Journal of AgriSearch 4(1):16-22
An Open Access International Peer Reviewed Quarterly

ISSN : 2348-8808 (Print), 2348-8867 (Online)
http://dx.doi.org/10.21921/jas.v4i1.7413

# Concentration Variability of Fertilizers in Pressurized Fertigation System

P KUMAR*, RP SINGH[1] AND VK TRIPATHI[2]

*Forest Research Institute (ICFRE), Dehradun, Uttarakhand, India*

**ARTICLE INFO**

| | | |
|---|---|---|
| Received on | : | 18.01.2017 |
| Accepted on | : | 03.02.2017 |
| Published online | : | 01.03.2017 |

## ABSTRACT

An experiment was conducted to measure the variability in urea-N and potassium concentration with injection time at different operating pressures. It was done with urea and muriate of potash (MOP) for different amounts of fertilizers (10, 16 and 21 kg of urea and 5, 7.5 and 10 kg of MOP) at different operating pressures (1.5, 2.0, 2.5 and 3.0 kg $cm^{-2}$).Polynomial and exponential forms of empirical equations were developed to determine the concentration of fertilizer in the tank with injection time. In the first half an hour the remaining concentrations of both the fertilizers of different amounts in fertigation tank was less than 40% and in the next one hour the remaining concentration was less than 10%. There was no significant effect of operating pressure on change in fertilizer concentration with injection time. However, higher operating pressure may be used to apply the maximum amount of fertilizer in the beginning of the injection duration. The exponential form of equation is easier in use and also accurate for relating the concentration of fertilizers in fertigation tank with injection time. The constants of exponential equation obtained for different operating conditions can be used by the designers of pressurized irrigation system for economical and accurate use of pressure difference method of injecting fertilizers.

**Keywords:** Urea variability, MOP variability, operating pressure, drip irrigation.

## INTRODUCTION

Sprinkler and trickle irrigation system can be used to apply fertilizer along with the irrigation water. Fertigation involves injecting a water soluble fertilizer, herbicide, insecticide, fungicide in to the irrigation system (Deshmukh and Hardaha, 2014). Injection of chemicals for agricultural use is called chemigation. It is an important multipurpose function of pressurized irrigation system. The optimum utilization of water and fertilizersare possible by drip irrigation through fertigation (Raina *et al.*, 1999; Raina 2002). Fertigation technology started with uneven nutrient distribution by fertilizer tanks, and continued with water pressure driven fertilizer injectors to the modern contemporary array of fully computerized fertigation units. Pressure differential (PD) method makes advantage of the system pressure head differences for injecting fertilizer into trickle irrigation systems. The valves, venturi, elbows, or pipe friction causes pressure difference. A closed tank, which must withstand the pressure of the irrigation system, is mostly used in PD system. Although it is not possible to maintain a uniform concentration of the fertilizer being applied through the PD system, it is preferred by the farmers due to absence of moving parts and simplicity in operation without requiring any extra pump. Further, PD may be economically used when one fertilizer tank is to serve more than one subunit in a rotation for which it is necessary that the most of the fertilizer within the tank must be discharged before it is refilled and moved to the next subunit. Nakayama and Bucks (1986) developed an equation to relate percentage of fertilizer remaining in a tank as a function of time and discussed the application of the equation, with the fact that the amount of mixing that occurs in the tank will depend on the solubility of the fertilizer, size, and shape of the tank, specific gravity of the fertilizer, rate of flow through the tank and temperature. The chemistry of fertigation is an essential factor in the success or failure of the technique. Its scope covers interaction between fertilizers and irrigation water, behavior in soil solution and rate of availability to plants, influence of soil structure, the compatibility of commercial fertilizers with application techniques, the composition of nutrient solution and crop response (Singh and Pandey, 2014). Fertigation facilitates optimization of nutrient supply according to the specific requirement of the crop in different phonological stage of growth and development (Shen, 1995).Knowledge about compatibility of fertilizers is important, before feeding fertilizers in a fertilizer tank. For example, the nitrate of $(NH_4)^2$ $SO^4$ and KCL in the tank considerably reduce the solubility of the mixture due to formation of $K_2SO_4$. Similarly fertilizer like calcium nitrate and potassium sulphate cannot be mixed together in one tank. The other forbidden mixtures are - magnesium sulphate with di-or-mono-ammonium phosphate, calcium nitrate with any phosphates or sulphates, phosphoric acid with iron, zinc, copper and manganese sulphates. Field experiments of three conventionally used injectors, a water-driven piston proportional pump, a venture device, and a differential pressure tank were conducted by Li *et al*. (2007) to evaluate the effects of injector types and emitters on fertigation uniformity and results indicated that both manufacturing variability of emitters and injector types had a very significant effect on the uniformity of fertilizer applied.

[1]Irrigation and Drainage Engineering Department, GBPUA&T, Pantnagar, India
[2]Centre for Water Engineering and Management, Central University of Jharkhand, Ranchi, India
*Corresponding Author Email : parmanand30@gmail.com

The relationship between water application uniformity and fertigation uniformity for a trickle irrigation system was established for different injection methods. Asadi *et al.* (2002) studied the influence of different rates of N fertigation on corn yield and nitrate leaching. Nitrogen source was urea and there were 3 fertigation treatments (i.e. 0, 100, 150 and 200 kg N $ha^{-1}$). The average maximum yield 3.52 t $ha^{-1}$ was obtained at 200 kg N $ha^{-1}$ and lowest yield 55 kg $ha^{-1}$ was obtained at 0 kg N $ha^{-1}$.

Hebbar *et al.* (2004) studied the effect of fertigation with sources and levels of fertilizer and methods of fertilizer application on growth, yield and fertilizer-use efficiency of hybrid tomato in red sandy loam soil and they found increased root growth and NPK uptake by water soluble fertilizer fertigation. Patel and Rajput (2005) observed the effect of fertigation daily, alternate day, weekly and monthly on onion crop and $NO_3$-N of soil. The $NO_3$-N in lower soil profiles (30-60 cm soil depth) was marginally affected in daily, alternate day and weekly fertigation. However, fluctuations of $NO_3$-N concentration in 0-15 cm, 15-30 cm, 30-45 cm and 45-60 cm soil depth was more in monthly fertigation frequency. After the crop season 30% $NO_3$-N was leached through the profile in monthly fertigation. Daily, alternate day and weekly fertigation did not significantly affect yield of onion, 29.2, 28.0, 27.4 t $ha^{-1}$ respectively and application of 57.7 cm irrigation water and 3.4 kg $ha^{-1}$ urea in daily fertigation resulted in maximum yield of onion (29.2 t $ha^{-1}$) with least amount of leaching of $NO_3$-N (23%). Raina *et al.* (2005) investigate the effect of fertigation on nitrogen dynamics, growth, yield and quality of apricot. Different levels of nitrogen (100, 80, 60 and 40% of recommended dose) were tried through drip fertigation and compared with conventional soil application both under irrigated and rainfed conditions and furthermore, suggested 40% savings of N fertilizer besides marked increase in yield.

Fertigation with a completely automatic drip irrigation system and hydraulic fertilizer pumps were used through solenoid operated hydraulic valves (Hasan and Sirohi, 2006). The most suitable dose of nitrogen, phosphorus and potassium was found to be 30, 15 and 30 ppm respectively in peach and 60, 30 and 60 ppm respectively in citrus during the initial stages of growth. Water soluble fertilizers viz., Potassium nitrate, Ammonium nitrate and Phosphoric acid were used for fertigation. Potassium nitrate was the only source of potassium while nitrogen was found in both potassium and ammonium nitrate. Fertigation gives advantages such as higher water and fertilizer use efficiency, minimum losses of N due to leaching, supplying nutrients directly to root zone in available forms, control of nutrient concentration in soil solution and saving in application cost (Solaimalai *et al.*, 2005). Raina *et al.* (2011) studied the effect of drip fertigation with different levels of conventional and water soluble fertilizers on nutrient distribution in soil. Thus, fertigation becomes prerogative for increasing the yield of most of the crops under drip irrigation. The amount of fertilizer and operating pressure of the irrigation system has not been adequately addressed by the researchers. Hence, the present experiment was conducted to study the effect of amount and type of fertilizer, with operating pressure of the system on the concentration of fertilizer remaining in the tank with time for a PD system.

## MATERIALS AND METHODS

### Experimental Set-up and layout

Fertigation system was installed in the Fluid Transport Machinery Laboratory of Irrigation and Drainage Engg. Department, of College of Technology, G. B. Pant University of Agri. and Technology, Pantnagar which is situated at latitude of 29° N and longitude of 79° 18' E which altitude of 243.9 m above the mean sea level. Water source for fertigation system was a sump. Experimental setup consists of centrifugal pump, fertilizer tank with bypass system with regulating valve, pressure gauge, and laterals. A tube was connected from the fertilizer tank to the main line for injection of fertilizers. Water was diverted from the main line to the tank where fertilizer was dissolved. A regulating valve was connected with main line between inlet and outlet of fertilizer tank to control pressure and flow rate of the tank (Fig. 1).

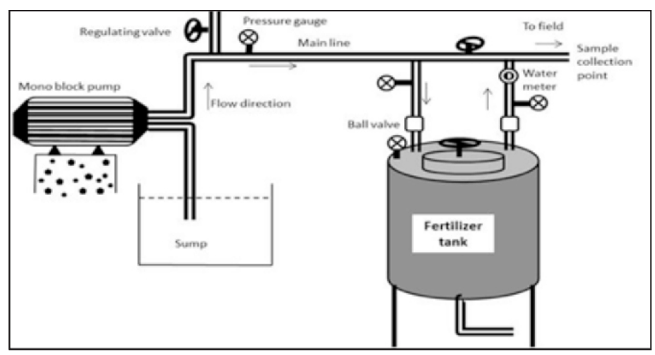


Fig.1: Schematic diagram of fertigation system

The operating pressure and discharge of the main line was controlled with the help of regulating valve. The fertigation system was operated at different operating pressures of 1.5, 2.0, 2.5, and 3.0 kg $cm^{-2}$ and the corresponding flow rate of tank was measured as 18, 32.4, 39.0 and 45.0 $lmin^{-1}$ respectively with the help of water meter. It was connected between main line and end portion of outlet of the tank (Fig. 1). The mono block type of centrifugal pump was used in this experiment and operating head of pump was 21 m with discharge 375 $lmin^{-1}$ at speed 2850 rpm. The Bourden type pressure gauge having a range of 0-4 kg $cm^{-2}$ was used to measure inlet and outlet pressure of fertilizer tank.

### Types of fertilizer used in fertigation

Two types of fertilizer namely urea and MOP were used in the experiment. Both fertilizers play an important role for major nutrients of plants. Urea as a solid fertilizer is rich source of nitrogen containing 46% N and MOP is source of potassium containing about 60% K (Pair *et al.*, 1975). The solubility of urea was 78 parts in 100 parts of water, whereas it was 35 parts in 100 parts of water for MOP. More soluble fertilizer takes less injection time, so solubility nature of fertilizer decides injection time of fertilizer. The irrigation water was mixed with fertilizer (urea, MOP) and measurements of concentration were taken at different operating pressures.

Urea: Urea (46-0-0) a very soluble nitrogen fertilizer, does not react with water to form ions. It is applied satisfactorily by fertigation with no adverse side effect to either the water or to the irrigation system (Keller and Bliesner 1990). Urea is slightly absorbed in the soil and moves with the irrigation water, flexibility in urea placement is achieved through water management. Wilson and Albano (2011) monitored nitrate-N concentrations using urea and nitrate-based soluble formulations.

MOP: Potassium (K) is an important plant nutrient and is required in relatively large amount for higher yield. It must be monitored to ensure that it will not be a limiting factor in crop production (Nakayama and Bucks, 1986). The choice of potassium (K) is based on crop need, crop tolerance, application method, and other elements in the fertilizer, fertilizer availability and cost. Fertilizer KCL also called MOP accounts for 90% of the K fertilizer used followed by $K_2SO_4$, $K_2SO_4.2MgSO_4$, $KNO_3$, $K_2HPO_4$ and $KH_2PO_4$. Potassium chloride may be undesirable for some plant because of chloride toxicity but for most of other plants it has been used successfully.

**Dosage of fertilizer**

Generally in the field amount of fertilizer is decided on the basis of types of crop and area to be irrigated. In the present study three dosage of fertilizer were selected (10, 16 and 21 Kg of Urea and 5, 7.5 and 10 Kg of MOP for 0.1, 0.15 and 0.2 ha area respectively). These dosages of fertilizers were based on requirement of fertilizer for one ha tomato crop. They were matching with the amount for which requirement is 100 Kg N and 60 Kg K (Singh, 2004).

Measurement of urea-N concentration: The sample of urea mixed irrigation water was collected just before entering the main line for measurement of change in urea-N concentration with injection time of fertigation system at different operating pressures (i. e. 1.5, 2.0, 2.5, and 3.0 kg $cm^{-2}$) and amounts of urea (i.e. 10,16 and 21 kg) kept in fertilizer tank. The regulating valve was used to operate the system at different pressure. These samples were collected at time intervals of 0, 30, 60, 90 minutes as injection period and by changing the operating pressures. The urea-N concentration was analyzed colourimetrically with the help of spectrophotometer in terms of optical density of selected wavelength according to Dougleas and Bremner (1970).

Measurement of MOP concentration: The MOP concentrations were also measured for same operating pressures and injection period. The amounts of MOP were 5, 7.5 and 10 kg. The samples were analyzed calorimetrically for potassium concentration with the help of flame photometer having a wavelength of 767 nm according to Mehlich and Monroe (1952).

**Fitting of regression equations**

Two types of empirical equations (polynomial and exponential) were fitted. The first category of empirical equations was to relate the instantaneous concentration flowing out of the tank with injection time. The second category of empirical equations was to relate the remaining concentration in the tank with injection time. Since the reduction in concentration of fertilizer varies with injection time, operating pressure, amount of fertilizer, empirical equation with constants depending upon these factors will be useful.

Polynomial form: The polynomial form of equation for relating the instantaneous concentration with injection time was fitted in the following forms.

$$C = a1t2 + a2\,t2 + a3 \qquad [Eq.1]$$

In which C is concentration (in ppm) of fertilizer in tank; t is the injection time in minute; a1, a2 and a3 are constants.

Exponential form : The exponential form of equation for relating the instantaneous concentration and concentration remaining in the tank with injection time was fitted for polynomial form.

$$C = a\,e\text{-}(bt) \qquad [Eq.2]$$

In which C is concentration (in ppm) of fertilizer in tank; t is the injection time in minute; a and b are constants.

## RESULTS AND DISCUSSION

**Concentration variability of fertilizers**

The samples were collected from main line before deliver to the field for measurement of fertilizers concentration at different amount of fertilizer, operating pressures and injection time in irrigation water. The changes in concentration of fertilizers, empirical equations have been developed to determine the concentrations of fertilizers at any injection time and operating pressure.

**Urea concentration and operating pressure**

The initial concentrations at zero injection time were in the range of 1083 ppm to 1239 ppm at all operating pressures for the amount of 10 kg urea (Table 1). The sufficient change in concentration even within few minutes due to high initial concentration and it is also seen that concentration at 30 minutes were in rang of 318 ppm to 422 ppm. Therefore, concentrations were less than 80 ppm at 90 minutes and slow rate of changing concentration after 30 minutes. The concentrations at all pressures have reduced sharply (i.e. more than 60%) within 30 minutes and the change in concentration is about 30% between 30 min to 90 min. The changes in concentration with time at all the operating pressures were more or less uniform throughout the injection time. At the injection time of 90 min; the remaining concentrations were less than 10 % for all the operating pressures. Further, it was found that the operating pressures of 2.5 kg/$cm^2$ and 3 kg/$cm^2$ gave the maximum reduction in concentration with injection time. The initial concentrations (1139 ppm to 1678 ppm) of 16 kg urea at zero injection time (Table 1) were observed and the concentrations at 30 minutes were varied from 300 ppm to 500 ppm. Further, concentrations were less than 145 ppm at 90 minutes and this shows a slow rate of changing concentration after 30 minutes. The concentrations at all pressures have reduced about 70% within 30 minutes and during 30 min to 90 min, the change in concentration is about 25%. At the injection time of 90 min; the remaining concentrations were less than 10% for all the operating pressures. Further, it was found that the operating pressure of 3 kg/$cm^2$ gave the maximum reduction in concentration with injection time. For 21 kg urea at all operating pressures, the initial concentrations at zero injection time were in the range of 1908 ppm to 2115 ppm and the concentration at 30 minutes were in rang of 500 ppm to 668 ppm. Further, concentrations were less than 141 ppm at 90 minutes (Table 1). Moreover, the concentrations observed at all operating pressures have reduced more than 65% within 30 minutes; between 30 min to 90 min, the change in concentration is about 25%. At the injection time of 90 min; the remaining concentrations were less than 7% for all the operating pressures. Further, it was also found that the operating pressure of 3 $kg/cm^2$ gave the maximum reduction in concentration with injection time. The above discussion shows that there was no effect of amount in reduction of concentration with time.

Table 1: Concentration of urea at different operating pressures

| Amount (kg) | Injection Time (min) | Operating Pressure ($kg/cm^2$) | | | |
|---|---|---|---|---|---|
| | | 1.5 | 2.0 | 2.5 | 3.0 |
| 10 | 0 | 1083 | 1239 | 1109 | 1097 |
| | 30 | 422 | 410 | 410 | 318 |
| | 60 | 162 | 99 | 111 | 77 |
| | 90 | 76 | 74 | 45 | 33 |
| 16 | 0 | 1139 | 1430 | 1625 | 1678 |
| | 30 | 330 | 472 | 455 | 436 |
| | 60 | 91 | 186 | 146 | 67 |
| | 90 | 57 | 57 | 144 | 50 |
| 21 | 0 | 2115 | 1908 | 2011 | 2106 |
| | 30 | 592 | 668 | 503 | 632 |
| | 60 | 212 | 153 | 181 | 169 |
| | 90 | 63 | 38 | 141 | 84 |

**Concentration and amount of fertilizer (Urea)**

It can be seen from Figs. 2a to 2d, the initial concentrations at zero time are different due to different amount. The trend of change in reduction of concentrations with injection time is more or less similar for all the operating pressures. There was negligible effect of amounts of fertilizers in reducing the maximum concentrations within 90 min. However, in these concentrations it was found that operating pressure of 3 $kg/cm^2$ gave the maximum reduction in concentration of urea with injection.

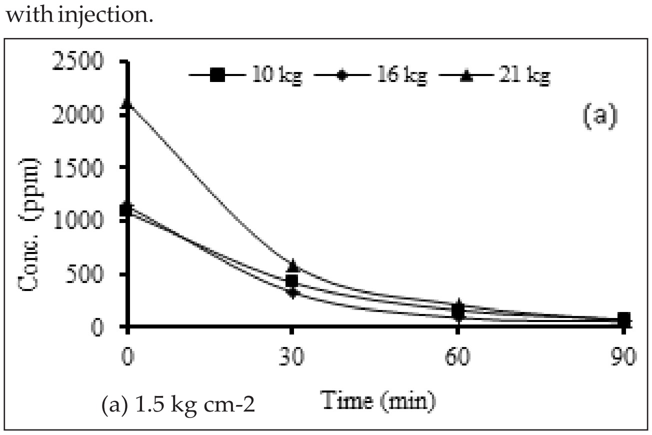


Fig.2a : Effect of injection time on concentration of urea at 1.5 $kg\ cm^{-2}$

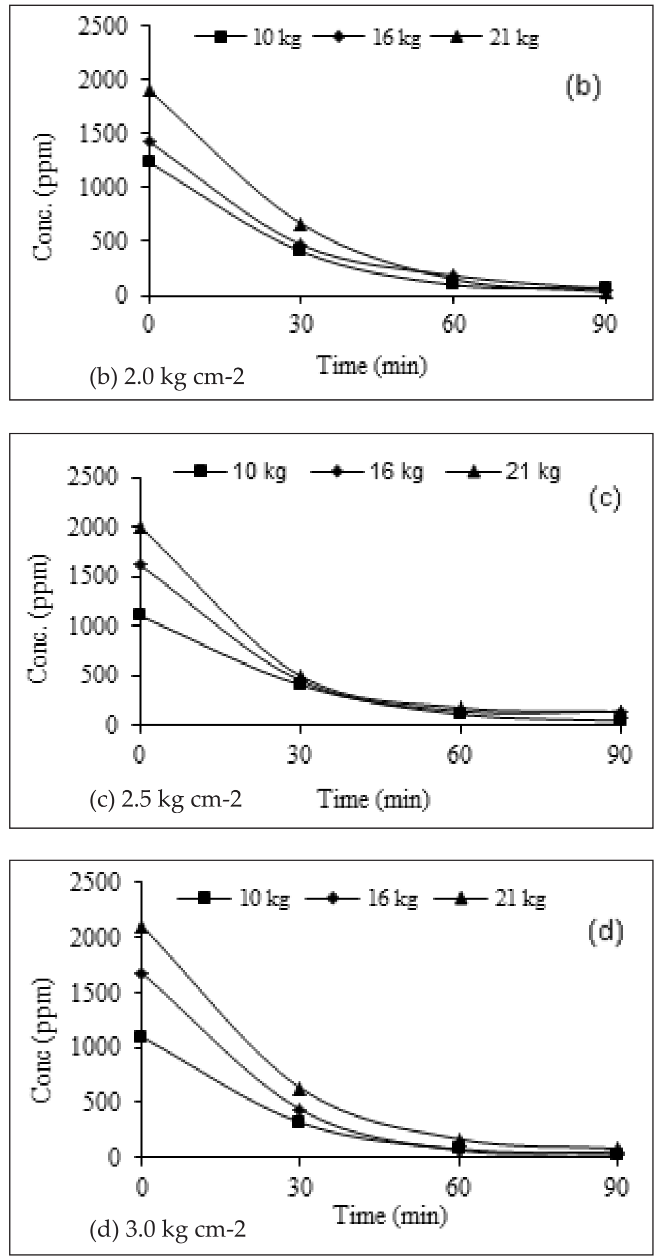


Fig.2b,c and d : Effect of injection time on concentration of urea at (b) 2.0 $kg\ cm^{-2}$ (c) 2.5 $kg\ cm^{-2}$ (d) 3.0 $kg\ cm^{-2}$

**MOP Concentration and operating pressure**

The observed values of MOP concentration in fertilizer tank were used to develop relationship between changes in concentration of potassium with time at different operating pressures and amounts. The initial concentrations (1000 ppm to 1300 ppm) at all operating pressures of 5 kg MOP at zero injection time can be seen from Table 2, and also seen that concentrations at 30 minutes were in rang of 200 ppm to 500 ppm. Further, concentrations were less than 130 ppm at 90 minutes. This again shows a slow rate of changing concentration after 30 minutes as in the case of urea. The concentrations at all pressures observed reduced sharply (i. e.

more than 65%) within 30 minutes and change in concentration is about 30% during 30 min to 90 min. The remaining concentrations were less than 12% at the injection time of 90 min for all the operating pressures. Further, the operating pressures of 2.5 kg/cm$^2$ and 3 kg/cm$^2$ observed that the maximum reduction in concentration with injection time. It was observed that for 7.5 kg MOP the initial concentrations at zero injection time were in the range of 3760 ppm to 4600 ppm at all operating pressures and also seen that concentration during 30 minutes were in rang of 476 ppm to 1112 ppm (Table 2). Further, concentrations were less than 300 ppm during 90 minutes and the slow rate of changing concentration after 30 minutes. It can be also observed that the MOP concentrations were observed reduced 70%, 75%, 83% and 87% at 1.5 kg/cm$^2$, 2 kg/cm$^2$, 2.5 kg/cm$^2$ and 3 kg/cm$^2$ pressures respectively within 30 minutes and between 30 min to 90 min, the change in concentration is about 15%. The remaining concentrations were less than 8% during 90 min injection time for all the operating pressures. Further, it was found that the operating pressure of 3 kg/cm$^2$ observed that the maximum reduction in concentration with injection time. The experiment for 10 kg MOP observed that the range of initial concentrations was 3792 ppm to 4392 ppm at zero injection time and also seen that concentration rang of 300 ppm to 600 ppm during 30 minutes and concentrations were less than during 220 ppm at 90 minutes at all operating pressures (Table 2). It can be further observed that concentrations at all operating pressures have reduced with the same trend as for the amount of 7.5 kg i.e. more than 80% within 30 minutes and change in concentration is about 10% between 30 min to 90 min.; the remaining concentrations were less than 7% at the injection time of 90 min for all the operating pressures. Further, it was also observed that the operating pressure of 3 kg/cm$^2$ gave the maximum reduction in concentration with injection time, which is equal to the case of previous amount. The above discussion shows that there was no effect of amount in reduction of concentration with time.

Table 2: Concentration of MOP at different operating pressures

| Amount (kg) | Injection Time (min) | Operating Pressure (kg/cm $^2$) | | | |
|---|---|---|---|---|---|
| | | 1.5 | 2.0 | 2.5 | 3.0 |
| 5 | 0 | 1280 | 1252 | 1024 | 1140 |
| | 30 | 440 | 248 | 352 | 280 |
| | 60 | 210 | 166 | 174 | 72 |
| | 90 | 130 | 110 | 40 | 44 |
| 7.5 | 0 | 3760 | 4368 | 4000 | 4600 |
| | 30 | 1112 | 1080 | 664 | 576 |
| | 60 | 360 | 280 | 320 | 192 |
| | 90 | 260 | 200 | 304 | 128 |
| 10 | 0 | 3840 | 4156 | 4392 | 3792 |
| | 30 | 608 | 576 | 416 | 368 |
| | 60 | 280 | 228 | 240 | 208 |
| | 90 | 220 | 216 | 156 | 106 |

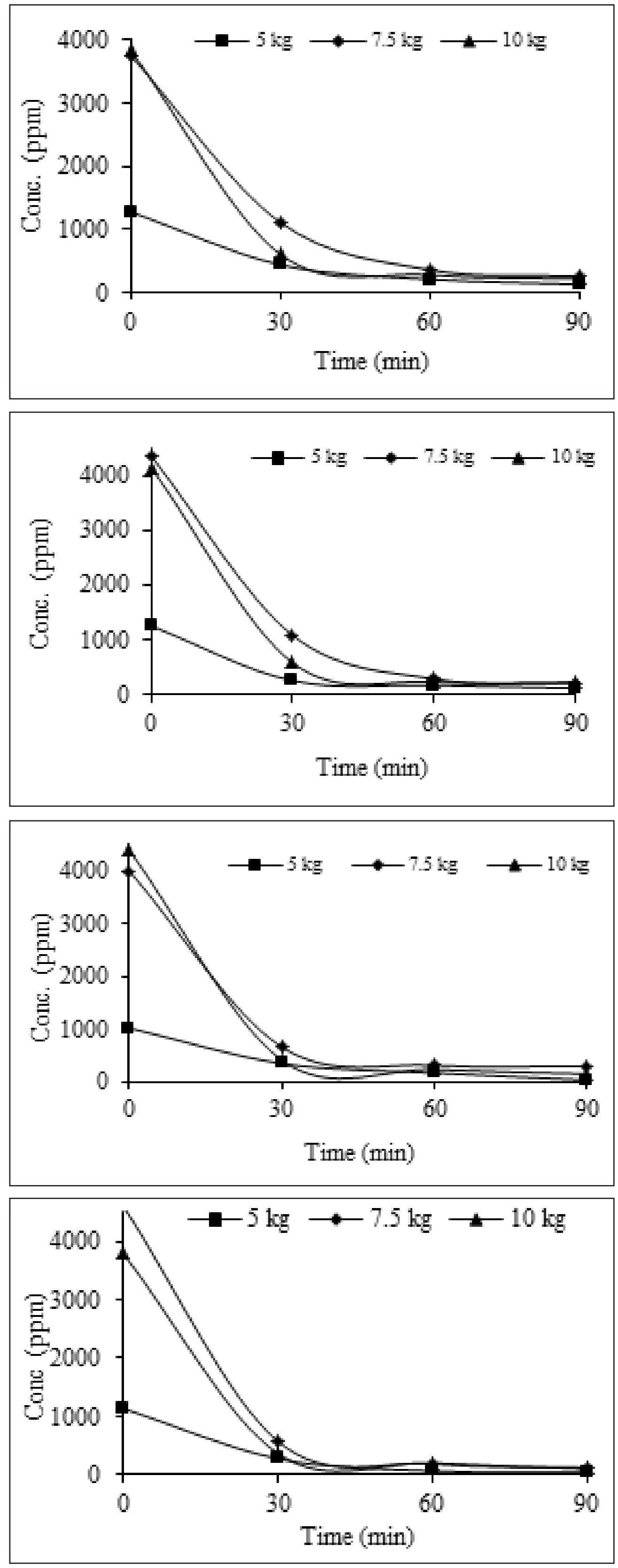


Fig. 3: Effect of injection time on concentration of MOP at (a) 1.5 kg cm-$^2$ (b) 2.0 kg cm-$^2$ (c) 2.5 kg cm-$^2$ (d) 3.0 kg cm-$^2$

**Concentration and amount of fertilizer (MOP)**

It can be seen from Figs. 3a to 3d, the initial concentrations at zero time are different due to different amount and the trend of change in reduction of concentrations with injection time is more or less similar for all the operating pressures. There was negligible effect of amounts of fertilizers in reducing the maximum concentrations within 90 min. However, in these concentrations it was found that operating pressure 3 kg/cm$^2$ gave the maximum reduction in concentration of MOP with injection time.

**Empirical Equations**

The empirical equations for change in concentration with injection time were developed by using data of table 1 and table 2.

**Recommend values of constants**

The highly significant relationship exhibited between concentration of fertilizer and injection time. The coefficient of determination varied from 0.98 to 0.99 for urea (Table 3) and 0.94 to 0.99 for MOP (Table 4) at all doses and operating

Table 3: Constants for equations relating concentration of urea with injection time

| Amount of fertilizer (kg) | Operating Pressure (kg/cm²) | Constants | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Polynomial | | | $R^2$ | Exponential | | $R^2$ |
| | | $a^1$ | $a^2$ | $a^3$ | | a | b | |
| 10 | 1.5 | 0.1597 | 25.312 | 1071.7 | 0.99 | 1045.1 | 0.0298 | 0.99 |
| | 2.0 | 0.2233 | 32.787 | 1227.4 | 0.99 | 1086.4 | 0.0329 | 0.95 |
| | 2.5 | 0.1758 | 27.462 | 1100.7 | 0.99 | 1123.2 | 0.0364 | 0.99 |
| | 3.0 | 0.2042 | 29.818 | 1080 | 0.99 | 1032.9 | 0.0398 | 0.99 |
| 16 | 1.5 | 0.2153 | 30.992 | 1120.8 | 0.99 | 981.07 | 0.0342 | 0.96 |
| | 2.0 | 0.2303 | 35.408 | 1404.3 | 0.98 | 1425.9 | 0.0353 | 0.99 |
| | 2.5 | 0.3244 | 45.04 | 1597.3 | 0.98 | 1246.1 | 0.028 | 0.89 |
| | 3.0 | 0.3403 | 48.135 | 1652 | 0.99 | 1432.1 | 0.0414 | 0.94 |
| 21 | 1.5 | 0.3817 | 56.137 | 2069.4 | 0.98 | 2039 | 0.0386 | 0.99 |
| | 2.0 | 0.3125 | 48.542 | 1891.8 | 0.99 | 2132.2 | 0.0441 | 0.99 |
| | 2.5 | 0.4078 | 56.473 | 1965.8 | 0.98 | 1545 | 0.03 | 0.92 |
| | 3.0 | 0.3858 | 56.488 | 2074.4 | 0.99 | 1925.9 | 0.0366 | 0.98 |

Table 4: Constants for equations relating concentration of MOP with injection time

| Amount (kg) | Operating Pressure (kg/cm²) | Constants | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Polynomial | | | $R^2$ | Exponential | | $R^2$ |
| | | $a_1$ | $a_2$ | $a_3$ | | | | |
| 5 | 1.5 | 0.2111 | 31.267 | 1257 | 0.98 | 1101.2 | 0.0253 | 0.97 |
| | 2.0 | 0.2633 | 35.393 | 1207.2 | 0.95 | 870.63 | 0.0257 | 0.87 |
| | 2.5 | 0.1494 | 23.883 | 1001.5 | 0.98 | 1070.2 | 0.0348 | 0.98 |
| | 3.0 | 0.2311 | 32.453 | 1116.4 | 0.98 | 945.67 | 0.0371 | 0.96 |
| 7.5 | 1.5 | 0.7078 | 101.21 | 3697.8 | 0.99 | 3116.8 | 0.0305 | 0.94 |
| | 2.0 | 0.8911 | 124.55 | 4279.6 | 0.98 | 3516.2 | 0.0353 | 0.94 |
| | 2.5 | 0.9222 | 121.11 | 3866.8 | 0.96 | 2536.6 | 0.0282 | 0.82 |
| | 3.0 | 1.1 | 145 | 4434 | 0.96 | 2985.3 | 0.0395 | 0.90 |
| 10 | 1.5 | 0.8811 | 116.59 | 3708.2 | 0.96 | 2505.1 | 0.0312 | 0.86 |
| | 2.0 | 0.9911 | 129.76 | 4011.2 | 0.96 | 2547.7 | 0.0327 | 0.83 |
| | 2.5 | 1.0811 | 140.25 | 4206.6 | 0.94 | 2494 | 0.0352 | 0.83 |
| | 3.0 | 0.9228 | 120.44 | 3631.7 | 0.94 | 2281.9 | 0.0377 | 0.80 |

pressures for the polynomial equation whereas, for exponential equation varied from 0.89 to 0.99 for urea (Table 3) and 0.82 to 0.99 for MOP (Table 4) at all doses and operating pressures. The exponential form of equation will be easier to use because only two constants a and b are required as it has been also preferred by Rolstan *et al*. (1986). These constant can be used to know the value of remaining concentration of fertilizer in tank at different application time. Since the instantaneous concentration and remaining concentrations are calculated from the same source of measurement and trend of graphs for both the cases are similar, the values of remaining concentration can be used as standard information for practical purpose. However, the empirical equations are fitted for both cases (i.e. instantaneous and remaining).

## CONCLUSIONS

The main objective of study was to relate the variability of fertilizer concentration with injection time in fertigation system. The empirical equations were developed to determine the change in urea-N and potassium concentration of fertilizer in tank with injection time at different operating pressures. Polynomial and exponential forms of empirical equations were compared. The reduction rate of concentration of urea and MOP with injection time was more or less same in the fertigation system and injection time for applying the fertilizer through fertigation system is not affected with amount of fertilizer. In the first half an hour the remaining concentrations of both the fertilizers (urea and MOP) are less than 40% and in the next one hour the remaining concentration is less than 10%. There is no significant effect of operating pressure on change in fertilizer concentration with injection time. However, the operating pressure of higher value may be used to apply the maximum amount of fertilizer in the beginning of the injection duration. The exponential form of equation is easier in use and accurate for relating the concentration of fertilizers in fertigation tank with injection time. Designers of pressurized irrigation system can use the methodology to obtain the constants of exponential equation for different operating conditions, amount and type of chemical for economical and accurate use of pressure differential system of fertigation into the pressurized irrigation systems.

## REFERENCES


Asadi EM, Clemente RS, Gupta AD, Loof R and Hansen GK. 2002. Impact of fertigation via sprinkler irrigation on nitrate leaching and corn yield in an acid sulphate soil in Thailand. *Agriculture water management* **52**: 197-213.

Darwish T, Atallah T, Hajhasan Sand Chranek A. 2003.Management of nitrogen by fertigation of potato in Lebanon. *Nutrient cycling in Agroecosystem* **67** (1): 1-11.

Deshmukh G and Hardaha MK. 2014.Effect of irrigation and fertigation scheduling under drip irrigation in papaya. *Journal of AgriSearch* **1**(4): 216-20.

Douglas LA and Bremner JM. 1970. Extraction and colorimetric determination of urea in soil. *Soil Sci. Soc. Am. Proc*. **34**: 859-62.

Hasan M and Sirohi NPS. 2006. Irrigation and fertigation scheduling for peach and citrus crops. *Journal of Agricultural Engineering* **43**(4): 43-6.

Hebbar SS, Ramachandrappa BK, Nanjappa HV and Prabhakar M. 2004. Studies on NPK Drip Fertigation in Field Grown Tomato (*Lycopersicon esculentum* Mill.).*European Journal of Agronomy* **21**(1): 117-27.

Keller J and Bliesner RD. 1990. Sprinkler and trickle irrigation. Van Nostrand, New York, NY.

Li J, Meng Y and Li B. 2007. Field evaluation of fertigation uniformity as affected by injector type and manufacturing variability of emitters. *Irrigation Science* **25**(2): 117-25.

Mehlich A and Monroe RJ. 1952. Report on potassium analysis by means of flame photometer method. *J. Assoc. Offic. Agr. Chem*. **35**: 588.

Nakayama FS and Bucks DA. 1986. Trickle irrigation for crop production, design, operation and management. Elsevier Science Publishers. Amsterdam, Netherlands.

Pair CH, Hinz WW, Reid G and Frust KR. 1975. Sprinkler irrigation. Washington, D. C. 2005. Sprinkler Irrigation Association.

Patel N and Rajput TBS. 2005. Effect of fertigation frequency on onion (Allium cepa) yield and soil nitrate nitrogen. *Indian Journal of Agricultural Sciences* **75**(11): 725-30.

Raina JN, Sharma T and Suman S. 2011.Effect of drip fertigation with different fertilizers on nutrient distribution in soil, leaf nutrient content and yield of apricot (*Prunus aremeniaca* L.). *Journal of the Indian Society of Soil Scienc e* **59**(3): 268-75.

Raina JN, Thakur BC, Suman S and Spehia, RS. 2005. Effect of fertigation through drip system on nitrogen dynamics, growth, yield and quality of apricot cv. New Castle. *Acta Horticulture* **696**: 227-29.

Raina JN, Thakur BC and Verma ML. 1999. Effect of drip irrigation and polyethylene mulch on yield, quality and water use efficiency of tomato (*Lycopersicon esculentum*). *Indian Journal of Agricultural Sciences* **69**: 430-3.

Raina JN. 2002. Drip irrigation and fertigation: Prospects and retrospects in temperate fruit production In Enhancement of Temperate Fruit Production (Jindal KK and Gautam DR, Eds.), pp 296-301. Directorate of Research, University of Horticulture and Forestry, Nauni, Solan, India.

Rolston DE, Miller RJ and Schulbach H. 1986.Fertigation : Trickle irrigation for crop production, design, operation and management. Amsterdam, Netherlands. Elsevier Science Publishers. pp. 317-344.

Shen M. 1995. The history of fertigation in Israel. Dahlia Greidinger International Symposium on Fertigation; Technion, Israel institute of Technology, Haifa, Israel, 26 March-1 April, 121-140.

Singh AK and Pandey AK. 2014. Dynamics of anthracnose disease of chilli in responses to water and nitrogen management under drip and flood irrigation. *Journal of AgriSearch* **1**(3):151-6.

Singh NP. 2004. Basic concept of vegetable science. International Book distributing Co. pp. 49-50.

Solaimalai A, Baskar M, Sadasakthi A and Subburamu K. 2005. Fertigation in high value crops – a review. *Agricultural Reviews* **26**(1):1-13.

Wilson PC and Albano JP. 2011. Impact of Fertigation versus controlled-release fertilizer formulations on nitrate concentrations in nursery drainage water. *Hort. Technology.* **21** (2): 176-80.


**Citation:**

Kumar P, Singh RP and Tripathi VK. 2017. Concentration variability of fertilizers in pressurized fertigation system. *Journal of AgriSearch* **4**(1): 16-22