Micro Irrigation Engineering
Prof. Kamlesh Narayan Tiwari
Agricultural and Food Engineering Department
Indian Institute of Technology-Kharagpur

Lecture - 31
Numerical Examples on Emission Devices and Fertigation

Hello, participants of the Micro Irrigation Engineering subject. Now it is lecture 31. In lecture 31, we will deal with numerical problems related to micro irrigation system mainly selection of the micro irrigation device, and some problems we will work out on the fertigation system.

So selection of emission devices mainly drippers, how many numbers of dripper and what should be its capacity. And then what should be the capacity of the tank or what should be the rate of fertilizer concentration it should be given. So we will work out some problems. So let us enter into the problem.

So the question 1 is given here. A drip irrigation system is to be installed to irrigate a 2-hectare area of a citrus crop to be operated for 6 hours. And we need to determine the injection rate of liquid fertilizer when the ratio between fertilization time and irrigation time is 0.35 and the rate of fertilizing per irrigation cycle is 25 kg per hectare.

Means in each irrigation cycle 25 kg of fertilizer is to be given along with irrigation water. And the concentration of nutrients in 1 liter is 0.2 kg per liter. So this is the concentration of nutrients in the liquid.

So we are given area that is 2 hectare. We have been given the fertilization cycle that is 25 kg per hectare. And then concentration of the liquid is 0.2 kg per liter. This is the ratio of fertilization time to irrigation time. And then time of operation of the drip system is 6 hours. And we need to determine the injection rate of liquid fertilizer that is q_{fi}. And this is to be calculated by using the expression.

$$q_{fi} = \frac{F_r \times A}{c \times t_r \times I_t}$$

This is already discussed in theory class. So this q_{fi} that is the rate of injection of liquid fertilizer in liter per hour can be given by rate of fertilizing that is the quantity to be applied per irrigation cycle. So this Fr to be multiplied with the area. So this area is known to us that is 2 hectare divided by the concentration c that is 0.2 kg per liter and then multiplied by the ratio of fertilization time by irrigation time.

This is your ratio, this is also known to us. This is given as 0.35 and irrigation time is 6 hours. So having given these values one can calculate. So just simply we are substituting these values, which is given as

$$q_{fi} = \frac{25\times2}{0.2\times0.35\times6} = 119.04\ Lh^{-1}$$

So this is very simple thing that we get q_{fi} equal to 119.04 liter per hour is the rate of injection of liquid fertilizer into the drip irrigation system.

Second question it is to determine the total capacity of drip irrigation which is to be designed, which is to be designed for banana crop of 2.5 hectare area. So banana crop is grown in 2.5 hectare area. So area is given to us. And a dripper of 4 liter per hour capacity is used for a crop which is having 2 meter by 2 meter spacing. So each plant is having the area of 2 meter by 2 meter. And there are total 6 number of station, operating stations in the field. So this information is also available to us. That in Ns equal to 6.

We have been given area is 2.5 hectare. Number of station 6. Discharge capacity of a single dripper is 4 liter per hour. And then spacing means row to row spacing is 2 m and plant to plant spacing that is Sl that is lateral spacing is 2 m. The equation which is applicable in this case is

$$Q_s = K\ \frac{A}{N_s}\ \frac{q_s}{S_r S_l}$$

Now K is unit constant. This is a unit constant. So if we are using Q means we want to get the discharge capacity in liter per second. Area if we are using area in hectare and the average discharge of the dripper qs in liter per hour. And then emitter spacing if I am putting it Sr in meter and then lateral spacing we are keeping in meter. K is given by 2.778.

So having given these information if I want to get discharge in liter per second that is total system capacity in liter per second then these units are to be used in order to multiply with K as 2.778. So these information are very easily it is given that is 2.5 means area is given. So area by number of station that is 2.5 by 6. And then qs divided by 2 into 2.

$$Q_s = 2.778 \times \left(\frac{2.5}{6}\right) \times \left(\frac{4}{2\times 2}\right) = 1.1575 \text{ Ls}^{-1}$$

So we get here 1.1575 liter per second. So we can say that the system capacity is 1.16 liter per second is desired in this case.

Question 3, we are required to determine the capacity of drip irrigation emission device which is to be used to irrigate mango crop of 5 m by 5 m spacing means, each plant or each tree is having spacing of 5 m by 5 m. And then wetted area is 16% means plant is at very early stage.

Normally for horticulture plantation like mango plantation, the wetting percentage is varies from a very small value and it is given say from 16% to 60%. So it is in very early stage and we are not wetting for the entire area. So only the part of area it is to be wetted by drip irrigation system or dripper. The available operation time is 4 hours means dripper or drip system is operated for 4 hours.

And application efficiency of drip irrigation system is 90%. The depth of irrigation is 10 mm. So depth of irrigation is known to us. Application time is known to us. The spacing of each plant is known to us. So we will find out what should be the capacity of a drip emitter.

So this information is known to us, it is given 5 m by 5 m. Wetting percentage is given as 16%. The depth of irrigation is 10 mm. Time of operation is 4 hours. 90% is the efficiency. So discharge of a single dripper can be given by area of one plant multiplied by the depth of irrigation divided by operating hours multiplied by application efficiency or system efficiency.

$$Q = \frac{A \times d}{H \times E_a}$$

Now this area which is there it is only the partial area to be wetted. So this area is not 5 m by 5 m, which is for one particular plant because plant is in early stage. It is not covering the whole area. So at its early growth stage, it is only 16% of the area. So this plant we will be when we want to give irrigation with the dripper at early stage this area is 4 square meter. And then depth is known to us, operating time is known to us.

So we can work out. So depth is given as 10 mm. This is 4 square meter and then the operation time is 4 hours. And this is the application efficiency that is your irrigation efficiency.

$$Q = \frac{4 \times 10}{4 \times 0.90} = 11.11\ Lh^{-1}$$

So this can be worked out as 11.11 liter per hour. So one dripper of 12 liter capacity is sufficient. Of course, this is a higher size dripper means we need to select a dripper which should not form runoff.

So if a single dripper is to be used, then it will be one dripper of 12 liter per hour or we can have two drippers, we can have two drippers in that case our operation time has to be increased. So means the selection of dripper will be made based on the particular type of the crop, how much is the wetted zone and what is the type of soil, that selection is theoretical part.

As per the numerical value is given in the question the so one dripper of 12 liter per hour capacity is adequate to apply water.

Question 4, here we are required to determine the number of emission devices needed for desired wetting pattern of 60% of banana crop, okay. So we need to find out how many number of drippers will be required. The spacing between the emission point and emission devices are 2 meter and 0.15 meter, respectively. So emission point 2 meter, emission device that is 0.15 meter. The plant row spacing is 2.5 meter.

This is another information. The maximum diameter of wetted circle formed by single point source emission device for a given soil is 10 cm. So, 10 cm is the diameter of wetting made by a single dripper. So we can say the soil is when you see this particular value, one kind of interpretation one can make that it is a highly porous soil. So wetting formed in the radial direction is lesser. Maybe more depth of water going vertically downward.

Now, in order to solve this particular question, these are the data which is given means percentage wetting area is 60%. L that is the spacing between adjacent row is 2.5 meter. And then we are having the spacing between the emission point is 2 meter. And then spacing between the emission devices is 0.15 meter that is 15 centimeter. And diameter of wetting is 10 centimeter.

$$N_e = \frac{100\, W_p\, S\, L}{D_w\, S_e}$$

So when we are substituting these values in this question, we get the value that

$$N_e = \frac{100 \times 0.6 \times 2 \times 2.5}{10 \times 15} = 2$$

S is given as 2 and L is given as 2.5. The Dw is 10 centimeter and the spacing between the emission devices this is 15 centimeter. So keeping these values in centimeter, we will get number of emission device is 2. This is adequate to provide irrigation in the desired rate. And then so this way one can get the value.

Now I am talking about question 5. In question 5, we are given the values that we need to give water of 40 millimeter for a close growing crop and we need to determine the concentration of nutrients in irrigation water when the ratio between fertilization time and irrigation time is 0.4. And the rate of fertilizing irrigation cycle is 50 kg per hectare. So we need to determine the concentration of nutrient in irrigation water. And the data are given to us.

Let us see details that we are given depth of irrigation 40 millimeter. The fertilization, ratio of the fertilization time to irrigation time is 0.4. And then the value we are given rate of fertilizing per irrigation cycle is 50 kilogram per sector. So concentration of nutrients in irrigation water can be estimated by expression

$$C_f = \frac{100\, F_r}{T_r \times I_d}$$

This is very straightforward.

We need to substitute the value and one can get the concentration in ppm.

$$C_f = \frac{100 \times 50}{0.4 \times 40} = 312.5\ ppm$$

So by this, we will get the value of concentration of nutrient in irrigation water is 312.5 ppm will be the appropriate answer for this question. So this is a straightforward question when this particular expression and their units are properly substituted.

Question 6. We have been given the data that rate of fertilizer per irrigation cycle is 50 kilogram per hectare. The area of crop in which fertigation is to be given is 5 hectare. The concentration of nutrient in the liquid fertilizer is 1 kg per liter. This is a high concentration. But we have been given this numerical problem. Let us work out what should be the capacity of fertilizer in the tank. So these values are given.

So it is a very straightforward question means the capacity of the tank it is given by

$$C_t = \frac{F_r \times A}{c}$$

The Ct equal to rate of fertilization per irrigation cycle that is expressed in kg per hectare. Then the area to be irrigated this is given to us, that is 5 hectare. We have been given the concentration of the nutrient in kg per liter. So this is also known to us. So we are just simply substituting

$$C_t = \frac{50 \times 5}{1} = 250\ L$$

So, capacity of the tank is 250 liter. So this answer is straightforward. So one can calculate. Now, these are the examples, which I have given. Based on this, other problem, and then the designing the entire fertigation unit, this information, and these expressions can be used to design the fertigation unit.

So you can refer for more examples these books, which are textbooks for micro irrigation engineering subject.

So in this particular tutorial problem, we discussed about the computation of the emitter capacity, how many number of emitters are required when irrigation is to be given and we also worked out the problem which dealt with how to find out the concentration of the nutrient, what should be the capacity of the tank.

And we also worked out from the given data, how the capacity of the tank and other associated things it can be worked out. In the forthcoming lecture, we will discuss about the installation, operation, and maintenance of drip irrigation system. So thank you very much.