**Micro Irrigation Engineering**
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**Lecture - 38**
**Micro Sprinkler Irrigation System**

Hello, participants now we are starting lecture 38. Lecture 38 is Micro Sprinkler Irrigation System. In previous lectures, we discussed about water movement through porous media when we apply water through a drip emitter. We also discussed how to develop a dripper by using basic fundamentals of the Navier-Stokes theorem and then solving that this equation by using SolidWorks software and giving the appropriate design parameters and fabrication of a dripper.

This particular topic which I am going to discuss here on the micro sprinkler irrigation system, this topic also falls under the family of micro irrigation.

Now here we will discuss what is the importance of a micro sprinkler system, how this can be installed, how important this particular system is and what are the different system components, how this could be laid out in the field. We will also discuss about some of the points which are dealt with in the design of micro irrigation system.

So, as it says, that the micro sprinklers are of low capacity water emitting devices and they fall under the category of sprinkler type, but smaller in than conventional sprinkler irrigation system, and the discharge rate is relatively lesser. It is about 250 liter per hour up to this discharge this delivers the water.

These micro sprinklers are placed on relatively close rectangular or triangular spacing depending on the requirement and they are given appropriate overlap. These could be used to irrigate close-growing crops, potatoes, carrots, leafy vegetables, and groundnut. This has been found that these crops response is much better. This method is reliable, highly efficient, and easy to operate and handle.

The system is seasonal means one can use it and then bring it back after the crop season is over. It operates at low pressure. It has a solid set installation, means once it

is installed then at the end of the crop season the system can be removed or brought back, and then again it can be reinstalled when new irrigation, a new crop is being planted.

The micro sprinklers differ from each other with respect to their size, shape, its performance and according to the operating principle micro sprinkler can be broadly classified as rotating type or static type. So in the case of rotating a hollow rotor is provided just above the nozzle and in which the water comes out under pressure. Unlike overhead sprinklers, micro sprinkler does not have any striking arm to rotate.

This is what you see here on the top in the water is coming means here there is a micro tube, water comes with the pressure and then there is enough pressure that causes the rotation and then the water is coming out of the sprinkler and that sprinkles around that.

The curvature of the rotor is so designed that it is pushed by the pressure of water flowing through it and it starts rotating in the opposite direction of the curvature. So curvature here is provided in the rotor. Accordingly, this guides the sprinkler to rotate.

In the case of a static type micro sprinkler, there is no rotor. Instead, a flat or conical hard plate is just above the nozzle so that water coming out through the nozzle strikes against it and it spreads in all direction. This is the gap which you are seeing on the top of this particular plate. So this is a hard plate and then this is serrated.

So at the time, the hard plate becomes serrated so that the water can be ejected through these serrations in all directions. This is what you see how the water is coming out on the top. So water is getting distributed all throughout. So there is equal distribution of water in all or particular specified directions. Maybe at a certain part, it is kept open and certain it is closed. So maybe it is used for half the circle or one quarter of the circle or full circle.

Micro sprinkler assembly essentially consists of a head, micro tube. So this part is head. If you see here this is the head part and then there is a micro tube which is known as spaghetti which connects to the lateral pipe. So this end here which we are

seeing here, there is a connecting nozzle or it is similar to the barb which looks like the drip emitters.

So supporting stake, there is a supporting stake, this is the stake which holds the micro sprinkler at a specified height from the ground. So if the crop height is a little large, then this stake is further extended and then another radar plastic rod is made so that the height can be increased. The head of the micro sprinkler is basically a rigid frame and is made up of a plate.

The water emitting nozzles are fixed in different ways to sprinkle water. It is the frame which guides the micro sprinkler to precipitate water in different patterns and directions. So on the top or in the side or depending on the way the serration, it has been made, accordingly, the water distribution it takes place. The internal diameter of the water emitting nozzle is very small. It could be in the order of 1 to 2 millimeter through which the water comes out under pressure. The size of the water particle depends upon the internal diameter of the emitting nozzle and the pressure behind it.

The micro tube is a semi-rigid tube which is made up of LLDPE that is linear low-density polyethylene. The internal diameter of the micro tube is 3 to 6 mm. It joins the inlet opening of the micro sprinkler with the lateral line. A small connector nozzle is also provided at the end of the micro tube to connect it to the lateral pipe. So one end is connected with the microtubule with the lateral pipe and the other end is connected with that nozzle.

The size of this connector depends upon the size of the micro tube. So this connector will be according to the size of the micro tube. So this is what you can see here. This is one type of thing that it means, this part it goes to the lateral. So this is the threaded part. So sometimes, there are other types of micro sprinklers directly that can be attached.

So this part goes to the micro sprinkler which is fitted here. Another part is also. So instead of putting into the lateral, they are means discharge micro sprinklers are there where this arrangement is normally used. This is another type, threaded, so the

threaded part is connected with the micro sprinkler. Another part, this is barbed which goes inside this particular is connected this goes inside the lateral pipeline.

And barbed-barbed, so this is another kind of arrangement that both the ends barbed to the micro tube. One end goes to the micro tube, the other end it goes to the lateral pipeline. So it will depend upon the type of micro sprinkler which we are using and then the size.

Orifice control micro sprinkler, the most common type of micro sprinkler are orifice control emitters where the flow rate at any given pressure is governed primarily by the orifice diameter. So it is the relationship because orifice type when we are talking means Q is directly proportional to the area and the square root of the operating pressure.

So Q is equal to Cd into the area multiplied by the root 2gH. So H becomes your operating pressure. So orifice control emitters are turbulent flow devices where the flow rate is regulated by dissipating energy by the friction of water against the wall of the passages and between the fluid particles themselves. Turbulent flow emitters have shorter flow paths and larger diameter passages than laminar flow devices.

So the concept is the same as being used in the case of the micro irrigation drip emitters we discussed. The basic fundamental which are used there these are also used for orifice control type of micro sprinklers. The flow velocities are greater and the potential for clogging is less than the laminar flow devices. And with orifice control emitters, the orifice diameter at the base of the emitter determines the flow rate.

So top of the emitter determines the pattern and diameter of spread. Mainly micro sprinkler we use when the crop is close spacing, besides this clogging is another thing. So this is the important part that when the quality of water is poor and drippers as well as filters it gets clogged repeatedly. In that case, because the orifice size in the case of the micro sprinkler is relatively larger. So the possibility of getting clogged, clogging problem is minimum in this case.

Vortex flow micro sprinkler is another kind of micro sprinkler. So vortex control emitters are less sensitive to pressure variation than laminar or turbulent flow emitters and such emitter has the exponent 0.4. This Q that is discharged out of the vortex control micro sprinkler is given by discharge Q equal to Kd into P to the power x. P is the operating pressure, Kd is the coefficient of discharge, and x is the exponent.

So here vortex flows when we are talking, so x is 0.4. In vortex emitter water is forced to form a vortex or whirlpool at the center of the emitter. As water rotates centrifugal force pushes it towards the outer edge of the thing. This is what you see here. The water is coming and then it is pushing it toward the outer edge. So because of the vortex action, this causes the drop in the pressure in the center where the orifice is located. And the result is a reduction in the energy of water at the discharge point resulting in a controlled flow rate. So emitter flow rate is controlled by the vortex design and orifice diameter. This is how it is happening. So this falls under the category of pressure compensating. Because it is coming less than 0.4.

Now, specifically pressure compensating micro sprinklers are another part. Here the exponent x, it becomes further lesser than 0.1 sometimes or it is between 0 to 0.3 in this range all that it is falling under the pressure compensating.

So pressure compensating micro sprinklers, the pressure compensating means use the inlet pressure to modify the shape, length, and diameter of the flow path to control the flow rate. A diaphragm that is placed over here, which will be coming at this place where it is fitted. So this diaphragm it is made up of an elastic material which deforms to control the flow rate.

As the pressure increases the diaphragm restricts the passage of diameter. This is the beauty of this particular device. So as the pressure compensating emitters are designed to discharge fairly constant discharge over a wide range of pressure where the emitter exponent is usually 0.1. Theoretically, it should be 0 but 0.1 to 0.3 this is the range normally it is given for pressure compensating type of micro sprinklers as well as micro pressure compensating drip emitters.

A major shortcoming of the pressure compensating emitter is the change in the elasticity of the diaphragm over time. So the material it is of high-quality material and this material itself is very expensive. This is made up of silica. So if means with the time, its elastic property it changes so it does not work. So the characteristics of pressure compensating also it changes.

In addition, the diaphragm will often retain some moisture when the pressure is off. The moisture may allow microbial growth within the emitter and emitter clogging may occur. Another problem can result from the invasion of ants seeking the food source all this kind of problem may invade when we are using this kind of drip emitters.

The factors that affect the uniformity of water distribution from a micro sprinkler. These factors mean they are affected by the hydraulic parameter of the micro sprinkler, system parameters of the network, and climatic parameters of the environment. These three parameters they influence the water distribution pattern. So hydraulic parameters, what are the parameters related to hydraulic? It could be the pressure discharge relationship, it can be a correlation with the stake height, rate of water application, and then the waiting radius. Another point is the correlation with the depth of water application, rate of discharge, and uniformity of water distribution with respect to discharge and stake height.

So if someone wants to study and or design the system for a given set of conditions then one can also relate for a given particular type of sprinkler how to do such type of sprinkler they behave with the pressure discharge relationship where the coefficient of discharge, as well as the exponent, can be determined. Then one can also for a given set of conditions and then how much is the wetted diameter, how much is the water application at a given pressure for a given stake height how does it behave. So this relationship can be, so such relationship can be established, and when this particular type of a sprinkler, a micro sprinkler system is installed in a field. So this will help to obtain the higher uniformity of water distribution.

The system parameter mainly with the pressure losses in the pipe network, the influence of climatic parameter. Now climatic parameter, it is the mean wind speed.

That also changes the uniformity of water distribution. The temperature of the place, because that influences the evaporation. So when the water sprinkles, so droplets get evaporated before it falls on the ground or it falls on the plant foliage. Humidity, on the evaporation of the sprinkling water, also influences. So such parameters are considered while we are interested to get better uniformity. So that should be considered while designing.

Now the next point here is system layout and components. So the layout of the system it consist of control equipped with regulating valves. More or less the same way, same equipment, except fertigation equipment, all other equipment are needed in the case of micro sprinkler design. The only thing is that their filter size may be or the mesh size will be differing. Of course, that will also depend upon the quality of water.

So these valves mean water regulating valves that is non-return valve, shut off valve, as well as a filter. So the 200 to 300 microns or 40 to 60 mesh. And no injectors are needed because in this case, fertigation is except in a few fertilizers or chemicals as and when needed that can be connected. But as such the other fertilizers because it may be harmful to the leaf of the plant. So the fertigation system is not recommended to use in micro sprinkler irrigation system.

The arrangement of main and sub-main lines, hydrants manifold is the same as the drip irrigation piping network. The size of the manifold feeder lines should be 50 to 60 mm in case the pipe size is of 75 means in no case it should exceed more than 75 mm. Now pipelines of 50 to 63 mm are recommended for the flow carrying the water of 12 to 18 cubic meter per hour when the water is distributed en route continuously. For that purpose, such type of layout is suggested. And then the pipes used for the systems distribution network are mainly rigid PVC pipelines. It would be PVC or the HDP that can be laid and these can be laid above the line. This could be laid below the ground surface depending on the conditions available there.

Irrigation scheduling. This system enables a high degree of control both when to apply and how much irrigation water to apply. Means the timing, as well as the depth of water, is to be taken into consideration. That is how irrigation scheduling is

defined. So restrictions imposed by the system are limited. Thus, there are more timing options in the irrigation scheduling program.

The vegetables are mostly shallow-rooted crops. So selected option is generally that of fixed depletion irrigation. Means the fixed depletion that can be applied. The application depth of about 20 to 30 mm is common. Of course, such values are to be determined depending on the climatic condition, depending on the particular type of crop and it's rooting depth.

But this is a general value that one can use this depth of irrigation. And total water requirement it varied from 300 to 400 mm in terms of depth. This is for the whole crop season. And the total number of irrigation required is about 12 to 15 at appropriate intervals.

So here in a micro irrigation system or whether it is a micro sprinkler or drip irrigation system, we are mainly focusing that the water means soil moisture depletion should not be more and it should be at the field capacity so that the plant does not have to suffer due to moisture content unless and until there is a shortage of water supply. Then the deficit water supply program can be made where strategy can be made to supply water at deficit way without compromising the yield of the crop.

Emitter wetting pattern you can see here that this is one of the wetting patterns where you see a wetting pattern of a spinner type of micro sprinkler. So in the case of a spinner kind of a micro sprinkler, what we see the wetting is near the sprinkler head. On this particular side, you can see that this is the center at which the sprinkler stake is there. And when the spinner type of sprinkler is there, this is a typical water distribution pattern but more depth of water is obtained that is based on the research carried out. It is obtained near the sprinkler stake. So wetting patterns of a micro sprinkler are important for sandy soils where root zones are shallow. This is for a specific case for sandy soil.

And spinner emitters are of higher application uniformity than spray-type of emitters. Both types of emitters will give higher uniformity when pressure is higher than 103 kilopascal. Now, this is the value. So what you see, the water availability is six times

more than the outer periphery. So this is the typical water depth pattern. And then this is another type of wetting pattern for the spray type of micro sprinkler where in case of spray type of micro sprinkler we see the water depth of water at the outer periphery are considerably large as compared to the near this stake. So this is another way that the how water distribution it is it has taken place.

So by using the catch can the data were collected and then it is found that how the data, how the moisture distribution or droplet distribution it takes place. So on either side of the data where it is seen that it is about 3 m on either side. So this is the more or less, you can see here about 2.5 meter is the radius of the coverage. And then at the outer radius, the depth of water is more as compared to the center.

Design criteria for micro sprinkler deliver the water in a low application rate and in fine drops. Such drops mean these could be easily drifted by wind or air. So we need to take or when we need to operate the system when there is a less or moderate or no wind condition exist. Then if the wind is a problem then the overlap should be increased, overlaps should be increased.

So in order to ensure high uniformity of water application, the spacing should be decreased or overlap should be increased, we can say, not exceeding 50% of the diameter of coverage. So sprinkler spacing along the lateral and between the lateral it is normally given as 5 to 7 meter.

So this is what you see when the sprinkler, this is the sprinkler and this is the wetting circle it has been formed. And then another sprinkler which is placed. So here it is about 50% overlap it is given. So this keeps on overlap so the water which is getting, received by the land surface. So this kind of soil moisture distribution takes place.

So individually sprinklers overlapped and resulting distribution of water in the soil. So individual sprinkler overlap it looks like this and then when the resulting distribution of water soil moisture it is it looks uniform. So this is the requirement for getting very good higher application efficiency. Hence, the common spacing is 5 m by 5 m, 5 m by 6 m. So depends on the particular type of emitter and its wetting diameter.

Furthermore, to mitigate the adverse effect of wind relatively large number of sprinklers per unit area should be operated simultaneously. The operation shifts should be arranged so that the area irrigated at the same time is as compact as possible. Generally, micro sprinkler laterals are made up of low-density polyethylene pipe of 32 mm diameter and so as to it becomes easy to handle as well as assemble and place it to the other site.

The maximum possible length of the various sizes of lateral on the ground level depends on the number of sprinklers and the spacing and the flow rate. Another component design is similar as we discussed in the case of the drip irrigation system.

So these are the reference books. And so you may please refer these papers, these books for your much more detailed study about this topic.

And so let us summarize this particular lecture. We discussed about what is a micro sprinkler and then rotating as well as the static type of micro sprinklers. We also discussed about different other types of an orifice, vortex, pressure compensating micro sprinkler, wetting pattern of micro sprinkler, irrigation schedule, and design consideration. So these points we covered in this particular topic. In the forthcoming lecture, we will discuss about the bubbler irrigation system. So thank you very much for your kind attention.