Fig. 1. Here is one of those creek bottom fields that responds so generously to straight nitrogen and will continue to do so for a few years. Eventually the lush growth of grass resulting from nitrogen treatment will pump the mineral content down to a point when response to N only just "peters out." "A stitch in time" on such fields "will often save nine." Where straight nitrogen is applied to pastures, it is a good idea to check the phosphate, potash, and pH levels and then put on what soil tests indicate is needed.

Nitrogen Use Accentuates Need for Minerals

By C. J. Chapman

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THE great increase in the use of nitrogen fertilizer by farmers in this country has been an almost phenomenal development in the past three or four years. Anhydrous ammonia has swept into the Midwest like a cyclonic storm and its use in Wisconsin is keeping pace with that in other Corn Belt States.

Most of us are familiar with the fact that at the close of the war in August 1945, the capacity for the production of synthetic ammonia in the nine gunpowder plants in this country amounted to some 700,000 tons (fixed nitrogen). Agronomists wondered if even 50% of this capacity would ever be used as fertilizer in the postwar period. A few of us caught a glimpse of what we thought was the great potential in terms of low cost feed, food, and fiber production, and started talking and writing about it. Today, nitrogen is being used on a scale that exceeds the most extravagant speculation of any who predicted this gigantic growth in nitrogen production and use as a fertilizer. Present capactiy for the production of fixed nitrogen in this country now hits close to three million tons.

Ammonium nitrate as a source of

low cost nitrogen has come into wide use on corn and other crops in Wisconsin and other Midwest States. In fact, the demand these past three or four years has greatly exceeded supply. Farmers are now using another source of low cost nitrogen—anhydrous ammonia. This liquefied form of ammonia gas (NH_3) carries 82½% nitrogen. It must be held in rust-resisting steel tanks under pressure of from 150 to 200 lbs. per square inch. The application of this liquid gas calls for special type and rather costly applicators. Injected or "knifed" into the soil, it is fixed chemically and held there until the soil warms up. At temperatures above 60° it nitrifies and becomes available to the growing crops or is used by and built into the tissues of bacteria or fungi and thus held for later use when these bacteria and fungi decompose.

Nitrogen Use Increases Need for Minerals

The great expansion in the use of nitrogen has accentuated the need for minerals in our soil. We must stress as never before the importance of lime, phosphate, and potash to back it up. In fact, there will be an increasing need for certain trace and secondary minerals in order to balance out fertility. Low cost nitrogen fertilizer has extended crop production horizons —but unless we balance out the fertility of our soils with both major and minor elements, we may see a general decline in the productiveness of the soils in this country.

This may be a good time to present some yield data that are of far greater significance now than when the work was conducted. It was 10 years ago that plans were made for an extensive program of fertilizer demonstrations in northern Wisconsin. This program of demonstrations came about as a result of a demand on the part of county agents in these northern counties for help from the College of Agriculture. "What's wrong with northern Wisconsin's agriculture?" This was the question that during the summer of 1944 was put to the adminis-

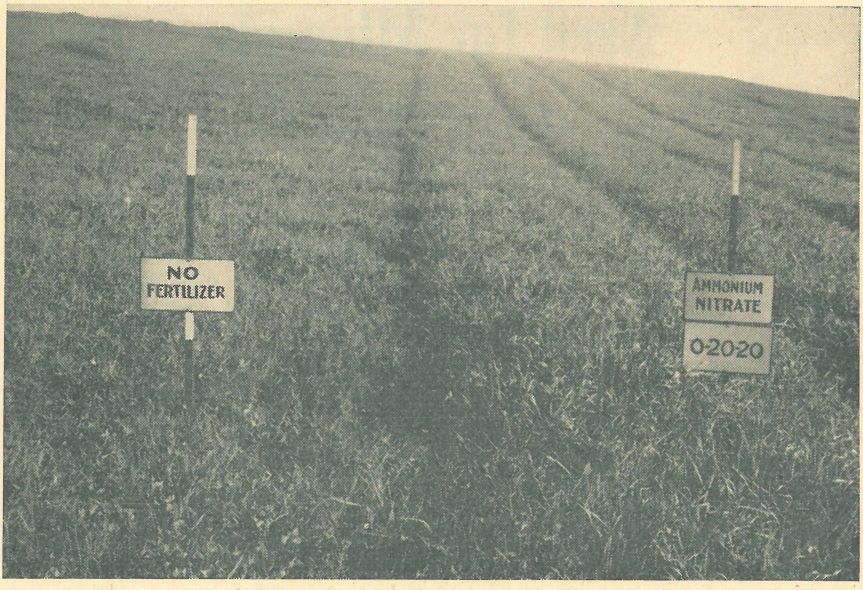

Fig. 2 This is a picture of one of the many fertilizer demonstrations carried out in northern Wisconsin where nitrogen alone would not do the job. Yields per acre: Ammonium nitrate at 200 lbs., 2,700 lbs.; ammonium nitrate at 200 lbs. plus 0-20-20 at 250 lbs., 5,700 lbs.; no fertilizer, 1,800 lbs.

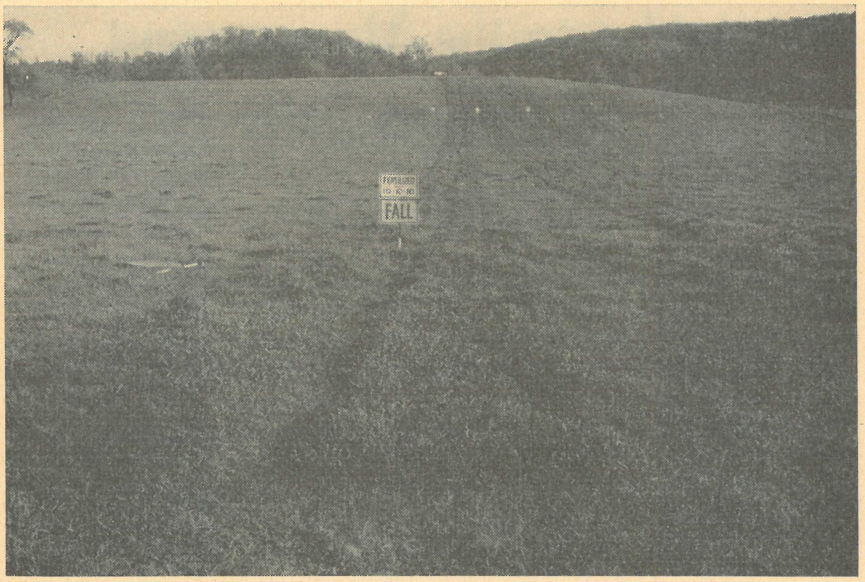

Fig. 3. Soil tests for available phosphorus, available potassium, available nitrogen and acidity on samples taken from this field indicated a fair to low content in all elements. (Available P, 10 lbs.; Available K, 180 lbs.; Available N, 325 lbs.; pH, 5.5). Little wonder that the application of a complete (10-10-10) fertilizer made such a tremendous showing. A comparison was made of fall vs. spring application. The fall treated area got off to an earlier start than where fertilizer was applied in the spring, and yields were somewhat better.

trative heads of the College. The initial step was a two-day conference at Ashland of administrative heads, including departmental chairmen as well as county agents and farm leaders from this northern area, Dr. E. B. Fred (then dean of our College of Agriculture) and Walter Hodgkins (then president of the University Board of Regents).

The livestock people offered the suggestion that there was much to be desired in the way of herd improvement. "Too many scrub cows! Poor quality feed," they said. They suggested a program of artificial insemination for the dairy farmers of this northern area.

The economics people voiced their opinions. "Cut costs of production! Increase the output of quality feed! Betters cows and a greater diversification of farm income," they said.

The crops people summed up the situation in very few words: "Convert the weed-infested hay and pasture meadows of the area into good, high quality, protein-rich forage crops! Grow more grain and practice a system of shorter rotations!"

Professor Emil Truog, then chairman of the Department of Soils, elaborated on the basic fundamentals of soil fertility, lime, and fertilizers, and the importance of mineral-rich soils as a starting place in a program of crop improvement and the eventual development of better herds of dairy cattle. Without question, Professor Truog had hit upon the real and basic reason for low yields and poor quality of hay and grain in that north country.

Topdress Grassland Meadows With Nitrogen

The first year we started out with nitrogen only on those old June grass or timothy quack meadows. The results were very good on some fields but on others just fair, and in some cases all it did was to green up the

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Nitrogen Use Accentuates Need for Minerals

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Fig. 4. Pastures treated with balanced fertilizers such as 10-10-10 or 12-12-12 produce an abundance of protein, vitamin-mineral rich feed that makes milk at low cost.

grass. There wasn't much of any increase in total yield.

The second year, 1946, on one half of each acre plot, we backed this nitrogen up with an application of 0-20-20. The results were outstanding, in fact, spectacular. But which was it?—the phosphate or the potash that was responsible for the greatest increase in yield on those plots that received the 0-20-20 in addition to the nitrogen?

Some of my associates, who had consistently opposed the application of superphosphate as a topdressing on pastures, insisted that it was the potash in the 0-20-20 that was chiefly responsible for the phenomenal increases in yields of grass. So in 1947 we split our acre plots into three strips—one strip with nitrogen only, one with nitrogen plus superphosphate, and the other received the complete treatment of nitrogen plus 0-20-20.

The results of our 1947 work proved without question that phosphate was important and would produce substantial increases in yield, but where potash was added, yields of grass or hay were hiked to even higher levels. Table I gives the results of all the 1947 demonstrations. Table II gives the average yield for the nitrogen only plots. Table III gives the average of all plots where nitrogen only was compared with plots where minerals (P and K) were added.

This piece of extension work in northern Wisconsin in the years 1945, 1946, and 1947 is highly significant now in the light of the recent tremendous development in the use of nitrogen fertilizers.

TABLE I.—RESPONSE OF GRASS PASTURES OR HAY MEADOWS TO TREATMENT WITH NITROGEN IS LIMITED WHEN PHOSPHATE OR POTASH IS LACKING

Name and address of farmer & soil type	Crop	Treatment & rate per acre	Yield per acre	Increases per acre	Cost of fertilizer [1]	Value of increase [2]	Profit over cost of fertilizer
Bayfield County			*lbs.*	*lbs.*			
Joe Brandis Mason, Route 3 Superior loam	Timothy & quack 10% clover	Ammonium nitrate at 200#	2,250	375	$6.00	$3.75	$−2.25
		Ammonium nitrate at 200# + 0–20–0 at 250#	3,900	2,025	7.88	20.25	12.37
		Ammonium nitrate at 200# + 0–20–20 at 250#	5,625	3,750	12.67	37.50	24.83
		No fertilizer	1,875				
Louis Larson Grandview Superior loam	Timothy & quack (pasture)	Ammonium nitrate at 200#	2,100	975	6.00	9.75	3.75
		Ammonium nitrate at 200# + 0–20–0 at 250#	3,900	2,775	7.88	27.75	19.87
		Ammonium nitrate at 200# + 0–20–20 at 250#	4,500	3,375	12.67	33.75	21.08
		No fertilizer	1,125				
Walter Wold & Sons Cable Kennan loam (High fertility level)	Timothy & 15% clover	Ammonium nitrate at 200#	6,225	2,475	6.00	24.75	18.75
		Ammonium nitrate at 200# + 0–20–0 at 250#	4,120	Yield data	inconsistent		
		Ammonium nitrate at 200# + 0–20–20 at 250#	6,300	2,545	12.67	25.45	12.78
		No fertilizer	3,750				
Arnold Jacobson Washburn Superior sandy loam	Timothy & June grass 10% clover	Ammonium nitrate at 200#	1,500	150	6.00	1.50	−4.50
		Ammonium nitrate at 200# + 0–20–0 at 250#	2,250	900	7.88	9.00	1.12

		Ammonium nitrate at 200# + 0–20–20 at 250#	3,000	1,650	12.67	16.50	3.83
		No fertilizer	1,350				
Ashland County Joe Schneider Ashland, Route 1 Superior clay loam	Timothy & 10% clover	Ammonium nitrate at 200#	4,950	2,100	6.00	21.00	15.00
		Ammonium nitrate at 200# + 0–20–0 at 250#	4,125	1,275	7.88	12.75	4.87
		Ammonium nitrate at 200# + 6–20–20 at 250#	6,000	3,150	12.67		18.83
		No fertilizer	2,850				
Nester Heine Marengo Superior clay loam (Plot # 1)	Timothy & 25% alfalfa	Ammonium nitrate at 200#	3,750	2,100	6.00	21.00	15.00
		Ammonium nitrate at 200# + 0–20–20 at 250#	4,200	2,550	12.67	25.50	12.83
		0–20–20 at 250#	3,075	1,425	6.67	14.25	7.58
		No fertilizer	1,650				
Nester Heine Marengo Superior clay loam (Plot # 2)	Timothy & 10% clover	Ammonium nitrate at 200#	5,550	3,300	6.00	33.00	27.00
		Ammonium nitrate at 200# + 0–20–0 at 250#	5,775	3,525	7.88	35.25	27.37
		Ammonium nitrate at 200# + 0–20–20 at 250#	7,125	4,875	12.67	48.75	36.07
		No fertilizer	2,250				
Mrs. Theresa Bucheger Butternut Kennan loam (High fertility)	Timothy & 10% clover	Ammonium nitrate at 200#	7,200	3,600	6.00	36.00	30.00
		Ammonium nitrate at 200# + 0–20–0 at 250#	6,750	3,150	7.88	31.50	23.62

TABLE I.—RESPONSE OF GRASS PASTURES OR HAY MEADOWS TO TREATMENT WITH NITROGEN IS LIMITED WHEN PHOSPHATE OR POTASH IS LACKING—*Continued*

Name and address of farmer & soil type	Crop	Treatment & rate per acre	Yield per acre	Increases per acre	Cost of fertilizer [1]	Value of increase [2]	Profit over cost of fertilizer
			lbs.	*lbs.*			
		No fertilizer	3,600				
Christ Vogt, Jr. Butternut Kennan loam	Timothy & 10% clover	Ammonium nitrate at 200#	4,500	1,500	6.00	15.00	9.00
		Ammonium nitrate at 200# + 0–20–0 at 250#	6,300	3,300	7.88	33.00	25.12
		Ammonium nitrate at 200# + 0–20–20 at 250#	7,500	4,500	12.67	45.00	32.33
		No fertilizer					
Harold Mertis Glidden Kennan loam	Timothy & 10% clover	Ammonium nitrate at 200# + 0–20–0 at 400#	4,800	2,550	(Nitrogen only charged) 6.00	25.50	19.50
		Ammonium nitrate at 200# + 0–20–20 at 400#	7,050	(Nitrogen plus ½ potash charged) 4,800	19.34	48.00	28.66
		0–20–0 at 400# only	2,250				
John Frankie Highbridge Kennan loam	Timothy & 10% clover	Ammonium nitrate at 200#	1,350	225	6.00	2.25	−3.75
		Ammonium nitrate at 200# + 0–20–0 at 250#	2,625	1,500	7.88	15.00	7.12
		Ammonium nitrate at 200# + 0–20–20 at 250#	3,600	2,475	12.67	24.75	12.08
		No fertilizer	1,125				

Iron County Anton Gibowski Saxon	Timothy & clover	Ammonium nitrate at 200#	3,900	2,550	6.00	25.50	19.50
		Ammonium nitrate at 200# + 0–20–0 at 250#	4,500	3,150	7.88	31.50	23.62
		Ammonium nitrate at 200# + 0–20–20 at 250#	5,625	4,275	12.67	42.75	30.08
		No fertilizer	1,350				
Niile Maenpaa Hurley Kennan loam (Old sod)	Timothy & June grass	Ammonium nitrate at 200#	1,275	525	6.00	5.25	−.75
		Ammonium nitrate at 200# + 0–20–0 at 250#	2,250	1,500	7.88	15.00	7.12
		Ammonium nitrate at 200# + 0–20–20 at 250#	2,625	1,875	12.67	18.75	6.08
		No fertilizer	750				
K. H. McKellar Hurley, Route # 1	Timothy & June grass	Ammonium nitrate at 200#	1,725	975	6.00	9.75	3.75
		Ammonium nitrate at 200# + 0–20–0 at 250#	1,875	1,125	7.88	11.25	3.37
		Ammonium nitrate at 200# + 0–20–20 at 250#	2,475	1,725	12.67	17.25	4.58
		No fertilizer	750				
Ed Maki Hurley, Route 1 Kennan loam	Timothy & June grass	Ammonium nitrate at 200#	2,625	850	6.00	8.50	2.50
		Ammonium nitrate at 200# + 0–20–0 at 250#	3,750	1,875	7.88	18.75	10.87
		Ammonium nitrate at 200# + 0–20–20 at 250#	5,475	3,600	12.67	36.00	23.33

TABLE I.—RESPONSE OF GRASS PASTURES OR HAY MEADOWS TO TREATMENT WITH NITROGEN IS LIMITED WHEN PHOSPHATE OR POTASH IS LACKING—*Continued*

Name and address of farmer & soil type	Crop	Treatment & rate per acre	Yield per acre	Increases per acre	Cost of fertilizer [1]	Value of increase [2]	Profit over cost of fertilizer
			lbs.	*lbs.*			
		No fertilizer	1,875				
Mulford Callam Hurley, Route 1 Kennan loam	Timothy & 10% clover (2nd year hay)	Ammonium nitrate at 200#	2,025	75	6.00	.75	−5.25
		Ammonium nitrate at 200# + 0–20–0 at 250#	5,100	3,150	7.88	31.50	23.62
		Ammonium nitrate at 200# + 0–20–20 at 250#	6,000	4,050	12.67	40.50	27.63
		No fertilizer	1,950				
	Timothy & June grass (Old sod)	Ammonium nitrate at 200#	2,475				
		Ammonium nitrate at 200# + 0–20–20 at 250#	5,100	(Increase 2,625	for 0–20–20 o 6.67	ver nitrate) 26.25	19.55
Sawyer County Victor Olker Hayward Sandy loam	Timothy & 10% clover	Ammonium nitrate at 200#	3,375	1,000	6.00	10.00	4.00
		Ammonium nitrate at 200# + 0–20–10 at 225#	4,000	1,625	8.39	16.25	7.86
		No fertilizer	2,375				
	Pasture timothy & June grass	Ammonium nitrate at 200#	2,750	1,250	6.00	12.50	6.50
		Ammonium nitrate at 200# + 0–20–0 at 250#	4,000	2,500	7.88	25.00	17.12

		Ammonium nitrate at 200# + 0–20–20 at 250#	4,750	3,250	12.67	32.50	19.83
		No fertilizer	1,500				
Carroll Holland Hayward, Route 1 Kennan loam	Timothy & 10% clover	Ammonium nitrate at 200#	4,250	500	6.00	5.00	−1.00
		Ammonium nitrate at 200# + 0–20–0 at 250#	5,250	1,500	7.88	15.00	7.12
		Ammonium nitrate at 200# + 0–20–20 at 250#	6,000	2,250	12.67	22.50	9.83
		No fertilizer	3,750				
B. O. Wells Hayward Kennan silt loam	Timothy & June grass	Ammonium nitrate at 200#	4,000	2,250	6.00	22.50	16.50
		Ammonium nitrate at 200# + 0–20–0 at 250#	4,500	2,750	7.88	27.50	19.62
		Ammonium nitrate at 200# + 0–20–20 at 250#	5,000	3,250	12.67	32.50	19.83
		No fertilizer	1,750				
Transient Camp (Old Indian School Farm) Sandy loam	Timothy & June grass	Ammonium nitrate at 200#	2,000	1,250	6.00	12.50	6.50
		Ammonium nitrate at 200# + 0–20–0 at 250#	2,625	1,875	7.88	18.75	10.87
		Ammonium nitrate at 200# + 0–20–20 at 250#	3,250	2,500	12.67	25.00	12.33
		No fertilizer	750				

(1) The entire cost of ammonium nitrate and one half the cost of 0-20-0 and 0-20-20 charged here. Ammonium nitrate figured at $60.00 per ton.
(2) Hay figured at $20.00 per ton.
(3) Pasture plots (a portion fenced out and harvested as hay).

TABLE II.—AVERAGE YIELDS OF ALL HAY OR PASTURE PLOTS (1945, 1946, 1947) IN BAYFIELD, ASHLAND, IRON, VILAS, PRICE, AND SAWYER COUNTIES WHERE AMMONIUM NITRATE ONLY AT 200# PER ACRE WAS COMPARED WITH NO TREATMENT. (A PORTION OF PASTURE PLOTS FENCED OUT AND HARVESTED AS HAY).

Treatment and rate per acre	Hay yield per acre	Increase per acre	Value of increase [1]	Cost of fertilizer [2]	Profit over cost of fertilizer
Ammonium nitrate at 200# (average of all plots)	3,961	1,819	$18.19	$6.00	$12.19
No fertilizer (average of all plots)	2,142				

(1) The entire cost of ammonium nitrate and one half the cost of 0-20-0 and 0-20-20 charged here. Ammonium nitrate figured at $60.00 per ton.
(2) Hay figured at $20.00 per ton.

10-10-10 or 12-12-12 the Answer?

It is not surprising that with this background, the writer has been one of the leading advocates of balanced fertility in his program of pasture improvement. While I have talked and written much about 10-10-10 for pastures, I have recognized the fact that the mineral needs of soils vary and farmers must be guided in their use of fertilizer by regional needs, soil tests, and experiment station work.

But one thing I am sure of and that is the fact that this great increase in the use of straight nitrogen—whether it be ammonium nitrate, urea, or anhydrous ammonia—will pump minerals out of our soils at an accelerated rate. I shall continue to talk about the great potentials for low cost feed, food, and fiber production through the use of nitrogen fertilizer—but along with it, the use of adequate supplies of minerals—both major and minor.

TABLE III.—AVERAGE YIELDS OF ALL HAY OR PASTURE PLOTS (1946 AND 1947) IN BAYFIELD, ASHLAND, IRON, VILAS, AND SAWYER COUNTIES WHERE AMMONIUM NITRATE ONLY WAS COMPARED WITH AMMONIUM NITRATE IN COMBINATION WITH 0-20-0 OR 0-20-20 AND NO TREATMENT. (YIELDS OF THE 0-20-0 AND 0-20-20 PLOTS WITH NITRATE WERE AVERAGED TOGETHER).

Treatment and rate per acre	Hay yield per acre	Increase per acre	Value of increase [1]	Cost of fertilizer [2]	Profit over cost of fertilizer
Ammonium nitrate at 200# per acre (average of all plots)	3,289	1,429	$14.29	$6.00	$ 8.29
Ammonium nitrate at 200# plus 0–20–0 or 0–20–20 at 250#	4,749	2,889	28.89	9.90	18.99
No fertilizer.....	1,860				

(1) The entire cost of ammonium nitrate and one half the cost of 0-20-0 and 0-20-20 charged here. Ammonium nitrate figured at $60.00 per ton.
(2) Hay figured at $20.00 per ton.
(3) Pasture plots (a portion fenced out and harvested as hay).