Spatial and temporal variations of fertigation with reference to a non electric proportional liquid dispenser

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Abstract: Fertigation refers to the combined application of water and soluble fertilizer through an irrigation system. Now-a-days micro irrigation techniques such as the drip and micro sprinkler irrigation systems are gaining momentum and popularity among the farmers. A study has been carried out to find out the most efficient fertigation system. Fertilizer tank, venturi assembly, chemical injector pump, and non-electric proportional liquid dispenser (NEPLD) are the different possible systems through which fertigation could be accomplished in closed conduit pressurised irrigation system. Besides the simplicity and affordability, the fertilizer tank leads to poor uniformity of application. Chemical injector pump solves the problem of non uniformity of application, but higher cost of operation and complexity involved in maintenance of this equipment makes the farmer reluctant to use this system. Non-electric proportional liquid dispenser (NEPLD), a state-of-art fertigation technology which can be installed directly in any waterline can solve the above mentioned problems.

Key words : Fertigation, Fertilizer tank, Venturi assembly, Chemical injector pump, NEPLD.

Introduction

Fertigation refers to the combined application of water and soluble fertilizer through an irrigation system. Normally many soils in India are coarse textured with low organic matter content and are inherently low in fertility. Such soils often require replenishment of nutrient deficity by application of manures and fertilizers to increase crop yield. Now-a-days micro irrigation techniques such as the drip and micro sprinkler irrigation systems are gaining momentum and popularity among our farmers. Conventional method of applying fertilizer by broadcasting uniformly on the surface or by drilling a continuous band of fertilizer alongside the row crop, are not compatible with drip irrigation system, because in drip irrigation system water is applied only to a fraction of soil volume (near the root zone). In this wetted zone only we have to apply fertilizer with nutrients, which are essential for plant growth. Surface application of dry fertilizer may not ensure optimum placement, requires lot of manpower and time consuming processes compared to fertigation through drip system. Drip irrigation is more desirable than other irrigation methods for several reasons. Two improvement advantages are (1) water conservation (drip requires about half as much water over the growing season as surface irrigation) and (2) the potential for significantly improving fertilizer management. Fertigation is the timely application of small amounts of fertilizer through drip tubes directly to the root zone. Compared to conventional ground application, fertigation improves fertilizer efficiency. Subsequently, comparable or better yields and quality can be produced with 20 per cent to 50 per cent less fertilizer (Darbie M.Granberry, 1996). This paper describes the various possible methods fo fertigation, management of fertigation systems, methods for determining and its efficiency of application.

Materials and Methods

The present study was carried out in a farmer's field at Kalapalayam, Coimbatore to find out the most suitable fertigation mechanism among the different available methods of application. Selecting and sizing a fertilizer injection pump should be based on the fertilizer to be injected, the rate of injection, and any restrictions or requirements on the method of fertilizer injection. In closed-conduit pressure irrigation systems, fertigation could be accomplished by the following modes:

Fertilizer tank

Fertilizer mixture can be injected directly from the stock supply tank or form injector feeder tank. Injector feeder tank or fertilizer tanks are useful for injecting a specific volume regardless of the injection rate. When the tank is empty, the desired volume of fertilizer mixture has been injected. In this type, an appropriate size of tank is connected to main pipeline through valves. Fertilizer is mixed with water at right proportion in the tank itself before starting the irrigation. Manual adjusting of valves controls the intake rate of fertilizer through the irrigation system. This procedure eliminates excess applications of fertilizers due to pump or controller failure. The size of the feeder tank required will depend on the volume of fertilizer mixture to be injected which inturn will depend on either the total amount or volume of fertilizer to be applied or the length of the injection period. In addition to the desired level of fertilization, these situations require knowledge of the irrigated acreage per zone or number of plants (or trees) irrigated in each zone.

Venturi assembly

The venturi system creates a pressure differential that forms a vacuum. As water flows through the tapered venturi orifice, a rapid change in velocity occurs. This velocity change creates a reduced pressure (vacuum), which draws (pulls), the liquid to be injected into the system. Since the injection rate will vary with the pressure differential across the venturi a precise regulating valve and a flow meter are recommended for calibrating the system.

Chemical injector pump

Positive displacement metering pumps are often used to inject chemical solutions into drip irrigation systems. Portable positive displacement pumps can be moved from field to field. Metering pumps may be powdered by small electric motors or by hydraulic drive systems. Hydraulic drive systems use the water pressure in the system to power the pump. In the past, injection rates of positive displacement pumps were adjusted by changing the length of the piston stroke. However, injection rates of some of the more recent models can be adjusted with a variable frequency drive. This drive varies the speed of the injection pump with a flow rate of the irrigation system.

Non-electric proportional liquid dispenser (NEPLD)

The dispenser consists of hydraulic piston pump that operates without electricity, using water pressure as the power source. The water in the mainline, on its way through activates the dispenser, which takes up the required quantity of concentrate directly from the container. Inside the dispenser, the concentrate is mixed with the water, and the water pressure forces the solution down stream to mainline. Also one can set the dose of concentrate from 0.2 per cent to 2 per cent with respect to the volume of water entering the mainline. Normally in all drip irrigation system, the quantity of water discharged per hour can be calculated easily. Also if we know the quantity of fertilizer to be applied and its proportion, we can calculate the percentage of dosage and small shall be set in the dispenser. It has a flow rate ranging from 500 litres/hour to 20,000 litres/hour and it withstands pressure ranging from 0.15 kg sq.cm to 10 kg/sq.cm.

Fertilizer mixtures & injection rate

Fertilizers are available in different form and concentrations. Formulations usually contain two or more nutrients and the solubilities of various formulations vary significantly. Fertigation involves deciding which nutrients (and how much) to apply, and what proportion. Solubility indicates the relative degree to which a substance dissolves in water. Solubility of fertilizer is a critical factor when preparing stock solution for fertigation, especially when preparing fertilizer solutions from dry fertilizers. Fertilizer formulation vary considerably in their ability to dissolve in water. The following table (Table 1) shows the solubility of some important fertilizers

Table 1. Solubility of selected fertilizers in pure water

Fertilizer formulation	Solubility (kgl^{-1})
Ammonium nitrate	1.17
Calcium nitrate	1.02
Potassium chloride	0.28
Potassium nitrate	0.13

Table 2. Average flush times from drip lateral (16 mm OD)

Lateral flow rate in 'l hr⁻¹'	Lateral length in 'm'	Flush time in 'min'
	50	12
	100	15
200	150	16
	200	18
	50	17
	100	19
150	150	22
	200	23
	50	20
	100	24
100	150	26
	200	28
	50	33
	100	38
50	150	42
	200	45

Hot water increases solubility and makes dissolving fertilizer easier and quicker. Hot water may be especially helpful when dissolving a fertilizer such as potassium nitrate, which actually cools the solution as it dissolves. Because solubility is reduced when water cools, it is not a good practice to heat water in order to dissolve "extra" fertilizer (more than is soluble at normal temperatures). As the solution cools, this extra fertilizer will come out of solution (precipitate or "salt out") and possibly clog drip emitters. If two or more fertilizers are to be mixed in the same solution, their combined solubility is tested by mixing them in one to five litres of water (mix precise amounts so the concentrations will be the same as the concentrations desired in the stock solution). If the fertilizers dissolved completely in this test, it indicates the correct preparation of concentrated solution. If the fertilizers is not dissolved means it indicates high concentrated solution. Preparaton of nutrient stock solutions from dry fertilizers may require considerable time and effort and can generate sediments and scums as waste products. Therefore, commercially prepared liquid fertilizer solutions (true solutions, not suspensions) that are completely water soluble are often used. To obtain the higher uniformity in application, it is appropriate to maintain the desired concentration of fertilizer in the irrigation water. This requires injecting a supply mixture or stock solution at the proper rate to maintain the desired concentration. Concentrations may be expressed in per cent (%) or in parts per million (ppm) both of which refer to the ration of the mass or weight of fertilizer to the mass or weight of the mixture. A 1% solution is equivalent to a 10,000 ppm concentration. Many fertilizer solution concentration level is very low hence ppm is convenient unit to use.

Results and Discussion

In the fertilizer tank system, since the manual adjusting of valves controls the intake of fertilizer, the intake rate and total flow rate in mainline cannot be predicted. Also, this adjustment of valves reduces the actual system flow rate, which leads to increased time of operation. Accuracy of application will be poor in this type. The only advantage of this type is simplicity of design and affordability. The above said problem was not experienced in the chemical injector pump system, but since the discharge rate of chemical injector pump is constant, the different concentration of application can be applied by only adjusting the mainline discharge rate with respect to discharge rate of chemical injector pump. So it becomes a more complex operation and also it needs electricity, which may increase the total running cost of the system. Venturi injectors and fertilizer tanks generally result in more variable injection rates, which may be acceptable with chemicals that do not need to be injected at precise rate, such as many fertilizers. And comparing to above methods the non-electric dispenser seems an ingeniously simple system. The dispenser is completely hydraulic and so required no electrical connection and its precise dosing avoids the waste and reduces the risk of pollution through concentration of fertilizers.

The length or duration of the injection cycle must be consistent with the irrigation cycle and should provide sufficient post-injection flush time to purge irrigation lines of injected fertilizers. The purge time required is based on the velocity of the water in the pipelines and the hydraulic distance between injection location and most distant emitters. Main and sub-main pipes generally are sized to restrict flow velocities less than 1.5 m/sec. Because most of the irrigation systems will have less than 800 m of main and sub-main pipe from the mainline to drip laterals, most injected fertilizers in this portion of the irrigation system will flush within 10-20 min after injection has ceased. Flow velocities within the drip lateral is much lower than the main and sub-main pipes and require longer period of flush time than those pipe sections. Fertilizer flush times are shown in following table (Table 2) for drip laterals of different combinations of lateral length and tubing discharge rate. Emitter discharge rate and emitter spacing combinations was used to determine the tubing discharge rate in lhr^{-1} per 100m. Moderate flow rates 225-300 lhr^{-1} per 100m requires 20-25 min of flush time in addition to the time required to flush main and sub-mains. Also it has been found that low flow rate drip irrigation products require long flush times therefore 30-40 min. flush times may be very common to many drip irrigation systems.

Injection periods and calibration

The injection period was determined from the volume of the fertilizer to be applied and the rate of injection One calibration procedure involves placing accurate flow meter on the injection line and then measuring the volume of chemical/fertilizer injected during the specific time period. A measurement period of 2-5 min should suffice, however the longer operating hours increase measurement accuracy. Another calibration procedure involves physical measurements of the injected fertilizer during the measurement period. The first method measures the initial volume and the final volume after specific injection period. The injection period should be atleast several minutes, but short enough so that all of the fertilizer has not been injected

Summary and Conclusion

It has been observed that the Non-electric proportional liquid dispenser (NEPLD) acts as the via medium solution for the first three methods namely fertilizer tank, venturi assembly and chemical injector pump. The important advantage is the dose of concentrate injected to the system is always proportional to the volume of water entering the dispenser, whatever variation in flow or pressure that may occur in the mainline. Also the dose of concentrate can be set externally from 0.2 per cent to 2 per cent with respect to the volume of water entering the mainline.

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(Received: July 2002; Revised: July 2003)