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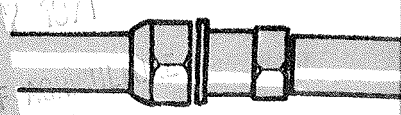

Applying Fertilizer in the irrigation water

EXTENSION SERVICE
UNIVERSITY OF NEBRASKA COLLEGE OF AGRICULTURE
COOPERATING WITH THE U.S. DEPARTMENT OF AGRICULTURE
AND THE COLLEGE OF HOME ECONOMICS.
E. F. FROLIK, DEAN; J. L. ADAMS, DIRECTOR

Paul E. Fischbach[1]

Applying plant nutrients through irrigation water is increasing in popularity. The practice seems to have many cost-cutting and yield-boosting factors going for it.

Applying nitrogen fertilizer in irrigation water is more effective than applying it mechanically on sandy soils and just as effective as mechanical application on fine textured soils. It also can save the labor and power of a mechanical application of fertilizer.

Applying fertilizer in the irrigation water probably dates back to when an irrigator dug a pit, put barnyard manure in it, then ran his irrigation lateral through it.

By 1950, anhydrous ammonia became plentiful and many irrigators applied it in the irrigation water with good results, but problems started to develop when they used it in gated pipe or sprinkler systems. Ammonia makes the salts in the water drop out, plugging sprinkler nozzles. Salts also coat the inside of aluminum sprinkler and gated pipe. The problem isn't especially troublesome in surface irrigation where siphon tubes are used and in gated pipe systems where water contains a limited amount of salts (less than 400 parts per million).

In the late fifties and early sixties, nitrogen solutions of ammonium nitrate and urea were introduced. These nitrogen solutions will not cause the salts to precipitate out of the irrigation water. Soon after the nitrogen solutions were introduced on the market, many types of accurate metering and injecting devices were made available. Now there are many fertilizer solutions on the market and in plant nutrient ratios to fit the irrigator's need.

One advantage of applying nitrogen fertilizer through the irrigation system is that it is applied at the time the crop needs it. The closer nitrogen can be applied to the time when the plant uses it, the more effective the nitrogen will be.

Corn, for example, uses most of its nitrogen from the rapid growth through the milk stage. Applying part of the nitrogen in the irrigation water during this time assures the irrigator that adequate nitrogen will be available during critical stages of crop growth.

Another advantage of applying nitrogen fertilizer through the irrigation system is that it can save one or more field operations.

When nitrogen fertilizer is applied mechanically it can be accomplished in the fall, spring (pre-plant) or side-dressed. However, storing all the nitrogen in

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the soil before the plant needs it may not produce top yields. Why? No matter in what form the nitrogen is applied—anhydrous ammonia, urea, ammonium nitrate, etc.,—it all eventually changes to nitrate in the soil. If heavy rains occur in the spring or early summer after the nitrogen fertilizer has been applied and changed to nitrate, the water percolating down through the soil will carry nitrate-nitrogen down with it. Therefore, some of the nitrogen may be pushed to depths below the root zone. These fields may need more nitrogen fertilizer to produce top yields. A good way to apply more nitrogen is in the irrigation water.

A good job of applying fertilizer in the irrigation water requires the same management as doing a good job of irrigation.

Sprinkler Irrigation Systems

If a sprinkler system is designed to give good water distribution from one end of the lateral to the other, it will apply fertilizer with the same uniformity, provided the fertilizer is uniformly mixed with the irrigation water and injected uniformly into the system. Fertilizer solutions can be injected during the entire sprinkling time. Some operators prefer to shut off the fertilizer injection about two hours before changing the sprinkler set. However, with all moving types of sprinkler systems, the fertilizer solution should be applied over the entire sprinkling time.

Surface Irrigation

If the surface irrigation system is properly designed, constructed and operated for maximum crop production, it will distribute the fertilizer solution uniformly.

To accomplish this, the field or length of run should be shaped to a fairly uniform grade. In general, the length of runs should not exceed 600 feet on loamy sand soils and 1,300 feet on silty clay loam soils. However, some clay soils have high intake rates; consequently, the length of run should be shortened accordingly.

For best results, the surface irrigation system should include a reuse system to pick up the runoff water and put it back into the system or on another field. When irrigating, water should flow through the field in two or three hours on loamy sand soils and six to seven hours on silty clay soils. The operator will need to use a maximum allowable furrow stream size.

When using a reuse system with a surface irrigation system, the fertilizer can be injected continuously. However, if no reuse system is used, the fertilizer injector should be shut off soon after the water has reached the far end of the field.

Some irrigators prefer to operate the irrigation system until the water has advanced three-fourths of the distance of the furrow, then start injecting the

fertilizer solution. Fertilizer will need to be injected at a higher rate—probably about twice the rate as the previously described procedure but for only one-half the total time of injection.

Fertilizer Meter-Injectors

There are many commercial meter-injectors on the market for injecting fertilizer solutions into sprinkler, gated pipe or siphon tube irrigation systems.

Preliminary tests at the Agricultural Engineering Department, University of Nebraska, indicate that 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 should be injected into the system just ahead of an elbow or tee in the irrigation line. Turbulence in the water created by the pipe fittings will assure uniform mixing.

A float box which will give a uniform flow of the fertilizer solution into the irrigation water is all that is needed for siphon tube or spile irrigation. A good place to meter the fertilizer solution into the irrigation system is at the pump site. Usually there is a stilling basin or a structure to dissipate the energy created by the water as it comes out of the pump discharge pipe. The fertilizer can be metered into the irrigation water at this place for adequate mixing of fertilizer and the irrigation water.

There are four decisions irrigators will have to make before applying nitrogen fertilizers in the irrigation water:

1. Amount and kind of fertilizer to use (Table 1).
2. Number of acres that will be irrigated per set (Table 2).
3. Amount of time for application of fertilizer (Table 3 gives time to flow water through a field in various soils).
4. The rate at which the fertilizer solution will be injected into the system (Table 4).

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

Kind of fertilizer solutions	% Nitrogen	Wt. per gal. at 60° F. (lb.)	Rate of N per acre, lb.		
			20	30	40
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[a]	37	9.91	5.4	8.1	10.8
Ammonium Nitrate-Ammonia[a]	41	9.48	5.1	7.7	10.2
Aqua Ammonia	24	7.47	11.2	16.8	22.4
Anhydrous Ammonia[a]	82	5.15	4.7	7.1	9.4

[a]Calculations based on temperature of 60° F.

Table 2. Computing number of acres per irrigation set.

Length of run or sprinkler lateral, ft.	Number of rows per set[a]									
	20	40	60	80	100	120	140	160	180	200
300	0.5	0.9	1.4	1.8	2.3	2.8	3.2	3.6	4.1	4.6
500	0.8	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

[a]40-inch rows. (To convert acres shown in Table to 30-inch rows multiply by 0.75; to 20-inch rows multiply by 0.50.) 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. 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

Table 4. Flow rates for various size orifices at several net pressures.

Net pressure PSI	Orifice size inches[a]									
	0.029 gpm.	0.046 gpm.	0.059 gpm.	0.070 gpm.	0.078 gpm.	0.089 gpm.	0.098 gpm.	0.107 gpm.	0.120 gpm.	0.140 gpm.
10	0.055	0.13	0.21	0.30	0.38	0.50	0.62	0.74	0.92	1.3
20	0.077	0.18	0.30	0.43	0.54	0.71	0.88	1.1	1.3	1.8
30	0.094	0.22	0.37	0.53	0.66	0.87	1.1	1.3	1.6	2.2
40	0.11	0.25	0.41	0.61	0.77	1.0	1.2	1.5	1.8	2.5
60	0.13	0.31	0.52	0.75	0.94	1.2	1.5	1.8	2.3	3.1

[a]Flow rates based on water 8.34 lb./gal.
For Solution 32—11.05 lb./gal. multiply by 0.87.

The amount and kind of fertilizer is usually determined by soil tests, availability of the fertilizer and costs. Some farmers determine their nitrogen requirements by the amount needed by the crop to produce a predetermined yield.

For surface irrigation, the number of acres per set is dependent on the rate of water flow, intake rate and the length of run. The period of time for injection of the fertilizer is determined by the time required to flow the water from one end of the field to the other.

For sprinkler irrigation, the acres are determined by the length and number of lateral lines, and the spacing between lateral moves. The period of time of injection of the fertilizer can be the entire irrigation set time or any portion of it.

For continuously moving sprinklers, the entire area or any portion of it served by the sprinkler can be considered. However, the period of time for the injection of the fertilizer must correspond with the area covered.

Steps to Take in Applying Nitrogen Fertilizer in Irrigation Water

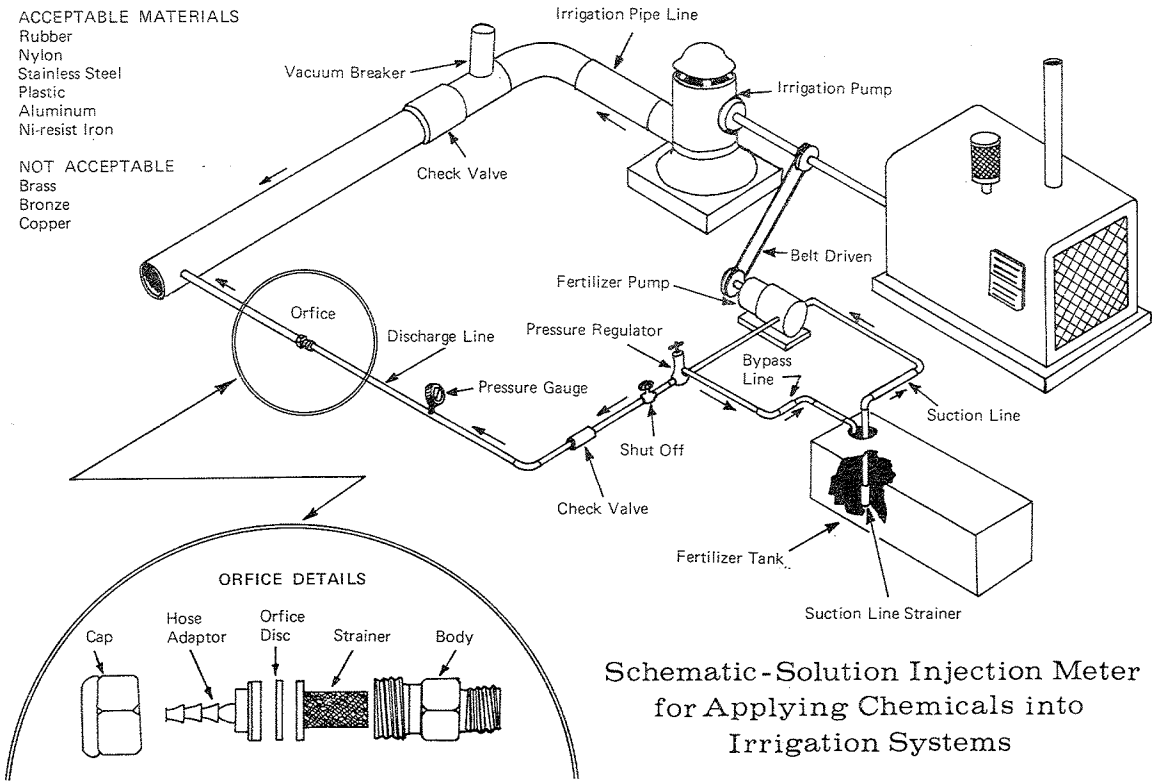
		Example	Your Field
Step 1.	Decide on amount of nitrogen you want to apply per acre (Table 1).	30 lb. of N/ac	_____
Step 2.	Decide on the kind of nitrogen fertilizer you want to apply (Table 1).	solution 32% N	_____
Step 3.	Determine number of gallons or pounds of fertilizer needed per acre (Table 1).	8.6 gal./acre	_____
Step 4.	Determine the number of acres in each irrigation set (Table 2).[1]	5.9 acre	_____
Step 5.	Multiply gal./acre or lb./acre of fertilizer times acres per irr. set. (Example: 8.6 x 3.9 = 50.7)	50.7 gal. of fertilizer solution per set	_____

[1] For center pivot continuously moving sprinklers use acreage covered in complete revolution or any portion of it.

Step 6. Determine the amount of time required and when to apply the fertilizer solution (See Table 3 for surface irrigation). For sprinkler irrigation use sprinkler set time or any portion of it.[2]	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 5) by total time in minutes (Step 6).	0.21 gal./min.	_____
Step 8. Select the proper orifice size and net pressure to give the desired rate of flow. Table 4 (caution, correct orifice pressure for viscosity of fertilizer used.) (Diam. of orifice 0.059 0.21 gpm. ÷ 0.87 = 0.24 gpm. Net pressure 0.14 psi)		
Step 9. Start irrigation pump.		
Step 10. Start fertilizer pump meter injector with by-pass open and shut-off valve closed.		
Step 11. Read pressure on discharge line pressure gauge. Record.		
Step 12. Open fertilizer shut-off valve and adjust pressure regulator so that pressure gauge shows the desired excess pressure. Example: Need 14 psi net pressure with 0.059 orifice. (Step 8) Pressure recorded in Step 11 is "50 psi". Adjust pressure regulator until (50 psi plus 14 psi) 64 psi is shown on pressure gauge.		

[2]For center pivot continuously moving sprinklers use time to correspond with the acreage covered.

Figure 1 shows a fail-safe arrangement of irrigation valves and fertilizer injection equipment designed so that no fertilizer can drain back to pollute the irrigation well or water supply.



Schematic-Solution Injection Meter for Applying Chemicals into Irrigation Systems