APPLICATION TECHNIQUES OF FERTIGATION

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Abstract

Advances in micro-irrigation techniques have facilitated greater adoption of the application of fertilizers to crops through irrigation water; the technique is termed as fertigation. Fertigation is used extensively in commercial agriculture and horticulture and is starting to be used in general landscape applications as dispenser units become more reliable and easy to use. Some irrigation systems offer the ability to use high-frequency fertigation likes drip irrigation systems. Irrigation and fertigation system design, soil type, crop stage, chemical type, fertigation time and irrigation water quality are important parameters for an appropriate fertigation. Fertilizer application techniques are also an important factor in achieving success. All techniques for incorporating a chemical with the irrigation water create a specific level of chemical concentration during irrigation. The various techniques may be classified into three main groups. These are; (i) gradual decrease of chemical concentration, (ii) constant level of chemical concentration, (iii) intermittent chemical concentration. In this article, the methods and equipments of fertigation and some research results of the fertigation frequencies on crops are presented.

Keywords: *fertigation, application techniques, injection, fertigation frequency*

INTRODUCTION

Fertigation is basically to supply fertilizers via irrigation water to the crops (Cetin and Tolay, 2008). This- a modern agro-technique, provides an excellent opportunity to maximize yield and minimize environmental pollution (Hagin et al., 2002) by increasing fertilizer use efficiency, minimizing fertilizer application and increasing return on the fertilizer invested. In fertigation, timing, amounts and concentration of fertilizers applied are easily controlled.

Thus, fertilizers are delivered through the irrigation water. The use of fertigation enables for highly accurate nutrient supply to plants. A small and frequent application of fertilizers, in the exact amounts that meet crop requirements, increase the efficiency of nutrient uptake and minimizes nutrient loses. However, using fertigation requires careful management and many factors must be taken into consideration.

The application of fertilizers is highly site-specific, depending on soil type, climatic conditions and water quality. Fertilizer demand in intensive plant production systems is particularly variable, changing rapidly during the season and the year and even within day and night. The nutrient requirements of annual crops is very much dependent on the biological stage of growth, varying from seeding to harvest, and likewise in orchard crops from vegetative to fruiting periods (Kafkafi and Tarchitzky, 2011).

Some of the basic advantages of fertigation are that efficiency of nutrient utilization is excellent, distribution of fertilizer is uniform, micro-nutrients and soil conditioners can be very effectively applied and poor quality irrigation water can be used (Anonymous, 2013a). Thus, fertigation ensures the fertilizer will be carried directly to the root zone. Amounts and timing of fertilizer application can be precise. Studies have shown that compared to broadcast applications, dramatically less fertilizer needs to be used to achieve similar growth and yield due to direct application to root zones when using fertigation. When using fertigation combined with scheduling of irrigation there may be savings of up to 50 percent of the amount of water is used, compared to a fixed irrigation schedule. Dependent on soil type, leaching of nutrients into the ground water can be reduced. Fertigation allows for increased flexibility at reduced rates of fertilizer timed more closely to tree demand. Compared to broadcast

application of fertilizer, fertigation of phosphorus and potassium allows rapid movement into the root zone.
Although the fertigation is a modern agro-technique for irrigated agriculture, there are some disadvantages. Fertigation using drip-irrigation or micro-irrigation is very sensitive to clogging, nutrient content in the used wastewater might vary and difficult to predict, it may require expert design and installation and not all parts and materials may be available locally.
In addition, uniformity of application depends on uniform water distribution. Poor system design, plugged lines and emitters means poor distribution. Fertilizer amounts cannot be varied to suit individual tree requirements. Only soluble forms of fertilizer can be used. Soil acidification is a significant problem with the use of any acid fertilizers regardless of application method particularly in poorly buffered soils, and low pH soils. This problem is intensified with drip irrigation. Some nutrients are leached readily, particularly nitrogen, boron and sometimes potassium particularly in coarse textured soils. Roots are generally restricted to areas close to the emitter. A smaller root volume may result in uptake difficulties for non-fertigated non-mobile nutrients, such as copper whose uptake is dependent on root length.

APPLICATION of FERTIGATION

Application Methods

There are two main methods of fertigation as quantitative (i) and proportional (ii). When using fertigation, fertilizers solutions are prepared in advance in stock tanks and the solution is then injected into the irrigation water. The most common fertigation methods to do so are the quantitative method and the proportional method.

The quantitative method (i) is commonly used in soils. In this fertigation method, the grower first decides how much fertilizer to be applied per area (e.g. kg/ha). This quantity of fertilizer is then delivered through the irrigation system. The proportional method (ii) is mostly used in soil-less media and sandy soils. In this method a defined quantity of the stock solution is injected into each unit of water flowing through the irrigation system (e.g. l/m^3, mg/l)
Depending on the methods of fertigation, application methods may use given below (Anonymous, 2013b).

1. Continuous application: Fertiliser is applied at a constant rate from irrigation start to finish. The total amount is injected regardless of water discharge rate.
2. Three-stage application : Irrigation starts without fertilisers. Injection begins when the ground is wet. Injection cuts out before the irrigation cycle is completed. Remainder of the irrigation cycle allows the fertiliser to be flushed out of the system.
3. Proportional application : The injection rate is proportional to the water discharge rate, e.g. one litre of solution to 1000 litres of irrigation water. This method has the advantage of being extremely simple and allows for increased fertigation during periods of high water demand when most nutrients are required.
4. Quantitative application : Nutrient solution is applied in a calculated amount to each irrigation block, e.g. 20 litres to block A, 40 litres to block B. This method is suited to automation and allows the placement of the nutrients to be accurately controlled.
Different application methods of fertizers in fertigation are given in Fig. 1. (Manor et al., 1983).

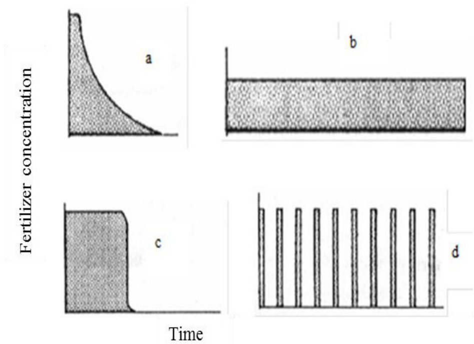

Figure 1. Decreasing nutrient concentration depending on time (a), fixed concentration during irrigation (b), fertigation in a part of irrigation (c) and equal and fixed quantities application of fertigation for same irrigation intervals (d) (Manor et al., 1983).

On the other hand, the selection of the correct injection equipment is just as important as the

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selection of the correct nutrient. Incorrect selection of equipment can damage parts of the irrigation equipment, affect the efficient operation of your irrigation system or reduce the effectiveness of the nutrients.
The three usual methods of injection are (Anonymous, 2013b):

1. Pressure differential injection: A pressure differential tank system is based on the principle of a pressure differential being created by a valve, pressure regulation, elbows or pipe friction in the mainline, forcing water through a bypass pipe into a pressure tank and out again, carrying a varying amount of dissolved fertiliser. Advantages are very simple to operate; a stock solution does not have to be premixed, easy to install and requires little maintenance, changing fertiliser is easy and ideal for dry formulations. Disadvantages are concentration of solution decreases as fertilizer dissolves, leading to poor placement of nutrients, requires pressure loss in main irrigation line, tank must be able to withstand irrigation line pressure and proportional fertigation not possible, limited capacity, accuracy of application is limited and determined by volume rather than by proportion.

2. Suction injection: Suction of fertiliser through the intake of the pump is a common method of application and is the simplest method. The pumping unit develops a negative pressure in its suction pipe (unless the suction is flooded). This negative pressure can be used to draw fertiliser solutions into the pump. A pipe or hose delivers the fertiliser solution from an open supply tank to the suction pipe. The rate of delivery is controlled by a valve. This connection must be tight to prevent air entry into the pump. Another hose or pipe connected to the discharge side of the pump can fill the supply tank with water. A high-pressure float valve can be used to regulate this inflow into the tank. If necessary the system can be automated with a direct-acting solenoid valve. For multiple block usage, two or more tanks can be set up in series and operated when required. Advantages of this injection are very simple to operate; a stock solution does not have to be premixed, easy to install and requires little maintenance, ideal for dry formulations and low cost. Disadvantages are concentration of solution decreases as fertiliser dissolves, placing most of the nutrients below the effective root zone if tank is operated when irrigation is commenced. Proportional fertigation is not possible unless several tanks are used, limited capacity, danger of suction air entering the pump unless all fittings are airtight, risk of corrosion of pump bowl. Flushing the system is necessary and risk of contamination of water supply if chemicals flow back down suction pipe when pumping unit stops. A check valve is necessary and automation is difficult.

3. Pump injection: This is the most common method of injection of fertiliser into irrigation systems. Injection energy is provided by electric motors, impeller-driven power units and water-driven hydraulic motors. The pumps are usually rotary, gear, piston or diaphragm-type which deliver fertiliser solution from the supply tank into the pressurised mainline. This method can be very accurate. Pumps are generally not simple in design and can include a number of moving parts, so wear and breakdown are more likely. The three systems available are electric injection pumps, piston-activated pumps and diaphragm-activated pumps. Piston-activated and diaphragm-activated pumps are both hydraulic injection pumps; these dominate the fertigation market at present. Electric injection pumps include single or multiple piston, diaphragm, gear and roller pumps. Advantages are simple and effective, relatively easy to install and maintain, either proportional or quantitative fertigation is possible, no pressure loss in the main irrigation line, suitable for high head systems and automation is relatively easy. Disadvantages are pumps must develop a minimum mainline pressure to operate, need electric power source to operate and injection rate not easily adjusted.

Injection Equipments

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 (Anonymous, 2013c).

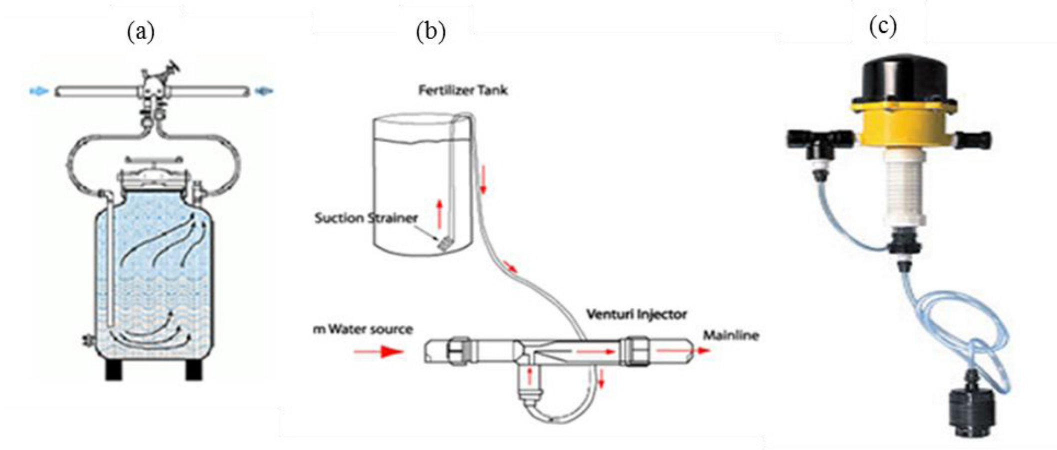

Figure 2. Different injection equipments for fertigation. Fertilizer (closed) tank (a), venturi system (suction) and a hydraulic pump (c)

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 (Fig. 2a). 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. A by-pass fertilizer tank is the simplest way to apply fertilizers through the irrigation water. Injection of the fertilizer is not proportional to the water discharge rate. As the dilution ratio and rate of injection are not constant, fertilizer concentration is high at the beginning and decreases as irrigation progresses.

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 to 2 inches and with injection rates of 40–2 000 litres/h. They are relatively cheap compared to other injectors (Fig. 2b).

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 (Fig. 2c). 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.

CONCLUSION

Fertigation is affected by different crop species and growing stages, different environmental conditions (soil, climate etc) and growing media. Modern fertigation should be able to regulate quantity applied, duration of applications, proportion of fertilisers and starting and finishing time.

In fertigation, one-third of phosphorus and approximately one-fourth of the nitrogen are, basically, incorporated into soil before planting. The remaining fertilizer, which contained nitrogen, phosphorus, potassium and some minor elements, is applied by fertigation every one or two irrigation cycles (Cetin and Tolay, 2008).

In application of the fertigation, a pressure differential is created by throttling the water flow in the control head and diverting a fraction of the water trough a tank containing the fertilizer solution (Sne, 2006). This application is commonly used because it is cheap and simple. The other equipments, venture system and pumps, are also used depending on precision application and cost of these.

The effects of application of fertigation on crops are different depending on using equipment, practical application, crop species, soil and climate conditions. Kırda et al.(1997) stated that there were no significantly differences on continuously and discontinuously application of nitrogen in greenhouse for tomatoes. Thompson et al. (2003) found that there was no any significant effects of application frequency of nitrogen by fertigation on broccoli yield. However, the application frequency of fertigation increased yield and nutrient elements uptake by crops under the soilless (perlite) conditions (Silber et al.,2003). This is very important for the media which has lower nutrient concentration. In addition, Fernandes et al.(2003) stated that daily application of fertigation increased the crop yield compared to weekly application for water melon. İbrahim (1992) determined that fertigation applied for each 2 days increased the crop yield compared to the application for 15 days. On the other hand, total N uptake was appreciable higher with increasing N rate and with more frequent than with less frequent fertigation for tomatoes (Badr and Abou El-Yazied, 2007). Fertigation of P at any rate also resulted in more available P compared to soil applied treatment (Shedeed et al., 2009).

Considering the results on fertigation, the effects of the applications of fertigation are different on crops depending on climatic and environmental conditions, and methods of applied. Although the fertigation is a modern agro-technique, it needs more data and information and multi-disciplinary works such as soil fertility, plant nutrient, plant physiology and irrigation.

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