

CHAPTER 16: Fertigation

INTRODUCTION

In micro-irrigation, fertilizers can be applied through the system with the irrigation water directly to the region where most of the plants roots develop. This process is called fertigation and it is done with the aid of special fertilizer apparatus (injectors) installed at the head control unit of the system, before the filter. The element most commonly applied is nitrogen. However, applications of phosphorous and potassium are common for vegetables. Fertigation is a necessity in drip irrigation, though not in the other micro-irrigation installations, although it is highly recommended and easily performed.

FERTILIZER INJECTORS

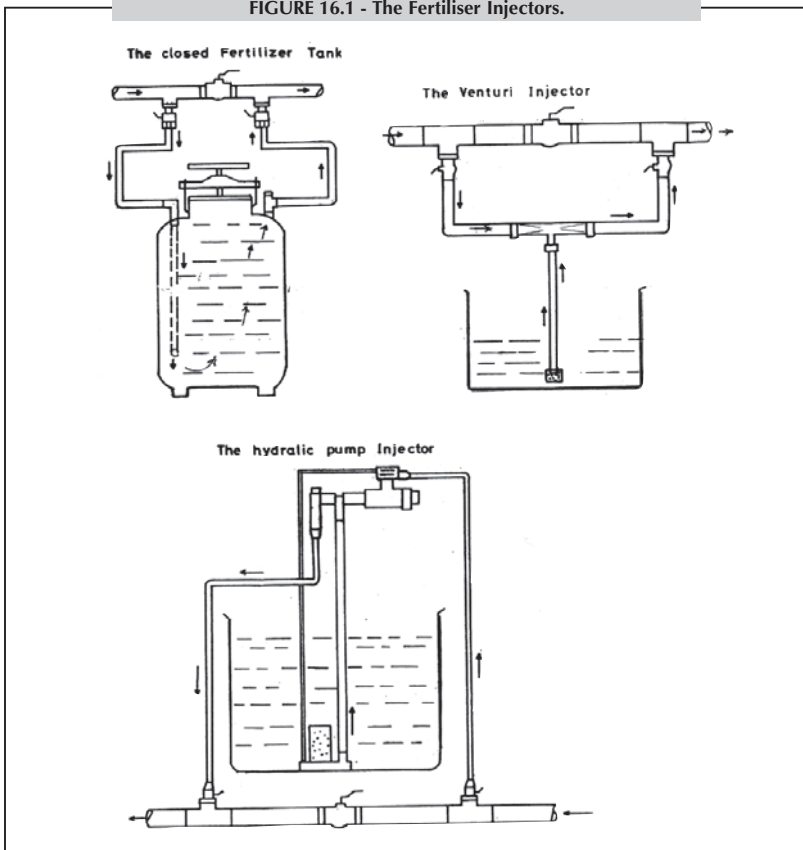
Several techniques have been developed for applying fertilizers through the irrigation systems and many types of injectors are available on the market. There are two main techniques: the ordinary closed tank; and the injector pump. Both systems are operated by the system's water pressure. The injector pumps are mainly either Venturi type or piston pumps. The closed tanks are always installed on a bypass line, while the piston pumps can be installed either in-line or on a bypass line.

- 1 Fertilizer (closed) tank.** This is a cylindrical, epoxy coated, pressurized metal tank, resistant to the system's pressure, and connected as a bypass to the supply pipe of the head control. It operates by differential pressure created by a partially closed valve, placed on the pipeline between the inlet and the outlet of the tank. Part of the flow is diverted to the tank entering at the bottom. It mixes with the fertilizer solution and the dilution is ejected into the system. The dilution ratio and the rate of injection are not constant. The concentration of fertilizer is high at the beginning and very low at the end of the operation. However, this apparatus is still in service on a very small scale in some countries because of its low cost and easy manufacture (Figure 16.1).
- 2 Venturi type.** This is based on the principle of the Venturi tube. A pressure difference is needed between the inlet and the outlet of the injector. Therefore, it is installed on a bypass arrangement placed on an open container with the fertilizer solution. The rate of injection is very sensitive to pressure variations, and small pressure regulators are

sometimes needed for a constant ejection. Friction losses are approximately 1.0 bar. The injectors are made of plastic in sizes from $\frac{3}{4}$ to 2 inches and with injection rates of 40–2 000 litres/h. They are relatively cheap compared to other injectors.

- 3 **Piston pump.** This type of injector is powered by the water pressure of the system and can be installed directly on the supply line and not on a bypass line. The system's flow activates the pistons and the injector is operated, ejecting the fertilizer solution from a container, while maintaining a constant rate of injection. The rate varies from 9 to 2 500 litres/h depending on the pressure of the system and it can be adjusted by small regulators. Made of durable plastic material, these injectors are available in various models and sizes. They are more expensive than the Venturi-type injectors.

FIGURE 16.1 - The Fertiliser Injectors.



FERTILIZER APPLICATION

The fertilizer solution in liquid form is fed into the system at low rates repeatedly, on a continuous basis, during irrigation. The flow rate of the injector should be such that the calculated amount of solution is supplied at a constant rate during the irrigation cycle, i.e. starting fertigation right after the system starts operation and finishing a few minutes before the operation ends. Regarding the choice of the fertilizers, apart from the amount and the kind, other parameters need to be considered, such as solubility, acidity, compatibility and cost.

Solubility

The fertilizer stock solution should always be dissolved in a separate container and then poured into the suction tank (Figure 16.2). The types of fertilizer should be highly soluble and when dissolved in water must not form scums or sediments which might cause emitter clogging problems. The solution should always be agitated, well stirred and any sludge deposited in the bottom of the tank should be periodically removed. The injector suction pipe should not rest on the bottom of the tank. Hot water helps dissolve dry fertilizers. Their degree of solubility varies according to the type and the country of origin. Potassium nitrate (13-0-46) seems to have a low solubility of approximately 1:8, i.e. 1 kg of dry fertilizer in 8 litres of water. The solubility of potassium chloride (0-0-62) is 1:3, while ammonium nitrate (34-0-0) and calcium nitrate (15.5-0-0) have a high solubility of approximately 1:1. Dry phosphorous fertilizers have a lower solubility than nitrates at about 1:2.5.

Acidity

The acidity produced by the several forms of nitrogen varies from type to type and is greatly affected by the kind of irrigation water and the type of soil. At least one check on the soil pH should be carried out at the beginning of the season and one at the end. Furthermore, a complete ionic analysis of the water is necessary.

Quantity

A simple method for calculating the amount of fertilizer required for fertigation is to divide the annual application by the number of irrigations. Various recipes have been developed in different countries based on the conventional nutrition dosages. The total quantity of fertilizers applied is also related to the length of the growing season and the irrigation requirements.

Table 16.1 presents some of the recipes applied in Cyprus for fertigation on a continuous basis, at a constant rate and feeding, during irrigation.

TABLE 16.1 - Net concentration of fertilizers in ppm (mg/litre, or net fertilizer g/m³ irrigation water)

Crop	N	P	K
Citrus	50	12	15
Bananas	50	15	40
Tomatoes	180	50	250
Cucumbers	200	50	200
Bell peppers	170	60	200
Cabbage	100	60	200
Onions	100	50	150
Squashes	200	50	200
Potatoes	150	50	180
Groundnuts	120	50	200
Watermelons	150	50	150

Note:

The above recipes vary in accordance with the fertilizer reserves in the soil.

FIGURE 16.2 - Preparing the fertilizer solution.



The above recipes are recommended for irrigation water with very low salinity. As a rule of thumb for average quality water, the maximum fertilizer concentration, which is added to the irrigation total salinity, should have an EC of about 0.5 dS/m. For higher concentrations, the salinity level in the soil root zone must be checked frequently and the application adjusted according to the soil test results.

EXAMPLE – Fertigation with vegetables

- Crop: Tomatoes;
- Concentration of NPK fertilizers: 180-50-250;
- Type of fertilizers available: Ammonium nitrate (33.5-0-0) NH_4NO_3 ; Diammonium phosphate DAP (16-48- 0); $(\text{NH}_4)_2\text{HPO}_4$; Potassium chloride (0-0-60) K_2O ;
- System flow: 23 m^3/h ;
- Irrigation dosage: 18 m^3 ;
- Duration of application: 1.5 hours.

Phosphate and potassium are given in oxides, therefore they are converted into P and K elements by multiplying by 0.4364 and 0.8302 respectively.

Calculation of the amounts of fertilizers needed in grams per cubic metre of water:

$$\text{K} = 250 \times 100 \div (60 \times 0.8302) = 0.502 \text{ kg } \text{K}_2\text{O}$$

$$\text{P} = 50 \times 100 \div (48 \times 0.4364) = 0.239 \text{ kg } (\text{NH}_4)_2\text{HPO}_4$$

This amount also provides 38 g of N.

$$\text{N} = (180-38) \times 100 \div 33.5 = 0.424 \text{ kg } \text{NH}_4\text{NO}_3$$

Thus, for 18 m^3 of water, which is the irrigation dosage, the exact quantities are:

$$0.502 \text{ kg} \times 18 = 9.036 \text{ kg } \text{K}_2\text{O}$$

$$0.239 \text{ kg} \times 18 = 4.30 \text{ kg } (\text{NH}_4)_2\text{HPO}_4$$

$$0.424 \text{ kg} \times 18 = 7.63 \text{ kg } \text{NH}_4\text{NO}_3$$

The amount of water needed for the dilution of the above quantity of fertilizers is estimated by taking into account the solubility of the fertilizers:

9.036 kg K_2O x 3 litres	27.00 litres
4.30 kg Ca (H_2PO_4) x 2.5 litres	10.75 litres
7.63 kg NH_4NO_3 x 1 litre	7.63 litres
Minimum amount of water needed	45.00 litres

If the fertilizers are diluted in 60 litres of water and the duration of the irrigation is 1.5 h (1 h 30 min), then the injection rate should be about 40–45 litres/h in order to complete the fertigation in approximately 1 h 25 min.