Water management
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Lecture No 13
Crop Water Requirements (Contd.)

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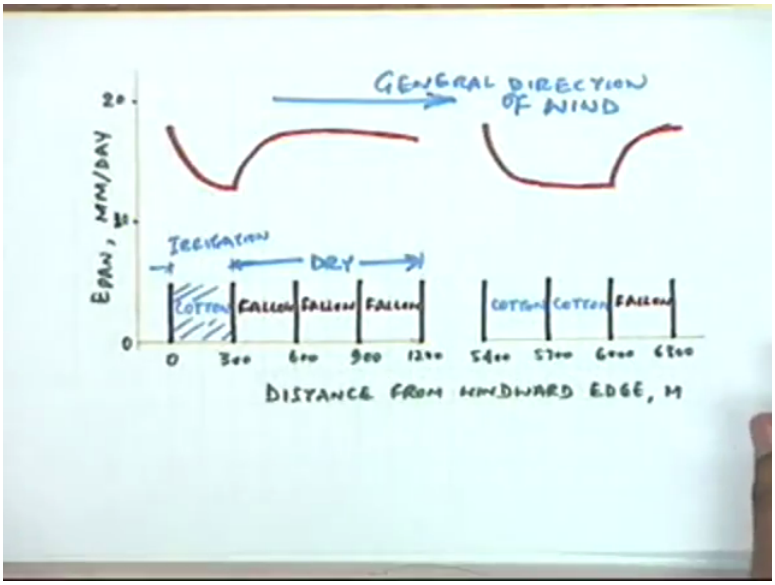

Okay in the last class we were looking at the local effects on the ET crop how we can incorporate some of the local effects due to the agricultural practices or due to the local conditions and we were we had left with looking at the effect of change in environment because of the irrigation coming up in that area at the time when we are collecting the data the micro environment or the micro climate was different than the climate which has been obtained after the project has come into picture and had seen that the one example that whenever there is a dry condition whenever there is condition where you have an arid climate semiarid climate and you have the areas, irrigated areas surrounded by the fallow area is which are dry areas and not irrigated areas then you will have the advection effect, the advection will be experienced and because of that you will have the conditions looking at the general wind direction.

Now if you look at the windward side the starting edge of the windward side of the field will have the clothesline effect whereas subsequent to that you will have the oasis effect. In the case of oasis effect what it means? It means that the conditions have become such that the evapotranspiration has reduced because of the fact that the air mass which has passed over

the or which is passing over the irrigated area is becoming cooler and is becoming more humid.

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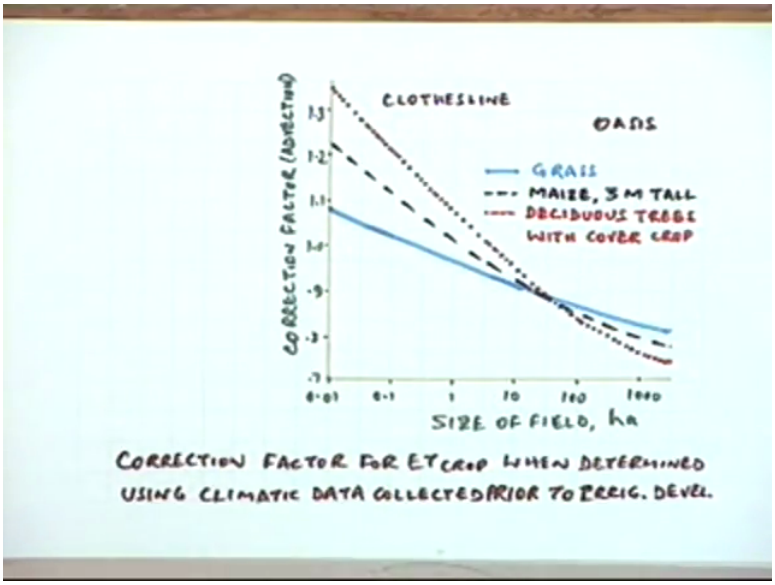

So because of that its capacity to evaporate or its capacity to evapotranspirate will reduce and therefore we have also looked at that as a correction you will find that if your areas are very large the irrigated areas are very large the net effect will be that you will have to put a correction factor which is less than 1 because of the enhanced oasis effect, so that will be the end result that will be the end result in terms of reduced value of evapotranspiration than what you have observed in the conditions were such that you are you were using the data on small patches of irrigated areas which was surrounded by which were followed by the fallow areas or the areas which are not irrigated, so that will make a difference of maybe 5 to 10 percent and you can put a correction factor on the crop coefficient.

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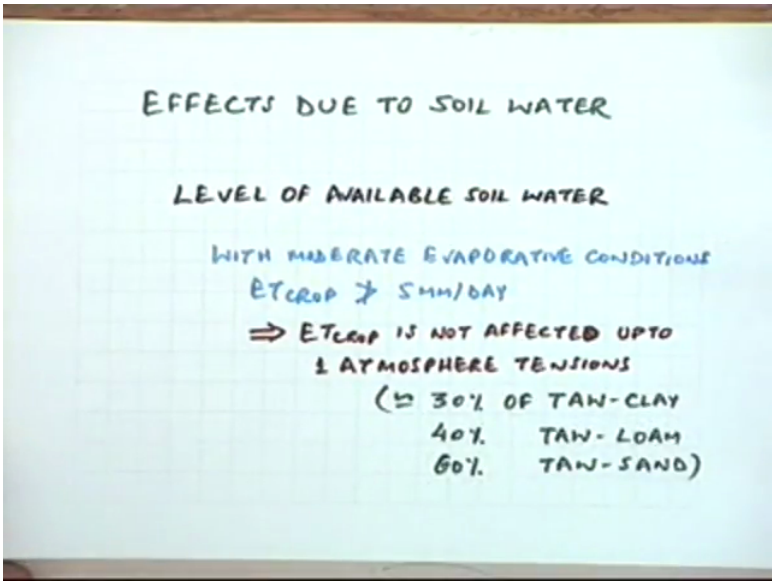

Let us look at some of the other effects which can be, which can be taken into consideration, the affect due to the soil water, the level of available moisture or the level of moisture which is prevalent at a particular time that will also influenced the evapotranspiration activity and that is what is shown here that it also depends on what is the condition of the climate, the climatic conditions will also influence but assuming that the climatic conditions are not very different than the factor which is influencing the other factor which is influencing the ET crop will be that what is the what is the type of soil for example if we assume that if we know the type of soil because ultimately the moisture holding capacity or the way the moisture is held is a function of soil characteristics as well.

So if we if we assume that the soil characteristics are known then we know by now that the moisture depletion or the moisture deficit which is being created up to a particular level you might be in a position that the root system might be in a position to extract the moisture without any problem but when the tension increases then the evapotranspiration activity will also be affected. In general the ET crop is not affected up to a stage where the atmospheric tension is close to 1 atmosphere and at that stage, there is a stage for different soil types for example in the case of clay that stage will be attained when you reach a level of 30 percent of total available water, TAW is total available water and in the case of loam this level of 1 atmosphere will approach at station where you have extracted around 40 percent of the total available water and in case of sand up to around 60 percent of total available water, so these are the indicators these are the indicators you will at least you can now visualise that much

moisture is available in fact without influencing the evapotranspiration characteristics or without reducing the evapotranspiration in a particular crop.

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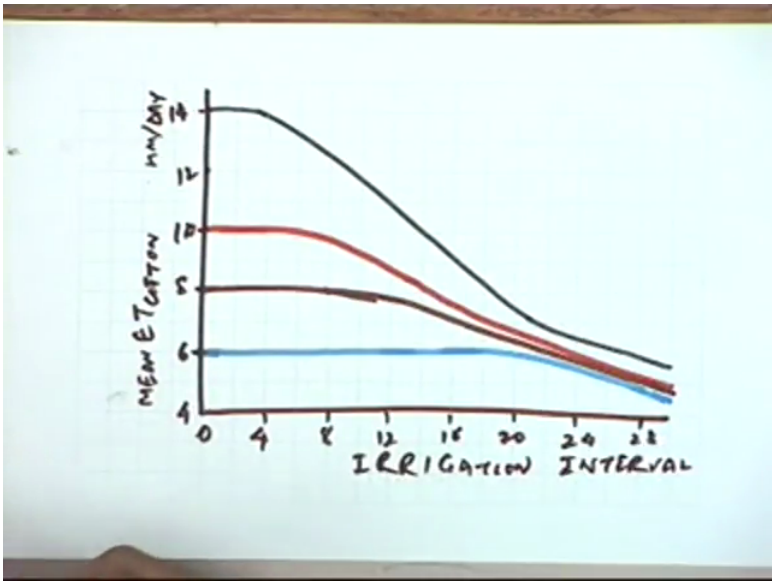

Let us have a look at this variation on some actual case where the cotton has been used as a crop, so if you if you plot mean ET cotton and millimetres per day this means ET cotton is between the for the period between the irrigations was the mean value of evapotranspiration and on this side if you plot irrigation interval, let us say that we have the irrigation interval varying from these values and so on and on this side the scale is sometime something around…How that irrigation interval influences the ET crop? In other words what you are saying is that if you are applying the water more frequently then what will be the effect on ET crop than if you will apply the water at a larger interval.

For example in this particular case it has been observed that when you are applying the water, if the mean ET cotton is 6 millimetre per day then as long as you are applying the water at a reasonably large interval also it is not making much effect only after if you go beyond interval of around 18 days it is making some impact on the ET crop whereas if this evapotranspiration requirement is much higher for example if is other extreme you might find that in this particular case might be having something of this nature that even if since the evapotranspiration level is very high, even if you apply water very frequently you will find that in general the…

If you would have applied the water at the desired rate then the evapotranspiration, the potential evapotranspiration could have been 14 and that is the maximum which there is a

peak consumptive use date or the peak evapotranspiration, whereas because of the fact that you are applying the irrigation at a longer intervals the evapotranspiration, the actual evapotranspiration has reduced, so you also know by now that the evapotranspiration is directly related with the that ultimately yield of the crop, if the crop is not in a position to evaporate or evapotranspire at the desired rate, it will have the impact on the ultimate yield, okay. So in this situation your yield will be affected if you are not supplying the moisture at the proper rate. Similarly in the intermediate situations you will find a similar effect that the effect might not be as much as in the case of situation where your evapotranspiration was very high.

So is basically that rate at which the deficit is being created that is going to influence what is the rate at which you must replenish the deficit, so that is what is depicted in this particular case and for other cases also there will be slightly more but again there is some impact which shows that we are trying to basically bring in some other factors that when we go in for the designs we have to ensure that we know these relationships, we know what is the impact of delay in the moisture supply on the crop yield and those things will have to be incorporated those things will have to be looked into for proper management of water.

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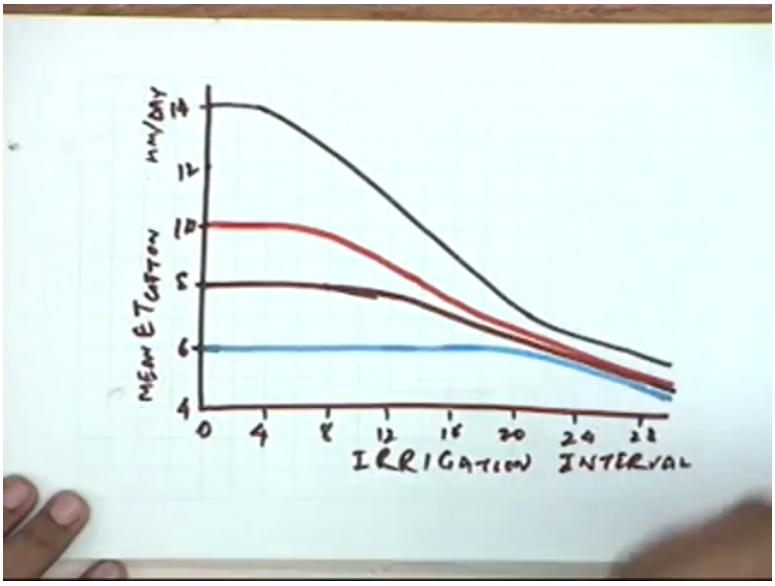

Now as far as in this particular situation depending on the actual level of your evapotranspiration, the factor which has to be incorporated will be dependent upon what is the what is the actual practice you are adopting, what is the actual irrigation interval which you are taking into consideration? And on that basis you can incorporate the effect or the correction factor on the K c value, okay. The K c value will also be influenced if your

evapotranspiration is not allowed to take place at the desired rate that is what is happening in this case. That is very essential to understand that if you are supplying the moisture at the rate which is the desired rate, in this case this is the desired rate then you should have been in a position to get the evapotranspiration at the same rate but since you are applying the irrigation at higher intervals.

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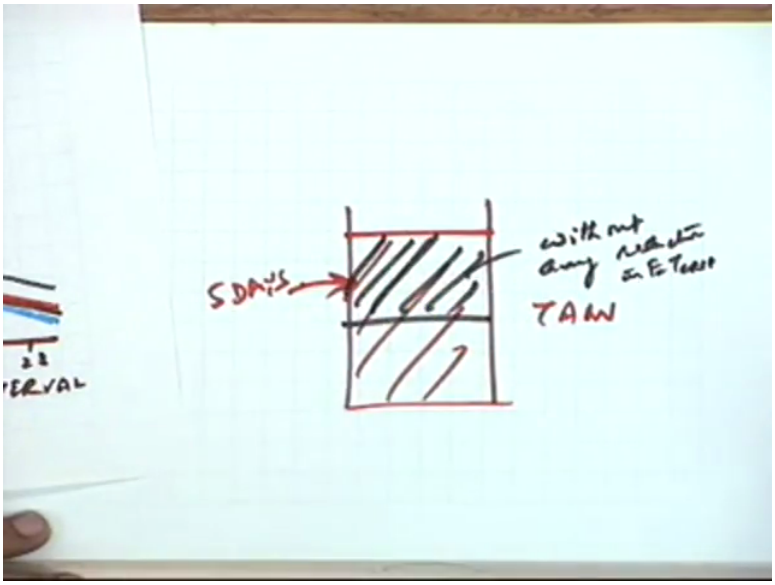

In other words what is happening is that you know this is your, the total available moisture, total available water out of this you can only this much can be extracted. This is what can be extracted by the crop systems without any reduction in ET crop, is not it? So if you keep this much moisture in the soil then the ET crop will occur at the potential rate if you reduce. Now what happens when I supply the moisture at a larger irrigation interval, the irrigation interval means that you are supplying your replenishing this deficit which is been created. If it takes at a particular rate it takes 5 days to bring down this moisture level to this level which is the level where up to which you do not have any effect on the ET crop.

If it takes 5 days…if I wait for 3 more days, if I make the interval 8 days then this soil is not having that much capacity to absorb the moisture to be serving the plant for 8 days and that 8 days limit is on the basis of what is the rate at which the moisture is getting depleted that is the ET crop at is dependent on ET crop, so if you are ET crop is highly it will mean that you will have to replenish the deficit which is created and the deficit will be created in a relatively small period and unless you replenish that deficit after those many days you are going to have problems, your yield is going to be affected.

We will come back to these concepts later also when we will go into the scheduling at this stage I think this much is sufficient to know that all these are the additional factors but at the same time let me point out at this stage that these factors which we are discussing, the local factors or the factors which are dependent on the local conditions as well as the agricultural practices this is not going to influence very drastically ET crop, the percentage up to which this might be influenced unless that there are some specific very specialised conditions you will find that the percentage will be the order of magnitude will be around 5 to 15 percent.

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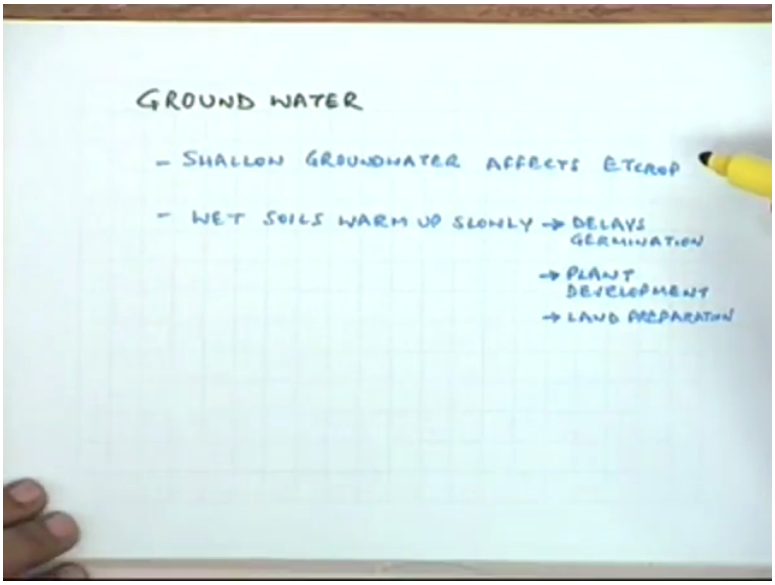

But at the same time in some situations it becomes quite very major factor and there can be a situation where it can be really detrimental if you not taking care of the these impacts. Let us now go to the groundwater, groundwater is another condition which will influence the K c values or can also say that it will influence the evapotranspiration activity, why? Because in the case of the groundwater, the level at which the groundwater is available.

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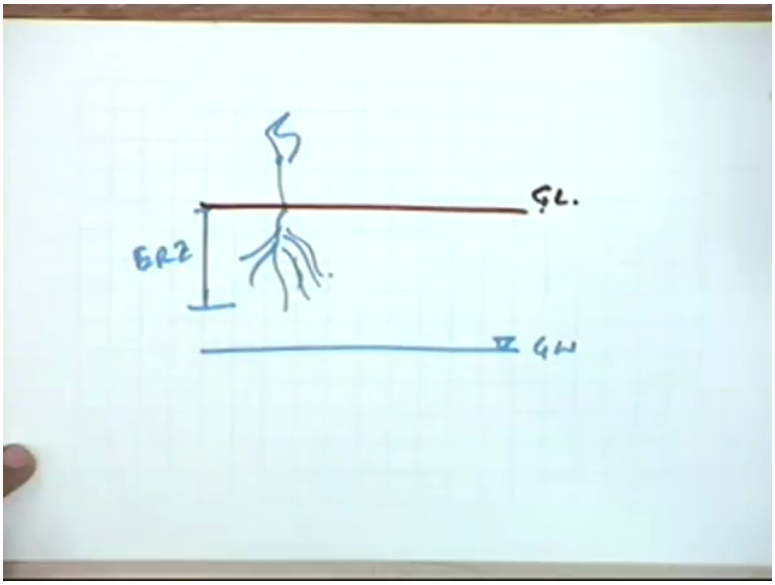

If you have if this is your ground level and your groundwater is somewhere and this at this level, this is the groundwater level. Now it depends what is the, what is the depth how deep the groundwater is in comparison to the ground level and it also depends on which crop you growing, what is the root system? What is the effective root zone? So if the effective root zone is this much then in some cases it might not influence the crop and that case is depends upon the soil type because how much this groundwater can influence this zone is a function of the capillary characteristics of the soil, so in some cases if the soil is light soil, the soil is sandy then the situation is not that bad in that situation the capillary zone will be very small and you might not…you might feel that in this particular case if the groundwater is somewhere here it might not influence the root zone.

Whereas if you have the heavy soil it will influence the root zone but in what way the this groundwater, in what way it influences the evapotranspiration, there are various items which will…one is that you will have the soil in this area will be its water content will be higher, it will be wet soil and that can create problem in terms of the agricultural operations. For example if you want to use the land preparation if the water content is very high the land preparation cannot be done very well because you cannot you cannot do many operations on the soil if it is very wet if the water content is very high. Secondly you will also find that the wet soil they do not even under the conditions when the energy is available, they get warm very slowly.

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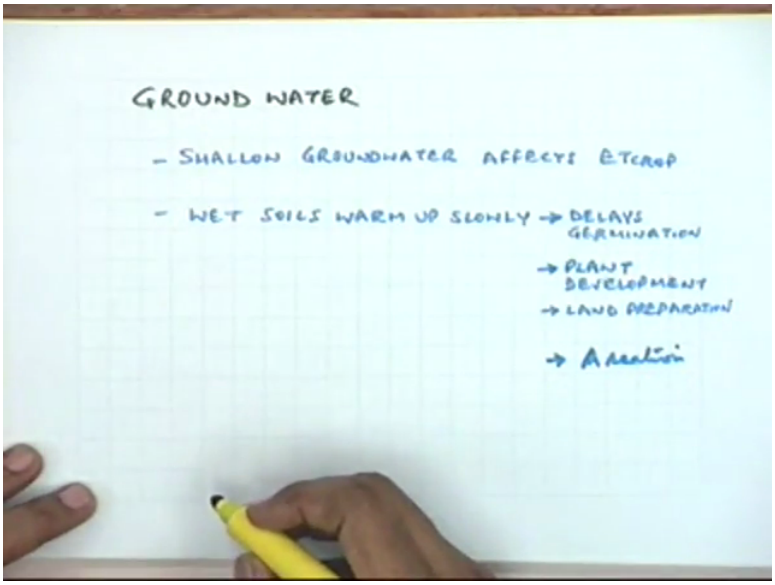

So because of the slow warming you will find that the delay in germination will be there because for the germination to take place the temperature in the soil has to reach at a particular level, so there can be delay in the germination. Land preparation is another situation where you are having problem is in terms of the groundwater availability. The prom plant development can also be delayed, these are some of the factors then along with this you will also find that there can be problems due to variation. If the moisture is always available in the soil at the groundwater level if the groundwater table is quite close, you will find that the (())(23:22) spaces will be always filled up with water and the irrigation can be a problem.

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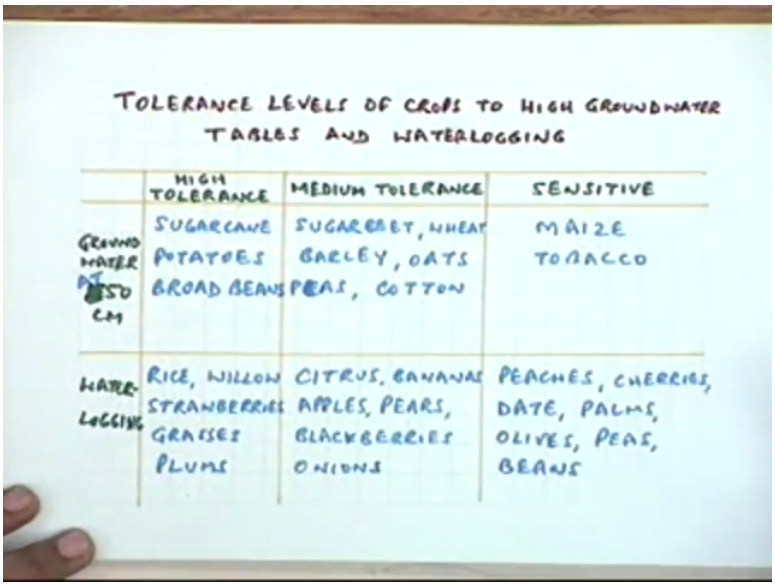

There are if you look at the crops there are many crops which behave differently in the these conditions of high groundwater availability and they have been divided into 3 different categories, those crops which are high tolerance towards the groundwater, medium tolerance and those which are sensitive crops. Now when the groundwater is at 50 centimetres these are the crops which are having high tolerance sugarcane, potatoes, broad beans and medium tolerance crops are sugar beet, wheat, barley, oats, (())(24:28) cotton, sensitive crops are maize and tobacco. Similarly under the water logged conditions, the water logging condition means that the groundwater is even still higher. Under those conditions rice, willow, strawberries, grasses most of the grasses, plums these are the high tolerance crop whereas the other extreme is the peaches, cherries, olives, peas, beans, so the characteristics of the crops will have to be looked into when you have these situations where the groundwater is very high is quite close to the root zone and as have told you that it is also going to be a function of which soil you are dealing with.

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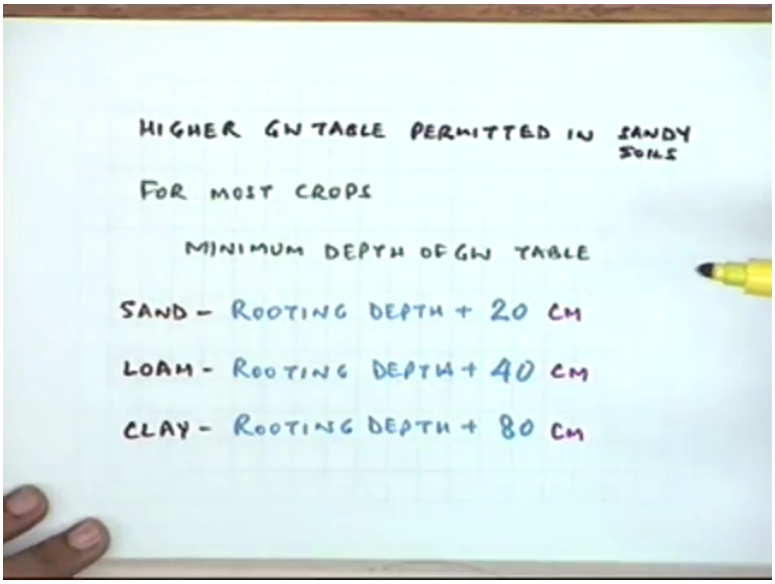

So in this case here the minimum depth of groundwater table, there is a general thumb rule which is been suggested here. If you have sand sandy soil, the rooting system or the root zone depth plus around 20 centimetres is the recommended depth to which the groundwater table should be beyond that and in the case of loamy soils plus 40 centimetres and in the case of clay soils plus 80 centimetres. Now if you have these conditions prevailing then in general you do not have to put any correction factor whereas if you are conditions are violated then you will have to look into the greater depth which crop you talking about, how much it will

influence because of the close proximity of the groundwater table and that effect has to be taken into account.

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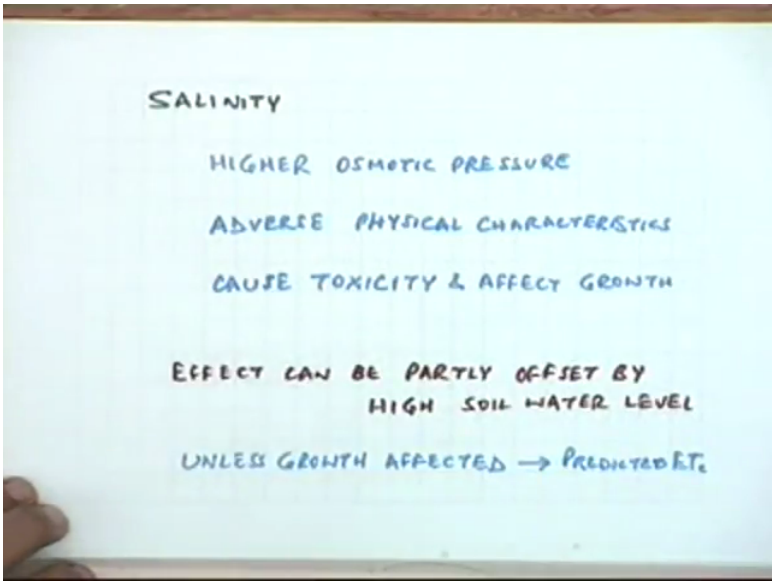

Then the next item which we like to look at it is Salinity, now salinity effects the evapotranspiration activity in many ways one is that it exerts the higher osmotic pressure, so because of this the root system will find it very difficult to extract the moisture is the salts which are available their osmotic pressure is much higher and that will create conditions where the levels which you are discussing which you are saying that in a particular soil the level of extraction by the root system we have defined those levels, those levels will not be valid anymore if you have the saline conditions then it will also affect physical characteristics of the soil.

The structure of the soil can be effected it will also cause toxicity and effect the growth, so this toxic conditions can be harmful to the crop development and salinity can from that angle it can influence the crops and once the crops are influenced then you have the influence on the evapotranspiration as well. One way to offset this particular situation is to keep the level of moisture it is available at any time in the soil at a higher level with the high moisture levels, these effects are reduced so there is one way of handling that situation than the other way is by reducing the salinity or by even doing the leaching process. Leaching is the process which you use lot of water to flush the salts which are harmful salts from the soil to a level much lower than the root zone system or the root zone depth.

So you apply lot of additional water on the surface and that water dissolves the salts which are problematic salts, those salts are taken to a level in that case the groundwater table has to be much lower, in case you have water logging problem you cannot do that but in those areas where the rainfall is quite high the leaching is automatically done whenever you get lot of rainfall at is doing the leaching process in a natural manner but in those situations where the rainfall is not excessive you might have to use the rainfall, the irrigation water sorry the irrigation water not the rainfall you have to use the additional irrigation water and that becomes the additional requirement of irrigation is known as leaching requirement which we will again when we look at the total requirements then we consolidate the requirements of irrigation we will come to that leaching requirement also but that is one way of reducing the salinity.

But in general the ET c value of the crop evapotranspiration is not change unless you are certain that the salinity is creating a problem or is creating some effect on the growth of the plant, so unless the growth is effected if there is some level of sanity you might ignore that there is no connection which is made on the K c value, the correction is required only when the level is such that it affects the growth of the crop.

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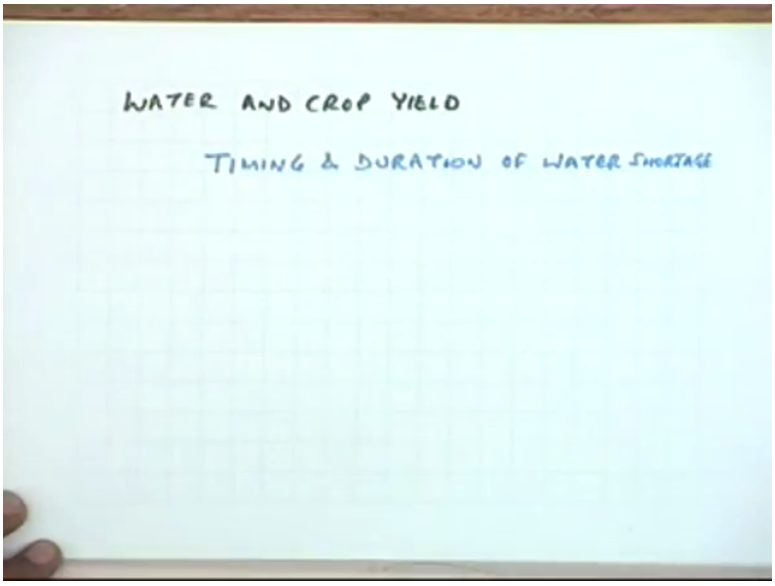

Then water and crop yield, this is another aspect which we have to understand, then the crop production, the timing and duration of water shortages we have slightly discussed in the earlier part when we were looking at the soil water availability, this concept was just brought in that when you are making the water available, at what time you are making the water

available and how much you are making the water available, those 2 things are going to decide what is going to be the crop yield ultimately.

There are situations where a deficit which is being created in the soil, the timing of the deficit is also very important because of the fact that the growth stages of the crop, there are some sensitive growth stages than the other stages which are less sensitive, so if you create a deficit in a stage which is less sensitive, it might not have very detrimental effect on the ultimate yield than the other situation where the growth stages very sensitive and if the deficit or if the conditions are deficit conditions during that stage, if that happens then you are going to have problems, then the impact on the ultimate yield is going to be much larger and that is shown on the using the actual data.

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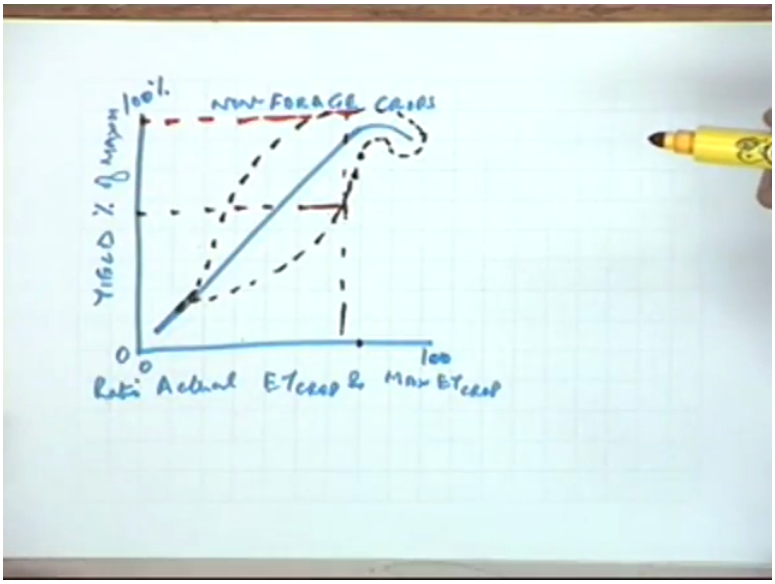

Let's (())(33:47) actual data of…this is from non-forage crops and is between yield as percentage of maximum yield, so that means from 0 to 100 percent what is the actual yield as percentage of the maximum yield which can be achieved in the crop? And on this side is the ratio of actual ET crop and the maximum ET crop, the maximum ET crop is that situation where which will be attain when you are supplying the moisture as much as is required, so if you plot this for non-forage crops, it has been plotted some…this is the variation, now this area this plot is a plot which is showing the mean variation which suggests that if your actual ET if your actual evapotranspiration reduces then the yield will also be reduce accordingly and the yield reduction is in this particular case, the yield reduction is looking to be proportional but it is not always show, it depends on many other factors, it depends on where those deficits are created in the total growth period of the crop.

These dotted portions is showing the variation that in general for different types of deficits for example if you have created the deficits in a stage which was very sensitive stage then in that case you might find that even if you had created a deficit which was not very high deficit but the impact which it made on the ultimate yield was very high and in this particular case for example let us say that if you are somewhere here…now your deficit creation is the actual ET is quite close to the 100 percent level but still amount of yield reduction which it has done it might be quite large in comparison to the other situations.

For example if you are somewhere here this is the yield percentage of the maximum, it has reduced by around 50 percent whereas if the stage was some other stage the same thing has been found that there is hardly any impact on the yield for example if you are looking at this extreme of the graph you find that there is hardly any difference in the yield when the same deficit was created in another stage, so this variation this scatter or this total area which has been shown here that proves the point that it is not only the deficit, the level of deficit which is important but it is also important at which stage a deficit was prevailing.

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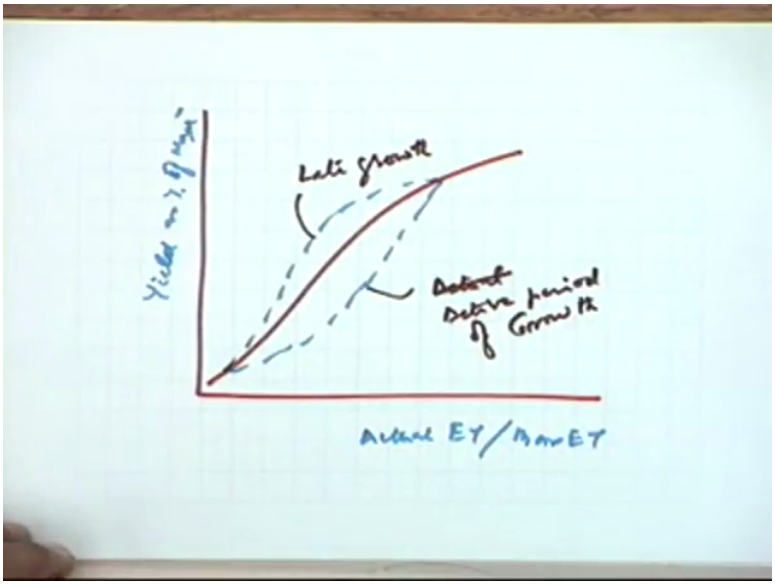

Now similarly for some other crops also for example in the case of sugarcane the plot is something of this nature and the scatter is…this is the same both the scales are same and on this side is the ratio of the actuality actual ET to maximum ET and this side is the yield as percentage of yield maximum yield. If you look at this particular area belongs to the situation where you have created the deficit in the late growth period and the side when the deficit is created in the actual active period of growth.

Now if you are creating any deficit in this period which is more sensitive period than the late growth period then you are getting more for the same level of ET reduction you are getting much less amount of yield or the yield reduction is much lowish. This area of relationship between the crop ET and the yield reduction is a very vast area and it has been treated separately in another (())(41:02) paper, paper number 33, the yield response to water, so that as a very elaborate explanation on all these factors how this yield reduction is taking place and what are the various characteristics of the crops on which it is based on.

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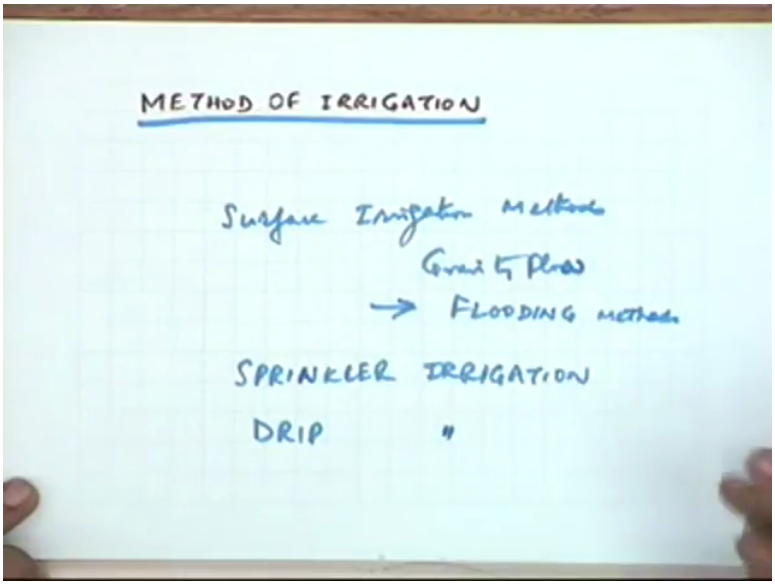

Now let us come to the other factors or the conditions which can influence the ET crop and one is the method of irrigation. Which method of irrigation you are using? That will also make some impact on what is the evapotranspiration or what is the influence on K c value. Now in what way this can influence the K c again the major factor which will influence is the way the moisture is being made available because these methods so far we have not discussed what are the various methods of irrigations?

We will be very soon discussing those but in general to tell you that there are methods which are known as surface irrigation methods which use that concept of the gravity flow and sometime they are also termed as flooding method that they can be some change in nomenclature but what we mean by that flooding is that you are making the water available on one side of the field and it flows under the gravity force to the downstream side of the field. Then there are methods like sprinkler irrigation methods in which you use the sprinklers and the waters is sprinkled over the area in which case it will wet the plants also

whereas in the case of surface irrigation methods those irrigation methods will not wet the foliage of the plant, the canopy will not be touched even.

Then you have the drip irrigation method wherein that case you are using the drippers and you are making the area which is providing the moisture to the root system, you are making that area wet so that the reduction in the moisture requirement can be made. So these are the major methods, now in these all these methods has been found that ultimately these methods do not make much difference in terms of the evapotranspiration requirement unless they are…in some case for example in the case of surface irrigation methods.

Since you are wetting the total soil it is felt that it might be more water consuming method but it is not so because in the case of sprinkler irrigation you might be reducing the amount of moisture which has to be supplied onto the area you might be in a position to have a better control on the irrigation method because you can operate the system anytime you feel like, you can operate it for any period of time as desirable whereas in these methods you cannot do that because there is a requirement that the water must know from the upstream end to the downstream end and that requirement is to be fulfilled so as to provide uniform depth over the whole length of the field but in this situation since you are putting the water from the top the crops gets wet and it enhances the evaporation.

The evaporation is much larger all that water which remain on the leaves that gets evaporated, so the evaporation losses increase then there are some losses which are spray losses which are because of the wind, the water might go to some other area where it is not intended to be applied on so that can be another loss. So in terms of the total requirement that requirement remains almost similar, there can be some saving in the case of drip irrigation methods, so from these point of views the method of irrigation and make some difference but not very drastic difference. You have to look at other conditions, the other prevailing conditions if you are looking at the sprinkler irrigation how much is the wind influencing the irrigation activities, so all of those things have to be incorporated and that is what I thing at this stage we can only just mention about those variations because of the irrigation method.

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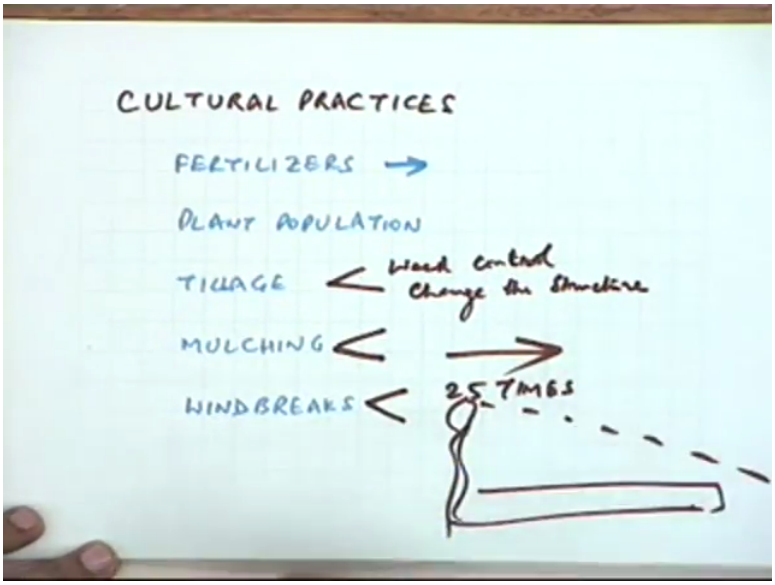

Then the cultural practices, these can also influence plant population, tillage, mulching and the provision of windbreaks. In the case of fertiliser it will only influence the evapotranspiration if the salts the desired salts in the soil are not available, so if in that situation unless you supply the fertiliser unless you supply the fertiliser from outside as additional nutrition which is desirable or which is required, it may not have any impact. If the natural salts are available then the fertilisers might not have any impact, so you have to look at what was the condition of the soils with respect to the condition of the soil only you have to look at these particular factors.

You can also to certain extent in even consider where the salts are where these salts are available. Are these available beyond the root zone depth or they are within the root zone depth or are you is your irrigation method is that is flushing the salts beyond the root zone depth or even if you are supplying the fertilisers, is it flushing the fertilisers beyond the root zone depth, if that is happening then it means there is some is going to affect the evapotranspiration activity, so only from that angle that since it is effecting the crop growth it might affect the evapotranspiration activity as well.

Then the plant population is not very major factor it will make some difference in terms of the evaporation because if the plant density is high then the crop will cover the ground and only in the beginning when is the initial stage you will find that the evaporation will be influenced to an certain extent but in in the later on stage when the crop coverage is going to be there anywhere then it is not going to make that difference also in the evaporation activity. So the evaporation activity is the major activity which is going to be the evaporation from the

soil is going to be influenced in this particular situation. The tillage is the process in which you just disturb the top soil for various reasons one is the weed control, you want the weed to be removed.

The other is to change the soil structure because many a times the soil gets sealed, the top soil gets sealed because of the impact of the raindrops and that ceiling process will change the structure, it might seal the pores and that ceiling process will influence the infiltration automatically and since the influence of infiltration will be to reduce the moisture getting absorbed into the soil more of the water which is going over the soil will be going as a waste (())(51:33) very little amount will be in a position to go into the get into the soil and thereby get absorbed. So from that angle tillage can make some difference if there is lot of weeds around and if going in for the tillage practice you might be able to influence the weed and thereby reduce the evapotranspiration.

Similarly the mulching in many situation people feel that so mulching…what is mulching first of all? Mulching is the process in which you let the crop waste be in the soil and remain there so that it can it can influence the things like the rain drop impact can be reduced, you also want in some cases to reduce the evaporation from the soil but it has been found that ultimately there are some advantages of mulching but there are at the same time some disadvantages also.

So it is not always true that through the mulching you will get the desired effects which you thought you will be getting. For example the disadvantages, one of the major disadvantages is that it creates the similar problems like the close proximity of groundwater, it will make the soil remain wet most of the time, it will also introduce many diseases those can be because of the mulching and because of the additional foliage being made available on top of the soil, so that can be there can be some impact of mulching it can be taken into consideration.

Windbreaks can also be influencing the ET crop, it has been found that the windbreaks there is a thumb rule that the height of the windbreaks which is being used will be deciding how much will be the influence of the windbreaks and the windward direction up to which extend it can influence it is around 25 times the height of the wind barrier, that wind barrier can be in the form of trees or it can be some artificial wind barrier also but the influences something of the similar nature that assuming that if you are providing the wind barrier, what is it doing? The other climate it cannot change, it can only change the wind speed, it can just reduce the wind speed.

For example if this is a barrier and we have the crops here this is the wind direction, now there will be an extent up to which you will have the you might save this particular area from the wind which was prevailing wind but the other parameters remains the same, so if there are some areas where wind direction of the wind speed is going to make a lot of difference in terms of the evapotranspiration activity that can be influenced, so with that we will close this chapter here, we have looked at all the aspects of the evapotranspiration requirements, how we compute those requirements? And what are the various methods? What are their plus points? What are their data requirements? And if there is any question I can respond.