CONSERVATION AGRONOMY TECHNICAL NOTES

U. S. DEPARTMENT OF AGRICULTURE   NEW MEXICO   SOIL CONSERVATION SERVICE

NOTE NO. 23

January 12, 1973

RE: Plant Food Elements - Nitrogen - "The Green and Growing Element"

At least sixteen elements have been commonly recognized as being essential for normal plant growth and development. These elements are carbon, hydrogen, oxygen, nitrogen, phosphorus potassium, calcium, magnesium, sulfur, zinc, iron, manganese, boron, copper, molybdenum and chlorine. There is some evidence that cobalt, sodium, flourine, lithium, vanadium and iodine may also be essential in plant growth.

The first three elements listed above - carbon, hydrogen and oxygen are usually obtained by plants from water and air. They are responsible for about 95 per cent of the dry weight of a plant. The remaining 5 per cent of the dry weight contains the three <u>primary plant food elements</u> - nitrogen, phosphorus and potassium; the <u>secondary elements</u> - calcium, magnesium and sulfur and the <u>minor</u>, <u>trace</u> or <u>micro elements</u> - iron, zinc, manganese, copper, boron, molybdenum and chlorine.

The primary, secondary and minor or trace elements must be secured by the plant from the natural supply present in the soil or from fertilizer materials added to the soil.

Attachment

AO
WRTSC, Portland - 2
Adjoining States - 1
NM Records Management - 1

Insuring that well balanced and adequate supplies of plant food elements are available for plant use is a key factor in any conservation program designed for high levels of management and production. Because of this, a series of Agronomy Technical Notes is planned to transmit information on plant food elements which are most likely to be deficient in our soils.

The attached technical note on Nitrogen is the first of the planned series. If additional copies of this technical note are needed for individual reference and use in the field, request them from the Plant Sciences Section.

NITROGEN - ABUNDANT or SCARCE?

Above the ground it's abundant. In its pure state nitrogen is a colorless, odorless, inert gas which makes up about 78-80 per cent of the air we breathe. In the air over every acre there are about 35,000 tons of nitrogen that can be utilized by either synthetic nitrogen fixation processes or by properly inoculated leguminous plants, such as the clover and alfalfa.

Small amounts of nitrogen are obtained by the fixation of nitrogen in the soil by certain bacteria. Storms producing rain and snow also wash small amounts of nitrogen from the atmosphere into the soil.

Almost all of the nitrogen found in soils is an integral part of organic matter. Organic matter averages about 5 per cent nitrogen. The ratio of carbon to nitrogen in most soils ranges between 10 and 12 to 1.

The amount of nitrogen in the soil varies, and did so even before cultivation took place because of differences in climate, soil properties, type of vegetation and other biological factors.

Over 40 years ago, Dr. Hans Jenny showed that nitrogen content of soils varied inversely with mean annual temperature. Average nitrogen content of surface soils varied from as little as 0.05 to 0.5 per cent or from 1,000 to 10,000 pounds of nitrogen per acre. He concluded that the average nitrogen content of soil increased two or three times for every 18°F. drop in mean annual temperature as you travel northward from the Gulf of Mexico to Canada.

Different management practices and amounts of nitrogen removed by crops will result in different levels of soil nitrogen within a given soil type. Usually the loss of nitrogen has been more rapid with clean-tilled crops, intermediate with cereal crops and smallest with legume and sod crops. Nitrogen increases in soils have occurred only when the nitrogen content was very low in the beginning.

<u>Organic nitrogen</u> is not subject to loss except where soil erosion occurs. However, before organic nitrogen can be utilized by growing plants, it must be changed to simple inorganic or mineral forms. This transformation is accomplished by various soil bacteria, fungi and other micro-organisms. The over-all process is called <u>mineralization</u> and involves the following steps:

Step 1. Organic matter nitrogen → ammonium ions (NH_4) + (Many kinds of soil micro-organisms can convert organic nitrogen to ammonium nitrogen.)

Step 2. Ammonium nitrogen (NH_4) → nitrite ions (NO_2)-

Step 3. Nitrite nitrogen (NO_2) → nitrate ions (NO_3)-

Specific bacteria are required for steps 2 and 3. These two steps in the process are commonly called <u>nitrification</u>.

Nitrification normally takes place so quickly in well-aerated soils that very little nitrogen will accumulate as NH_4 or NO_2. Because of this under most conditions the dominant mineral form of nitrogen is NO_3.

Factors which influence the rate nitrogen mineralizes include temperatures, soil moisture, soil pH, oxygen supply and other nutrients.

Crop residues which are returned to the soil are decomposed by soil micro-organisms. Depending upon the amount of residue and its nitrogen content, varying amounts of mineral nitrogen together with nitrogen from the rotting crop residues will be used as food by the living micro-organisms which are doing the work of decomposition.

This process of cycling nitrogen back into the organic pool of living microbial tissue and other soil organic matter is called immobilization - nitrogen mineralization and immobilization go on simultaneously in the soil. Until the needs of the micro-organisms to carry on decomposition have been met, little nitrogen is available for crop use.

NITROGEN LOSSES

If the rate of nitrogen mineralization more than satisfies the needs of both the micro-organisms and the crop, some of the excess NO_3 may be carried downward in the soil. Sometimes penetration is even below the root zone because of percolating water. This usually happens only when rainfall or irrigation water may be supplied in excess of that used by the crop and retained in the soil profile. Ammonium N (NH_4) does not move in this manner.

Under certain conditions nitrate N (NO_3) can also be lost by a process known as <u>denitrification</u>. In low-oxygen zones of the soil where aeration is poor because of water-logging, for example, nitrate N can be reduced to gaseous forms including certain oxides of nitrogen and elemental nitrogen gas (N_2).

AVAILABILITY OF SOIL NITROGEN

A determination of soil nitrogen content does not provide one with a reliable basis for predicting how much nitrogen the soil will deliver to a growing crop. Only a small fraction of the total soil nitrogen is available to a crop during one season. The range extends from practically none to as high as 10 per cent. With most agricultural soils the range is from 1 per cent to 6 per cent.

FUNCTION OF NITROGEN

1. Gives the healthy dark green color to plants.

2. Stimulates above-ground growth.

3. Induces rapid growth.

4. Increases yields of leaf, fruit or seed. Encourages the plumpness and succulence of fruit and grains.

5. Improves quality of leaf crops.

6. Increases protein content of food and feed crops.

7. Stimulates use of potassium, phosphorus and other nutrients.

8. Feeds soil micro-organisms during the decomposition of low-nitrogen organic materials.

An excess of nitrogen can produce harmful effects such as delaying maturity or ripening of the crop, lowering its quality weakening the plant, causing "lodging" and decreasing its resistance to disease. Therefore nitrogen must be used in balanced ratio with other plant foods.

SYMPTOMS OF A NITROGEN-STARVED PLANT

1. A distincly slow and dwarfed growth. A stunted plant.

2. A pale yellowish plant.

3. "Firing" of tips and margins of leaves, starting at the bottom of the plant and proceeding upward. In plants like corn, grain and grasses, the "firing" starts at the tip of the bottom leaves and proceeds down the center, or along the midrib.

4. Low protein content.

SOME PRINCIPAL SOURCES AND AVERAGE

Fertilizer Materials	Chemical Formula	Total Nitrogen N%
Ammonium Nitrate	NH_4NO_3	33.5
Mono Ammonium Phosphate	$NH_4H_2PO_4$	11
Ammonium Phosphate Sulfate	$NH_4H_2PO_4(NH_4)_2SO_4$	13
Ammonium Phosphate Sulfate	40% $NH_4H_2PO_4$ 60% $(NH_4)_2SO_4$	16
Ammonium Phosphate Nitrate Ammonium Nitrate Phosphate Ammonium Phosphate Nitrate	$NH_4H_2PO_4$ NH_4NO_3	24 27
Diammonium Phosphate	$(NH_4)_2HPO_4$	21
Ammoniated Single Superphosphate	Complex Ammonia Compounds	3-4
Ammoniated Triple Superphosphate	Complex Ammonia Compounds	4-6
Nitric Phosphates	Complex compounds	14-20
Ammonium Chloride	NH_4CL	25
Ammonium Sulfate	$(NH_4)_2SO_4$	20-21
Anhydrous Ammonia	NH_3	82
Aqua Ammonia	NH_4OH	20
Ammonia-Ammonium Nitrate Solutions	NH_4NO_3 NH_4OH	40
Calcium-Ammonium Nitrate Solution	11.6% $Ca(NO_3)_2$ 5.4% NH_4NO_3	17
Calcium Nitrate	$Ca(NO_3)_2$	15.5
Calcium Cyanamide	$CaCN_2$	20-22
Sodium Nitrate	$NaNO_3$	16
Urea	$CO(NH_2)_2$	45-46
Urea-Formaldehyde (urea form)	Reaction products of urea and formaldehyde	38
Urea-Ammonium Nitrate Solution	35.4% $Co(NH_2)_2$ 44.3% NH_4NO_3	32
Nitrate of Soda-Potash	$NANO_3KNO_3$	15
Potassium Nitrate	KNO_3	13

COMPOSITION OF NITROGEN FERTILIZER MATERIALS

Available Phosphoric Acid P_2O_5%	Water Soluble Potash K_2O%	Combined Calcium CA%	Combined Sulfur S%	Equivalent Acidity or Bacidity in pounds of calcium carbonate per 100 lbs. of each material	
				Acid	Base
--	--	--	--	62	--
48	--	1.4	2.6	58	--
39	--	--	7.0	69	--
20	--	0.6	15.4	88	--
20	--	--	--	60	--
14	--	--	--	60	--
53	--	--	--	75	--
16-18	--	15.0	12.0	4-7	--
42-45	--	12.9	1.0	11-14	--
14-20	--	8.0-10.0	0-4.0	15-29	--
--	--	--	--	140	--
--	--	--	24	110	--
--	--	--	--	147	--
--	--	--	--	36	--
--	--	--	--	80	--
--	--	8.8	--	9	--
--	--	21.0	--	--	20
--	--	37.0	--	--	63
--	--	--	--	--	29
--	--	--	--	71	--
--	--	--	--	--	--
--	--	--	--	57	--
--	14	--	--	--	25
--	44	--	--	--	23

HOW TO FIGURE FERTILIZER EQUIVALENTS - NITROGEN
Conversions Based on Contained Nitrogen

Nitrogen (N) in pounds X 1.2159	=	Ammonia (NH_3) in pounds
Ammonia (NH_3) in pounds X 0.8224	=	Nitrogen (N) in pounds
Nitrogen (N) in pounds X 4.4266	=	Nitrate (NO_3) in pounds
Nitrate (NO_3) in pounds X 0.2259	=	Nitrogen (N) in pounds
Nitrogen (N) in pounds X 6.25	=	Crude protein in pounds
Crude Protein in pounds X 0.160	=	Nitrogen (N) in pounds
Ammonium Sulfate $(NH_4)_2SO_4$ in pounds X 0.2120	=	Nitrogen (N) in pounds
Nitrogen (N) in pounds X 4.7168	=	Ammonium Sulfate $(NH_4)_2SO_4$ in pounds
Ammonium Sulfate $(NH_4)_2SO_4$ in pounds X 0.2574	=	Ammonia (NH_3) in pounds
Ammonia (NH_3) in pounds X 3.8793	=	Ammonium Sulfate $(NH_4)_2SO_4$ in pounds
Ammonium Sulfate $(NH_4)_2SO_4$ in pounds X 0.2426	=	Sulfur (S) in pounds
Sulfur (S) in pounds X 4.1211	=	Ammonium Sulfate $(NH_4)_2SO_4$ in pounds
Ammonium Nitrate (NH_4NO_3) in pounds X 0.4255	=	Ammonia (NH_3) in pounds
Ammonia (NH_3) in pounds X 2.3499	=	Ammonium Nitrate (NH_4NO_3) in pounds
Ammonium Nitrate (NH_4NO_3) in pounds X 0.3500	=	Nitrogen (N) in pounds
Nitrogen (N) in pounds X 2.8571	=	Ammonium Nitrate (NH_4NO_3) in pounds
Calcium Nitrate $Ca(NO_3)_2$ X 0.1707	=	Nitrogen (N) in pounds
Nitrogen (N) in pounds X 5.8572	=	Calcium Nitrate $Ca(NO_3)_2$ in pounds

Calcium Nitrate $Ca(NO_3)_2$ in pounds X 0.2076	=	Ammonia (NH_3) in pounds
Ammonia (NH_3) in pounds X 4.8172	=	Calcium Nitrate $Ca(NO_3)_2$ in pounds
Calcium Nitrate $Ca(NO_3)_2$ in pounds X 0.2442	=	Calcium (Ca) in pounds
Calcium (Ca) in pounds X 4.0942	=	Calcium Nitrate $Ca(NO_3)_2$ in pounds
Nitrate of Soda ($NaNO_3$) in pounds X 0.1648	=	Nitrogen (N) in pounds
Nitrogen (N) in pounds X 6.0679	=	Nitrate of Soda ($NaNO_3$) in pounds
Nitrate of Soda ($NaNO_3$) in pounds X 0.2705	=	Sodium (Na) in pounds
Sodium (Na) in pounds X 3.6970	=	Nitrate of Soda ($NaNO_3$) in pounds
Nitrate of Soda ($NaNO_3$) in pounds X 0.2004	=	Ammonia (NH_3) in pounds
Ammonia (NH_3) in pounds X 4.9905	=	Nitrate of Soda ($NaNO_3$) in pounds
Urea $CO(NH_2)_2$ in pounds X 0.4665	=	Nitrogen (N) in pounds
Nitrogen (N) in pounds X 2.1437	=	Urea $CO(NH_2)_2$ in pounds
Urea $CO(NH_2)_2$ in pounds X 0.5672	=	Ammonia (NH_3) in pounds
Ammonia (NH_3) in pounds X 1.7631	=	Urea $CO(NH_2)_2$ in pounds
Mono Ammonium Phosphate ($NH_4H_2PO_4$) in pounds X 0.1481	=	Ammonium (NH_3) in pounds
Ammonium (NH_3) in pounds X 6.7538	=	Mono Ammonium Phosphate ($NH_4H_2PO_4$) in pounds
Mono Ammonium Phosphate ($NH_4H_2PO_4$) in pounds X 0.1218	=	Nitrogen (N) in pounds
Nitrogen (N) in pounds X 8.2118	=	Mono Ammonium Phosphate ($NH_4H_2PO_4$) in pounds

Mono Ammonium Phosphate ($NH_4H_2PO_4$) in pounds X 0.6170	=	Phosphorus Pentoxide (P_2O_5) in pounds
Phosphorus Pentoxide (P_2O_5) in pounds X 1.6207	=	Mono Ammonium Phosphate ($NH_4H_2PO_4$) in pounds
Diammonium Phosphate $(NH_4)_2HPO_4$ in pounds X 0.2579	=	Ammonia (NH_3) in pounds
Ammonia (NH_3) in pounds X 3.8769	=	Diammonium Phosphate $(NH_4)_2HPO_4$ in pounds
Diammonium Phosphate $(NH_4)_2HPO_4$ in pounds X 0.2121	=	Nitrogen (N) in pounds
Nitrogen (N) in pounds X 4.7138	=	Diammonium Phosphate $(NH_4)_2HPO_4$ in pounds
Diammonium Phosphate $(NH_4)_2HPO_4$ in pounds X 0.5374	=	Phosphorus Pentoxide (P_2O_5) in pounds
Phosphorus Pentoxide (P_2O_5) in pounds X 1.8607	=	Diammonium Phosphate $(NH_4)_2HPO_4$ in pounds
Potassium Nitrate (KNO_3) in pounds X 0.4658	=	Potash (K_2O) in pounds
Potash (K_2O) in pounds X 2.1466	=	Potassium Nitrate (KNO_3) in pounds
Potassium Nitrate (KNO_3) in pounds X 0.1385	=	Nitrogen (N) in pounds
Nitrogen (N) in pounds X 7.2178	=	Potassium Nitrate (KNO_3) in pounds

SOME ADDITIONAL SOURCES AND AVERAGE
COMPOSITION OF PRIMARY PLANT FOOD MATERIALS

Animal Wastes and Organic Materials	Nitrogen (% N)	Phosphoric Acid (% P_2O_5)	Potassium Oxide (% K_2O)	Organic Matter (% OM)
Dairy Manure	.60-.70	.15-.30	.45-.65	30
Goat Manure	2.77	1.78	2.88	60
Hog Manure	.50-1.00	.35-.75	.40-.85	30
Horse Manure	.70	.25-.35	.52-.55	60
Sheep Manure	.95-2.00	.35-1.00	1.00-2.50	60
Steer Manure	.60-2.00	.15-.54	.45-1.92	60
Rabbit Manure	2.00	1.33	1.20	50
Poultry Droppings	4.00	3.2	1.9	74
Poultry Manure	1.00-1.60	.85-1.25	.40-.90	50
Seaweed (Kelp)	.2	.1	.6	80
Alfalfa Hay	2.5	.50	2.10	85
Alfalfa Straw	1.5	.30	1.50	82
Bean Straw	1.2	.25	1.25	82
Grain Straw	.60	.20	1.10	80
Cotton Gin Trash	.73	.18	1.19	80
Winery Pomace (Dried)	1.0-2.0	1.5	0.5-1.0	80
Olive Pomace	1.2	.8	.5	80
Wheat Straw	.50	.15	.60	90
Barley Straw	.83	.28	1.53	80
Rye Straw	.56	.26	.90	93
Oat Straw	.64	.20	1.25	90
Millet	.70	.18	1.70	87

SOME ADDITIONAL SOURCES AND AVERAGE
COMPOSITION OF PRIMARY PLANT FOOD MATERIALS

Organic Concentrates	Nitrogen (% N)	Phosphoric Acid (% P_2O_5)	Potassium Oxide (% K_2O)	Organic Matter (% OM)
Dried Blood	13.0	1.5	--	80
Fish Meal	10.4	5.9	--	80
Septic Sludge (Digested)	2.0	3.01	--	50
Sewage Sludge (Activated)	5.0-6.0	2.9	.60	--
Nitroganic	6.5	3.4	.30	80
Tankage	7.0	8.6	1.50	80
Cottonseed Meal	6.0-6.5	2.6-3.0	1.40-1.50	80
Bat Guano (Recent Deposits)	8.0-13.0	4.0-5.0	2.00	30
Bat Guano (Older Deposits)	1.0-4.0	10.0-20.0	trace	--
Bone Meal (Steamed)	2.82	26.30	--	--
Bone Meal (Raw)	4.27	18.50	--	--
Castor Pomace	5.2-6.0	1.8-3.0	.50-1.10	80

LEGUMES AND NITROGEN

Legumes are normally expected to obtain most of their nitrogen supply from the atmosphere through the symbiotic nitrogen-fixing bacteria. The amounts of nitrogen obtained this way vary widely with the plant and the environment. Estimates run from less than 50 pounds per acre per year from some annuals to around 200 pounds for alfalfa.

Efforts to supplement the legume nitrogen supply by fertilization have generally been disappointing. The explanation appears to be that nitrogen-fixing bacteria tend to cease fixation in the presence of large amounts of available nitrogen. This sharply depressed fixation caused by heavy rates of nitrogen application decreases as the supply of the element added becomes depleted.

Some Approximate Maximum Amounts of Nitrogen Fixed Per Acre by Various Legumes

Crop	Lbs. N.
Alfalfa	194
Ladino Clover	179
Sweet Clover	119
Alsike Clover	119
Red Clover	114
White Clover	103
Crimson Clover	94
Cowpea	90
Lespedeza (annual)	85
Soy Beans	58

It should be kept in mind that if legumes are to fix the greatest amount of nitrogen, all other nutrients must be present in the right amounts. In addition, optimum conditions of temperature, aeration and moisture must exist.

RELATIVE NITROGEN REQUIREMENTS FOR SOME NEW MEXICO CROPS AND PLANTS

Very High Requirements	High Requirements	Medium Requirements
Asparagus	Barley	Apples
Beets (Early)	Beets (Late)	Beans (Dry)
Cabbage (Early)	Broccoli	Bent Grass
Cauliflower (Early)	Brussel Sprouts	Bermuda Grass
Celery (Early)	Cabbage (Late)	Bluegrass , Kentucky
Lettuce (Head)	Cantaloupes (Fruit)	Brome Grass
Potatoes, Irish (Early)	Carrots (Early)	Carrots (Late)
Spinach	Cauliflower (Late)	Cherries
	Celery (Late)	Cotton
	Corn, Sweet (Early)	Corn (Field)
	Cucumbers	Corn, Sweet (Late)
	Flowers (Annual)	Deciduous Plants
	Lettuce (Leaf)	Deciduous Shrubs
	Muskmelons (Fruit)	Deciduous Trees
	Oats	Flowers, (Perennials and bulbs)
	Onions	Grain Sorghum
	Potatoes, Irish (Late)	Grapes
	Putting Greens	Lawn, Parks and Fairways
	Radishes	Millet
	Squash (Early)	Orchard Grass
	Tomatoes (Late)	Peaches
	Wheat	Peas (Early)
		Playing Fields
		Plums
		Rye
		Rye Grass
		Squash (Late)
		Strawberries
		Sudan Grass
		Tall Fescue Grass
		Tall Wheat Grass
		Timothy
		Tomatoes (Early)
		Watermelons

RELATIVE NITROGEN REQUIREMENTS FOR SOME
NEW MEXICO CROPS AND PLANTS (cont.)

Low Requirements	Low Requirements (Because Nitrogen is Supplied by Legume Organisms)
Beans, Lima or String	Alfalfa
Blackberries	Alsike Clover
Blueberries	Ladino Clover
Evergreen plants	Peanuts
Evergreen shrubs	Peas, field
Evergreen trees	Red Clover
Pears	Soy Beans
Potatoes (Sweet)	Vetch, hairy
Raspberries	White Clover

REFERENCES

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