Micro Irrigation Engineering
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Lecture - 10
Demonstration of Lysimeter

Welcome participants. This lecture is on the demonstration of Lysimeter. Lysimeter, in theory class, we have discussed different types of Lysimeters, and drainage type of Lysimeter will be demonstrated in the field. You will also see in the field weighing and non-weighing type of Lysimeter.

So, types of Lysimeter for determining evapotranspiration requirement of the crop. We will show you the runoff monitoring system from the horticultural field, plantation crop. You will also be shown a groundwater level measuring system. Now, all these parameters are important for water management studies, irrigation studies, or water balance studies. So, let us go to the field and try to learn these two types of Lysimeter one is weighing type Lysimeter and non-weighing type Lysimeter in the field.

In theory class, we have explained about Lysimeters. Lysimeter is the device that is used to measure the evapotranspiration requirement of the crop. We have learned in the theory class there are two types of Lysimeter, one is a weighing type of Lysimeter another one is a non-weighing type Lysimeter. In weighing type Lysimeter the entire soil sample on which the crop is grown or plant is grown is kept on a floating material that is, it could be water, it could be heavy metal.

So, any deflection due to a change in soil moisture content, due to precipitation, due to irrigation that is reflecting in the change in the value of displacement of the liquid. So, here in this particular class, I am explaining to you a laboratory model where one can find out the evapotranspiration requirement of the crop. This is a rose plant that is grown in an earthen pot, an earthen pot is filled with the soil and then this rose plant is grown.

Now, this is placed over a base and below the base, there is a rubber seal. The rubber seal which is coiled looks the same as the scooter tire. Now, when we are filling water, it increases, it flattens, it goes up water level because of the water level. So, it expands and the connection is made in such a way the water from the outlet is connected with a measuring scale. Now, this measuring scale it can be made vertical.

But this scale is made on an inclined manometer tube. The inclination is provided to get more sensitiveness and they increase in the length of the expansion. Now one of the most important parts is that this base should be perfectly level. So, by using the spirit level we are placing here and we see that the water bubble is exactly at the center. It means this particular base is perfectly level.

Now, what I want to show you here suppose, I am growing a plant and in this plant, we are giving water. Now water can be given by using a cylinder. Now if we are giving extra water, part of this water will go out, but it is perfectly made in such a way we will not give extra water. And also, we do not allow the water to go beyond the root zone depth. So, any amount of water that is being added to this particular pot will be remains in the soil that will cause an increase in the moisture content level.

And this moisture content that is taking place will be used by the plant for meeting its evapotranspiration requirement. Now when we are adding water means the soil is gaining. Now, this gain is you know reflected in the change in the water level in the inclined manometer. Right now, if I see I have not added water, at the particular level this is a 40 millimeter. At this particular point at 40 millimeters, when this particular plane is made inclined at 15 degrees.

Now, here there is a provision if you want to increase the sensitivity, we can further bring it down if you want to increase you know means from 5 degrees to 30 degrees, there is a provision we can change the angle. And at this particular point, I am taking observation at a 15-degree angle. Now, let us see that I want to add water. Now add water means just in place of water what I am doing, I am putting 200-gram weight.

Now by placing 200-gram weight there is a change in the water level. So, initially water level let me just see the initial water level it is about 45 millimeters. Now when I am placing 200 grams means a certain amount of water which is equivalent to 200 gram. Let us say it is added to the plant there is a change in the water level and that change in the water level is reflected as 65 millimeters.

Now, let us say that plant needs to more water. So, I am adding another 200 grams. So, by addition of another 200 grams, the change in the water level means there is an increase in the water level which is nothing but an increase in this soil moisture content I can say because I am just putting these weights in terms of analogy, I am putting in terms of adding water into the soil sample.

Now, once I am adding water to the soil sample, now this value has increased the moisture content to 90 millimeters. Now further if I am putting another 200 gram means further I am adding water so it has become from 95 millimeters to 115 millimeters. So, 20 millimeters is the change in the water level which is reflecting here. Now, let us say this much amount of water that is equivalent to 600 grams of water has been added to the soil. Now, the plant will be using this water for meeting the evapotranspiration requirement of the crop.

What I am telling here, I am just putting one thing I am not giving any additional water which is going as surface runoff, I am not allowing water to go beyond the root zone depth. So, water remains in the form of soil water content. So, now I am just seeing means after 24 hours, let us say next day I am coming and then I am observing whether the how much amount of water it had been withdrawn by the plant.

So, I am taking out water let us say 200 grams of water is taken out. So, 200 grams of water is taken out the value it has changed, it has come to 97 millimeters. So, 97 millimeters means whatever the value it was there, it was there initially let me tell you, it was there initially about 120. Now it is 123 millimeter and when I am taking out 200 means next day when I come here and I take observation I find that here now this reading is 97 millimeter.

So, from 120 to 97 millimeters, this much amount of water is lost due to the evapotranspiration requirement of the crop because I did not allow any water to go beyond the root zone, I did not allow any water to go is surface runoff. So, this is the water that has been used by the plant for meeting the evapotranspiration requirement. Now again I am taking out means after 24 hours or means after 48 hours let us say, I am coming for observation.

And I observe so 200 millimeters, it means there is a withdrawal of water has been taken by the plant and then I find that there is a difference in the value. Now, this difference in the value is I find here is 73 millimeters. So, from 97 millimeters to 73 millimeters it has come. So, this is the equivalent amount of water that has been consumed by the plant for meeting the evapotranspiration requirement.

So, like this, this particular gadget first needs to be calibrated that at what will be the range say in a particular angle right now I am putting about 15-degree angle. So, what is the range that water level will fluctuate and then this has to be calibrated then the second part is we can keep giving water and then we can find out how much amount of the water once we are putting water with the help of now, I will show you say this is another 200 gram I am taking out and then observation is 52 millimeter.

Now I will put water and just it will show you that here I am putting water say, this is right now it is you can see it is a 1500 ml and putting just simply water 1400 ml means 100 ml of water I am adding. Right now, observation is this is 50 millimeters, water level in the inclined manometer is 50 millimeters at a 15-degree inclination. I am adding 100 ml of water. Sorry, it has already gone more than 100 ml, so I am putting let us say another.

This is approximately let us say about this is 1200, about 1300. So, 200 ml of water I have added and the reading was 50 millimeters. At present this reading has come to 80 millimeters. So, 80 millimeters is the water level in the manometer, and the next day when I come and take an observation, I will take out this particular and again I will put it. So, I will take observation and then I will see how much amount of water is lost.

So, it will be the combined evaporation and transpiration it has taken place from the soil because you can see here no water is taken, it has gone beyond the pot and it has not been spelled out. So, this 200 ml of water which had been added here that can be seen that how much water it will be lost. So, that water will be consumed by the plant. This way one can find out what is the total water requirement for the entire season. If it is a long-duration crop, according to the size of the container, according to the depth of the container, the volume of the container can be decided.

We have fabricated three Lysimeters where crops can be grown inside the Lysimeter. We discussed the weighing type of Lysimeter where the entire part was floating above a rubber gasket. In this case, these Lysimeters are the non-weighing type of Lysimeters where different components of water movement take place that can be monitored.

So, this particular Lysimeter is one meter long, one meter wide, and one meter deep. It is driven into the soil and then the soil from the field is filled in. We have tried in these Lysimeters to maintain the same soil texture, same bulk density, and same compaction. So, over the years, when we have conducted an experiment, we find we can replicate or create conditions whatever the field condition exists in the adjoining area.

So, the same crop is being taken, we have taken in our experiment okra crop, we have grown moong crop, we have grown rice crop in the same thing to find out crop coefficient as well as evapotranspiration requirements of the crop. Now, these three Lysimeters are where we are collecting data. So, in one case, in this particular setup what we see is that here its bottom is kept open. So, in this one as well as in this particular Lysimeter the bottom is again it is kept open and in this particular Lysimeter, the bottom is kept closed.

So, this Lysimeter when we are giving water so, water is being given with the help of the micro irrigation system so a measured quantity of water is being supplied in the Lysimeter. In all these three cases same. Since the bottom is kept open so, evaporation means without a crop, the crop is not being taken. So, evaporation and then the water which goes beyond the root zone depth or 90 centimeters of the Lysimeter, is taking place from the Lysimeter.

Similarly, evaporation plus percolation, these two components are taking place in this Lysimeter whereas, in this particular Lysimeter we are growing crop. So, and then the amount of water which we have given their same amount of water is given in this Lysimeter. So, what happened? The bottom is kept open so, evaporation because plan or crop is being grown so, transpiration takes place and then also deep percolation means water which goes beyond the depth of Lysimeter beyond the root zone of the crop that is you know is considered.

So, evaporation plus transpiration plus deep percolation all three components takes place in this one. Whereas, in this particular Lysimeter the bottom is kept closed. So, the bottom is kept closed, it is only, and then no crop is being taken. So, the amount of water which we are adding in the left or the middle one means the first one or in the middle second Lysimeter here, the same amount of water is being given but it is kept since the bottom is kept you know closed so, water remains in the Lysimeter.

So, it is only evaporation that will take place. So, if you want to subtract the total component means evaporation plus transpiration plus the deep percolation loss then I can subtract the evaporation which has taken plus from this Lysimeter then I can know what is the evaporation?

what is transpiration plus deep percolation, there is also transpiration plus deep percolation. So, these components individually can be counted and measured.

Now, in Lysimeters we have placed soil moisture measuring instruments. So, there are two types of soil moisture measuring instruments where we are using FDR that is known as a frequency domain reflectometer. So, here this white, this particular pipeline which you see here. This is an access tube and the access tube is driven up to the Lysimeter even beyond the Lysimeter. This is driven up to 1.2 centimeters.

So, what happened? In this case, when we are giving putting the placing the Lysimeter here, you see there are these two electrical probes and the arrangement made this particular, it is 10 centimeter. So, the electrical field means when we are giving a high-frequency current when it is passed through. It generates the electrical field and this high frequency the current which is passed, it is a function of the dielectric properties of the soil.

So, a dielectric constant of water is 80 and when it is dry soil it is approximately 0 to 4. But at the moisture content of this soil, it is more getting influenced. So, though the waveguide it gets influenced by the availability of the moisture content in the soil. So, here it is you know 10 centimeters as it is being shown. So, you can see here, these observations are this is first 10 centimeters then we can take another 10 centimeters.

So, the moisture content in the soil at a different depth can be monitored. Now, since already this tube is above the ground about 10 centimeters above the ground. So, when we will take observation say when we will place 20 ccm the observation what we will get, this observation will give volumetric moisture content at 10 cm depth. So, here I am placing. So, this is the value is 13.2 mm per 10 cm.

Now, I can place that say I am putting it is a 30 centimeter. So, when it is 30 centimeters the value is 21.1 millimeters per 10 centimeters. So, the water content it is being you know, it is coming in a linear unit, but this can be expressed in the volumetric unit, also in percentage, it can be expressed. So, this is the one way of finding out the moisture content at different depths in the soil.

And so, the amount of water that is stored in the root zone depth can be measured by using a field frequency domain reflectometer. There is several devices time-domain reflectometer. Several other sensors are available to monitor the soil moisture content. Now when we are talking about when I was taking your class, so, in the theory class, I was told various components take place.

One is how much amount of water is added in the form of irrigation. So, the depth of water which is supplied to the Lysimeters for meeting the evapotranspiration requirement that can be you know a measured amount it is being given. So, this we are it can be given or in the form of rainfall, if something it is coming that can be added. So, that is the gain, amount of water and then water which is going as evaporation, loss as evaporation.

This we are taking the balance in the values in three as I told you and then the amount of water that is going beyond the root zone depth. So, one has to monitor the water level also if it is going to the water table level then that can be measured by what means measuring the water table or the amount of water which is you know at different depths, that the soil moisture content that can be measured.

The other way of measurement of soil moisture content is by using a tensiometer, which is by a tensiometer. So, a tensiometer is a device that measures the tenacity of the soil which is the water that is held by the soil particles. So, these tensiometers are available in you know different sizes. You can see here we have inserted one tensiometer, this is placed about 15 centimeters below the soil level.

And this is another suppose we were interested to find out the moisture content and this is at the deeper depth. So, a tensiometer is a tube that is filled with water. The other end of the tensiometer, a common tensiometer that is connected with a gauge that carries a vacuum gauge which is giving the negative pressure or tension or suction we say. Now in this particular tensiometer, we have placed a very special type of rubber membrane.

This is specifically made rubber membrane and when we are piercing in a needle, it gives the how much amount of that tension it is available. So, when we want to find out soil moisture tension at different depths, we place a tensiometer in the soil at different depths and then find out how much is the soil moisture tension at different depths. Now, this soil moisture tension is calibrated in terms of moisture content.

So, there is a calibration curve that is used when we are taking data. So, there is a lot of you know the development it has taken place with the time. So, here these are also connected with some digital or pressure transducer-based. In this one also, I will demonstrate to you there is a needle when we are placing the needle in the tensiometer, it gives the observation. It is giving 14 millibars, 14 millibar is the observation which we are getting the value of this tension which has been created.

Now, 14 millibar is equivalent to how much is the soil moisture tension, this has to be calibrated. Means at that particular depth, as I told you that it is placed at 15-centimeter depth so, a soil sample is to be taken. Now that the soil sample is to find out the gravimetric moisture content and then this calibration curve means for the different you know soil moisture tension and then corresponding soil moisture content will be obtained and from the calibration curve one can find out what is the value of soil moisture tensions.

So, different devices are available to monitor soil moisture content. So, the amount of water that is stored in the soil as soil water that is consumed by the plant for evapotranspiration. So, water that is available in the soil can be measured by any one of these devices. It can be the FDR, it can be TDR, it can be granular soil moisture sensors, it can be there are various devices. You have different types of soil moisture sensors that are available.

So, the soil moisture content in the soil and then the water used by the plant by taking the balance of soil moisture content, taking the balance of evaporation component, taking the balance or the deep percolation content, one can find out what is the evapotranspiration requirement of the crop. Now, in-field water balance when we are doing, we are measuring various components. These components when I was telling you when the rainfall occurs.

Some part of the rain will be absorbed by the soil through the infiltration process, some part of this water will be absorbed by the soil as the soil water which will be available or the plant for meeting its evapotranspiration required. Some part of the water will go as a deep percolation. Now when the intensity of the rainfall is more than the infiltration capacity of the soil this water will go as runoff.

So, let us see how the runoff monitoring is done which we have set up here where we are monitoring other components of the hydrologic cycle, other components of field water balance that is used for the determination of evapotranspiration.

In field water balance studies to determine various components of water balance say input component as irrigation or precipitation as runoff. When it falls on the ground, some part of the water it is appearing as surface runoff.

So, say this is my horticulture plantation. Now during the rainy season besides water, it goes through an infiltration process, it is intercepted by the plant canopy it is appearing part of the water it is appearing as surface runoff. That surface runoff is measured by using the appropriate device. So, here is what we see from this horticultural plantation area of sapota crop as well as for the Litchi plantation.

This is about half-hectare land in which these plantations have been made and in this half-hectare land, we are providing irrigation water through a drip irrigation system. But during the rainy season irrigation is not given, but we want to know what are the different components, which are playing, which takes place from these horticultural plants. So, the runoff part is what we see when it comes to this area. We see here, there are three outlets.

So, water from the middle outlet is being collected in a collection tank and water from the adjoining other two outlets from this area goes to the outside. And that is the outside channel it goes. So, when it comes to the middle pipeline, it goes to the collection tank. It is measured with the help of a digital water level recorder. So, digital water level recorder, as its name is said that it has one end, you can say this is a counterweight and this other end is float.

So, as the water in the tank will enter, it will cause a rise in the water level, and this rise in the water level will cause the float to come up, and then the counterweight will go down. So, this rise is measured in terms of whatever the runoff it has generated from this horticultural plantation, and this data are in a digital form. So, this is what I was telling you, this is a pulley and in this pulley, one end is a counterweight, another end is float and then this is driven and then here there is a battery and then data which are coming over here.

And these data there is a provision that one can download the data in a USB port and that can be analyzed. So, we have collected these data for more than five years period and then these data are you know used to compute how much amount of water it has gone in different processes of a hydrological cycle or irrigation water balance components. So, infiltration, deep percolation we are monitoring the water level, groundwater level, amount of water that is appearing as surface runoff.

So, all these components are there and then they can be accounted for in terms of the evapotranspiration requirement of the crop.

Runoff is influenced by several factors. One of the factors is vegetation cover. We have seen the horticulture plantation where Sapota and Litchi, was existing, and then runoff water was being monitored for that type of vegetation. When the agricultural crop is there where you will see it is a small height, short height crop which is covering the ground surface. It also influences the infiltration characteristics of this soil; it also influences the physical characteristics of the soil.

So, runoff is also being monitored from agricultural crop fields where we are cultivating in this field rice, moong. We also cultivated vegetable crop such as okra and then just a few weeks back we harvested broccoli crop. Now, water whenever rainfall occurs when excess rainfall occurs generates the runoff. So, runoff is being monitored from such a plot and that is in the same manner which I explained in this one that water. There are three outlets there is one outlet exist here.

There is another pipeline that is in the middle and then the other one. So, out of the total runoff, it is generated, it gets distributed to three outlets. So, two outlets go meet with the channel that is the outlet channel and then from the middle that is the center pipeline, it is connected to the water collection tank. Now water collection tank again it is you know means the digital water level recorder.

And this digital water recorder, it is the rise in the water level is monitored by you know, when there is a change in the water level so, the float rises and this means that the rise in the float level is monitored in terms of digital value. The solar panel connected to each of these water level recorders provides the power source to operate the water level recorder.
Another important component of water balance is deep percolation. So, water that goes below the root zone depth and that water if it meets with the water table.

This causes a rise in the water level. So, we discussed the measurements of runoff from different types of covers. Here, we also monitored runoff from the cashew plantation. So, we have a runoff monitoring gadget. Here is another component of monitoring of groundwater level. So, these groundwater levels are being monitored daily that how much amount of water is being used by the plant through the root system by capillary action in adjacent to this, there is a tube well.

This tube well the when it is being operated this, we want to also know how much amount of water it is getting affected, the water level is getting affected because of the operation of tube well in the far that is being used for irrigation purpose in our agricultural engineering department experimental form. We do monitor and we want to know that how much water has gone in the groundwater when we are recharging.

So, in this particular area, we have made a trench and this trench is basically meant for the water whatever is going in the trench as surface runoff. So, this gets deposited in the trench and that causes a rise in the water level. Now I will demonstrate to you when we are measuring the water level how water level from a piezometer. So, this is one piezometer which has been installed like this, you know adjacent to this there is another piezometer and those are small other pipelines that are kept at the shallow level and these are quite deep.

So, on a deeper level, these piezometers have been installed and I will show you what is the current water level in the piezometer. So, the observation is 6.3 meters. So, 6.3 meters is equivalent to about 20.6 feet. So, the water level at present in my experimental area which is the Kaaju plantation that is a cashew plantation area where we have observed that it is 20.6 feet. So, these data mean runoff data, the groundwater level data, soil moisture data, evaporation data, transpiration data are used to compute evapotranspiration loss.

So, in this particular field demonstration, we have learned two types of Lysimeter, weighing type of Lysimeter and non-weighing type of Lysimeter. Non-weighing type of Lysimeter which we installed; we have used for a variety of crops to determine its crop coefficient. We have published papers for a non-weighing type of Lysimeter. We have monitored runoff that also was shown to you digital water level recorder where runoff generated from horticultural plantation crop where Sapota, Litchi, and other crops also.

So, a similar gadget is used for monitoring the runoff which is taking place from any micro watersheds. And then groundwater level measurement whatever the water table rise is depletion in the water table it takes place that also we demonstrated you. Now in the forthcoming lecture, we will have a tutorial class on evapotranspiration requirements and crop water requirements.

So, thank you very much for your patience in hearing.