Fertilizing Through Irrigation Water
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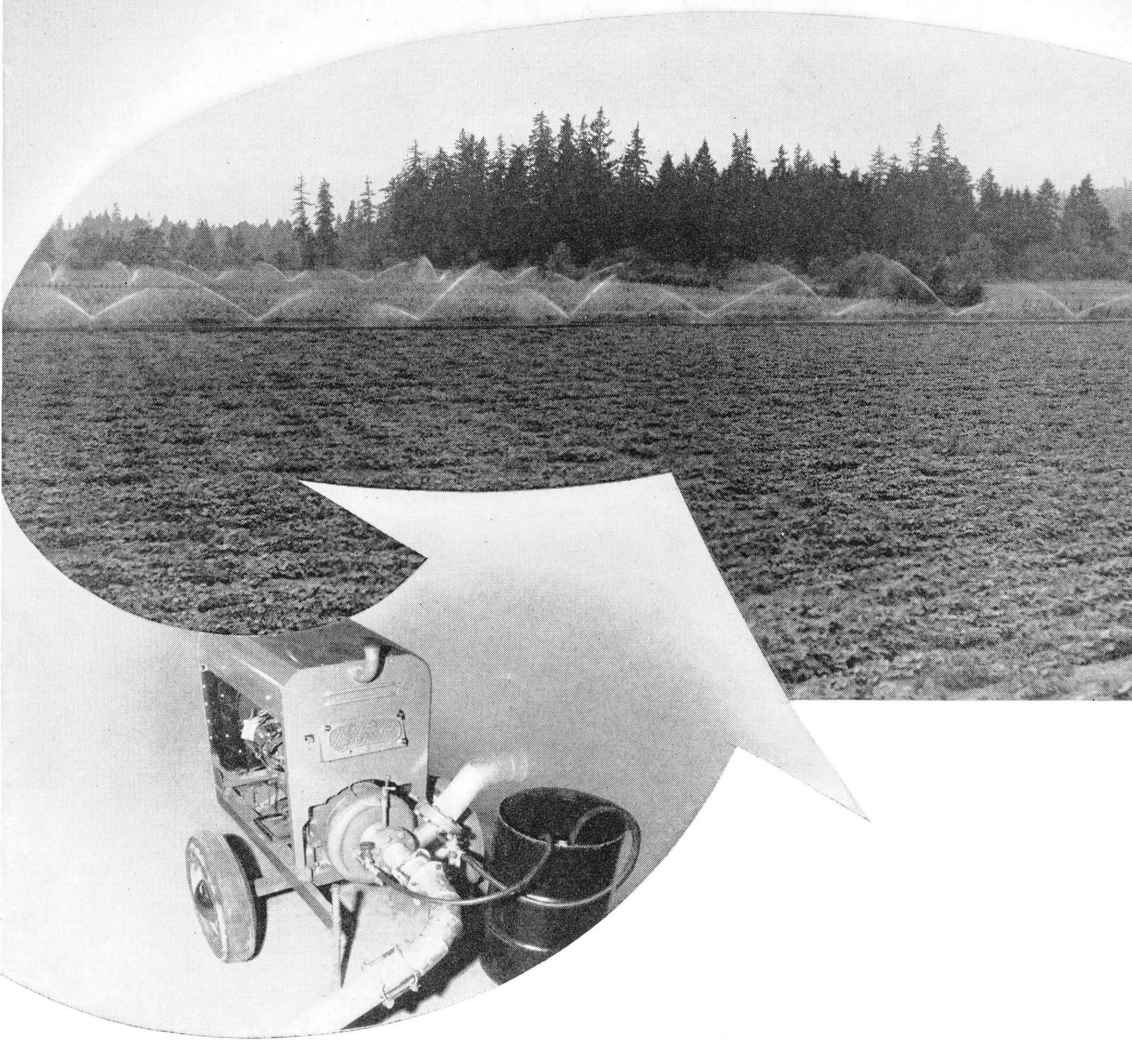
Through Irrigation Water



By John R. Davis and R. L. Cook

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Fertilizing Through Irrigation Water

By JOHN R. DAVIS[1] *and R. L. COOK*[2]

Most fertilizers can be applied efficiently to almost any crop through irrigation water, at any time during the growing season. The major plant nutrients—nitrogen, phosphorus, and potassium—differ in the way in which they can be applied, however. This is largely due to differences in chemical and biological activity in the soil, and to how much of the fertilizer material can be dissolved. The individual nutrients exist in the fertilizer and react in the soil differently, so are not equally suited to this method of application.

This bulletin explains why fertilizer materials are different in their adaptability to application through irrigation water. It also discusses how to apply fertilizers, the proper amounts to apply, and when to apply for the greatest benefits.

IN GENERAL

NITROGEN may well be applied through irrigation water. Most of the nitrogen fertilizers can be readily dissolved in water. Moreover, the chemistry of nitrogen in the soil is such that the idea of broadcasting the fertilizer through irrigation water is theoretically sound. This is true of the nitrogen materials sold as dry salts or as solutions so long as they do not contain free ammonia like anhydrous ammonia.

POTASH salts may also be applied satisfactorily through irrigation water. However, it is better to apply only a small portion of the total amount in this manner. The rest should be applied as dry fertilizer before planting, or in bands at planting time.

The PHOSPHORUS in the recommended grades of mixed fertilizer is only partly water soluble. Water-soluble forms of phosphorus are presently too expensive to be used on a large scale. Thus, phosphorus fertilizers generally should be applied as dry fertilizer before or at the time of planting. It is suggested that a little nitrogen, all of the phosphorus, and most of the potash, magnesium, manganese, boron and copper be applied at planting time. Additional applications of any of these nutrients except phosphorus may be efficiently made at

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any time when observations, soil tests, or green tissue tests indicate a need.

The fertilizer should be dissolved in water in a barrel or some other suitable container, then introduced into the pipeline while irrigation water is being applied. If the pump is of the centrifugal type, the solution is taken into the intake line. In the case of a deep-well turbine, the solution must be forced into the discharge line under higher pressure than that developed by the pump, fed directly into the well, or introduced into the line through commercial sprinkler-system fertilizer applicators.

FERTILIZERS SUITED FOR APPLICATION

Nitrogen

Nitrogen is well adapted to application through irrigation water. Most of the nitrogen in the soil exists in the form of organic matter. Soil organisms decompose organic matter and release the nitrogen as ammonia. Other organisms change the ammonia to another form of nitrogen, called "nitrate nitrogen," the form in which crop plants obtain most of their nitrogen.

If the organic matter in the soil is high in carbon content, such as straw or corn stover, the amount of nitrogen in this organic matter may be too low for the body needs of the organisms which bring about the decomposition. When this happens, the organisms collect all that is available in the soil, including the nitrogen that was applied as fertilizer at the time the crop was planted. Thus, nitrogen applied at planting time may be entirely used by soil organisms before the time comes when the crop actually needs it.

As an example of the rapid use of nitrogen by organisms, a research worker has found that an application of 300 pounds of nitrogen per acre at planting time did not furnish sufficient nitrogen to nourish sugar beets until harvest. In comparison, plants which had received the same total quantity of nitrogen fertilizer at three different times of application—one at planting time and two later—were well supplied with nitrogen throughout the season. From the weight of the crop produced and the analysis of the beets, only 50 percent of the nitrogen that was applied at planting time could be accounted for. In the other case it was possible to account for about 70 percent of the quantity applied, and the tests indicated some still available to the crop at harvest time.

Some state experiment stations have reported good response from nitrogen fertilizer applied as a side-dressing when corn was 2 to 3 feet high—but very little response when the fertilizer was applied at planting time or before. It is very likely that the nitrogen which was applied early in the season was either lost through leaching, or was used by soil organisms before the corn had made sufficient growth to require the additional application.

Research has shown that potatoes required only 7 pounds of nitrogen an acre during the first seven weeks of their growth period, but during the next five weeks the crop used 53 pounds an acre. Therefore, the logical time to apply nitrogen for such a crop is during that period of rapid growth when the need for nitrogen is great. Irrigation water offers a convenient means of making such applications during midseason.

Without irrigation, midseason applications of soluble nitrogen fertilizer may be less effective, if the surface soil does not contain enough moisture to dissolve the nitrogen salt. Deep placement at that season is not recommended, because of the danger of injury to roots. Irrigation water, therefore, furnishes a good solution to this otherwise difficult problem.

Anhydrous ammonia and nitrogen solutions containing free ammonia cannot be applied through sprinkler irrigation systems. So much ammonia would be lost into the air that the practice would not be economical. Free ammonia may also be damaging to green vegetation.

All of the three common nitrogen salts, ammonium sulfate, ammonium nitrate, and sodium nitrate are easily and completely soluble. They are recommended for application through sprinkler irrigation systems.

Dates as well as rates of application of nitrogen salts in irrigation water should vary with different soils and with crops. Operators should always apply a small amount of nitrogen at planting time, just in case rainfall is plentiful for a time and irrigation is not needed. To get maximum benefits from the fertilizer and irrigation water, nutrients should be available to the plant whenever and in the amount needed. Soil and green tissue tests, made throughout the growing season, will furnish clues as to when the plants need additional nitrogen to sustain their growth. Testing kits can be obtained from Michigan State College, and facilities are available for testing in several counties, under the supervision of your county agricultural agent.

With most crops it will be several weeks after planting before vegetative growth becomes rapid. Forty to eighty pounds of nitrogen applied per acre during the rapid growth period should be sufficient for most crops. Most efficient use will be made of the nitrogen if most of it is withheld until it is needed. If it is thought that the rapid growth period of the crop will last six weeks, it is recommended that one-sixth of the total quantity of nitrogen needed be applied each week.

NITROGEN IN THE SOIL.—Nitrate nitrogen may be leached readily from soil. Excessive amounts of water leaching through a fallow soil may cause serious losses of nitrate nitrogen in the drainage water. This may not happen on a soil which is covered with a rapidly growing crop because the plants use the nitrate as fast as it is formed by the soil organisms. Thus, where nitrate nitrogen (ammonium nitrate) is applied through irrigation water it is very essential that the water applied should not penetrate the soil deeper than the plant roots.

Ammonium nitrogen (NH_4) is fixed quickly and firmly into a stable form difficult to leach. Only the action of soil organisms will change it to the easily removed nitrate form. Thus, in an irrigation system where water applications are less exact, an ammonium form of nitrogen (ammonium sulfate) is to be recommended.

Urea is not fixed in the soil so readily as is the ammonium form. The precautions mentioned for nitrate nitrogen should be followed where fertilizers containing urea are applied.

Potash

Potash at planting time and through irrigation water:

Potassium salts are largely soluble in water, and the element does not readily form unavailable compounds in the soil. So it is easy, and theoretically correct, to apply potash fertilizer through irrigation water if desired. However, there is probably little reason to recommend the method of application for potash except when *additional* applications are needed.

Potassium does not leach readily and it is not used in large amounts by soil organisms, as is the case with nitrogen. Therefore, it is correct to apply all the potash at (or before) the time of planting. However, growers may not be able to predict exactly the needs of a crop, so when irrigation is practiced it will probably be most economical to apply a medium quantity at planting time and more through irrigation water as green tissue tests indicate a need. The tests should be made regularly at 10-day intervals.

Phosphorus

Phosphorus should be applied at planting time. Experiments conducted during recent years have shown that fertilizers containing phosphorus are much more efficient when applied in bands, rather than when mixed with the soil after a broadcast application. The greater efficiency is largely due to the lesser contact between the fertilizer and the soil, which results in less fixation of the phosphorus into forms not available to plants. Application of phosphorus in solution—as through irrigation water—would result in maximum contact between the phosphorus and the soil and, therefore, fixation of much of the phosphorus into forms not readily available to plants.

Another reason why phosphorus cannot be applied efficiently through irrigation water is that the cheaper sources of phosphorus are not readily soluble. Experiments have shown that even at low concentrations (3 pounds in 50 gallons of water) over half of the phosphorus in some mixtures failed to dissolve. This low solubility of the phosphorus in mixed fertilizer is due to the fact that the phosphorus is supplied as superphosphate. If an attempt is made to apply superphosphate through irrigation water, the undissolved portion must be discarded or forced through the system in suspension.

In order to force solid fertilizer through the sprinklers, it would be necessary to grind it finer than is generally done and provide some agitation equipment to keep the material in suspension. Even with very finely ground fertilizer there would be serious danger of clogging small-nozzle sprinklers. Soluble forms of phosphorus are too expensive as sources of phosphorus for large areas.

Other Elements

Most of the minor element salts, in the pure state, are soluble in water. However, the fertilizer grade of some of the salts contains insoluble impurities which should be filtered out before the solutions are sucked or forced into irrigation lines. This may be accomplished by filters over the intake openings.

Manganese applications may be needed for several commonly irrigated crops. Chief among these are beans, beets, certain grasses, and many shrubs.

Applications of borax, to furnish the element boron, may be needed for beets, turnips, rutabagas, cabbage, celery, alfalfa, and several other crops.

Experiments have shown that on certain organic soils copper may be a limiting factor in the production of some crops, and on others magnesium additions may be profitable.

Upon occasion, any of these elements can be applied in irrigation water. Over a longtime planning program, it is probably better to apply them with the planting time fertilizer. But where deficiencies show up during the growth of the plant, or where earlier applications have been neglected, the irrigation water can well be used for the application. Care should be taken to avoid excessive rates of application.

The reader is urged to refer to Michigan Extension Bulletin 159, *Fertilizer Recommendations,* for further details on the specific instances where these elements are likely to be needed. (See page 23 for a list of other available publications.)

HOW MUCH WATER TO APPLY

Soil type and organic-matter content should be considered in irrigation management. Sandy soils hold less water than clay soils. A 2-inch application of water might cause considerable leaching from a sand, but may be too small to wet a clay soil to the desired depth. The figures in Table 1 can be used as a general guide to determine the proper amount of water to apply.

*TABLE 1—Approximate amounts of water (in inches) to apply at each irrigation**

Depth of feeder-root-zone	Inches of water		
	Sandy soil	Loam soil	Clay soil
18 inches	½—1	1 —1½	1½—2
36 inches	1 —2	2 —2½	3 —4
48 inches	1½—2½	2½—3½	4 —5

*Based on irrigation when one-half of the available water in the feeder-root depth has been used.

However, because the above table is only general, one should examine the soil about a day after the irrigation to observe how far water has penetrated into the soil. Apply only the amount of water needed to wet the soil to the bottom of the root zone.

Also, soil moisture blocks can be used to good advantage in any irrigation system. The soil-moisture block is a small plaster-of-paris block in which electric wires are embedded. When the blocks are placed in the soil, in the root zone of the crop, the moisture in the soil penetrates the blocks until the moisture contents of the blocks and the soil are balanced. Then, by measuring the electrical resistance of the block with a small inexpensive meter, the moisture content of the soil can be determined. This makes it possible to apply water when needed and will be a guard against excessive watering which may wash out available nitrogen and certain other soluble nutrients.

METHODS OF APPLYING THE FERTILIZER

Most liquid fertilizers, water-soluble fertilizers, and even suspensions and emulsions can be easily introduced into either surface or sprinkler irrigation systems. Very little additional equipment and labor are needed.

Through a Centrifugal Pump

A centrifugal pump is used commonly in irrigation when water is pumped from lakes, ponds, streams, or very shallow wells. A practical

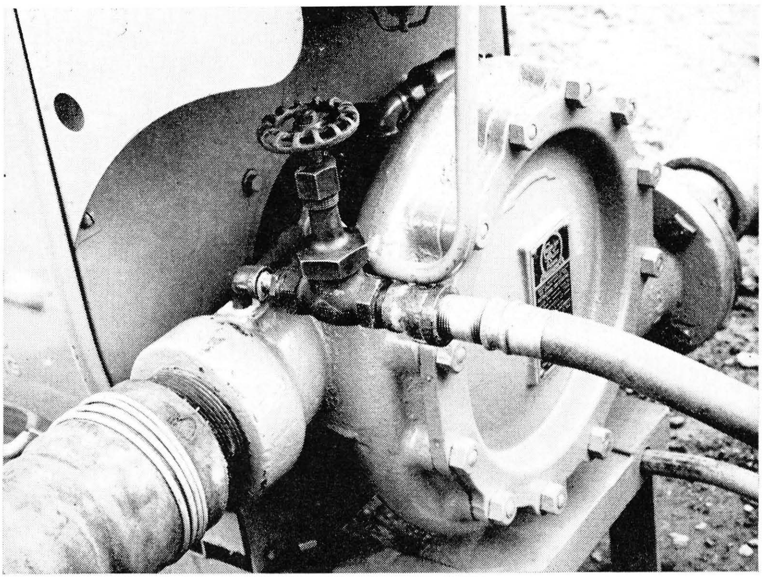

Fig. 1. Fittings used to introduce the fertilizer solution into the intake side of a centrifugal pump.

method of introducing fertilizer into such a system is to let the pump draw the fertilizer solution into the suction side of the pump.

To make the installation, a ½- to 1-inch diameter hole is drilled and tapped in the suction pipe close to the pump. (Some pumps have a plug that can be removed for this installation.) A pipe nipple is threaded into the hole. Next, a shut-off valve is attached to the end of this pipe nipple, and then a second short fitting or pipe nipple is attached to the valve. (See Fig. 1.) To the fitting or nipple is attached a length of garden hose—long enough to run into a barrel or other container in which the fertilizer is dissolved, or in which a solution is placed.

A similar attachment is usually made at the discharge side of the pump to provide a source of water to fill the barrel. Opening the valve at the intake side of the pump will then regulate the flow of fertilizer into the suction pipe and into the pump. (See Fig. 2.)

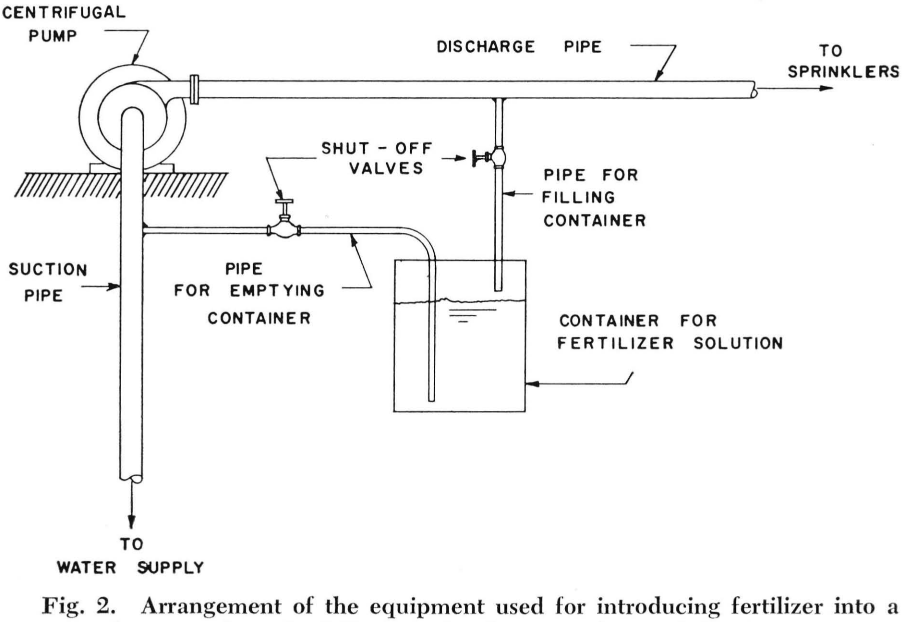

Fig. 2. Arrangement of the equipment used for introducing fertilizer into a centrifugal pump. (For flexibility, garden hose can be used in place of pipe.)

The size of the fittings required will depend on the location of the hole through which the fertilizer enters the pump and the available equipment. A 55-gallon oil barrel with one open end is usually suitable for a container, and a garden hose and fittings ½-inch or larger may be used for the line from the barrel to the pump.

Fig. 3. Using a spray rig to pump a fertilizer solution into an irrigation pipeline.

Both before and after the fertilizer has been applied, the valve in the fertilizer line attached to the pump suction pipe must be tightly closed. If not, it may leak air during pumping or possibly hamper priming the pump. If brass valves are used, clear water should be drawn through the fittings after the fertilizer to lessen the chance of corrosion. Replacing the valves—perhaps each year—may be necessary to prevent air leaks.

Several irrigators have avoided making a connection in the suction pipe. They have found it convenient to pour the dissolved fertilizer into the water source near the intake screen at the end of the suction pipe. They attach one end of a pipe or hose near the bottom of the barrel or container. The other end is placed within a few inches of the intake screen on the end of the suction pipe.

After the fertilizer has been dissolved in the water in the container, a valve in the pipe or hose is opened and the solution drains down to the end. When the pump is operating there is enough suction to draw the fertilizer solution into the pump, mixing it with the irrigation water.

If it is convenient, the fertilizer in solution can be poured through a funnel into a pipe directly over the suction pipe screen. The bottom end of the pipe should be close to the screen. If the fertilizer is poured slowly enough into the funnel, all of it should be drawn into the pump.

If the volume of water around the screen on the suction pipe is small, the fertilizer may be poured directly into the water source. For example, if the suction screen is placed inside a perforated barrel, or a box no larger than about 5 feet square, the fertilizer solution can be poured directly into the barrel or box, and most of it will be drawn into the pump. Pouring the fertilizer into a larger area, such as a 25-foot wide pond, may be less satisfactory; some of the fertilizer may not be drawn into the irrigation system.

All of these methods require that the pumping system be operating when the fertilizer is introduced. If fertilizer is poured into the water before the pump is started, much of it may be carried downstream or lost entirely.

Into Water Pumped by Turbine Pumps

Turbine pumps, which are deep-well irrigation pumps, do not exert suction in any part of the system, so the fertilizer must be introduced

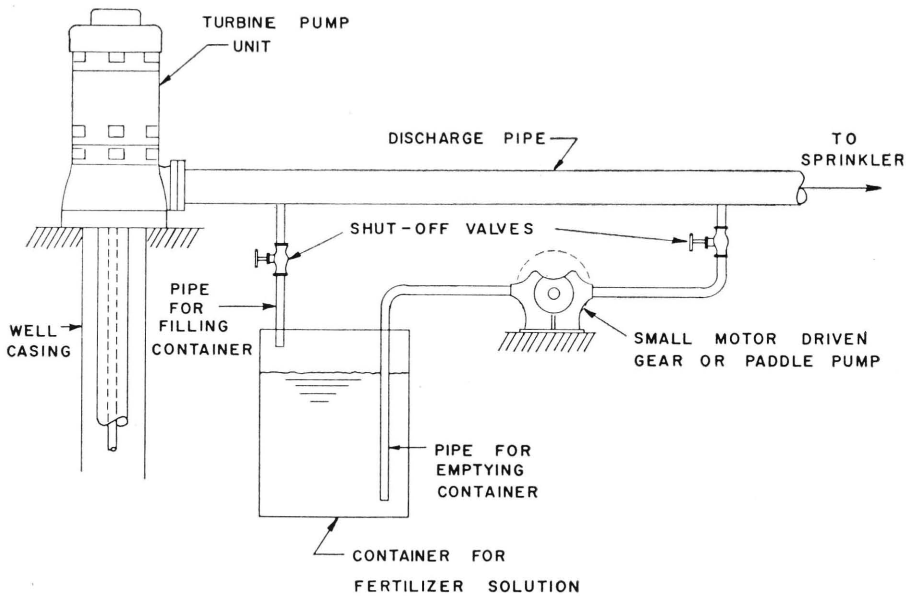

Fig. 4. Arrangement of the equipment used for pumping a fertilizer solution into an irrigation pipeline. (As with the centrifugal pump layout in Fig. 2, garden hose may be used in place of pipe.)

into the system by means other than that described for centrifugal pumps. One method used satisfactorily by irrigators is to tap the discharge pipe, attach a valve and suitable piping, and force the fertilizer solution into the pipe under higher pressure than that delivered by the irrigation pump. Some are using a spray rig for this purpose—mixing the fertilizer solution in the sprayer tank and forcing the solution into the pipeline with the sprayer pump. (See Fig. 3, p. 13.)

Small rotary, gear or piston pumps capable of developing high pressure also are used to inject the solution into the pipeline. (See Fig. 4.) Some gear pumps have bronze gears, which could be corroded by the fertilizer; other pumps have rubber or stainless steel parts that would not be affected. A disadvantage of this method is that the small pump must be purchased, maintained, and power must be available for it.

An answer to the problem may be to pour the fertilizer or the fertilizer solution down the well between the water delivery column and the well casing. (See Fig. 5.) Those who have tried this method

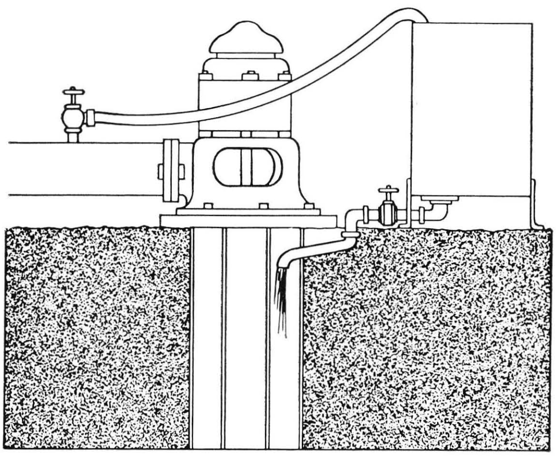

Fig. 5. One method of getting a fertilizer solution directly into a well for introduction into the irrigation system through a deep-well turbine pump.

report it quite successful and so far have reported no damage to the pump parts. The fertilizer can be detected in the pipelines almost immediately after it has been poured into the well. Fertilizers that are not soluble or that may permanently contaminate the well water should not be put into any well, regardless of the use to which the well is put.

Directly into the Line

Where the pump can't be reached easily or is at some distance from the field to be irrigated, it may be advantageous to introduce the fertilizer directly into the main line. Also, a few irrigation installations in the state utilize a municipal water supply. A spray rig or small high-pressure pump, as described above, could be used in these cases to inject the solution into the pipeline.

Commercial sprinkler-system fertilizer applicators are available, which enable fertilizer to be introduced into the irrigation pipe between the pump and the sprinklers. These applicators utilize a pressure difference somewhere in the line—between couplers, around elbows, or at a reducer—to force the fertilizer solution into the pipe. A large pressure tank is used to hold the fertilizer. Attached to the tank are two valves, and to the valves, high-pressure hoses, which in turn are attached to fittings on the pipe. (See Figs 6 and 7.) The cost of applicators ranges from $75 to $350.

Fig. 6. One type of commercial fertilizer applicator which utilizes a pressure difference for feeding the solution into the sprinkler system.

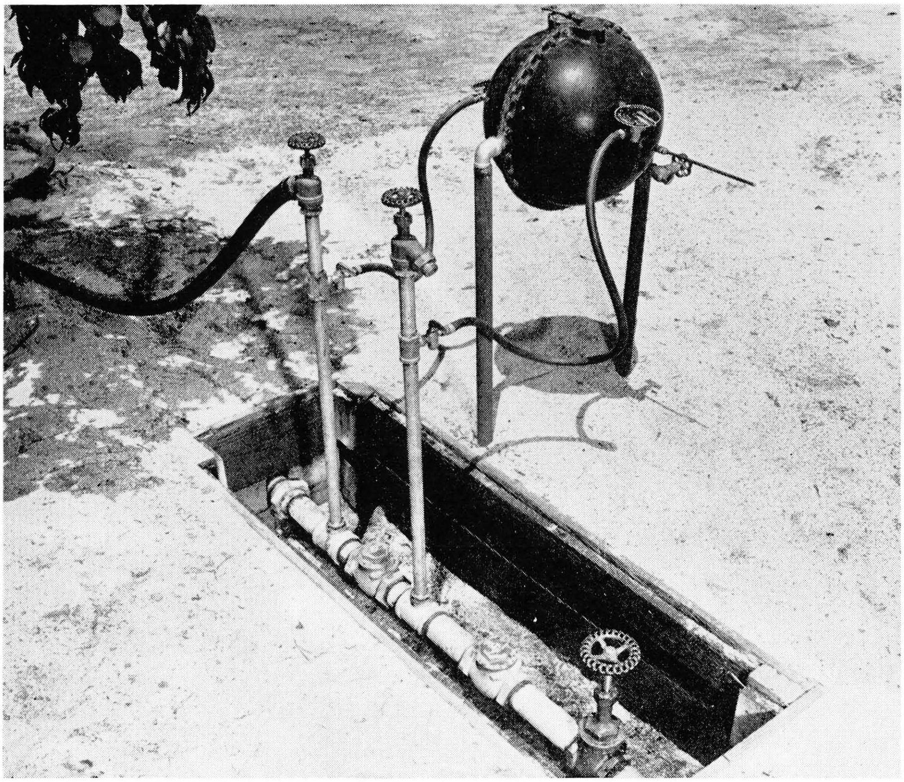

Fig. 7. Another type of commercial sprinkler-system fertilizer applicator, utilizing a similar principle to the one in Fig. 6.

For Small Areas or Greenhouses

Several fertilizer applicators have been put on the market for attachment to garden hose. The applicator is attached at the sill cock, in the hose, or at the nozzle. This equipment is inexpensive and would appear to be a satisfactory means of applying fertilizer to the lawn, shrubs, or garden. Aspirator units (Fig. 8) are available for fertilizer injection into a pipeline or hose anywhere in the system. Considerable piping may be required, the rate of fertilizer injection is slower than that of other methods, and some water pressure is lost while the aspirator unit is operating. However, it has the advantage of having no mechanical failures and requires no other power to operate.

Several greenhouse operators have installed small-size chlorinators or chemical feeders in their irrigation system. These feeders will proportion the fertilizer solution added to the water, thus keeping the fertilizer content of the water at a constant level.

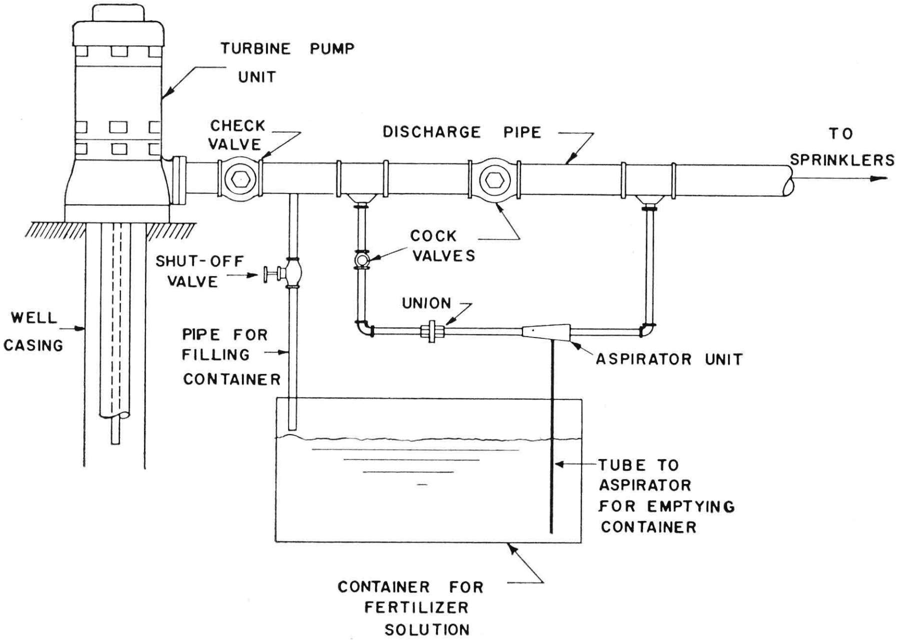

Fig. 8. Arrangement of the equipment necessary when an aspirator unit is used to suck the fertilizer solution into the pipeline.

Into Flowing Surface Waters

In applying fertilizers in small streams or in irrigation ditches, it is desirable to dissolve the fertilizer first. Secondly, in order to distribute the fertilizer uniformly in the stream, the concentrated fertilizer solution should be thoroughly mixed with all the water in the stream.

Tests at the University of Nebraska have resulted in the adoption of the following equipment:

A 55-gallon drum with a faucet near the bottom is placed on a board framework over the stream, a short distance from the area to be fertilized. The entire stream is diverted into the board framework. A V-shaped divider and baffles are placed near the entrance to this framework, to increase the speed of the water and increase the turbulence of the water as it passes under the drum. The fertilizer solution is then permitted to flow into the water at the V-shaped divider, thus mixing thoroughly with the water. Other means of applying water in streams, such as injecting a fertilizer solution through nozzles spaced at intervals across the stream, are also possible.

QUANTITIES OF FERTILIZER TO APPLY

After knowing how much fertilizer to apply during one irrigation, the number of pounds of nutrients needed for one sprinkler setting can be determined from Table 2. However, the figures given in Table 2 should be divided by the percentage of the element in the fertilizer,

TABLE 2—Pounds of fertilizer to use for each setting of a sprinkler line

Length of line in feet	Distance line moved per setting	Rate of nutrient application in pounds per acre				
		20	*40*	*60*	*80*	*100*
		Pounds of fertilizer per setting				
330 (20 rods).....	40 ft.	6 lb.	12 lb.	18 lb.	24 lb.	30 lb.
	60	9	18	27	36	45
	80	12	24	36	48	60
660 (40 rods).....	40	12	24	36	48	60
	60	18	36	54	72	90
	80	24	48	72	96	120
990 (60 rods).....	40	18	36	54	72	90
	60	27	54	81	108	135
	80	36	72	108	144	180
1320 (80 rods)....	40	24	48	72	96	120
	60	36	72	108	144	180
	80	48	96	144	192	240

to obtain the actual weight of bulk or bag fertilizer to be introduced into the system. (See Table 3.)

For example: An application of 60 pounds per acre of nitrogen is recommended, the length of the sprinkler line is 990 feet, and the lines are moved every 60 feet. Table 2 shows that 81 pounds of nitrogen should be introduced to apply the 60 pounds per acre. Now, if ammonium nitrate is used (33 percent nitrogen) the weight of fertilizer introduced should be 81 divided by .33 (for the 33 percent). In even pounds the result is about 245 pounds of fertilizer, or roughly three 80-pound bags.

Ammonium sulfate is the least soluble of the three nitrogen salts previously mentioned (discussed on pages 7 - 8). About 280 pounds can be dissolved in 50 gallons of water. The same amount of water will dissolve 108 pounds of potassium chloride. Soluble fertilizers dissolve readily at low concentrations, but if more fertilizer is added to

*TABLE 3—Approximate composition of fertilizer materials suitable for application through irrigation equipment**

Fertilizer supplying	Percent of nutrient
NITROGEN:	
Ammonium nitrate	33.0%
Ammonium sulfate (sulfate of ammonia)	20.5
Sodium nitrate (nitrate of soda)	16.0
Cal-Nitro (A-N-L)	20.5
Calcium Cyanamide (cyanimide)	22.0
Urea (uramon)	42.0-46.0
POTASH:	
Potassium chloride (muriate of potash)	50.0-60.0
Potassium sulfate (sulfate of potash)	48.0-52.0

The percentage of nutrient in the fertilizer is usually printed on the sack or label of all fertilizers.

*Whittaker, Colin W., "Mixing Fertilizers on the Farm," U.S.D.A. Farmers' Bulletin No. 2007, 1949.

the container, considerable stirring may be necessary. In such cases, a larger mixing tank may be desirable.

If large quantities of ammonium sulfate and potassium chloride are to be applied, it is desirable to apply them separately. When combined at high concentrations these two materials react to form potassium sulfate, which is much less soluble than the chloride.

HINTS ON PUTTING FERTILIZER INTO THE SYSTEM

There has been no evidence that introducing fertilizer into the irrigation system is harmful to either the pump, the pipe, or the sprinklers when the equipment is properly flushed out. Several irrigators have reported, however, that with the oscillating pipe system (See Extension Bulletin 309, *Supplemental Irrigation in Michigan*) the fertilizer has damaged the water-pressure motors used to oscillate the pipeline.

Irrigators who have oscillating pipe or the perforated pipe systems should also be certain that the fertilizer is very finely ground to avoid the risk of clogging the nozzles or holes in the pipe. When rotary irrigation sprinklers with nozzles larger than ⅛-inch diameter are used there is little possibility of clogging.

The introduction of fertilizer solutions into the irrigation system should preferably be done toward the end of the irrigation setting.

If the fertilizer is applied early during the irrigation, the water applied to finish the setting may cause the fertilizer to penetrate too deeply into the soil, deeper than the bulk of the plant roots. Thus, to prevent inefficient use of the fertilizer, it is best to apply it during the last half of the irrigation setting. This practice should be observed especially with urea and nitrate fertilizers.

Uniform fertilizer application is essential for good results. To achieve this uniformity of application, introduce the fertilizer into the system in a length of time sufficient to allow at least five rotations of the sprinkler heads. Thus, if the sprinklers complete one revolution in about 1 minute, allow about 5 minutes to introduce the fertilizer into the system. Most irrigators have found that it will take a longer time than this—about 10 to 20 minutes. It is important that during the time of fertilizer application—or at any time during the irrigation—water be applied slowly enough so that none of the water will run off the surface of the soil. Otherwise, non-uniform fertilizer and water application, soil erosion, and loss of water may result.

After all the fertilizer has gone into the irrigation system, allow an additional running time of 10 to 15 minutes to wash all the fertilizer off the plants and to flush out the pipelines, pump, and valves. Thus, if the fertilizer is introduced into the system toward the end of the irrigation setting as recommended, the total time requirement will be about 20 to 30 minutes.

The uniformity of fertilizer application is only as good as the uniformity of water application. This fact helps point out the need for a proper sprinkler-system design by qualified persons, and the proper use of the equipment according to the design.

MIXING AND STORING FERTILIZERS

Undesirable chemical reactions, losses of fertilizer, and danger of fire or explosions will be reduced if the following precautions are observed:

1. Calcium cyanamide should not be mixed directly with ammonium sulfate, ammonium phosphate, or ammonium nitrate, because of the undesirable chemical reaction that may occur.

2. Bags of ammonium nitrate should be stored in a dry place. If once opened, the bags should be reclosed tightly. The contents of torn bags should be promptly rebagged; any spilled ammonium nitrate should be cleaned up promptly. In one case, spilled ammonium nitrate ignited and started a fire in a truck.

3. Smoking or the use of open flames should not be permitted where ammonium nitrate is stored.

4. Keep ammonium nitrate away from steam pipes, electric wiring, and any combustible materials. If the ammonium nitrate has become mixed with a combustible material, discard or apply the fertilizer to the soil immediately; do not return it to the bag.

5. Store ammonium nitrate in a well-ventilated building to permit escape of gases in the event of fire. Large quantities stored for a considerable period should be placed in a building several hundred feet away from other buildings.

6. Completely destroy empty bags that have contained ammonium nitrate. Such bags are highly inflammable.

7. Sodium nitrate, though less hazardous than ammonium nitrate, should also be handled with the same precautions as described above for ammonium nitrate.

APPLYING INSECTICIDES AND FUNGICIDES THROUGH IRRIGATION WATER

The application of soil insecticides or fungicides in irrigation water cannot be recommended as a general practice. No general recommendations can be made. In specific cases, however, the application of soil insecticides and fungicides through irrigation water can be successful. Several farmers and turf growers have reported successful application of chlordane through the irrigation system for the control of white grubs.

Application of insecticides and fungicides through the irrigation system has three limitations. First, the insecticide or fungicide must be soluble in water, or of the emulsion type. Second, many fertilizers and insecticides are not compatible, so they should be applied to the soil separately. Most nitrate fertilizers are compatible with most insecticides, but potassium fertilizers are not compatible. Third, under present irrigation practices, there is the possibility that the soil insecticide may be forced too deeply into the soil by the irrigation water applied after the insecticide or fungicide is put through the irrigation system. Ask your County Agricultural Agent for more detailed information for your specific problems.

Introducing insecticides and fungicides into the irrigation system is similar to the methods used for introducing fertilizers. Unsatisfactory applications may result when material is poured into a body of water, such as a well or a pond, before it is sucked into the pumps. In these cases, the insecticide or fungicide may be diluted too much and all of it may not get into the irrigation system. For the best results, the insecticide or fungicide should be applied at the end of an irrigation setting, leaving just enough running time to wash out the equipment with clear water.

Applying insecticides or fungicides through an irrigation system for *foliage* treatment is inefficient and particularly so if clear water were pumped through later to wash out the equipment. In any case, very little of the chemical will attach itself to plant foliage—most of it will run off the plant onto the soil.

Applying chemical weed killers through an irrigation system is also inefficient, and unsatisfactory results are likely. Weed killers are applied best by the recommended methods, not through irrigation water.

REFERENCES

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