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TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE   BERKELEY, CALIFORNIA   SOIL CONSERVATION SERVICE

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CARBON AND NITROGEN CONTENTS AND RATIOS IN CROP RESIDUES

The attached Technical Note was prepared by J. W. Turelle, Regional Agronomist of the Technical Service Center in Portland.

Information in this Technical Note has application in California, particularly in the use of crop residues in conservation practices. Problems can arise when large quantities of crop residues are incorporated into the soil without provision being made for the required nitrogen and/or time necessary to allow for residue decomposition. Otherwise a "tie-up" of nitrogen may occur. Guidance is provided for calculating the amount of nitrogen required.

Additional data for the carbon and nitrogen content of residues common to the area should be added to this Technical Note for local use.

Attachment

TECHNICAL NOTES
U.S. DEPARTMENT OF AGRICULTURE — SOIL CONSERVATION SERVICE
WEST REGIONAL TECHNICAL SERVICE CENTER, PORTLAND, OREGON

CONSERVATION AGRONOMY NOTE NO. 24
W. TURELLE, Regional Agronomist

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"RULE OF THUMB ESTIMATES" OF THE RELATIONSHIPS OF CARBON TO NITROGEN IN CROP RESIDUES

1. Carbon and Nitrogen Content of Soil Organic Matter and Crop Residues

	Organic Carbon	Nitrogen
Crop residue	45%	0.1 - 2.5%
Soil organic matter	58%	3.0 - 6.0%

Average ratio of carbon to nitrogen in soil organic matter is 11.6 to 1 or 58% for C and 5% for N.

To convert organic carbon to soil organic matter multiply by 1.7.

To convert nitrogen to soil organic matter multiply by 20.

2. Importance of C:N Ratio in Relation to Crop Residues

a. Conversion of organic carbon in crop residues to soil organic matter is dependent upon the amount of nitrogen present in the residues.

b. Availability of nitrogen is determined by the C:N ratio. When the ratio is narrow (less than 30 or 35:1) nitrogen is released. If the ratio is wide (more than 30 or 35:1) nitrogen becomes temporarily unavailable.

3. Conversion of Crop Residues to Soil Organic Matter (Figures are approximate).

a. Crop residues contain about 45% organic carbon or 900 pounds per ton. Microorganisms use 2/3 of this carbon, or 600 pounds per ton, to change it to CO_2. Three hundred pounds of carbon remains for use as soil organic matter. 300 pounds x 1.7 = 500 lbs. (approx.) of soil organic matter under favorable conditions.

b. Both carbon and nitrogen are necessary to form soil organic matter. Assuming a soil organic matter-nitrogen ratio of 20:1, 500 lbs. of soil organic matter will contain 25 lbs. of nitrogen. Therefore, 25 lbs. of nitrogen is required for the conversion of a ton of crop residue to about 500 lbs. of soil organic matter when other conditions are favorable.

c. Assume a N content in a ton of wheat straw at 0.25%. This is equal to 5 lbs. of N. Since there is also 45% (900 lbs.) of organic carbon in this ton of straw the C:N ratio is 180 to 1. A nitrogen "tie-up" will occur as the amount of nitrogen needed for decomposing the residue is less than the approximate 25 lbs./ton required for this purpose. (Refer to Para. 3b). Twenty pounds of commercial N must be added in this case to make the conversion to soil organic matter.

d. Assume a N content in a ton of alfalfa at 2.25%. This is equivalent to 45 lbs. of N. The organic carbon content is 45% or 900 lbs. per ton alfalfa. The C:N ratio is 20:1. There is ample N (more than 25 lbs.) to help convert a ton of alfalfa residue to soil organic matter. The nitrogen not needed for decomposing residues will be available for the next growing crop.

4. Carbon and Nitrogen Content in Crops

Crops	Carbon (%)	Nitrogen (%)	C:N ratio
Peas in bloom	45.3	2.69	17:1
Alfalfa hay	43.1	2.34	18:1
Austrian peas (green manure)	45.0	2.53	18:1
Pea vines (mature)	44.0	1.50	29:1
Austrian pea straw	37.5	0.64	59:1
Wheat straw (Tetonia, Idaho)	43.6	0.49	88:1
Wheat straw (Moscow, Idaho)	43.6	0.26	168:1
Wheat straw (Oregon)	44.7	0.12	373:1

5. Data for Making Estimates

a. About 2% of total N in the soil becomes available for plant use with fallow or irrigation.

b. About 1% of total N in the soil becomes available for plant use under continuous cropping in non-irrigated areas.

c. Crop residues require a minimum of 1.25-1.5% nitrogen to avoid a temporary depressing effect on amount of nitrogen in the soil.

d. Approximately 500 lbs. of soil organic matter (humus) is the maximum that can be developed in the soil from one ton of crop residue - assuming all conditions are favorable for soil organic matter formation.

TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE — SOIL CONSERVATION SERVICE
WEST REGIONAL TECHNICAL SERVICE CENTER - PORTLAND, OREGON

CONSERVATION AGRONOMY NOTE NO. 28
F. L. BROOKS, JR., REGIONAL AGRONOMIST October 1967

FERTILIZER APPLICATION THROUGH IRRIGATION WATER

The following reproduction provides information concerning the application of various forms of fertilizer through irrigation water. This data should supply the answers to many of the questions received by the Soil Conservation Service concerning this practice.

Credit is given to the periodical IRRIGATION AGE, which published this information in its issue of July, 1967.

NITROGATION

Farmers are cutting costs and boosting yields applying nitrogen fertilizer in irrigation water

By Paul E. Fischbach

The practice of administering "plant stimulants" through irrigation water is an increasing-in-popularity prescription for farm crops. At this stage, the practice seems to have many cost-cutting and yield boosting factors going for it.

Applying nitrogen fertilizer in the irrigation water is more effective than applying it mechanically on sandy soils and just as effective as mechanical application on fine textured soils.

Applying fertilizer in the irrigation probably dates back to when an irrigator dug a pit, put barnyard manure in it, then ran his irrigation lateral through it. But only in recent years has it become a precise operation with consistent results comparable to mechanical application.

About the Author

Paul E. Fischbach is a professor... and the way he puts knowledge to work need not suggest anything impractical about the title. One of the nation's most respected irrigation engineers, he is Professor of Agricultural Engineering at University of Nebraska's College of Agriculture and Home Economics. A contributor to Irrigation Age almost from the magazine's beginning, Fischbach and his co-workers' research findings have helped set a frontrunner pace for plains irrigated farming.

cultivate or fertilize because time just won't permit both. In fact, he may need to cultivate (ditching operation) to irrigate.

Probably the best approach to top yields to be prepared to apply nitrogen fertilizer at any time - preplant, side dress or in the irrigation water. Storing all the nitrogen in the soil prior to the plant's need for it may not produce top yields.

Let's see why. Many plains locations this year received 12 inches of rain or more after the nitrogen was applied. Much of the rain penetrated into the soil, wetting it down to four or more feet. Consequently, the bulk of the nitrogen has been pushed down to lower depths in the potential root zone. These fields will need more nitrogen fertilizer in order to produce top yields. A good way to apply more is in the irrigation water.

In some areas, irrigation may not be needed near the critical stages of growth. Some irrigators may find themselves irrigating just to apply the fertilizer, although this is not likely to happen in the 17 western states. When corn is in the rapid growth stage through pollination, it is using 0.25 to 0.35 inches of water per day. Therefore, only three to four days after a rain, a one inch water application could be beneficially applied.

To do a good job of nitrogation, requires applying the same principles as doing a good job of irrigation.

Sprinkler irrigation systems. If a sprinkler system is designed so it gives good water distribution from one end of the lateral to the other, it will apply the nitrogen fertilizer with the same uniformity, provided the fertilizer is uniformly mixed with the irrigation water and is uniformly injected.

Only nitrogen solutions of ammonium nitrate and urea are recommended for sprinkler systems. Anhydrous ammonia, remember, has a tendency to precipitate the salts in the irrigation water and clog the sprinkler nozzles.

Nitrogen solutions can be injected during the entire sprinkling time or any portion of it. Some operators prefer to shut off the fertilizer injection about two hours prior to changing the sprinkler set. However, with all moving types of sprinkler systems, the nitrogen solution must be applied all during the irrigation time.

Surface irrigation systems. If the surface irrigation system is properly designed, constructed and operated for top crop production, it will distribute the nitrogen solution uniformly. Nitrate nitrogen goes where the water goes.

To accomplish this, the field or length of run should be land shaped to a fairly uniform grade. In general, the length of runs should not exceed 600 feet on loam sand soils and 1300 feet on silty clay loam soils. However, some clay soils have high intake rates and consequently, the length of run should be shortened accordingly.

When irrigating, water should flow through the field in two to three hours on loam sand soils and six to seven hours on silty clay soils. The operator will need to use maximum allowable furrow stream size. When applying nitrogen solutions in the irrigation water, the operator can inject the solution into the system until runoff has occurred for about 30 to 60 minutes. The entire irrigation set can be changed at this time, or the fertilizer turned off and continue irrigating until water has penetrated the desired depth into the soil.

There are many commercial meter-injectors on the market for injecting nitrogen solutions into sprinkler or gated pipe systems.

Preliminary tests at University of Nebraska indicate than an ordinary tap into the irrigation piping system is all that is required to get uniform mixing of the fertilizer solution with the irrigation water.

To be sure of uniform mixing, the fertilizer can be injected into the system just ahead of an elbow or tee in the irrigation line. Turbulence in the water, there, will assure uniform mixing.

For siphon tube or spile irrigation system, all that is needed is a float box which will give a uniform flow of the fertilizer solution into the irrigation water. A good place to put it into the system is at the pump site. Usually there is a stilling basin or something to dissipate the energy created by the water as it comes out of the pump. The fertilizer can be flowed into the irrigation water at this place. Adequate mixing will occur.

There are four decisions irrigators will have to make before they apply nitrogen fertilizer in irrigation water:

1. Amount and kind of fertilizer to use (see Table 1).

2. Number of acres that will be irrigated per set (see Table 2).

3. Amount of time for application of the fertilizer (see Table 3).

4. Rate at which the fertilizer solution will be injected into the irrigation system.

Soil tests are a reliable indicator of the amount of nitrogen to apply. Some farmers determine their nitrogen requirements by the amount needed by plants to produce a pre-determined yield.

For example, we know 200 bushels corn needs 325 pounds of nitrogen to produce the stalk and grain. However, some of this is stored in the soil and a soil test for initial nitrates will provide needed information.

It is not uncommon for irrigators to apply a total of 200 pounds of nitrogen on corn sometime during the cropping year to produce high yields. Some of it may be applied preplant, part of it side dress and a part of it in the irrigation water. As much as 150 pounds or more of nitrogen can easily be applied through the irrigation water. But, again, it is probably best that each farm operator have a choice of methods available to apply nitrogen.

One or a combination of methods may suit his needs best. Some choose to split an application of 200 pounds of nitrogen between preplant and the irrigation water. Others, of course, think other combinations better serve their interests. However, 20 to 40 pounds of additional nitrogen in the irrigation water constantly produces higher yields regardless of the amount previously applied.

It is important to get good distribution of fertilizer and irrigation water from the upper to the lower end of the field.

One method is to use as large an irrigation stream down each furrow as possible without causing serious erosion. (See maximum allowable furrow stream size for various slopes, Table 3) and inject the nitrogen solution continuously while irrigating. After the water reaches the far end of the field and water from all furrows has run off for 30 minutes, change the irrigation set. Even though the irrigation set has been changed to another set of furrows, water still will continue to run off the field from the original set of furrows. Runoff of water and fertilizer under this procedure will be about five percent.

Another method is to use as large an irrigation stream down each furrow as possible without causing serious erosion until the water has advanced three-fourths of the distance of the furrow. Then start injecting the nitrogen solution. This procedure is more complicated and requires more labor, yet doesn't produce any higher yields, according to Nebraska tests. There is also more time involved in watching the water so the operator knows when it has advanced to 3/4 the distance down the furrow. Consequently, fertilizer would need to be injected at a higher rate,- probably about twice the rate as the previously described method - in order to apply the same amount of fertilizer.

Maximum time for the water to flow through the field and the recommended length of the furrows for various textured soils is given in Table 4.

Intake and the rate of advance of water through the field is related to soil texture, except in the cases of some high clay content soils which have intake rates similar to a sandy loam soil.

Table 1. Amount of various nitrogen fertilizers required to give 20, 30 and 40 pounds of available nitrogen per acre.

Kind of Fertilizer	% Nitrogen	Wt. per Gal. at 60° F. (lbs)	Rate of N per acre, lbs. 20	30	40
Solutions				Gallons	
Urea-Ammonium nitrate	28	10.65	6.7	10.0	13.4
Urea-ammonium nitrate	32	11.06	5.7	8.6	11.4
Ammonium nitrate	21	10.73	8.9	12.4	17.8
Ammonium nitrate-ammonia*	37	9.91	5.4	8.1	10.8
Ammonium nitrate-ammonia*	41	9.48	5.1	77.7	10.2
Aqua ammonia	24	7.47	11.2	16.8	22.4
Anhydrous Ammonia*	82	5.15	4.7	7.1	9.4

*Calculations based on temperature of 60° F.

Table 2. Computing number of acres per irrigation set

Length of run in feet	Number of rows per set (40-inch rows) 20 ac.	40 ac.	60 ac.	80 ac.	100 ac.	120 ac.	140 ac.	160 ac.	180 ac.	200 ac.
300	.5	.9	1.4	1.8	2.3	2.8	3.2	3.6	4.1	4.6
500	.8	1.5	2.3	3.1	3.8	4.6	5.4	6.1	6.9	7.6
660	1.0	2.0	3.0	4.0	5.0	6.1	7.1	8.1	9.1	10.1
800	1.2	2.4	3.7	4.9	6.1	7.3	8.6	9.8	11.0	12.2
1000	1.5	3.1	4.6	6.1	7.6	9.2	10.7	12.2	13.8	15.3
1200	1.8	3.7	5.5	7.3	9.2	11.0	12.9	14.7	16.5	18.4
1300	2.0	4.0	5.9	7.9	9.9	11.9	13.9	15.8	17.8	19.8
1400	2.1	4.3	6.4	8.6	10.7	12.9	15.0	17.1	19.3	21.4

Table 2 can be used to determine the number of acres that will be irrigated by a given set of rows. In the left hand column of the table, find the length of run you are using. Then follow across to the right until you find the column under number of rows per set. The figure in this column is the acres being irrigated per set.

TABLE 3

Approximate Maximum Furrow Stream Size for Various Slopes*

Percent Slope	Gallons Per Minute Per Furrow
1.0	10
0.5	20
0.3	30
0.2	50

*Taken from formula 10/Slope

TABLE 4

Recommended Length of Furrows and Maximum Time For the Water to Flow Through The Field on Various Soil Textures

SOIL TEXTURE	LENGTH OF FURROWS	HOURS
Loamy Sands	600	2-3
Sandy Loams	800	3-4
Fine Sandy Loams	950	4-5
Silt Loams	1100	5-6
Silty Clay Loams	1300	6-7

Steps to Take in Applying Nitrogen Fertilizer In Irrigation Water

	Example	Your Field
Step 1: Decide on amount of nitrogen you want to apply per acre (Table 1)	30 lbs. of N/ac.	
Step 2: Decide on the kind of nitrogen fertilizer you want to apply (Table 1)	Solution 32% N	
Step 3: Determine number of gallons or pounds of fertilizer needed per acre (Table 1)	8.6 gal/ac.	
Step 4: Determine the number of acres in each irrigation set (Table 2)	5.9 ac.	
Step 5: Multiply gal./ac. or lbs./ac. of fertilizer times acres per irrigation set (Example: 8.6x5.9=50.7)	50.7 gal. of Fertilizer solution per set	
Step 6: Determine the amount of time required and when to apply the fertilizer solution.	240 minutes or 4 hours	
Step 7: Calculate the rate of flow of fertilizer solution into the irrigation water. Divide gal. of fertilizer per set (Step 4)	0.21 gal./min. 12.6 gal./hr.	
Step 8: Select the proper orifice size and net pressure to give the desired rate of flow. Information from manufacturer of Meter-Injector.	dia. of orifice 1/16" net pressure 10 psi	