Water Management
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Lecture 32
Sprinkler Irrigation System (Continued)

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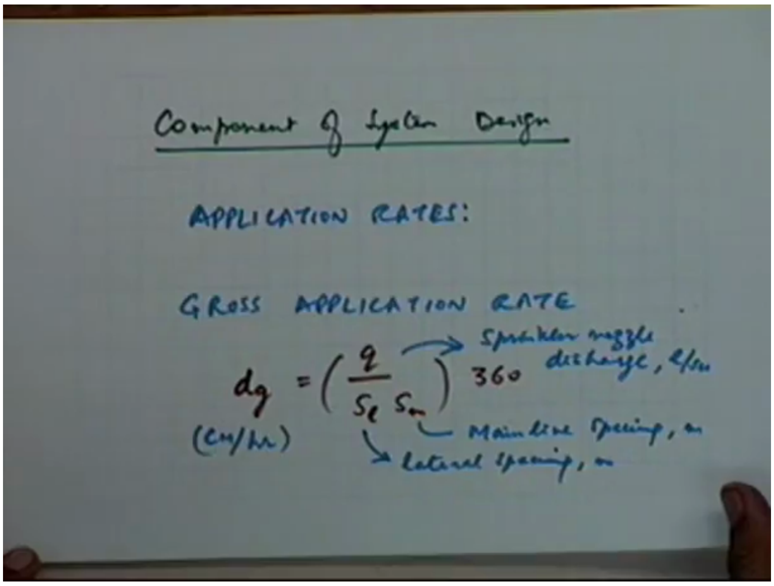

In last lecture we had started looking at the components of system design and we had started with the application rates, we had said that the application rate is of two types one is gross application rate and the other is the net application rate because these two are they can be very different depending on the conditions prevailing in the area. Let us look at the various expressions which we use to get the gross application rates and the net application rates.

The gross application rate we express this as d g as the function of the sprinkler nozzle discharge and the spacing of sprinkler head. In this expression the d g is d g is the gross application rate and it is given in centimetres per hour, this q is the sprinkler nozzle discharge and this is given in litres per second and these we have already seen that these are the spacings is the lateral spacing and the main line spacing both are in meters.

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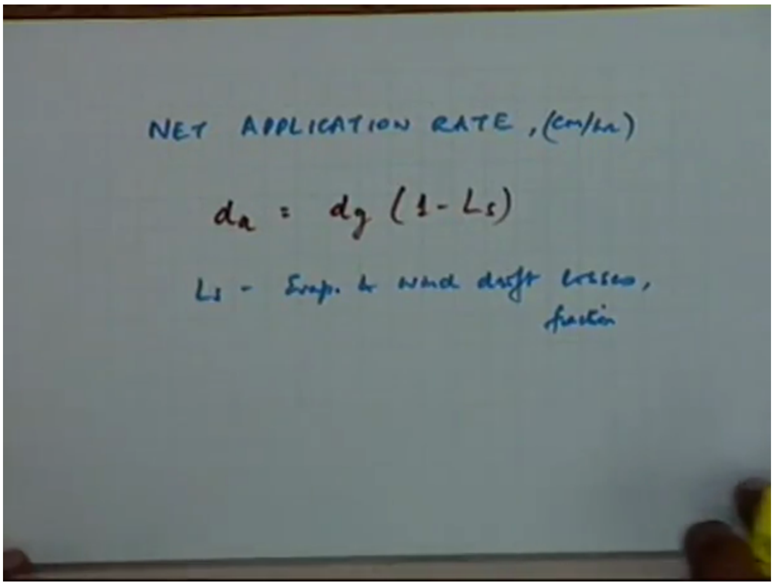

As per our discussion in the last class we had mentioned that the gross application that of the gross application rate will be effected because of the losses which are mainly because of the evaporation and wind drift losses. So accordingly the net application rate let us call it d a will be the gross application rate into 1 minus L s, where L s is the evaporation and wind drift losses in fraction and d g is the gross application rate in centimetres per hour, so d a will be also in centimetres per hour.

This quantity will be very important to be assessed because ultimately whatsoever you want to apply to the ground that is more important the net irrigation rate is more important than what is coming out of the nozzle is the nozzle discharge is if it is most of it is going to lossed then I think is not going to give you the end result which is the yield of the crop yield because the crop will be dependent on how much of that has been absorbed by the soil and which is basically dependent on the net application rate.

So the net application rate in this particular case is since the variation can be large in terms of the evaporation and wind drift losses. So the net application rate proper evaluation of the net application rate takes much more significance than you will find the loss rates in the other irrigation systems where the variation is not that drastic as in comparison to what you can get here.

By the same time you might land up with the situation where you have found that there are some losses which are known which you can evaluate and after taking into consideration those losses you find that the gross which becomes available or let me put it the other way round that if you know a gross and out of that gross the losses are very significant the remaining portion which is left is the net irrigation rate which is applicable if that becomes very small in some cases it might happen that is not applicable is not you might not be able to apply that rate so in that situation you will have to come out with some rates which are implementable.

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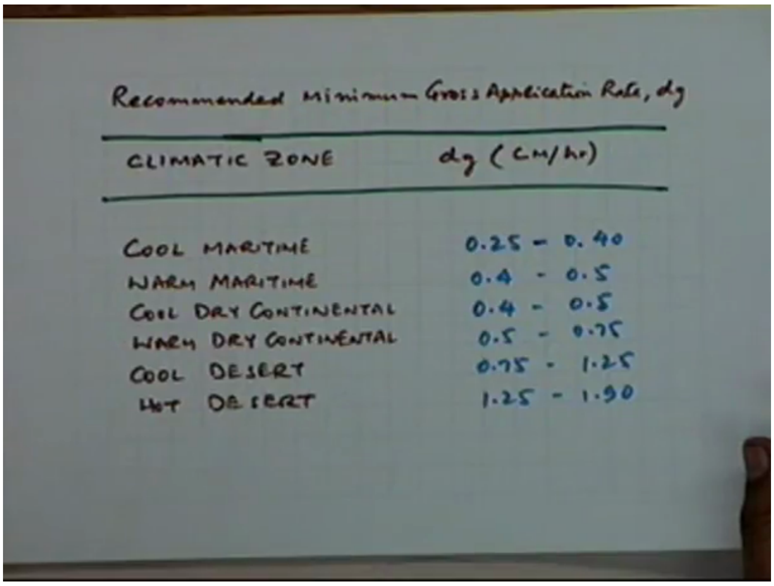

So that after taking care of the losses there is some net which can be implemented on to the field. So from that angle there has to be some lower constraint which has to be put on the gross application rate is what has been recommended after lot of experimentation in this particular chart or this the stable which is giving the recommended minimum gross rate is d g in centimetres per hour for different climatic zones.

And the values of these gross application rates the variation which has been given that in case your gross application rate is working out to be lower than this it might not become practicable you might have to adopt the rates which are these recommended rates otherwise your efficiencies will be really very drastically affected. So for cool maritime climatic zone your gross application rate can vary between 0.25 to 0.4 centimetres per hour, for warm conditions the warm maritime conditions the rate is 0.4 to 0.5, for cool dry continental conditions is again the rate is 0.4 to 0.5 centimetres per hour. Similarly for the other conditions these are the recommended rates.

So you can see here that the variation is really very large as the climatic conditions change your minimum gross application rate which can be effectively applied that really varies drastically from 0.25 to somewhere around 1.9 centimetres per hour under the worst conditions of hot desert conditions. This is a very important aspect that you must check your these recommendations are basically made available to check your design parameters under the prevailing conditions whether those conditions will be achievable or not because when you are making calculations their you will not get the field whether these things are really these parameters are the parameters which can be implemented.

So for that purpose all these recommended values have been obtained after lot of experimentation all over the place and these are ones which are recommended in literature so that that the designers can take help of these findings.

Now similarly there are guidelines on the maximum net application rate which can be implemented at a particular site and when you talk of the maximum application rates the criteria the major criteria is that should not have a rate which can produce enough. So that being the governing criteria, there should not be a rate which should I should provide the application the rate of application in such a manner that under the prevailing conditions your runoff generation should be avoided which means the slope will become a very important aspect.

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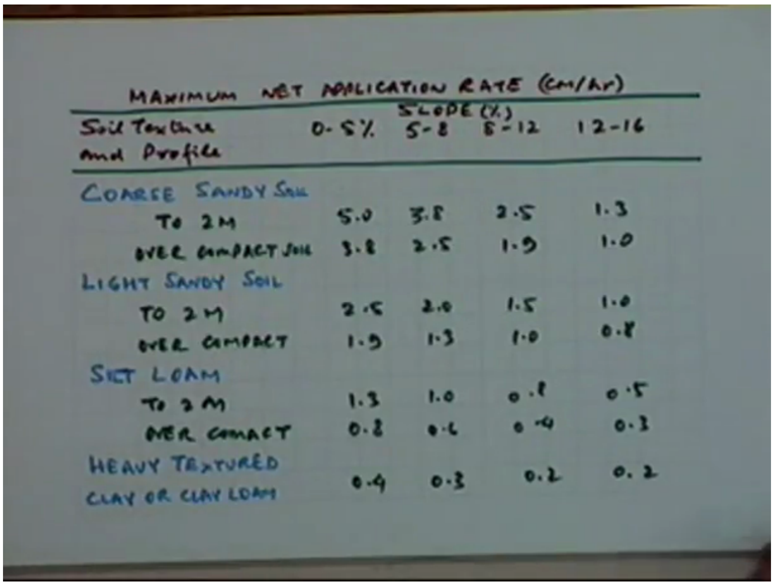

MAXIMUM NET APPLICATION RATE (cm/hr)

Soil Texture and Profile	SLOPE (%) 0-5%	5-8	8-12	12-16
COARSE SANDY SOIL				
TO 2M	5.0	3.8	2.5	1.3
OVER COMPACT SOIL	3.8	2.5	1.9	1.0
LIGHT SANDY SOIL				
TO 2M	2.5	2.0	1.5	1.0
OVER COMPACT	1.9	1.3	1.0	0.8
SILT LOAM				
TO 2M	1.3	1.0	0.8	0.5
OVER COMPACT	0.8	0.6	0.4	0.3
HEAVY TEXTURED CLAY OR CLAY LOAM	0.4	0.3	0.2	0.2

If you are looking at the minimum under the maximum application rate which can be applied which is the net application rate you have to consider basically the soil characteristics which will decide what is the infiltration rates and the slope which will decide what will be the velocities which can be obtained and even the infiltration rate can also be a factor because of slopes.

So the recommended values which have been given for the maximum net application rate which can be used under different conditions of soil texture and profile and the slope these are divided into these broad categories. The coarse sandy soil that is a soil texture and the profile is given in terms of whether the depth of the soil is less than 2 meters or beyond 2 meters (())(13:40) the to 2 meters of soil and the other condition is the coarse sandy soil over compact soil.

In this case the profile of the soil is the shallow soil or the deep soil. So if you have deep soil then you can afford to have a higher level of net application rate the maximum net application rate in that situation can be 5 centimetres per hour for a slope which is very small slope 0 to 5 percent, as the slope increases you will find that the the maximum allowable net application rate will reduce and the reduction is quite significant.

Now these limiting values they are obtained with respect to the the situation that the objective that there should not be any runoff produced under these conditions of soil texture, the soil profile and the slope. When you have more compact soil the profile is less than 2 meters then you have these recommended maximum net application rates which should be utilized.

Similarly in the other cases also to 2 meters and over compact soil you have these recommended values and in the case of silt loam you can also observe that as you go from the coarses soil to more heavy soils your rate of applications are also reducing and the reduction is also quite significant in this. Example from 5 centimetres per hour is come down to 0.8 centimetres per hour for silt loam under the compact conditions.

In the case of heavy textured clay or clay loams the profile of the soil does not make much of a difference so there is only single case because it is not very much affected by the soil the soil texture itself is the more influencing factor and as such the rate of application is very small. So in the case of heavy textured clay or clay loams you will find that there is as such the rate of application which is allowed or which is permissible if you want to avoid the (()) (17:31) of is very small rate varying from 0.4 centimetres per hour to 0.2 centimetres per hour.

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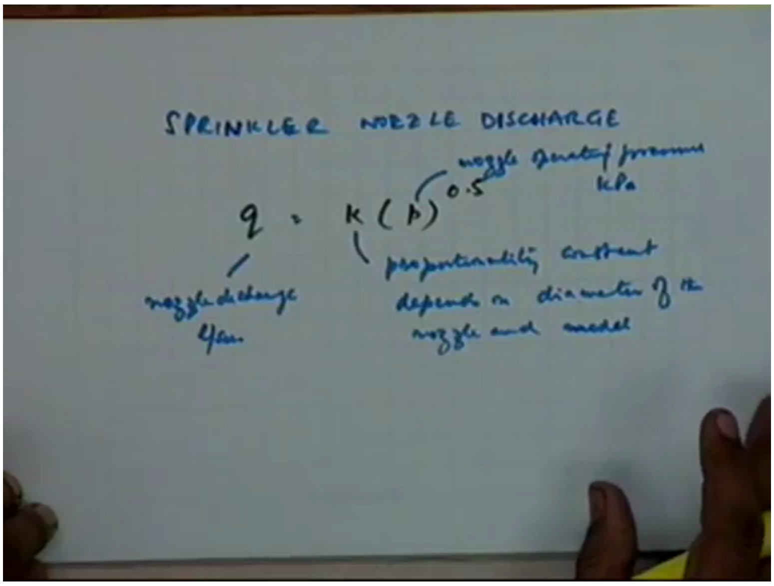

Then besides the application rates the next item which is quite important is the sprinkler nozzle discharge, sprinkler nozzle discharge it varies with respect to the pressure which is the prevailing pressure and it can be expressed with this function where q is the nozzle discharge in litres per second and p is the nozzle operating pressure in Kilo Pascal and k is a proportionality constant which depends on the diameter of the nozzle and the model of the nozzle what is the other nozzle and how the nozzle is effected, what type of they are will be a function of the model of the nozzle as well to certain extent.

So these key values are normally not given directly they are invariably they are available in terms of the tables which are waiting tables given by the manufacturers, when a manufacturer comes out with a new model of the nozzle they will give you accompanying table which will have all these different items which you want to which you are interested in some point of view of the discharge calculations or for other parameters which are design parameters those things are normally made available.

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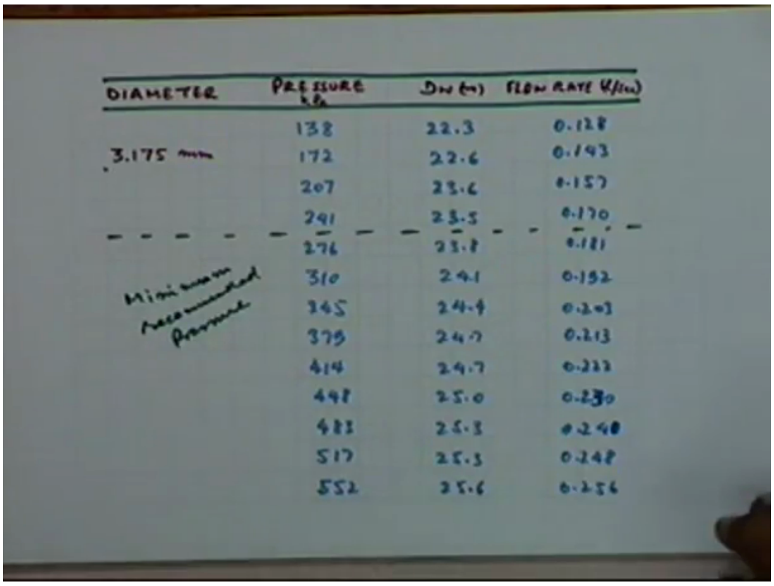

And a typical a typical table which will be made available for a specific nozzle this is one table which we have taken which is table provided by the manufacturer for specific model of the nozzle which has a diameter of 3.175 meters and the other the discharge variation is given with respect to the pressure variation and what will be the wetted diameter. So these three things are related for a specific diameter of the sprinkler head or the sprinkler nozzle you will find that the with the variation of the pressure your flow rate or the discharge rate will also vary and the diameter the wetted diameter will also vary.

This might give you the total pressure variation but along with that there might be a minimum recommended pressure. For example in this particular case it might be given a long with that you should use this range of pressures, this level give you the minimum recommended pressure. So below this are the pressures which are recommended pressures you can chose with respect to what is the prevailing pressure available, how much can be obtained under the conditions and accordingly what is the flow rate which is which will be obtained if you run the sprinkler under this pressure and this will be the wetted diameter.

These wetted diameters are again they are the diameters which are without the wind conditions, if you will have the wind conditions then there will be some change in the wetted diameter. Those things can be incorporated if you know the wind conditions, what are the prevailing wind conditions.

Let us now go on to another item which is the sprinkler spacing all these items which you are discussing is very important to understand that these items are items which will have to check your design for in some cases you might be having available or some of these items might be fixed. For example when we say that we want to select a particular nozzle, now if you are going to select a particular nozzle then you might have a choice, in many situations you might be already having some nozzles which you want to make use of.

So if that is the situation in that case your constraint the design constraint becomes that you want to utilize a particular nozzle which is which might be a generic nozzle size which you have procured and uncapped with because as a farmer you try to visualize that when you are going in for these systems you might use this sprinkler system for different types of crops and if you have a very big farm your conditions the soil conditions will also can vary in certain cases or if your farms have two different locations, soil conditions can also vary to certain extent.

But let us take that keep that out for the time being let us talk of a specific farm. When you vary the type of crop which you might be using from one season to another season, in that case you might find that the if you go in for a fresh design you might find that you might need a different sets of the equipment the equipment can be in terms of nozzles size of the different size of nozzles, or the laterals, the main pipes all those things in many situations you will like to fix these items if they are already available or you might procure those items which are in between items.

For example if you can use a sprinkler nozzle which is one level of size and you might take another level which is the next level so that the variation is not much you might use those intermittently for slide for taking care of slide variation in the the requirements or the application rates. All these items we are discussing separately ultimately you have to have a trade of between these things with respect to your constraints which are very in most of the cases which are very justifiable constraints, the constraints which are either economic constraints, you cannot afford to a procure different sizes of the pipes, you cannot afford to procure different sizes of the nozzles and those becomes your constraints.

But in the beginning when you go in for a fresh design then you have a choice you might do a very detailed design even to look at the conditions, how the crops will vary from one season to another season, whether the same set of equipment will be able when you will be able to use in those conditions also. So you might do a detail design for all the combination of conditions which you have under your your area where you have the farming activity going on.

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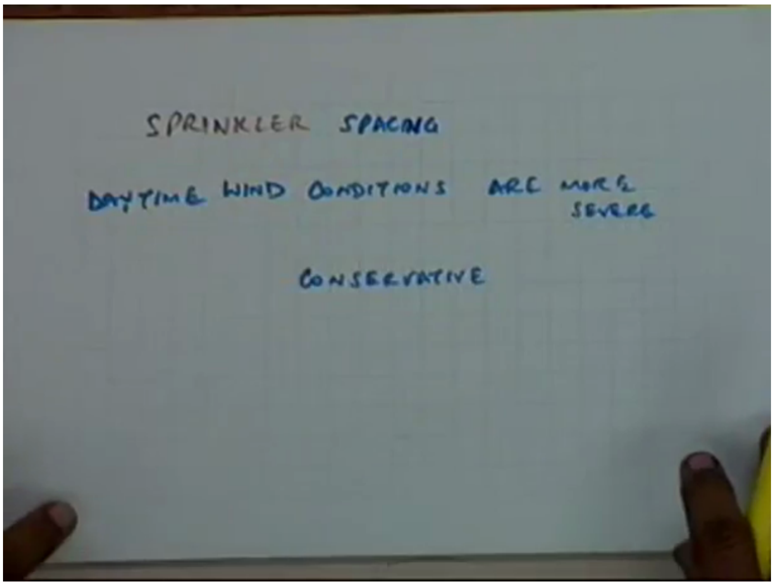

The sprinkler spacing the sprinkler spacing is very important aspect which we have been referring to quite often at most of the time the sprinkler spacing will be the most influencing factor in terms of whether you are talking in terms of the uniformity coefficient sprinkler spacing is the one which can be manipulated, the sprinkler spacing will also be important when you are trying to incorporate the wind conditions that again you want alleviate all the ill effects of the wind conditions through proper charge of the sprinkler spacing.

So when you are talking in terms of the sprinkler spacing you have to first decide what are the wind conditions which you must account for and if you take the wind conditions of the day time invariably the day time day time wind conditions will be more severe than the night time wind conditions the wind velocities doing the day time will be much higher than the night time wind velocities that is what has been observed all over the World in most of the places.

So the day time wind conditions are more severe if you base your design on the data which is only taking account of the day time wind velocities then you are going to have estimates which will be conservative estimates the design will be conservative because you will have higher wind velocities you will try to account for that by having more overlap thereby you will have a overlap which is excessive which may not be required.

So is is the design will be more conservative, it might be over design, whereas if you take the night wind conditions on the other extreme and your actual operations are in day time also then it can be the other way round. So what you do normally is that when you are going in for the designs when you go in for the selection of the sprinkler spacing you try to take the average conditions or you use a waiting factor which will give some (())(31:30) to the night conditions and give some (())(31:34) to the day conditions and you can have a trade of between the two.

So in that situation at the same time I think it is also equally important that if the farmer is quite sure that when he is going to use this system, if he is certain that he is going to use only in during the night time then even if you take the night conditions will be safe otherwise if you want to change your mind at that time it might be will be at the cost of having a very low efficiency because if the wind conditions are higher than what you have assumed in the designs is going to give you design which will be very ineffective or will be on the other extreme it will be a under design situation.

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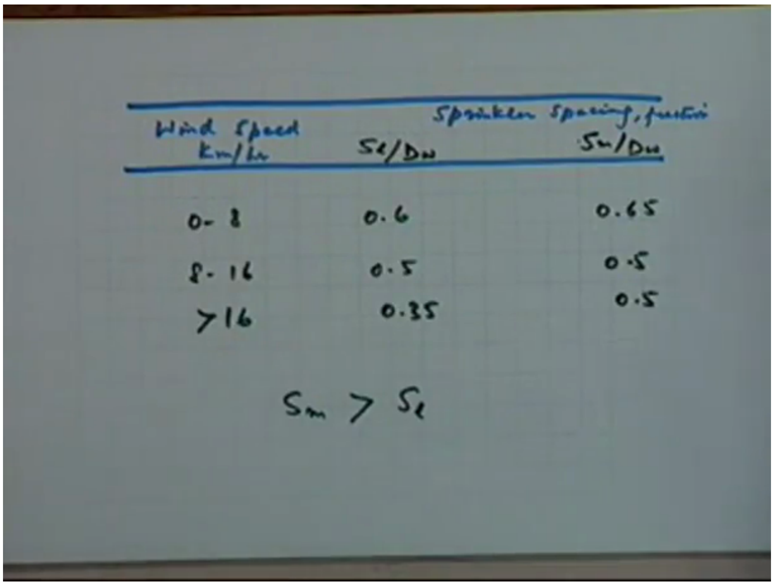

So when you are looking at these these sprinkler spacing aspects you will have to take the proper wind conditions, they are again in this situation they are recommendations which are available to account for this aspect with respect to the wind speed this is given in Kilo meters per hour, the sprinkler spacing in fraction has been provided as a ratio between S l and D w and S m and D w, the spacing has been provided with respect to different wind speed conditions as a fraction as a ratio between the spacing and the wetted diameter.

When the wind speed conditions are very low these are the recommended these are the recommended ratios. Now this type of information you can always use to find out what will be the D w under different wind conditions you can evaluate if you know that what is the spacing or if you if you can choose your spacing, where spacing normally as a function of again you have the existing laterals, the spacing will be when you buy the laterals you know that what is the spacing of the those the laterals spacing or the spacing between the two sprinklers which is normally available or which becomes a constraint on the farmers side that you have a lateral which is which is having a fixed spacing.

Similarly when you when you take a mean you know that what is the what is the point where the mean can be tapped or you can fix lateral at those locations. So that fixes your main line spacing S m. In general you will find that the spacing the main line spacing is invariably larger than the lateral spacing.

Why that is so this is again because of the economic constraints if you have the main line spacing if is lower or if is you have more spacing on the main line the all the gadgets which you require whenever you attach the lateral those can be reduced. So from that angle is invariably the lateral spacing is kept more than is kept less than the main line spacing that is a very usual trend which is used in the sprinkler irrigation system and some cases you might have the equal spacing also.

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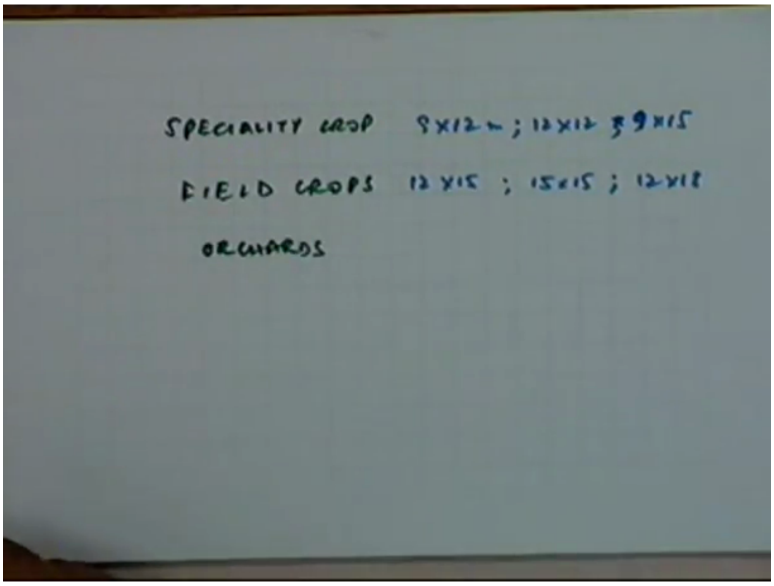

So looking at some of the usual spacing which are used in the sprinkler irrigation system you have the spacings which are with respect to the same three categories which we had earlier looked at depending on the type of crop which is under question, you have if you have the speciality crop which is having more value in that case you might go in for spacings like 9 by 12, or 12 by 12, or 9 by 15 meter.

The variation in these spacings are also dependent on how much is the what is the wind condition so you even choose spacings along with the situation that what is the wind condition prevailing in the in those localities and for field crops the spacings are which are used are slightly higher than the previous case and when you have the orchards spacings can still be wider because in that case will be function of what are the spacings of those individual trees or those plants.

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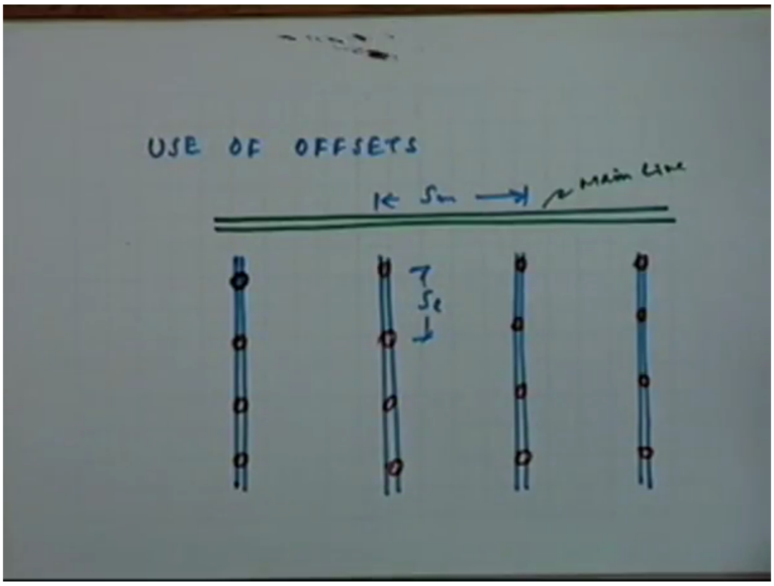

In conjunction with the spacing there is one aspect which is very important which is the aspect of offsets this is a very recent phenomena ad it pertains to the operation of these sprinkler irrigation systems that if you can use the the offsets first of all let us try to see that what we mean by the offset. Let us assume that you have you have a main line and out of this main line you are taking off I am not connecting it deliberately you are taking off the laterals on which you have sprinkler heads and they are with respect to the spacing between the laterals they are spaced accordingly, this is the total the 4 sets of laterals.

Normally you attach them here on to the main line in this case the spacings which are relevant or this is the spacing between the laterals or the lateral spacing and the main line spacing, okay. Now we have seen that when we want to operate the system in this manner we have to take we have to look into the overlap, the design contains what should be the S m, S l so that we can get a proper appropriate overlap so as to reduce the deep percolation losses and to increase the efficiency uniformity.

But we have seen that invariably if we look at the total field a part of the field will be over irrigated, part of the field will be under irrigated depending on how much is the total depth of water you have applied. So if you want to keep a balance if you want to keep the losses minimum you might do so by sacrificing the requirement that all the field should be getting the minimum required or the net depth.

In some portion of the field you will deliberately you will keep the depth lower than the net depth required so as to reduce the deep percolation losses to the minimum possible level.

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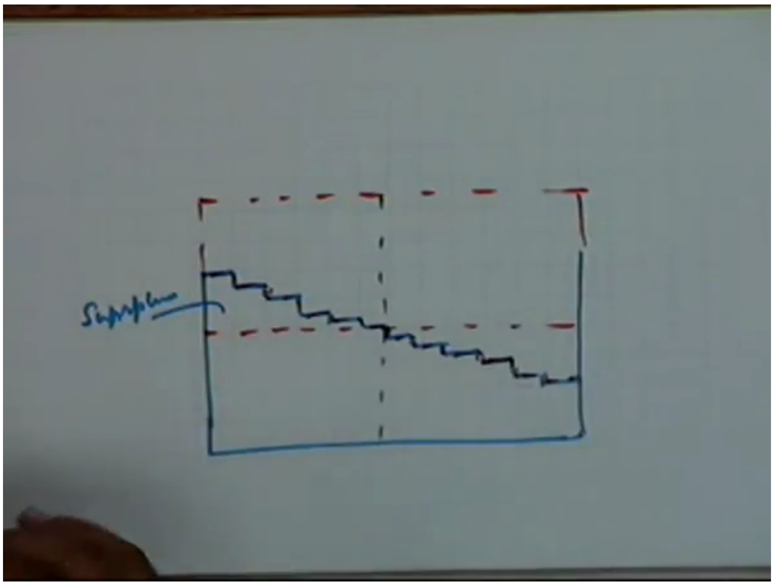

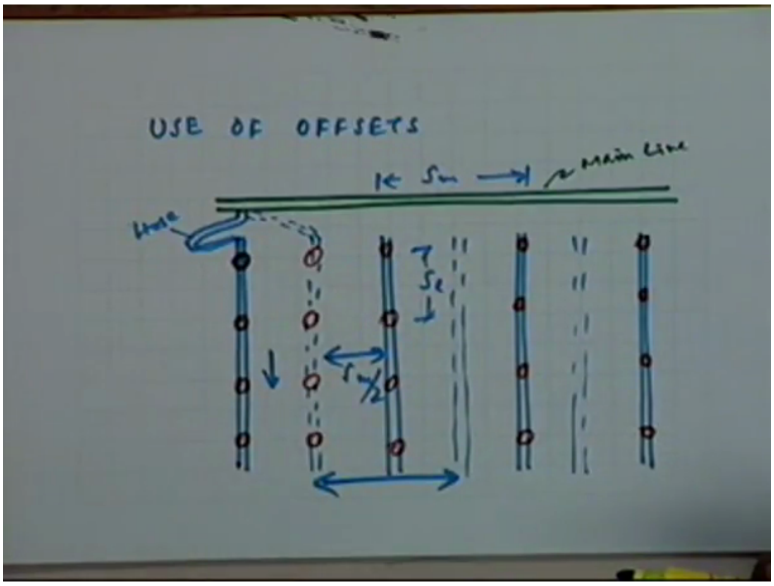

Now if you can let me put it like this let us let us try to have a look quick we had plotted earlier the we had depicted that through a plot that if this is our field and this is our net depth of application which is required, if we have 50 percent adequacy with respect to 50 percent adequacy you might get a situation where you have this situation for a specific level of the uniformity coefficient.

If I want to reduce this this deficit as well as this percolation loss, this I am getting mainly because of the fact that the overlaps are not very accurate they do not give me a uniformity coefficient which is which will ensure that all the places I am getting the equal depth and that this situation can be improved drastically if I change the spacing if I if I can have a control on the spacing in such a manner that I use one spacing at a particular time the spacing remains same but the location of lateral the next in the next irrigation I can change.

For example if I have in one irrigation I have this setup, in the next irrigation instead of using the the lateral at this location if I can use the lateral at this new location which is in between the two existing locations then this will be the place where I can place my lateral and the next lateral I can place at this location, the next lateral similarly I can place at this location, if I get this flexibility then I might be in a position to apply the depth which is the replica of this means those portions where there was a deficit earlier they will get additional and those portions where there was additional water earlier they will be getting deficit now.

So if that happens than what I have done is that I have super imposed another application which is just opposite to this or if I put it from upside down I might get another application which is like this now we are just matching with this it might not match this exactly like this so over two applications over two successive applications I will get this total depth out of which wherever there was deficit earlier here I had surplus earlier but now I have a deficit because now I am this is my level of I have put it upside down. So I have a deficit in this area still the for the next also this is the same level which is the required level of application.

So by doing by using this is what is known as the offset that I have I have offset the position of the lateral. In between the previous position of the two laterals that you can easily do by having a hose you might have a connection through a a flexible hose so that the water can easily come into this and then the next case this connection remains same but you can physical locate it there.

So this type of system this type of offset is very easily possible with the side roll system where you have the whole thing mounted on the wheels you can just you have to move it is only the position of the placing of the lateral which has to be changed. It has been found that this type of offset the use of offset in this particular case the spacing can be S m by 2 or any other spacing because now you have the total flexibility.

Looking at what overlap you want you have complete flexibility and by doing so it has been seen that is around it can give you advantage upto around 15 percent additional uniformity coefficient. Though it will vary from what is existing uniformity coefficient and how much it can be improved? If it was very poor it can improved more, if it was good uniformity coefficient earlier also that means in any case you are overlap for quite reasonably good is.

Student is asking: (())(50:28).

No it is not you are not reducing the spacing the spacing is still the same the spacing between the two remains the same.

Student is asking: But virtually you are applying twice, once you are applying with the same spacing and after that you are repeating the same spacing in between those.

No I think there is a slight I have to make another additional statement which I have made but which you have not caught this is not to be done over the same irrigation. These things are to be done over the successive irrigations in one irrigation you are using this setting when you go to the next irrigation then you are using the the chain setting. So that is not what you are saying I mean you have to look at may be the efficiencies have to be worked out in terms of the total period of the crop (())(51:25).

But even even if you will look at the efficiencies of two successive irrigations that is how you have to work out otherwise the efficiency will remain same. But what we are interested in is the efficiency in terms of the overall because in the previous case when we are keeping everything fixed all along throughout the total period of the crop those areas which were getting less water they are all along they are getting less water and those areas which are getting more water they keep on getting more water throughout.

So that is avoided here and that makes lot of difference because if you have put in more water that means we have brought it to the field capacity level at least and it will not retain beyond that all the deep percolation loss has gone out of the system or beyond the root depth. The only additional advantage is that the deficit is not distributed, okay.

Student is asking: Can we do the same thing with the nozzle location if we shift just by half location I mean we move this lateral S l by 2 in the new location.

In which direction?

Student is asking: in the same direction in which I think the laterals are placed, if we shift the laterals by S l by 2 distance than the nozzle will be in the new position and the distribution which we are getting in this diagram will just get the perpendicular shift?

Ya, that what he is trying to say is that if we do the same thing in the with the lateral also and the lateral you want to shift in this direction that is also possible because once you are is the overlap which is which you are having and the overlap is not from the one side, it is from both the sides. So you can resort to that also which is again possible by having a longer hose pipe you can even do that so that combination can also be tried but then it has to be there has to be some systematic way of doing this, that I fully agree that will also have the similar impact if not the same impact because why this is being done is in most of the cases as we have just said that the S m is much larger than the S l.

So the advantage which you are getting is more if we manipulate the (S l) S m sorry then the S l, what you are recommending is that we should manipulate S l S l as such is less than S m. So the overlap might not change very much even if you do that, okay.

Student is asking: Sir it is more convenient to change this.

Is more convenient to change this than to change in this direction because this direction you have already gone to the end of the field your length of the lateral is basically matching the length of the field invariably, we will come to that when we will come to the layout of these systems, okay any other question? Thank you then we will stop here.