Water Management
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Lecture 29
Sprinkler Irrigation System

Okay. Today we will start with the new topic, topic on sprinkler irrigation system. And during the discussion when we had discussed the various methods of irrigation, we had discussed in brief what do we mean by, what we understand by the sprinkler irrigation system. But we had not gone beyond that, we had not looked into what are the various types of sprinkler irrigation systems. Today we will start first with what are the various types of sprinkler irrigation system which are, they are many different modes of sprinkler irrigation method which is being used all over the world. But there are some methods which have become popular. So we will try to look at those methods first.

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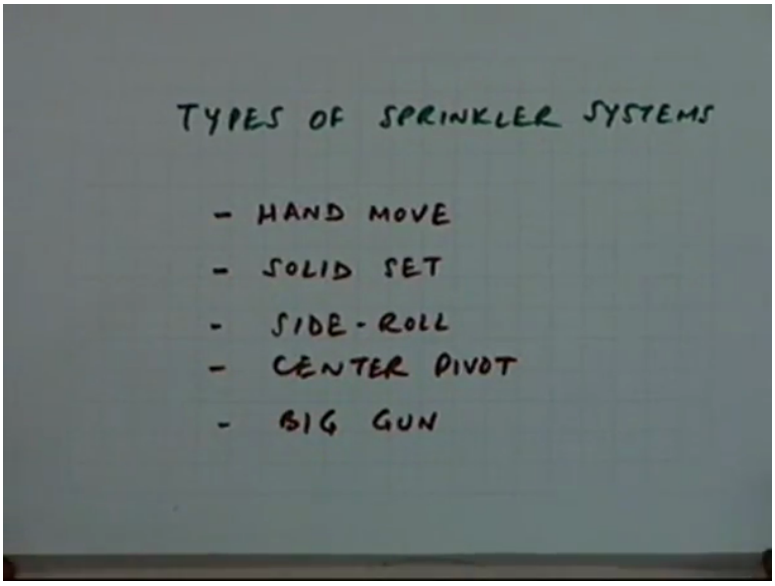

What are the various types of sprinkler systems? Out of the various types existing which are very common, there are some systems, conventional systems which are moved with the manual labor. Let me first put all those which we are going to have a look at: Hand move, solid set, side-roll, then center pivot, then you have big gun. These variations they have come about with respect to the requirements in terms of, in some cases with respect to the requirements of labor. In some cases you will find that the labor requirement is very low.

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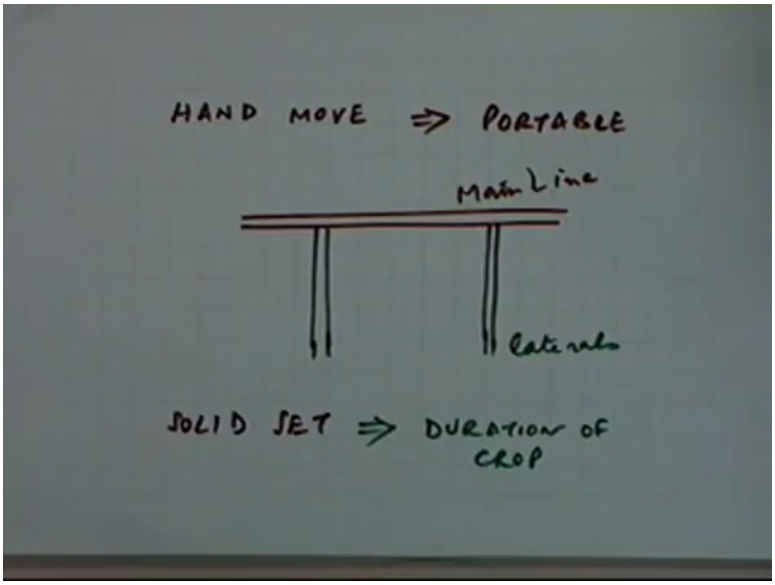

So let us have a look at these different types one by one. The hand move is the one which we had discussed during our the period when we were discussing the various methods of irrigation where we had said that there is a main line. And that main line will have different laterals. If we say that this is the main line, now these laterals are moved from one position on the lateral to another position using the manual labor.

You might, again the this hand move system you can also call this as a portable system. The level of portability again can vary. In some cases it can be completely portable in terms of you might be replacing the main line also and moving it from one plate, once place to another, the next place. That normally happens when you have availability of water along a channel. Whereas in some other cases it might be called semi-portable. Right now what we are referring to is a semi-portable system where you are only removing the laterals, the main line remains fixed. You might move the laterals from one position to another position so that the level of portability can be varying from situation to situation.

There is no such rule, the extent of portability can vary. So the other extreme can be the solid set. In the case of the solid set system you might be keeping everything fixed. The laterals as well as the main lines, they might be remaining fixed. If not permanently, at least for the duration of the crop. So if you keep the lateral fixed for the duration of the crop which in turn what it will mean?

It will mean that you will have to have those number of laterals which you are going to use in any position.

So the number of laterals requirement will be very high in that situation where you are not willing to remove the laterals. You might not be running all the laterals at the same time. You might be running only one segment at a time because these things are again, we will come to those details when we will discuss that how many laterals you can run at a particular time because all these things are dependent on what is the source of water supply, what is the quantity of water which is available and the relevant pressure.

So in another words what is the pump which you are using, what is the size of the pump and that will decide how much, how many laterals can be used in one set or at a particular time. That in turn also is dependent on what is the pressure requirement in each lateral because that is what is going to decide the distribution pattern of the wetted area or that sprinkler head. So in the case of solid set system you will keep the laterals permanently fixed. If your labor is very expensive, you might decide to do that. But that will be at the cost of more investment in terms of having more number of laterals.

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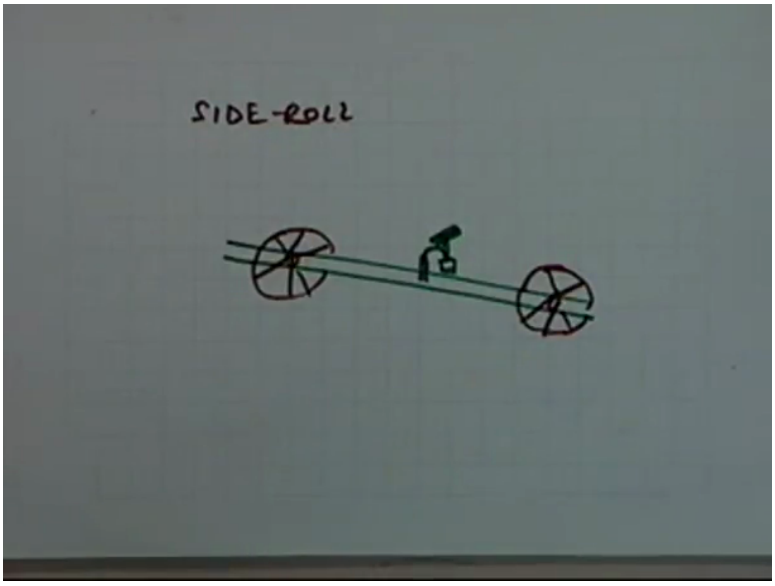

Then the side-roll system. In the case of side-roll system, this is to avoid the use of labor if the labor is very expensive. You might want to have a tradeoff between the situation that in one case in one extreme you have the solid set system where you need number of laterals which have to

be bought and fixed permanently in position or at least for the duration of the crop. The other extreme is that every time you remove the lateral from its position on the main line and then move the lateral to the next position after physically dismantling it which requires very regular labor.

So to avoid that situation and still reduce the number of laterals, a system was evolved where you can have a lateral mounted on some aluminum wheels and that you can roll. For example, you might be having a lateral, might have this lateral and this lateral is mounted on some wheels. So to this mounting now you can roll the whole thing. And the this itself is a lateral, that means there might be, there will be a nozzle, a sprinkler nozzle mounted on this.

You might feel that in some cases if the sprinkler is, the nozzle is mounted on this, since the whole thing is rolling, it might change the direction of the sprinkler head. So to avoid that, there was a, there is a mechanism by which you can avoid that, by having some mechanism by which you have a counterweight which is put so that to keep the sprinkler head always, there is a weight which is put which is quite heavy. So because of that weight the position of the sprinkler head will always be in the same position in which you want it.

That means the erect position, the vertical position. So those things are taken care of by having specialized those sprinkler heads which can be mounted on these laterals. But the advantage of this is that once you have done the irrigation or once you have applied the water by keeping this in one position, you can roll it to the next and that rolling also can be done through a motor. It can be some equipment which can have some driving force. So that driving can also be, the equipment can also be having that mechanism which can give you the driving force also.

Or you can move it manually. It depends on what is the size of the whole set. That is what we call the side-roll system which is quite reasonably useful in some situations but is used only in those situation where you cannot afford to employ the labor whereas in our conditions in our country the labor is not that bigger problem. So you might not need such a system.

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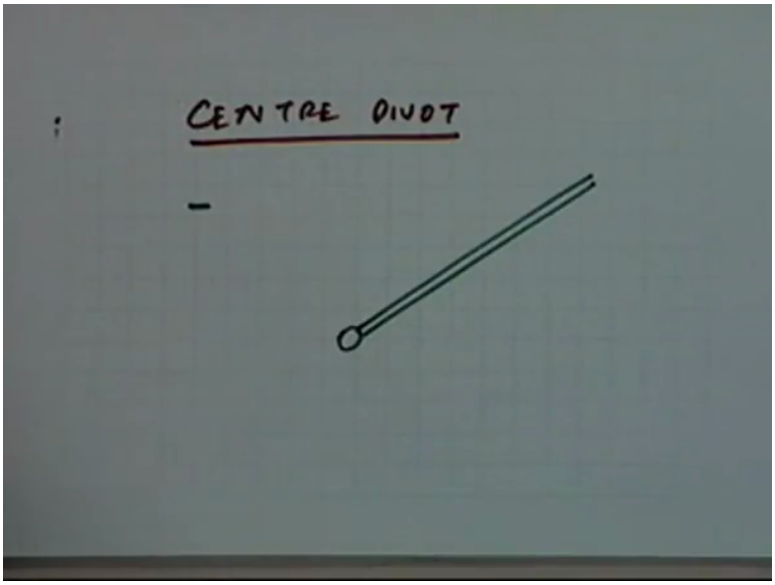

Then the center pivot system is another system which requires very less amount of labor. First of all what the system, what is the philosophy of this system? In this particular system, the source of water is at a central point and then from this source you are having a pivot arm, one pivot arm which is quite a long arm on which you mount the lateral. So this pivot can be, I can show you a figure of what this pivot arm can be.

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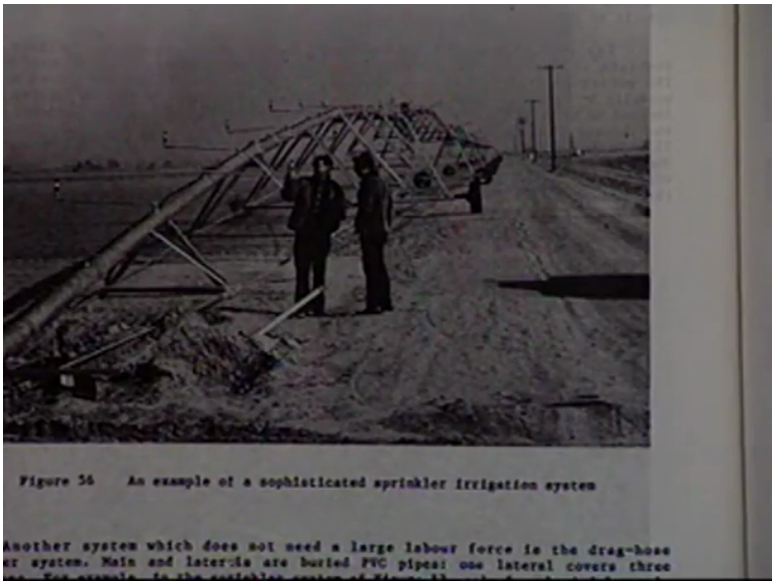

Is this clear? This figure? This is the pivot arm, this pivot arm is having at different locations, these sprinkler nozzles are attached at different locations all along the pivot arm. And this pivot

arm if you can notice here this is mounted on these wheels. So the whole arm can move in one direction. It can move about this pivot point which is the central point which is the source. This can move in the circular direction.

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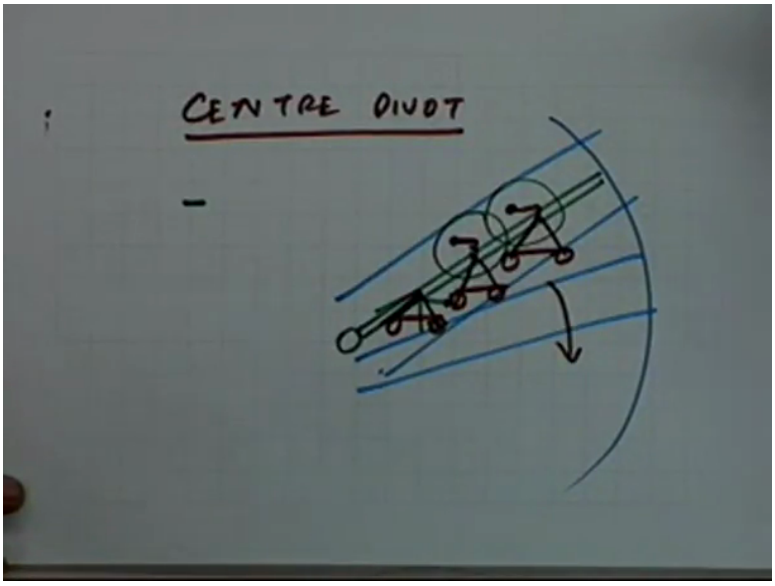

That means if you look at the total and this since is mounted on, different mountings are available. And this is mounted all along on these tripods which are in turn which are mounted on the wheels. You can give it a rotation. That means overall as this moves in this direction, as this moves in this direction, each individual you will be having at each location. The location of this sprinkler head either it can be up here or it can be down there, that varies.

So in either case as you have seen in the figure, you have these sprinkler heads somewhere mounted here at these locations in either direction. So when you are operating these, each one is wetting area which has its own area of influence. So at a particular time you are wetting a strip and as it moves in this circular direction, at each individual time you will find that ultimately you are wetting a circular area which is being wetted by the single lateral.

Now this pivot is, it can be very, it depends how big the pipe you have installed, what are the pressures under which is operating but is real big area. The extent can be hundreds of meters. So ultimately you will find that you have through a central pivot system, the source was at the central point. This source can either be in the form of a well or it can be in the form of main line which has been tapped here. And you will be getting area covered which is a circular area. The

disadvantage of this central pivot system is that you are wasting lot of area which is the corner area.

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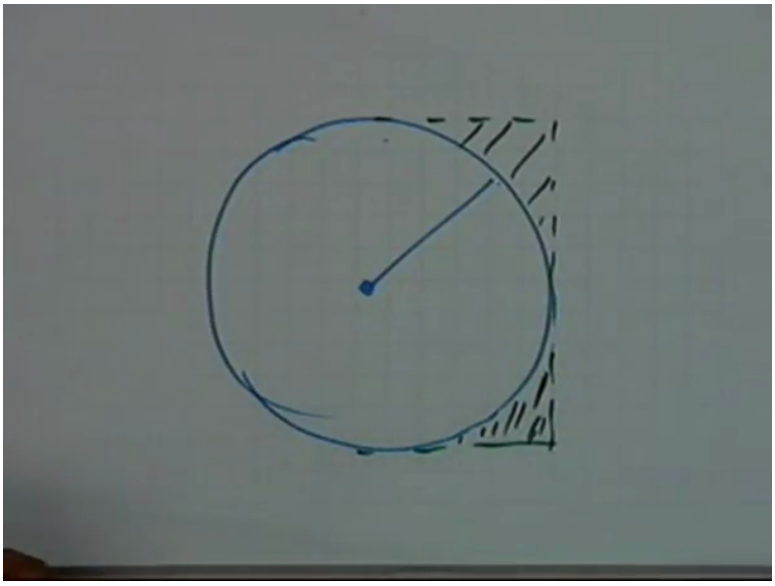

If I have covered this area with the central pivot system which is the extent of the pivot, so ultimately I have covered this area. Normally whenever you go in for the agricultural operations, you will not have the circular areas covered. This is a very big area, so it will be covering many many fields all along. But still it will be much more advantage is if you can have some way of covering these corner portions which are not being covered in this system. So you are wasting, this area is not getting any water.

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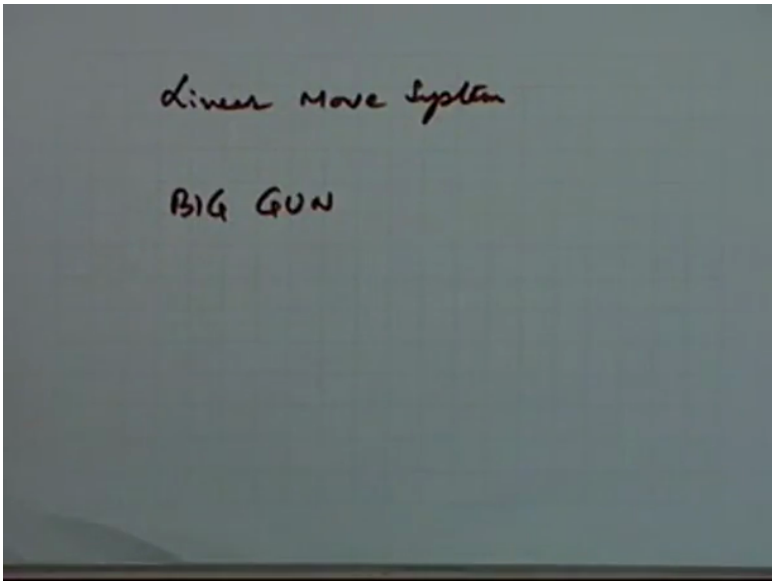

To avoid this problem, this central pivot system, the movement of the central pivot system is varied and is called a linear move system, is the same as central pivot but instead of getting rotated you are moving this pivot along some channel or some supply source which is a linear supply source. Only then it can be taken care of.

So under those conditions where you can have linear movement of this pivot, you can avoid getting these corner areas served. You can serve these areas. You can avoid the situation where you are having these corner areas are not served by the application of irrigation water. So that is what is only the operation of the pivot system or of the similar pivot which can be moved in a linear manner. And you can take care of rectangular areas which are more useful than the circular areas.

Then the big gun, this system is having a philosophy that you are having a big nozzle which is operating under much higher pressures. So what you are doing is that instead of using many number of sprinkler heads, you are using a single nozzle which is having a very distance, very large distance coverage. And through the use of that single nozzle you are irrigating the areas. The only disadvantage is that the pressure which are required, they are very, very high pressures. And the distribution is also not very uniform in the case of big gun system.

But in some situations the big gun system can be useful where you are not very much bothered about the uniformity, the type of crops are not very sensitive crops. And you have that prevailing

pressures which are required. Having discussed the different types of irrigation systems under the sprinkler irrigation system which are available, we will go onto the other related aspects of the system. But most of the times we will be discussing the conventional sprinkler irrigation systems where we have main line and the laterals. Either they are the flexible or the laterals which are having portability or they are the fixed laterals. That is only the method of application.

Basically it does not make any difference. As for the design is concerned, in the case of design, you have to decide on what are the pressures, what are the sizes, what are the spacings, those things will come. But we are not going to cover the designs of big gun or of central pivot systems. They are beyond the scope of our coverage here. We have just, in many cases the designs are not much different. They are similar because the basis behind those design is the same, is not very much different. Only thing is that you will have to take into consideration their overlaps, how those overlaps have to be considered, what will be the difference in the overlap when you have a pivot system or when you have a linear system or the conventional system.

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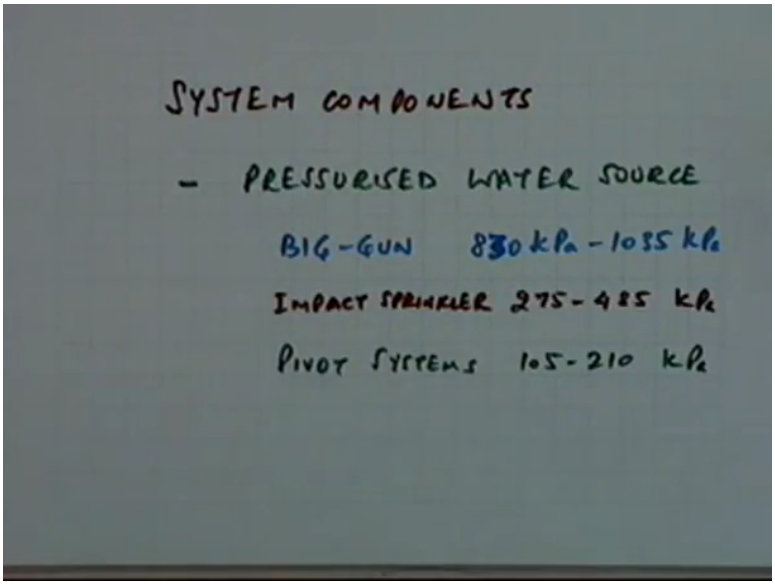

So let us go onto the system components. What are the basic system components which have to be taken care of? The first thing is that in all these systems which is true for all the systems which we have just mentioned that you need pressurized water source. That is a must. The extent of this pressure might be different from one system to another system. This, for example, the

system which we have just mentioned, for example, in the case of big gun, the prevailing pressures might vary between 830 kilopascal to 1035 kilopascal.

And the impact sprinkler, now these impact sprinklers are the conventional systems where we have the sprinkler heads mounted on the laterals and laterals are getting water from the main line. In those systems the pressures may vary between these limits. And the pivot systems are the systems which need comparatively lower pressures. So these are the pressure ranges. Now you can see here that the pressure requirement of the big gun is almost four times that of the impact sprinkler which is conventionally used for the areas which are the reasonably, the reasonable areas which you normally handle.

Whereas in the case of pivot system the areas which you handle, they are very large areas. And that is possible only in the case of cooperative farming or where you have very big farms which are under the same farmer or under, you might have a cooperative. So only in those situations you will find that the pivot systems are of much use. And you have, for many many hectares you have the same crop.

Whereas in our conventional systems as we know that in most of our projects the variability of the crops is very high, you might have very small size fields which are having the same crop and for each individual field you will have to have the sprinkler system if you are using one. And the impact sprinklers will be the one which will be quite useful in our situations.

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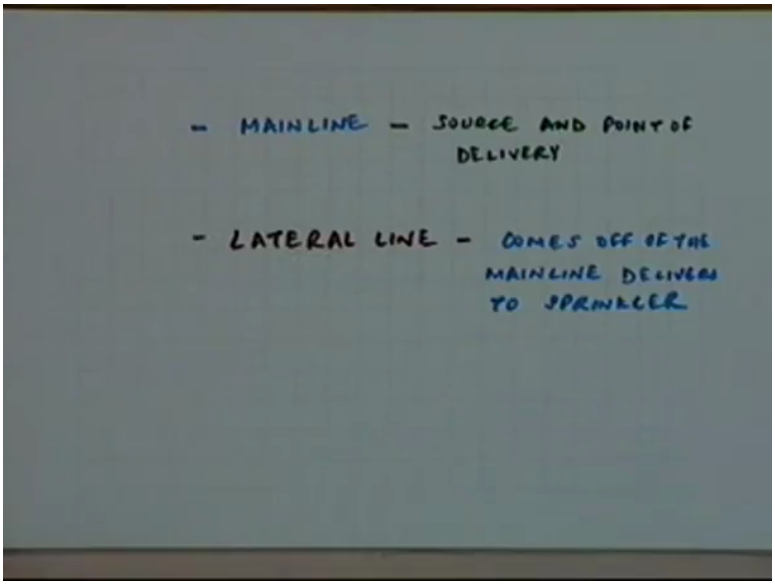

Then besides the pressurized water source you will need a main line. Main line is the connection between the pressurized source of water and the point of delivery. This main line might not be required for some systems. For example, when we have discussed the pivot system, in that case the main line is not required, directly you are having the connection between the source and the lateral. The main is not available in those systems. But in most of the systems you will find that the main line is a very important component of the system. Then besides the main line you have lateral line. The lateral line is the line which comes of the main line and it delivers the water to the individual sprinkler.

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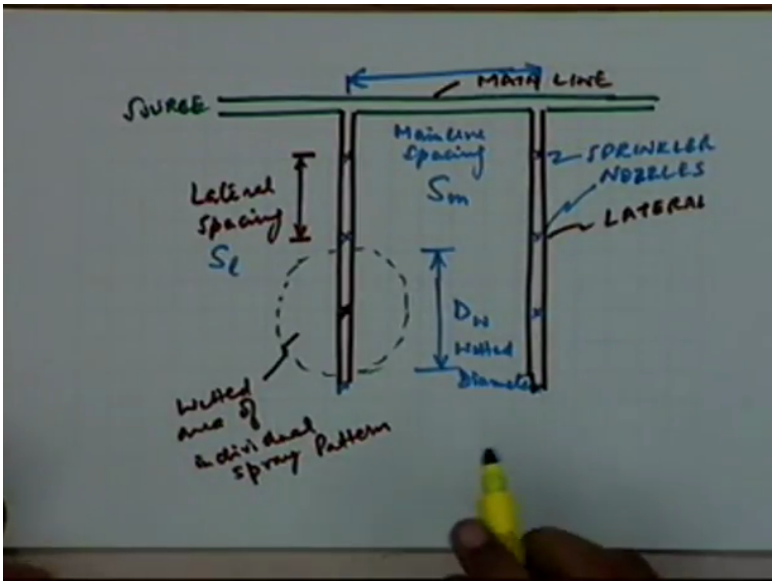

Taking a conventional system let us say that this is the source, this is the main line. Out of the main line you will draw the lateral from the main line. This is the lateral. And on the lateral these are the positions of the sprinkler heads. So these are the sprinkler nozzles. Then the other system components which are related are that you will like to know what is the lateral spacing, that at what spacing you have to provide these sprinkler nozzles on a particular lateral.

If we call this as Sl and what is the spacing between the two lateral positions on the main line? This is known as main line spacing and normally designated by Sm. Then besides this we will also be interested in what is the wetted diameter. So if you look at the area of influence of this individual sprinkler nozzle, this is the wetted area, the individual spray pattern. And this area, this nozzle, what is the spray pattern of this nozzle? That is designated by a parameter which is known as wetted diameter and designated by Dw.

These are some of the main quantities or some of the main items which we will be referring to quite often. These are the design parameters you can say which will be very important from the consideration of our objectives of design and is very essential to know these parameters, what these parameters mean.

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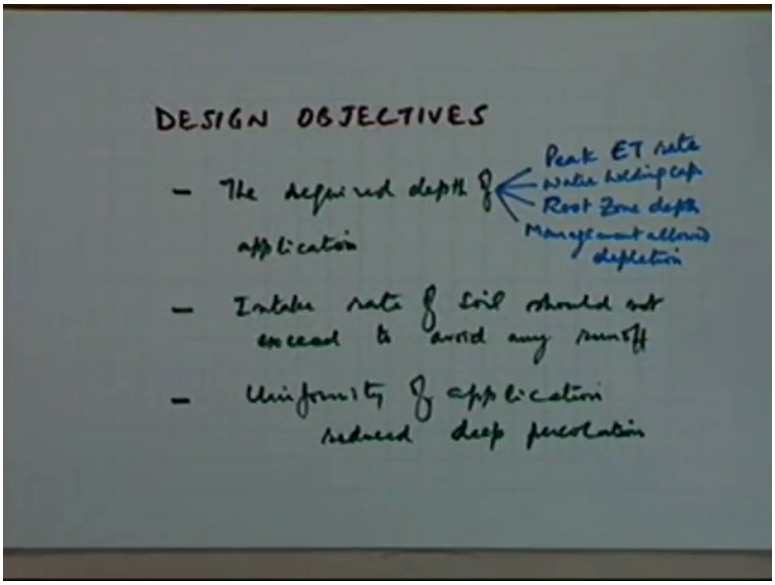

So let us now look at what are our design objectives. By now we know that the generic design objective which we have, which are true for all the irrigation methods irrespective of which method you use. And these design objectives are that we have to take care of the water requirements, we have to avoid the losses so as to keep those losses minimum ones. They are the same and they are not going to vary much from one method to another method. But let us have a relook into those design objectives.

The required depth of application, this required depth of application has to be satisfied as the prime design objective because you want the crop to grow well without stresses which it cannot sustain. Those stresses, we have to avoid that. Those stresses should be allowed to develop in the crop. So for that purpose we have to ensure that the required depth of application has to be provided to the soil at the time whenever it is needed.

And this we know that this required depth of application is dependent on many factors, is dependent on the peak period, evapotranspiration rates which is the function of the climate. So you have to, it will be a function of what is the peak evapotranspiration rate during that period which under consideration, and that will decide what is the required depth of application. It will also dependent on what is the water holding capacity of the soil, the root zone depth. These two put together, the extent of the soil profile which is providing moisture to the crop and the water holding capacity, these two put together will decide what is the available moisture.

And the management allowed depletion. These are the major factors which will decide because when at what exact time you want to irrigate that there is some level of flexibility in that and that is a function of a decision made either by the farmer or the management. So that is what we have discussed earlier that the management allowed depletion or the deficit can also influence how much is the requirement at that particular time.

Then the other design objective is which is true for this particular case. In the previous methods which we have considered so far, this objective was not the one which is, which we are going to discuss right now. This is a very particular objective which is only true for the case of sprinkler irrigation system and that is that the intake rate of soil should not exceed so as to avoid any runoff from the irrigation, irrigated field.

So in this particular method we do not allow any runoff to generate which means we will have to control the irrigation application to the extent that the there should not be any surface runoff which might crop off, which means that you will have to take into consideration what are the variations in the intake rates because intake rate is something which is dependent on the soil moisture conditions, is not fixed, it varies with respect to the soil moisture condition. So when we are designing the sprinkler irrigation, we will have to consider what is the prevailing intake rate of the soil under those conditions and control the irrigation application in such a manner that you do not get any surface runoff.

Then we also want the uniformity of application, so which is objective which is common objective. That was the objective earlier also. And this uniformity of application will result in reduction in the deep percolation. So if your deep percolation losses are large, uniformity will be, uniformity of application will be low. We have to design the system in such a manner that the uniformity of application can be as much as possible under the prevailing conditions.

Now the uniformity of application, at this stage we can just at least mention that in the case of sprinkler irrigation system you are getting a depth of application by the overlap of different application patterns which are for individual sprinkler heads. So there will be some level of inaccuracies involved or some level of non-uniformities which will be involved because of these overlaps and that will be dependent on many other factors. For example, the wind conditions which is going to be a major factor in deciding how well you can have the overlap, how effective

overlap can be obtained under those prevailing wind conditions will be a function of the level of wind conditions.

If the wind conditions are very excessive, the wind speeds are very excessive, you might find that the overlaps might be very difficult to obtain the uniformity throughout the area. We will discuss those things in details. I thought I just mention, make a mention at this stage that this is one of the condition which will decide how much will be the uniformity which can be achieved. Then in this system another design objective which is very often can be a deciding factor, is the tradeoff between the achieving the physical conditions, the physical requirements of the crop and in achieving those requirements how much you have to incur, how much expensive the system can be or how much expense you have to occur.

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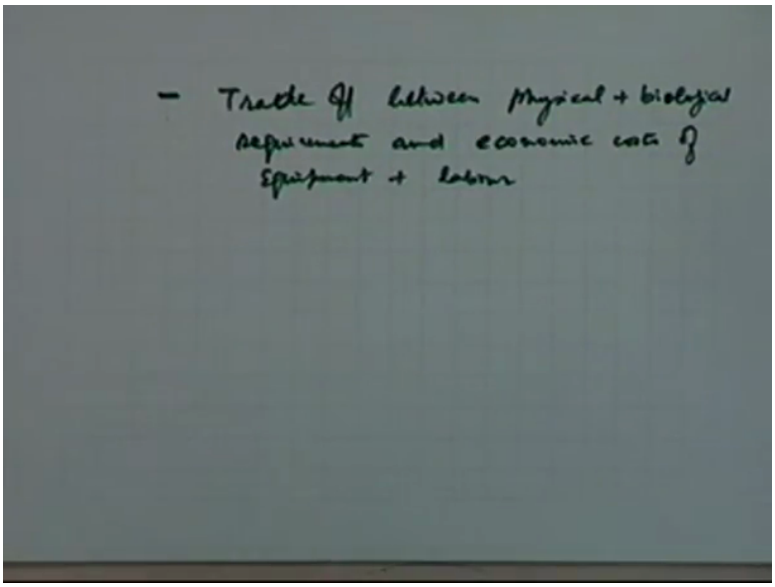

So the economy for the overall system is going to be a very major factor in this. The tradeoff between physical plus biological requirements and on the other hand the economic cost of equipment plus labor, these two factors are going to deciding ones. In some cases if you change the design, you might find that your initial cost goes up very much. You might have to invest a lot of money in providing all those equipment.

For example, if you go in for the permanent set system, is going to be the fixed system. You will require lot of pipes which will add to your initial investment. Whereas if you go in for a flexible system, your labor cost will be quite excessive. Similarly the cost like maintenance cost, the

recurring cost, all those thing you will have to see and compare them under different options. But at the same time you will also have to look at how well you are, by choosing a particular system how well you are in a position to cater to the requirements which is the basic need of the irrigation system.

So this tradeoff is a very important aspect and is a very subjective thing. This tradeoff will vary from place to place in those conditions or in those countries where the equipment is very expensive. People might go in for, the labor is cheap, you might choose a different option than in those places where is the other way around. So it is totally, is a very subjective objective, the design objective, that will vary from place to place, is very essential to understand that. But it can be a deciding factor at, in many situations.

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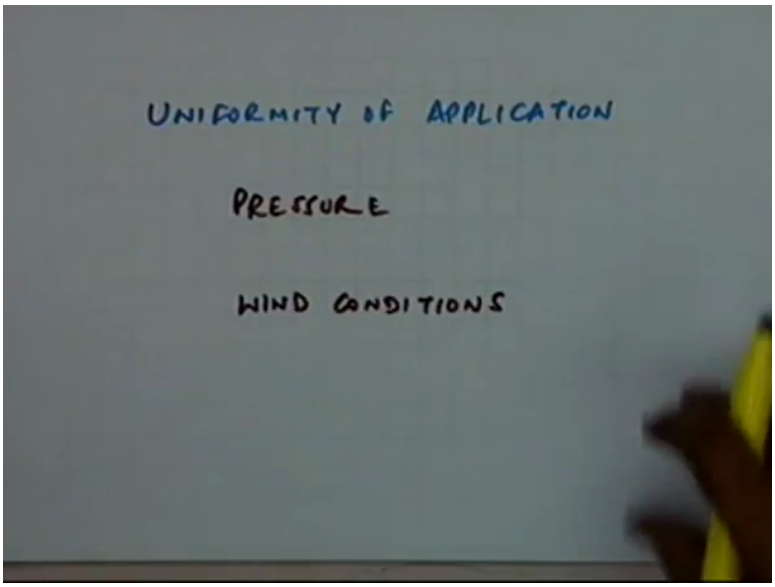

Then let us go onto the some other aspects which are, which we must understand before we go onto the next level of looking into the designs of these systems, is the uniformity of the application. We just mentioned in our objectives that we need to get uniformity of application. That uniformity of application is dependent on two basic factors. One is the pressure, the prevailing pressure and the other is the wind conditions.

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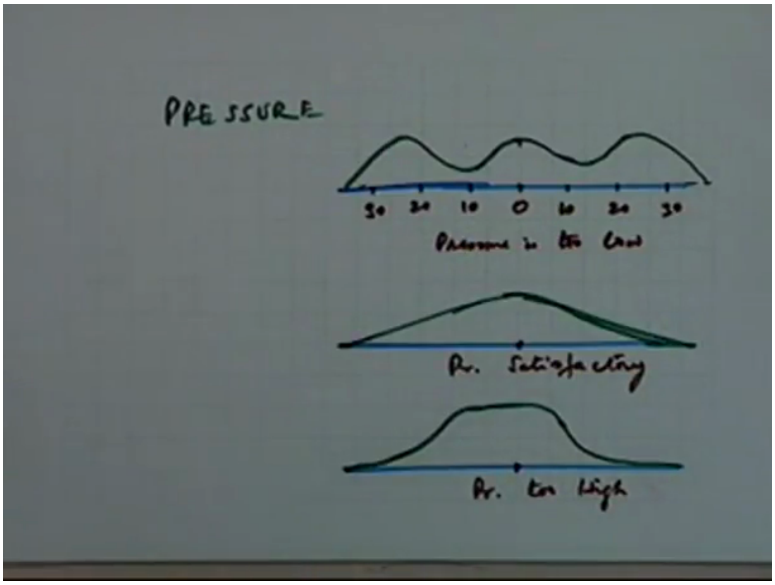

How the pressure influences the uniformity of application? Let us take three different cases when we operate the sprinkler nozzle under three different pressures. This is my location of the sprinkler nozzle. Let us say that this is the distance, this is the 0 level, this is 10, 20, 30 meters. So this is the central point where the sprinkler nozzle is fixed. If the pressure is too low, we will not give the order of magnitude, we are just saying relatively, because that will be the, this variation of the distribution of water will vary with respect to the size of the nozzle and the pressure.

So we are just trying to look at how relatively this pressure distribution will change, the pressure variation will change the distribution pattern. When the pressure is low, you might find that might get a distribution of water which is something of this nature. Because in this case what is happening is that since the pressure is low when the jet comes of the nozzle, it is not broken up into smaller particles, is not fully broken up, is not broken up to the extent that it can get distributed over this area of influence any uniform manner.

It might be having some, still some streams which are going as stream of water. There is some breakage of jet but not, is only partial breakage. So if that happens, you will find that this type of variation will be observed. On the other hand if the pressure is too high, you might get a variation which is something of this nature. And the pressure (varia), the variation of distribution might be something like a triangular variation if the pressure is satisfactory.

Now why we are saying that this is, this (variat) this distribution is more acceptable? Because ultimately we have to get the overall distribution by overlapping these individual distribution patterns and is very difficult to get a uniform distribution, the overall uniform distribution by having either of these two distribution patterns. That is the reason, otherwise there is no other reason. This is the only reason that why we want a distribution pattern of this type. Why we are calling this pressure to be satisfactory? Because by having this type of pressure distribution is much easier to have a better uniformity of application. Okay. Any question? So we will stop here.