	666
Prairie grass									
Matua	95.1	117.3	144.2	64.5	99.6	30.9	24.9	64.8	641

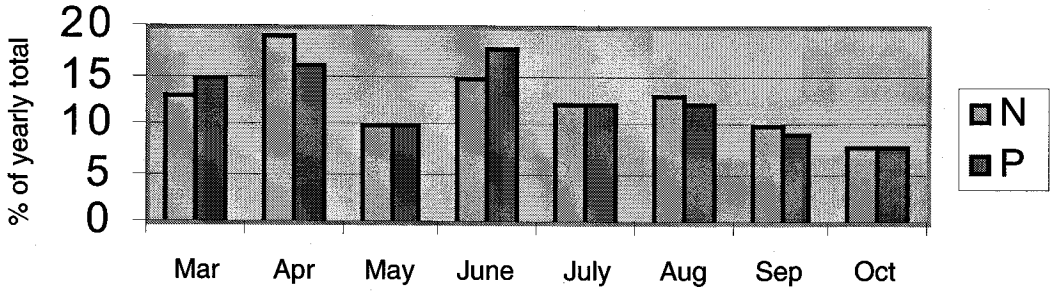

Figure 1.—Percentage of nitrogen and phosphorus removed per cutting in 2000.

Phosphorus removal ranged from 38.5 lb/acre to 54.7 lb/acre. Uptake values are shown in Table 3. Significant changes in plant P concentration occurred throughout the season. Early in the year, plant P levels ranged from 0.4 to 0.5 percent. In the dry time of the year, plant P dropped to 0.25 to 0.3 percent. Coupled with the decrease in total yield later in the season, this pattern dramatically influenced the amount of P removed during each cutting.

Plant tissue potassium values were fairly consistent throughout the season. Almost all differences in removal rates were yield related. Table 4 shows the potassium removal rates, which ranged from 435 to 636 lb/acre annually. Plant uptake seems to be closely related to soil K availability.

Table 3.—Phosphorus uptake, 2000 (lb P/acre).

	20 Mar	17 Apr	15 May	16 Jun	14 Jul	18 Aug	27 Sep	16 Nov	Total
Fescue									
Barolex	3.1	11.9	12.7	8.8	3.4	2.1	2.6	6.2	50.8
Barcarella	2.1	11.2	11.2	8.7	2.8	2.0	2.9	6.1	47.0
Fuego	2.9	9.4	10.3	8.7	3.6	1.8	1.9	5.0	43.6
AU Triumph	3.1	10.2	8.8	9.1	3.1	1.2	2.5	4.8	42.8
Seine	2.4	12.0	9.5	6.3	3.2	2.2	2.4	5.9	43.9
Orchardgrass									
Cambria	3.3	10.3	10.7	8.8	3.6	1.8	3.0	4.6	46.1
Pizza	1.5	11.3	11.5	8.2	3.7	2.4	3.2	4.3	46.1
Orion	1.7	12.1	10.1	3.5	3.5	2.1	2.6	3.8	39.4
Baridana	4.5	11.9	11.4	6.8	3.8	1.9	2.4	3.6	46.3
Ryegrass									
Tonga	4.3	7.6	7.3	9.4	3.4	1.5	1.8	3.2	38.5
Elgon	4.3	11.8	10.7	12.4	3.0	2.1	2.1	2.6	49.0
Herbie	2.9	12.4	12.9	9.2	4.2	2.8	2.2	2.9	49.5
Glenn	6.9	11.5	10.4	4.6	4.8	3.1	2.0	3.0	46.3
Barfort	4.4	9.7	12.5	8.2	2.8	2.0	1.8	3.1	44.5
Bronsyn	6.0	8.9	16.4	9.8	3.7	2.3	1.5	4.3	52.9
Bellramo	3.0	8.8	10.0	10.6	3.5	2.4	2.4	2.7	43.4
BG-34	4.3	12.5	13.6	9.5	4.0	2.3	1.9	3.2	51.3
Intermediate ryegrass									
Bison	5.6	11.4	14.0	9.1	3.9	2.6	2.6	3.9	53.1
Tetralite	5.2	9.2	14.7	8.9	3.3	1.8	2.2	2.2	47.5
Italian ryegrass									
Flanker	7.3	11.1	14.8	9.1	4.4	2.9	2.0	3.1	54.7
Festuolium									
Barfest	4.8	11.6	13.0	10.0	3.4	2.4	2.2	3.5	50.9
Prairie grass									
Matua	5.8	7.2	13.7	6.1	5.1	2.3	2.0	5.6	47.8

Table 4.—Potassium uptake, 2000 (lb K/acre).

	20 Mar	17 Apr	15 May	16 Jun	14 Jul	18 Aug	27 Sep	16 Nov	Total
Fescue									
Barolex	20.6	90.5	129.0	108.1	70.4	45.3	35.8	64.2	563.9
Barcarella	21.1	91.4	135.3	117.3	55.9	44.4	37.4	59.8	562.6
Fuego	16.1	83.1	116.0	128.1	57.5	30.1	25.4	55.4	511.7
AU Triumph	22.6	98.8	110.6	114.6	76.1	43.7	24.6	65.5	556.5
Seine	13.1	105.3	107.5	77.3	46.3	50.3	31.1	52.5	483.4
Orchardgrass									
Cambria	33.2	85.5	122.8	106.3	73.2	54.0	47.0	48.3	570.3
Pizza	14.1	114.1	127.5	94.5	79.0	41.8	42.7	51.0	564.7
Orion	12.8	115.4	135.5	64.6	75.0	46.5	37.0	37.5	524.3
Baridana	39.5	109.0	109.0	92.6	76.2	43.0	31.4	31.9	532.6
Ryegrass									
Tonga	31.0	78.5	87.3	113.3	68.3	33.0	28.5	38.5	478.4
Elgon	28.6	80.1	82.2	105.2	73.6	22.1	28.4	15.4	435.6
Herbie	15.8	60.5	127.2	99.3	82.0	46.7	28.9	29.5	489.9
Glenn	60.3	146.3	121.4	47.4	99.4	31.0	20.5	30.2	556.5
Barfort	31.4	92.0	148.2	101.0	77.8	49.3	12.4	31.1	543.2
Bronsyn	52.6	83.1	158.3	137.5	80.3	46.1	33.6	45.4	636.9
Bellramo	18.8	73.8	113.3	97.6	60.8	46.0	33.0	27.6	470.9
BG-34	27.1	119.8	168.1	112.7	59.3	31.1	22.7	36.2	577.0
Intermediate ryegrass									
Bison	52.9	107.6	149.9	91.6	56.2	48.9	43.1	58.2	608.4
Tetralite	52.6	91.7	167.6	102.8	53.1	36.0	30.5	24.8	559.1
Italian ryegrass									
Flanker	50.3	87.1	162.8	108.8	54.9	15.0	22.8	32.2	533.9
Festuolium									
Barfest	37.2	109.6	145.3	127.8	73.6	53.1	33.6	33.4	613.6
Prairie grass									
Matua	54.0	75.4	134.9	79.4	88.6	46.4	33.7	80.8	593.2

The second-year yield data are shown in Table 5. Yields ranged from 7.5 to more than 9 tons of dry matter per acre. Cambria, Pizza, Orion, and Baridana (all orchardgrasses) significantly outproduced all other varieties. Tetralite was the lowest producing variety. It is a hybrid variety called an intermediate ryegrass produced by crossing an annual and a perennial. Thus, it is no surprise that its productivity slowed in the second year.

Nitrogen uptake values the second year were significantly higher than in year 1 (Table 6), primarily due to increased yield, which resulted from plant maturity and growing season differences. The second growing season produced more growth throughout the summer, despite the continued drought. It is likely the grasses were deeper rooted the second year and thus more able to reach water. Perhaps some other factor also played a role.

Figure 2 shows the nitrogen and phosphorus removal per cutting as a percentage of the year's total removal. These numbers are spread throughout the season more evenly than in 2000. Early-season data were affected by an irregularly timed cutting due to bad weather. Table 7 shows the percentage of the season's total dry matter removed per cutting for both years.

Table 5.—Yield data, 2001 (lb dry matter/acre).

	22 Mar	20 Apr	6 May	8 Jun	28 Jun	24 Jul	19 Aug	1 Oct	Total
Orchardgrass									
Cambria	2,000	2,579	1,344	3,106	2,042	2,492	1,299	2,397	17,259
Pizza	1,978	3,116	1,465	3,059	1,971	3,485	1,308	2,194	18,576
Orion	1,887	2,865	1,698	3,369	2,746	2,405	1,652	2,565	19,187
Baridana	1,785	2,890	1,408	3,036	2,163	2,519	1,707	2,379	17,887
Ryegrass									
Tonga	1,193	2,201	1,657	2,766	2,239	2,407	1,985	1,151	15,599
Elgon	1,528	2,220	1,840	2,377	2,217	2,275	1,879	1,500	15,836
Herbie	1,347	2,493	1,862	2,873	1,969	1,895	2,004	1,718	16,161
Glenn	1,351	2,160	1,769	2,946	1,770	2,043	2,109	1,455	15,603
Barfort	1,156	1,979	1,743	2,787	1,983	2,275	1,747	1,112	14,782
Bronsyn	1,371	2,126	1,807	3,327	2,003	2,627	1,795	1,501	16,557
Belramo	1,749	2,222	1,768	3,165	2,192	2,749	2,199	1,206	17,250
BG-34	1,513	2,368	1,695	3,179	2,034	2,831	1,640	1,589	16,849
Intermediate ryegrass									
Bison	1,294	2,160	1,769	3,171	1,859	2,140	1,954	1,004	15,351
Tetralite	1,528	2,245	1,389	2,688	1,984	1,542	1,644	721	13,741
Italian ryegrass									
Flanker	1,566	2,369	1,666	2,484	2,088	1,365	1,667	1,010	14,215
Festuolium									
Barfest	1,382	2,058	1,596	3,002	1,598	2,070	2,215	1,202	15,123
Prairie grass									
Matua	1,831	2,007	1,522	3,014	2,233	2,813	1,378	1,573	16,371

Table 6.—Nitrogen uptake, 2001 (lb N/acre).

	22 Mar	20 Apr	6 May	8 Jun	28 Jun	24 Jul	19 Aug	1 Oct	Total
Orchardgrass									
Cambria	111	145	67	109	80	93	38	70	713
Pizza	105	178	63	105	86	95	44	66	742
Orion	107	144	68	109	100	92	41	89	750
Baridana	101	149	59	102	85	76	82	74	728
Ryegrass									
Tonga	66	109	60	88	94	94	64	44	619
Elgon	84	119	61	82	71	93	76	54	640
Herbie	73	126	63	99	72	80	72	57	642
Glenn	69	110	64	102	68	86	87	53	639
Barfort	66	98	56	98	85	91	70	43	607
Bronsyn	67	106	61	103	70	101	63	54	625
Belramo	98	110	57	114	83	114	84	44	704
BG-34	82	128	56	104	79	108	61	55	673
Intermediate ryegrass									
Bison	61	115	57	112	71	66	68	40	590
Tetralite	84	118	53	89	87	48	53	27	559
Italian ryegrass									
Flanker	76	125	57	66	71	41	47	32	515
Festuolium									
Barfest	81	110	59	92	66	75	76	38	597
Prairie grass									
Matua	99	103	56	99	90	96	42	50	635

Table 7.—Percentage of dry matter removed per cutting in 2000 and 2001.

	March	April	May	June	July	August	Sept	Oct/Nov
2000	8.8	17.7	18.7	17	13.4	9.1	6.5	8.4
2001	9.5	14.4	10.1	18.2	12.7	14.5	11	9.5

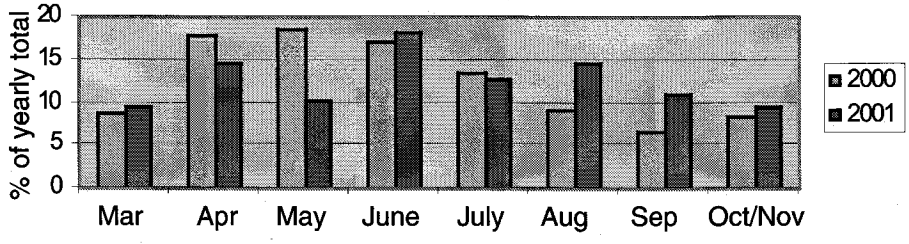

Figure 2.—Percentage of nitrogen and phosphorus removed per cutting in 2001.

Phosphorus removal data are depicted in Table 8. The average P removal rate was 57.1 lb/acre, with varieties ranging from 47.3 to 69.7 lb/acre. The P removal rate was 8 lb higher on average than in 2000.

Conclusions

Tillamook County's climate is as productive for cool-season grasses as any in the world. With intensive harvest management and proper fertility, annual yields can exceed 9 tons of dry matter/acre and nitrogen utilization 700 lb/acre.

Phosphorus utilization also seems high, with actual P removal rates approaching 70 lb/acre in some varieties. Phosphorus concentration in the plant seems to change dramatically throughout the season, being high in the spring and decreasing by almost 50 percent in the early fall.

Increased cutting frequency and irrigation would enhance yields and uptake values.

References

Gamroth, M. and J. Moore. 1995. Nitrogen cycling in grasses. Special report, Center for Applied Agricultural Research, Oregon Department of Agriculture.

Table 8.—Phosphorus uptake, 2001 (lb P/acre).

	22 Mar	20 Apr	6 May	8 Jun	28 Jun	24 Jul	19 Aug	1 Oct	Total
Orchardgrass									
Cambria	12.0	11..0	4.7	10.8	7.1	7.2	3.0	6.9	62.7
Pizza	11.6	11.9	5.1	13.1	6.9	11.1	3.5	6.5	69.7
Orion	10.9	12.2	5.9	11.45	9.6	6.2	3.0	7.1	66.3
Baridana	10.3	11.9	4.9	10.6	7.6	6.0	4.1	6.7	62.0
Ryegrass									
Tonga	6.2	7.7	5.8	9.7	7.8	7.5	5.4	3.6	53.7
Elgon	8.1	7.8	6.4	7.6	7.8	7.7	6.6	4.2	56.2
Herbie	6.3	8.7	6.5	10.6	6.9	6.4	7.0	5.1	57.5
Glenn	7.1	7.5	6.2	10.6	6.4	7.9	6.5	3.9	56.1
Barfort	5.9	6.9	6.1	8.6	6.9	7.1	6.1	3.4	51.0
Bronsyn	7.5	7.4	6.3	11.6	7.0	7.1	5.9	3.9	56.7
Belramo	10.0	11.8	6.2	11.4	7.4	7.1	7.7	3.5	65.1
BG-34	7.4	8.2	5.9	10.1	7.1	9.9	5.7	4.9	59.2
Intermediate ryegrass									
Bison	7.2	7.6	6.2	11.4	6.5	6.0	5.5	2.9	53.3
Tetralite	8.5	7.8	4.8	8.6	6.9	4.5	4.3	1.9	47.3
Italian ryegrass									
Flanker	7.5	10.0	5.8	7.2	7.3	4.2	4.3	3.0	49.3
Festuolium									
Barfest	7.5	7.2	5.6	11.1	5.6	6.6	7.1	3.8	54.5
Prairie grass									
Matua	8.0	7.0	5.3	9.0	7.8	9.3	2.9	4.7	54.0

This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties.

Published September 2002.