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Short communication

Use and efficiency of a liquid nitrogen fertilizer on grassland

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Abstract

Liquid nitrogen fertilizers are, per unit of N, generally cheaper than granulated ammonium nitrate because of lower production costs. Although very corrosive, the storage and handling of liquid nitrogen fertilizers does not usually present any problems. The applicability and efficiency of a commercial liquid nitrogen fertilizer (containing 39% N, half urea and half ammonium nitrate) on grassland was investigated in comparison with granulated ammonium nitrate (27% N). The liquid nitrogen fertilizer was applied on continuously grazed paddocks without any repercussions for animal health. No scorching was observed provided that certain measures were adopted while spraying the fertilizer: i.e. little dilution with water, use of low pressure and large droplets and application on dry grass in cloudy whether. In comparison with the granulated ammonium nitrate, the liquid nitrogen fertilizer was less efficient; dry matter yield and N-uptake of the grass treated with the liquid nitrogen fertilizer were 76% and 73% respectively of the dry matter yield and N-uptake of the grass treated with the granulated ammonium nitrate fertilizer.

Fertilization, especially with nitrogen, represents the biggest single cost in grass production. Because liquid nitrogen fertilizers can be produced less expensively then granulated ones, their price per unit of N, delivered to the farmer, is also lower.

Another advantage is that liquid fertilizers are easy to handle (despite being corrosive) and can be distributed uniformly over the field. The greatest advantage can be expected on the large grass areas of continuous grazing systems. Because of these benefits, an investigation was carried out to assess the potential use and efficiency of liquid nitrogen fetilizer in comparison with granulated ammonium nitrate nitrogen, from 1983 up to 1987. In 1983 and 1984, the grass quality, especially NH_3 and NO_3 concentration directly after spraying, and animal behaviour were assessed. From 1985 to 1987, the grass yield and nitrogen uptake were measured under mowing conditions.

Materials and methods

Experimental sites

The trials took place at the Plant Breeding Station at Merelbeke (Ghent) on permanent grassland (grazing trials) and on newly sown swards (cutting trials) on sandy loam soils.

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Treatments

At the start of the grazing season of 1983, an area of 2 ha was divided into two equal blocks and stocked with 5 bulls per ha. During the grazing seasons of 1983 and 1984, one half of the area received 52 kg N/ha in liquid fertilizer form (1/2 NH_4NO_3-N and 1/2 urea-N) every 3 weeks while the animals stayed on the grass (continuous grazing system). The original fertilizer (39 kg N/

100 liter) was diluted with water up to 25 kg N/100 liter to the required volume with normal spraying. Spraying was done under low pressure (1.5 kg/cm^2) to form large droplets thereby minimising scorching of the grass and clover leaves.

In April 1985, perennial ryegrass var. Vigor was sown in small plots of 6m × 1,5m in 4 replicates. Liquid nitrogen fertilizer was sprayed under low pressure of 1.5 kg/cm^2 at rates of 80 and 100 kg N/ha/cut in concentrations of 27.5 kg N/100 liter. Grass yield and composition of these plots were compared with those given 60, 70, 80, 90 and 100 kg N/ha/cut as ammonium nitrate.

In 1985, two cuts were taken and in 1986 and 1987, four cuts were taken. P- and K-fertilization was the same for both subjects: 40 kg P_2O_5 and 120 kg K_2O/ha/cut.

General information

Grass yield was measured using a Haldrup harvesting machine. Samples for NH_3 analysis were cut and analysed in the laboratory as soon as possible. Samples for dry matter, crude protein and nitrate analysis were dried in a forced draught oven at 85° for 16 h and milled through a 1mm sieve.

Total nitrogen, including nitrate, was determined according to a modified Kjeldahl method and the nitrate content was measured spectrophotometrically according to the xylenol method. The ammonia concentration was determined after extraction of the fresh grass with distilled water according to the AOAC-method.

Results and discussion

Grazing experiment

The first question regarding the use of liquid nitrogen fertilizers on grassland was possible health problems for the grazing animals. Although spraying was done under low pressure conditions, creating large droplets that could drip down from the grass leaves, a quantity of fertilizer liquid could always stick to the leaves and might have been consumed directly by the grazing animals. Table 1 presents the evolution of the ammonia and nitrate content of the grass before and after spraying. The nitrate concentration during the first 4 h after application of the fertilizer was high enough to cause nitrate poisoning [6]. Nevertheless, no health problems in the animals were ever observed. This is because grazing animals spread their grass intake, and thus nitrate intake, throughout the day. Grazing behaviour did not vary at all between the two groups of bulls. It was observed that the average height of grass over the grazing seasons 1983 and 1984 was significantly shorter in the area which received liquid nitrogen fertilizer: 7.9 cm in comparison with 8.2 cm in the area receiving ammonium nitrate. The grass growth, measured under cages between two subsequent fertilization dates, of the liquid nitrogen fertilizer section, amounted to only 80% of the yield of the granulated fertilizer section. This lower grass production together with a lower grazing height resulted in a corresponding lower gain in the weight of livestock. During the course of the two years of experiments, beef production on the area treated with liquid nitrogen fertilizer was 94% of that produced on the granulated one.

Table 1. Nitrate and ammonia concentration of the grass before and 2, 4 and 24 hours after liquid N-fertilizer application

	Time before or after N-application			
Nitrate and ammonia concentration	Just before	2 h after	4 h after	24 h after
% NO_3/DM	0.32	3.73	2.53	1.29
% NH_3/DM	–	0.48	0.31	traces

Cutting experiments

In Table 2, the grass yield after equal nitrogen application as liquid or granulated fertilizer is presented for 10 cuts from 1985 to 1987.

An application of liquid nitrogen fertilizer resulted in a higher grass yield in spring, but over the 10 cuts, the total grass yield of the granulated fertilizer form was significantly higher. Black et al. [4] found lower losses of granulated urea-N by volatilization in spring than at other times of the year, but always higher N-losses than with granulated nitrogen fertilizer. Fogh [5] found

Table 2. Grass yield (kg DM/ha) at different levels of liquid N-fertilizer (liq) and granulated ammonium nitrate (gran)

N-rate/cut		Mowing date										
		1985		1986				1987				
		05.09	23.10	22.05	01.07	26.08	04.11	22.05	25.06	28.07	04.09	Total
liq	80 N	1660	2270	3530	2770	1270	1520	3490	2830	2880	2720	24930
liq	100 N	3050	2370	3790	2980	1270	1920	4130	2770	3190	2830	28300
gran	60 N	2210	2440	3030	2900	1760	1680	2960	2860	2770	2540	25130
gran	70 N	2640	2550	3250	2810	1740	1900	3450	2840	3010	2780	26970
gran	80 N	2920	2700	3400	2880	1920	2100	3630	2900	3330	2870	28660
gran	90 N	3140	2740	3620	3000	1840	2420	3960	2930	3550	2970	30170
gran	100 N	3300	2760	3680	3000	2250	2650	4120	2910	3900	3210	31780
l.s.d.	5%	190	210	390	n.s.	170	250	330	n.s.	290	170	750

lower DM yields and total-N uptake while spraying a nitrogen solution (1/2 $NH_4NO_3 - N + 1/2$ urea-N). He did not refer to any differences in application period.

It is possible that weather conditions in spring (low temperatures) are less favourable for NH_3-volatilization, while the direct N-availability from the dissolved urea-N might be higher than from the granulated N-formula and furthermore, losses of NO_3-N by leaching may occur [3] [7].

The N-concentration in the solution is very important. No more water should be added to the commercial liquid N product than is necessary for normal spraying. In trials where a solution of 22 kg N/100 liter was used, a dark colouring and even light burning of grass leaves was visible. Too much dilution decreases the hygroscopicity of the solution, but increases the contact: nitrogen solution-leaf area, resulting in a greater likelihood of burning damage.

Weather conditions are always important for the application of N-solutions (containing ammonia-N). The temperature and humidity of air and sward are determining factors in the efficiency of liquid nitrogen fertilizer use. Best results are always obtained under wet conditions and low temperatures. [1] [5]

Table 3. Dry matter, crude protein and nitrate content of the grass at different levels of liquid nitrogen fertilizer (liq) and granulated ammonium nitrate (gran) (average of samples taken at each cut in 1985, 1986 and 1987)

N-rate/cut		% DM	% CP/DM	% NO3/DM
Liq	80 N	19.85	14.99	0.02
Liq	100 N	18.73	16.06	0.03
Gran	60 N	19.68	15.19	0.02
Gran	70 N	18.78	16.07	0.04
Gran	80 N	18.02	16.85	0.08
Gran	90 N	17.70	17.87	0.10
Gran	100 N	17.53	18.97	0.21
l.s.d.	5%	0.62	0.67	0.05

Under dry weather conditions, liquid nitrogen fertilizers are less effective than granulated ammonium nitrate because of volatilization [8]. This volatilization is due to the presence of NH_3-N. Even distributed in granulated form, urea is less effective than ammonium nitrate under dry weather conditions [2]. The results from Table 2 confirm the results mentioned above. The N-efficiency of the liquid nitrogen fertilizer is even better in the cold, wet springtime, but worse in the drier, warmer summertime. The average N-efficiency over the 10 cuts of the liquid fertilizer was 76% of the granulated form.

Table 3 presents the results of dry matter, crude protein and nitrate contents of both grass swards. All these figures clearly demonstrate that the liquid nitrogen was less effective. Indeed, a lower protein and nitrate content together with a higher dry matter content, under equal regimes of N-treatment/cut/ha indicate a lower N-uptake. The N-uptake (result of N-concentration and grass yield) of the grass treated with liquid nitrogen fertilizer was only 73% of the N-uptake of the grass treated with the granulated nitrogen form.

Concluding remarks

Because weather and spraying conditions are of great important in the N-efficiency of a liquid nitrogen fertilizer (1/2 NH_4NO_3-N and 1/2 urea-N), the applicability of this kind of nitrogen fertilizer on grass is limited. Weather conditions in Belgium and other parts of Northern Europe are inclined to be too changeable to ensure maximum efficiency of this form of nitrogen fertilizer.

The farmer has greater flexibility in managing grass production with the use of granulated ammonium nitrate fertilizer. Although the cost of spraying a liquid nitrogen fertilizer is lower, and nitrate poisoning in the grazing animals does not occur, the farmer still obtains higher grass yields and beef production with the granulated form.

Although in spring conditions for the application of the liquid nitrogen formula may be better, this would probably not justify the purchase of the equipment needed for storage and spraying.

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