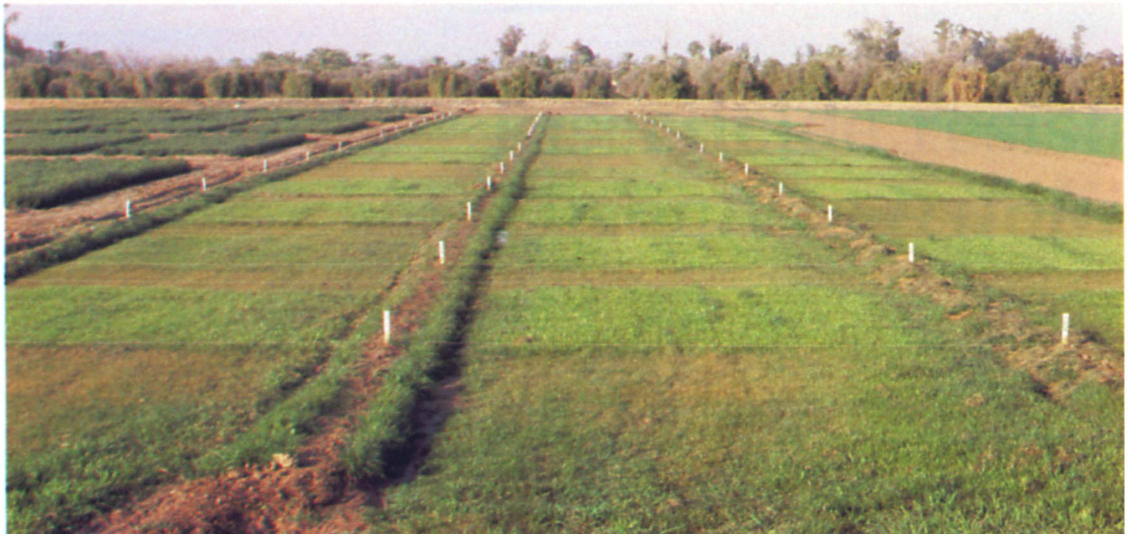

Ryegrass nitrogen fertilization plots at El Centro.

Soil nitrate level best measure of ryegrass nitrogen needs in Imperial Valley

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Annual ryegrass produces superior yields of hay or pasturage with excellent palatability, a protein content above 20 percent, and other desirable qualities. The new fertilizer technology provides a highly favorable economic return. However, the nitrogen fertilization rates required for highest yields may cause plant nitrate-nitrogen concentrations that are toxic to livestock.

Both acute and chronic poisoning may occur with high forage nitrate concentrations, according to recent reports. Acute poisoning may be expected when forage nitrates exceed 10,000 ppm on a dry weight basis. Feeds with 1,000 to 1,500 ppm nitrate were reported to be safe to all nonpregnant animals under all conditions. Feeds with nitrate levels up to 4,000 ppm were reported safe when their contribution to the total dry matter was reduced proportionately to as little as 25 percent. Tolerance to nitrate in ruminants was also increased by high-quality diets with readily available carbohydrates. Larger animals are also reportedly more tolerant than smaller animals.

The University of California and U.S. Department of Agriculture Agricultural Research Service (USDA-ARS) cooperated in a two-year field study conducted at the USDA-ARS Imperial Valley Conservation Research Center in Brawley, California, to determine the optimum nitrogen fertilization rate for maximum dry matter and protein yields within tolerable nitrate-nitrogen concentrations for livestock. Livestock operators or hay growers need a diagnostic test using plant or soil nitrate-nitrogen concentrations to guide nitrogen applications to annual ryegrass.

Procedure

Seed of the Uncivex annual ryegrass was planted at 50 pounds per acre on the flat in bordered strips. Before planting, triple superphosphate, at 200 pounds per acre, was mixed into the upper 6 inches of the Imperial silty clay soil. The seed was planted in dry soil and irrigated October 2, 1975, and October 20, 1976, for germination.

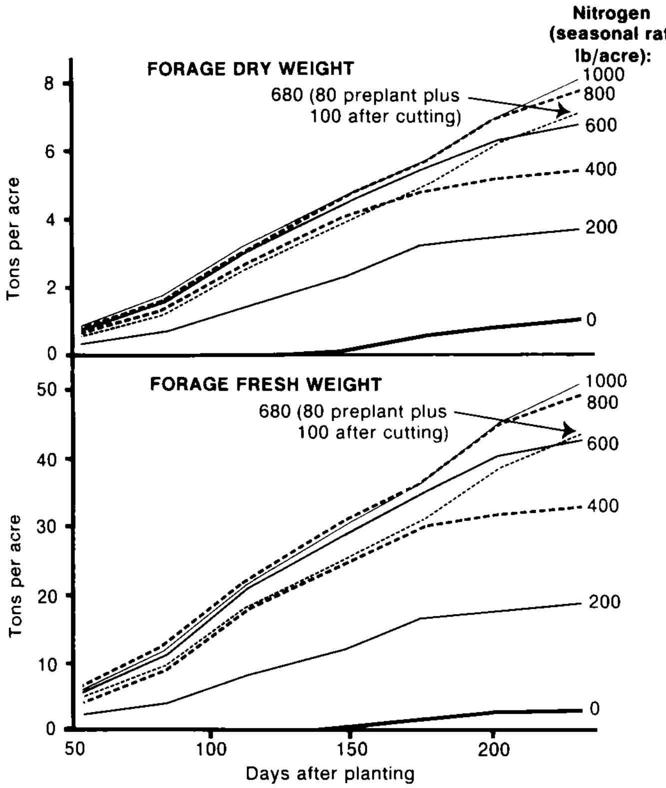
In six treatments, nitrogen, as ammonium nitrate, was broadcast at seasonal rates of 0, 200, 400, 600, 800, and 1,000 pounds nitrogen per acre, in five equal applications: at planting and after each of the first four cuttings. A seventh treatment was added in the second year, in which nitrogen was applied at 80 pounds per acre, preplant, plus 100 pounds per acre after each cutting for a seasonal total of 680 pounds nitrogen per acre. Each plot was 20 by 20 feet with an unfertilized strip of 10 feet separating adjacent plots within borders and a 7 foot border. The seven treatments were tested in a randomized block design with six replicates.

Sudan grass was grown in the field between June 9 and August 30, 1976, to remove the nitrogen remaining in the soil after the first year's test. The sudan grass was irrigated frequently without nitrogen applications, and all hay was removed from the field.

The ryegrass was cut about 2½ inches above the ground in December and at about monthly intervals thereafter. Fresh forage from a 30- or 36-inch by 20-foot strip across each plot was weighed, and a representative sample was dried for analysis and dry-weight determination. The soil was sampled to a 2-foot depth in 1-foot increments. All forage was removed from the field, the field was broadcast-fertilized according to schedule, and the plots were flood-irrigated. The plots were irrigated a second time between cuttings if the soil matric potential at a 9-inch depth decreased below −0.5 bars, as indicated by tensiometers.

Results

The first year of study provided limited information. Residual nitrogen in the soil when the test began was sufficient to produce high forage yields at the first cutting of all plots, regardless of nitrogen application rate. A fungus infection, *Rhizoctonia solani* Kuhn, caused excessive plant losses in March and early



Cumulative yields of annual ryegrass planted October 20, 1976, increased rapidly at nitrogen rates up to 400 pounds per acre. Higher rates maintained yields longer.

TABLE 1. Annual ryegrass hay nitrate-nitrogen concentration and average soil nitrate concentration in upper 2 feet at each cutting date in the second year of study.

Nitrogen treatment	Dec 13	Jan 12	Feb 9	Mar 16	Apr 13	May 11	Jun 9
lb/acre	Hay nitrate content (ppm)						
0	*	*	*	198	147	138	159
200	160	182	218	119	120	126	133
400	1,490	1,350	2,000	571	1,240	131	145
600	5,130	5,290	8,210	4,740	4,730	790	360
800	6,800	6,610	10,100	7,270	9,970	2,960	1,360
1,000	7,500	8,660	10,700	8,920	10,700	3,510	2,250
680	1,960	1,480	4,730	1,810	3,290	1,290	2,200
	Soil nitrate (ppm)						
0	0.9	0.8	0.3	0.5	2.7	0.8	0.1
200	1.1	1.1	0.2	0.4	2.9	1.3	0.2
400	1.6	2.4	0.4	0.4	3.3	1.2	0.1
600	4.0	13.1	8.1	3.6	4.8	1.6	0.2
800	9.3	18.4	30.4	22.5	25.4	8.6	0.5
1,000	22.8	43.1	47.1	47.7	52.5	22.4	23.4
680	1.1	1.8	3.1	0.4	4.7	1.7	4.3

* No hay yield.

TABLE 2. Protein and total digestible nutrients (TDN) of annual ryegrass hay cut on March 16 and April 13, 1977.

Nitrogen treatment	Protein		TDN	
	Mar 16	Apr 13	Mar 16	Apr 13
lb/acre	%			
0	11.6	10.3	56.9	58.1
200	12.7	13.0	56.1	55.7
400	16.1	18.6	53.4	53.2
600	23.4	23.8	51.5	51.9
800	25.0	26.8	51.0	51.1
1,000	26.5	26.8	50.8	51.0
680	18.8	22.0	52.9	52.4

termination of the test. Data from the second and third cuttings in late January and February agreed with data from the second year's study.

Seven cuttings were obtained in the second year, the last cutting on June 9, 1977 (see graph). The summer planting of sudan grass had depleted the soil nitrogen sufficiently to prevent harvestable yield for the first three cuttings of the treatment with no nitrogen and resulted in negligible yield for the entire season. Forage and dry weight increased rapidly with rates up to 400 pounds nitrogen per acre. The 200- and 400-pound rates did not provide sufficient nitrogen to maintain yield after nitrogen application had stopped (for the sixth and seventh cuttings). The 600-pound rate maintained yield for the sixth cutting, and the 1,000-pound rate maintained yield for the seventh cutting. The treatment at 80 pounds nitrogen per acre, preplant, plus 100 pounds per acre after each cutting also maintained yield through the seventh cutting. The ratio of dry weight to fresh weight was high only at low-yielding treatments and seasonally averaged about 16 percent at nitrogen rates of 400 pounds per acre or more. Most of the yield from the seventh cutting of all treatments was seedstalk and immature seed.

Plant nitrate-nitrogen concentrations were excessive for livestock tolerance at seasonal application rates of 600 pounds per acre or more (table 1). Except for the cutting on February 9, the treatment receiving nitrogen at 80 pounds per acre, preplant, plus 100 pounds after each cutting produced forage with satisfactorily low nitrate-nitrogen concentrations for use as sole- or primary-source livestock feed. Since harvests on February 9 and April 13 were less than one month after the preceding harvest, unlike other cuttings, the interval could have been increased by one week in those cases to reduce the plant nitrate level.

Protein increased markedly and total digestible nutrients decreased slightly with increase in nitrogen application rate (table 2). Protein content was slightly higher for a December 13 cutting than for the data shown in the table. At the nitrogen rates of 400 and 680 pounds per acre, which maximized yields with acceptable plant nitrate-nitrogen concentrations, the protein content ranged from 16 to 22 percent.

Nitrate concentrations of 10 to 20 ppm in the upper 2 feet of soil at harvest ensured near maximal yields for an additional cutting without further nitrogen applications and without excessive hay nitrate contents (table 1). Very little nitrogen was stored in the unharvested parts of the plant. At hay concentrations of 2000 to 3000 ppm nitrate, insufficient nitrogen remained in the soil to ensure a satisfactory yield at next cutting without further nitrogen application. Hence, the soil nitrate-nitrogen concentration, but not the plant nitrate-nitrogen concentration, could be used as a diagnostic guide for nitrogen applications to ryegrass.

Conclusions

A broadcast application of 80 to 100 pounds nitrogen per acre, in the form of ammonium nitrate, at planting and after each monthly harvest maximized forage or hay yield without causing plant nitrate concentrations to exceed animal tolerance. At this fertilization level, protein content averaged about 20 percent on a dry-weight basis.

Plant nitrate-nitrogen concentration is not a useful diagnostic guide for maximizing yield. A soil nitrate-nitrogen concentration of 10 to 20 ppm will ensure a nearly maximal yield at the next cutting, while keeping plant nitrate-nitrogen at concentrations tolerable for use as a sole- or primary-source livestock feed. This fertilization practice should provide a highly favorable economic return.

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