Water management
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Lecture No 12
Crop Water Requirements (Contd.)

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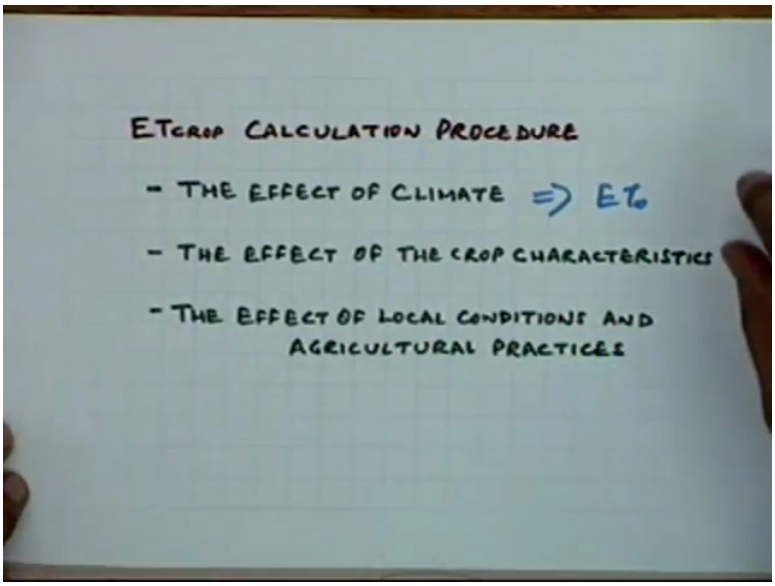

In the last class we were looking at the effect of…we had started with ET crop of calculation procedure again is the same slide and we were in the process of looking at the facts of the crop characteristics on ET crop and we had seen how we can account for those variations in the crop coefficient and the grain and the vegetable crops.

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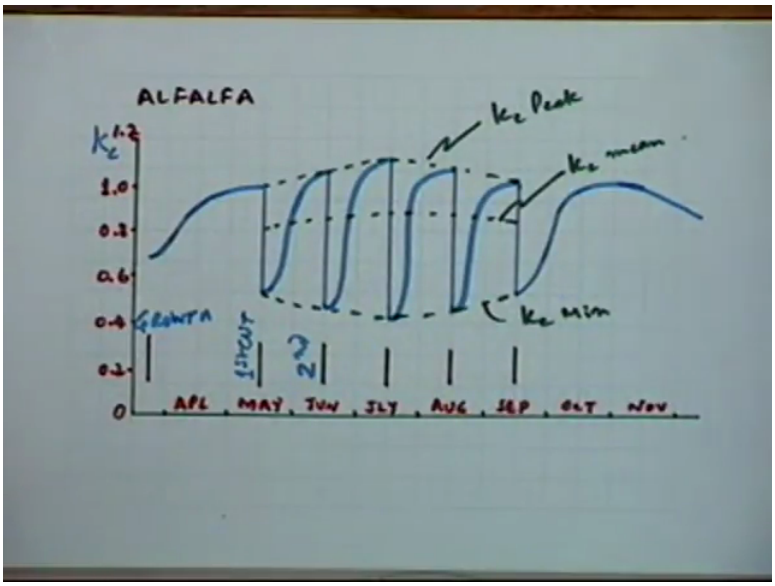

Now those are some of the crops, there are many other crops which behave in a very different manner, let us have a look at some other crops other than the grain crops and the vegetable crops. For example Alfalfa is another crop if you try to see the variation of K c value in the case of Alfalfa it will not belong to that same pattern which we have looked at so far where we have the 4 4 broad stages and then within the growth stage we had seen that how we can construct that K c variation for some of those crops depending on the growth stages data available. Looking at Alfalfa and this particular crop this is a crop which is…for the crop it is a kind of grass and in this case this is the variation which is…this is not a complete picture.

If you look at this variation this is the time when the growth starts this is that level, now after the beginning of the growth you will find that the K c value will increase which is depicted here over this period from April to May, now by middle of May you might go in for the 1st cut were in the case of most of the fodder crop you will cut the crop many a times you want to use that for the cattle feed and all these fodder crops you will have you will use the plant for the cattle feed and is cut many a times. In the case of Alfalfa also once you go in for the 1st cut once the crop is cut the ET crop will reduce drastically. It is obvious that the evapotranspiration activity, once the crop is reduced in size is just where the stem is there you will find that the ET crop value will reduce and ET crop reduction means the reduction in the crop coefficient, is not it?

So again once the crop again starts growing you will find again the wall value of K c will start increasing and it will reach a stage where again you go in for the 2nd cut after that much period, it depends how much is the period between the next cut, so you will find that this process will continue after each cut you will have the that K c the K c factor will drop drastically once the size is reduced to a very small size. Again the crop starts growing the K c value will start increasing, so that is along with that you might see the variation that there is a variation because of the cutting of the crop but even otherwise there is a general trend, if you look at this if you look at this the peak which is reached in each case is also increasing with the climatic changes.

Now that peak, the peak value of K c in each case is changing, so there are some impact on the K c value because of the climate also in this. Similarly the lower value, the minimum value of this K c factor also is varying if you go from one month to the next month you will find that that also is…and if you want to just take because this is what is happening in actual factors but if you are only interested in the values which are mean K c values, so this is what

is the maximum K c value, you can say it is the K c peak that is the K c minimum and K c mean.

Along with this you will also find that in some situations there will be an impact of…When you irrigate and how much you irrigate? If you are changing the moisture conditions at some level that will also have its impact on the value of K c as we have seen in the case of previous crop that the vegetable and the grain crop. A similar impact will be seen in the case of Alfalfa also if you are supplying irrigation and the K c value, the local K c value will be different, so this is what is important that if you are in the process of using these K c values you must know what is the range which is applicable to a specific crop and these ranges have to be used accordingly looking at what are the climatic conditions and what is the crop species which you are considering.

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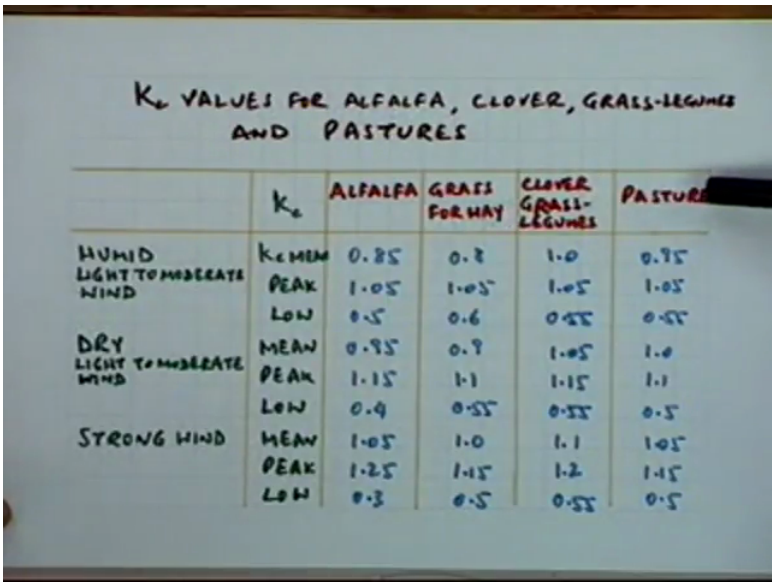

In this table the values of K c have been shown for many other crops which are of the similar varieties For example Alfalfa we have seen that how the actual K c value changes from time to time and for any grass or the clover and grass legumes and pastures all these the other varieties of different varieties of grasses and for them the values have been given in terms of the K c mean value, the peak K c value and the low K c value or the minimum K c value which can be observed for different climate, different climatic conditions for example in the case of Alfalfa when you have humid and light to moderate wind, the K c mean is 0.85, peak value will be something 1.05 and the lower value is 0.5. Similarly for other varieties also the values, the rangers these are not the actual values but they are sort of order of magnitude values which can be used for the design purpose, whereas if you using these things for actual

dissolution of water you might like to…to see the actual value the variation of K c as we have seen here.

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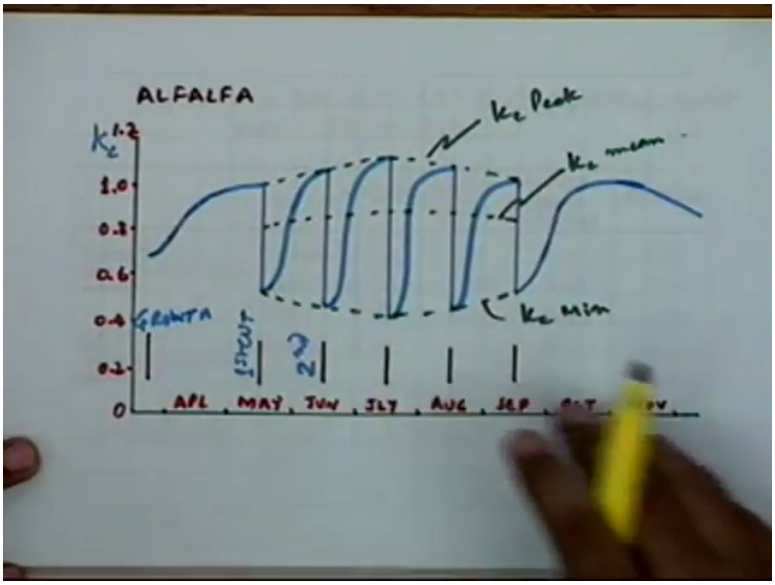

So if you are trying to plan your irrigations then you might like to utilise the actual K c variations, so it depends the importance of your variable which a pickup whether you want to use the mean values if you are designing the system you might be satisfied with the mean value is only of K c otherwise you might for specific purpose you might like to utilise the specific values which are either in the form of peak values or low values.

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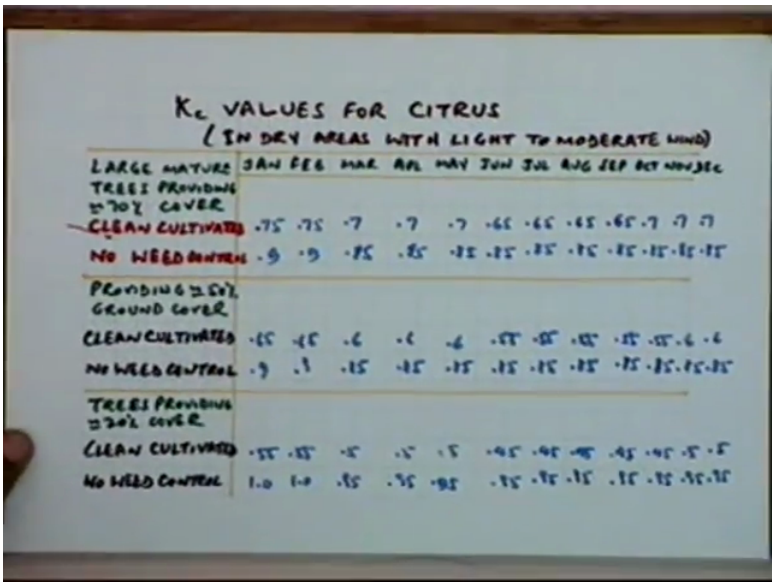

Similarly for some other crops in this particular case the citrus or the K c values vary from different types of conditions and the stable climate has been confined to the dry areas with light to moderate wind. Now if the climate changes you will have another set of tables which will depict on how will be the variation of K c in the case of citrus but here the variation has been depicted with respect to what is the ground coverage. Large mature trees providing 70 percent cover and there are 2 conditions which have been considered one is the clean cultivated, no weed control, so in one case you are trying to control the weed if there is some weed control then you will find that the K c values are much lower because the evapotranspiration is lower otherwise the water which is not even meant for the weed or which is meant for the citrus is taken by the weed.

So that the amount of water which is being lost through evapotranspiration is higher because of the weed availability, so in that case you are finding the K c factor is a value which is much higher than the value when it is clean cultivated. So here this also gives an insight that when you going for the water management aspect which are the areas where you like to put some constraints you like to indulge in those activities which can save water. Similarly when the groundcover is only around 50 percent then the other 2 cases these are the values from for different months, you can see the variations that the variation is not very drastic is only from 0.65 to 0.6 and then 0.55, so depends on the climate also. Similarly for the situation when the trees providing around 20 percent cover you have a different value, okay.

So all these crops is important that you must… There are many other crops which are covered here I have not I am not covering all the crops there every crop which is different from the usual crop for example if you take bananas there will be a different K c values, if you take rice crop, rice crop is a unique crop wherein that particular situation you are your water availability and the soil is much different than the normal crops, so the K c values will be entirely different, so you can refer to this particular reference or looking at the K c variations for various crops.

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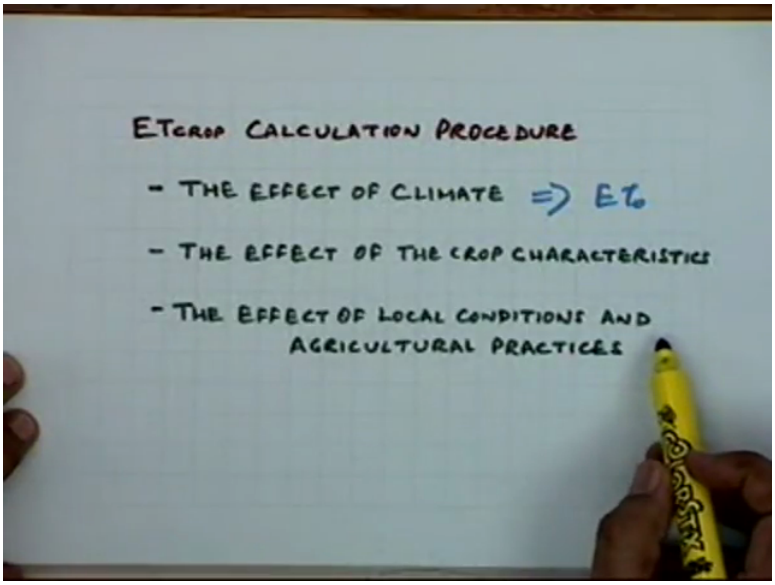

Let us now move onto the next aspect which is the effect of local conditions and agricultural practices on the ET crop, we have so far seen that what is the value what is the ET naught that was the effect of climate then we have also seen what is the effect of the crop characteristics and besides these 2 things there is a 3rd effect, there is a 3rd factor which will affect what will be the ET is actual ET crop at a particular location because so far we have assumed that there is no restriction on the amount of moisture availability, we have assumed we have made that assumption when we have, when we had evaluated ET naught we had not looked into the constrained that if the moisture is not available what will be the value of ET naught be had not done that, we had assume it was assumption, inbuilt assumption that there is no limitation on the moisture availability, so under that condition what will be the maximum, what will be the potential evapotranspiration that is what is the ET naught which we have computed so far.

Similarly when we go to the next 2nd aspect of to incorporate the effect of the crop characteristics still the assumption is the same, we are still assuming that all the conditions whether there is the condition of water availability or the condition of the practices, the agricultural practices or the fertility of the soil or even the nutrients available in the soil in the form of fertilisers all those things are they are the average or the optimum values, we have not constrained the conditions with respect to the local conditions which might be the prevailing conditions, so the prevailing conditions unless you incorporate those conditions and see that what will be the impact of those conditions on the K c values, these exercise is not complete because if your condition differ from the conditions which are assumed then your value which you are predicting is not the appropriate value for that location under those

conditions, okay. So for that now we will look at which are those conditions which should be looked at and what will be the impact on the ET crop at a particular location for a particular crop.

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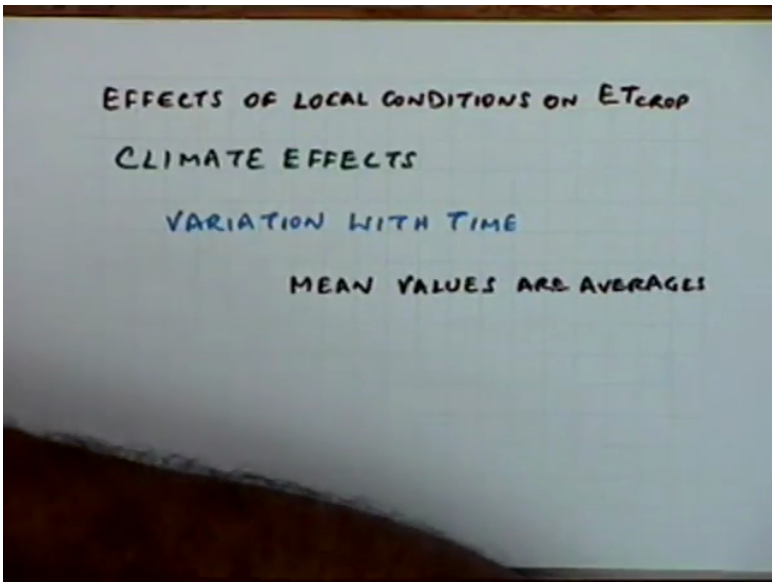

So to start with the 1st factor which will look at is the climate effects or the climate effect the local conditions and the 1st is the variation of the climate with time. So far we have only looked at these climatic factors in terms of averages we have not looked at their variation, whenever we have said that the climate effect effects all the factors which we have considered so far they are in averages, long-term averages maybe at the same location if you keep on observing the temperature you will find that.

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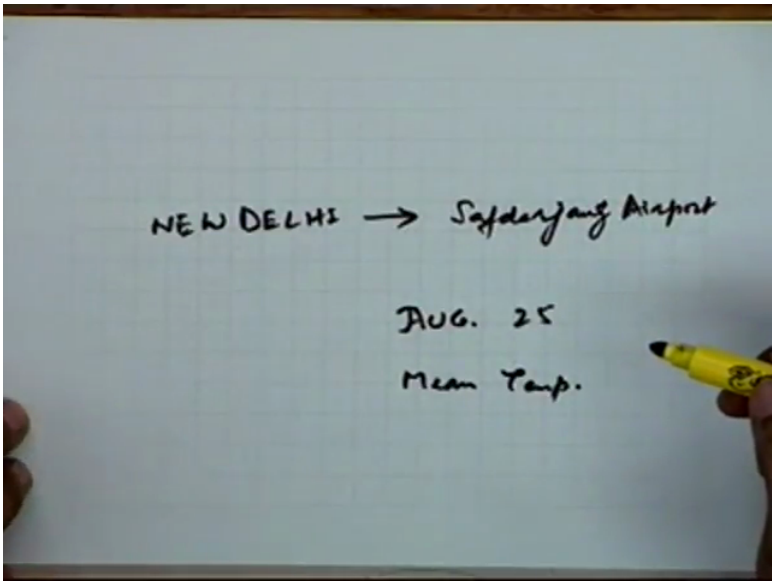

If you consider the temperature at a location let us say that our Delhi we have the observatory at Safdarjung Airport, are you aware of this? There is an observatory at Safdarjung airport, you must have passed this road many a times if you look on your left you will find that there is an observatory at that location, so that is the is listed under New Delhi there is another one at the Palam airport, so those are the 2 observatories which are available in Delhi. At this if you find out what is the value of temperature on 25th August the value will change every year, the 25th August maximum temperature or the mean temperature if you take this, the mean temperature value of that particular day will keep on changing from year to year, it will not remain same, so when you talk of an average condition you might take last 50 years 25th of August and you take a value which is an average value which is assigned to that particular day.

In actual practice it might vary a lot and when you looking at the ET crop, the ET crop which is prevailing on a particular day will be dependent on what is the value of that various factors which are influencing the ET crop on that particular day, the actual value even if you take the mean value it might not be very much different but that is what we have to look into how much different those values can be and what impact they can make on the evapotranspiration computations.

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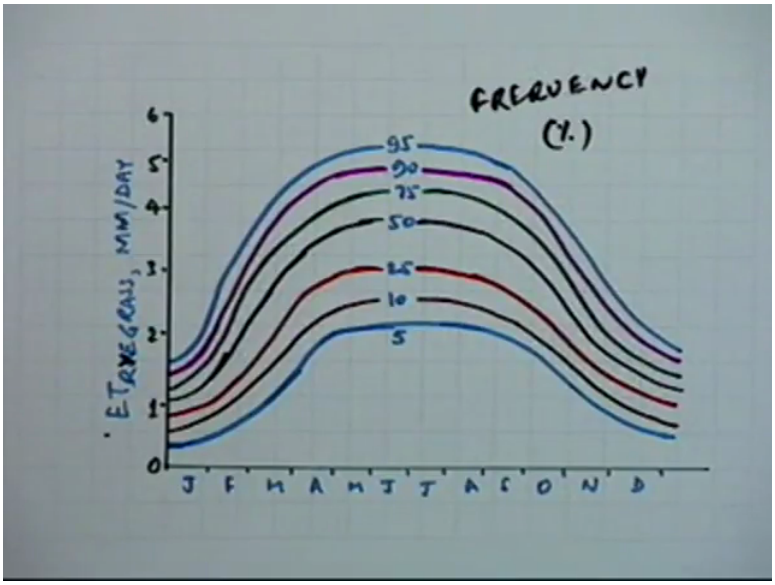

Now this is the exercise which was done for a computation of ET ryegrass at a particular location it was observed that these are the this is the, let us say first what is this plot? Now this is a plot of frequency distribution in percentage is what has been given, so on each particular day this is the daily data which has been plotted here from January to December. Now the each value the data was you have to have a very long series of data if you want to do the frequency analysis. If you assume it was the something was made that on a particular day the ET crop, the ET ryegrass data is normally distributed, so if you are making this assumption if you plot this on each particular day, the plot will be that there will be some value which will be having 95 percent frequency, 90 percent, 75 and 5 percent, so this is the scatter which has been obtained.

The ET crop value varies considerably one level in this particular case if you take the month of June it varies from almost 2 millimetres per day to around 5.5 millimetres per day, if you consider the frequency from 5 to 95 percent, the range will be still more if you go up to the next level. Now this variation is there in actual practice, if you take the actual data for example on even if you take the monthly data in the month of June these are the variations, if you take the data of last 15 - 20 years or maybe more, so this will not like this. Similarly if you go to the months which are having less amount of evapotranspiration still this scatter is there, it is not as much as you have here but in this case in the month of December it might be between this value and somewhere here some point so 2 point something, so that scatter shows that when you are going in for the design of a system which value you should use? It will make a lot of difference if you use the mean value which is 50 percent.

You will use in this in the normal design what you do, you want to take care of the peak consumptive use requirement or the peak crop use requirements, if you can cater to the peak requirements the other portions of the crop growth can be always cater to, so in this case if you are taking the peak consumptive use which is somewhere falling in the month of June or July and if you take only 50 percent frequency level you will get value of 3.5 millimetres per day, so if you base your design on the 3.5 millimetres per day requirement then it has a chance of success of only 50 percent at means every 2nd year you will find it may fail your requirements might not be met with because your requirements at the 50 percent level is 3.5 and if you go about that level your requirements are much higher.

So if you try to cater to the 100 percent requirement then it is quite a high value, it is around 6 or so 6 millimetres per day is the requirement from the ET crop point of view and to fulfil that requirement your requirement of water will also be quite high, so you will have to design a system which can which can be 100 percent safe you can say that every year whatsoever may come or whatsoever are the conditions you will be in a position to satisfy the ET crop requirement but at the same time the values are so high that your capacity constraints or the capacity requirements of the system will go very high.

So you have to you have to come out with some trade off, some compromise so that you can have the designs which are reasonable, which are not very huge which might be very costly of your…so from that angle if you if you try to look at that condition you might have to sacrifice some of your what you say the confidence with which you can see that you can meet the requirements. So that risk has to be taken you have to deliberately knowingly you have to say that you do not mind if you do not get the requirement fulfilled for 2 years out of 10 years that means around 80 percent of the time your requirement can be met with, so if that situation is there then you can refer to be 80 percent requirement and design the system accordingly. Whereas where these concepts will make lot of difference, these things will influence your designs because they influence your requirements, okay.

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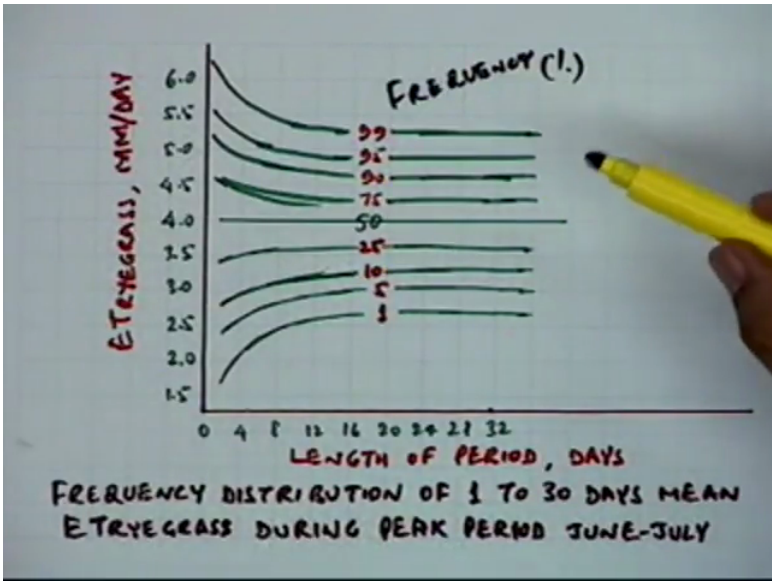

Similarly there is another way of here one more same data is used but is plotted in a different manner in this particular case what has been done is that on this side is the length of the period in days which has been used, so at this level you are using only one day data when you go to the next level, now this level you using 8 days data, 8 days mean data, so it depends the frequency scatter is again these are the frequency values in percentage, the scatter when you consider the daily data then these scatter is very high as you take more and more average data if you go towards this you are taking the monthly data somewhere here you might be considering the monthly mean monthly data the scatter is reduced in comparison to when you have considered the daily data but the other things again still remain whether you or how much risk you are prepared to take that you have to decide. Normally in our Indian conditions we again go by around 75 percent to 80 percent confidence or 75 to 80 percent of the average value you can say that is what we use in the design.

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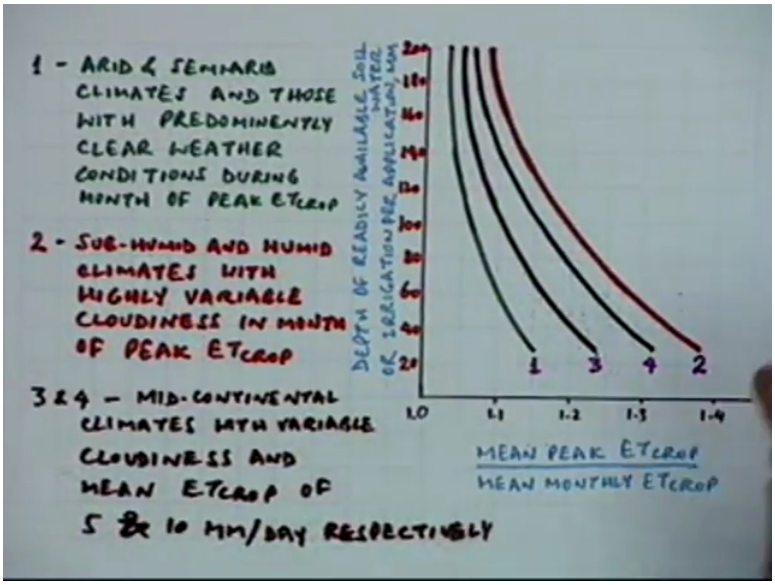

Again another way of looking at the effects of climate on the time or in time is another depiction of where a plot has been made between the mean ET crop and the mean monthly ET crop ratio versus the depth of readily available water or the irrigation per application. On the side these are the values in millimetres which show that what is the level of moisture availability, so this depiction shows that with the moisture availability and for different climatic conditions these are the conditions which I will explain how the peak ET crop varies with respect to the mean ET crop. For example the 1st one this particular variation is shown is for arid and semiarid climates which are predominantly clear weather conditions during the month of peak ET crop.

So in that situation you will find that the variation in general if more moisture is available you will find the impact is not much, if the readily available moisture is quite high the impact is not much because then in that case ratio the mean peak ET crop to the mean monthly ET crop ratio is close to one which means both the values are same, similar. So the higher you are on this side the mean peak ET crop value is much higher than the mean monthly ET crop value, okay. So in this situation you will find that in comparison to this climate when which is arid and semiarid climate and which has clear weather conditions. If you look at the last number 2 curve which is this one, this curve with red that is for sub-humid and humid climates with highly variable conditions variable cloudiness in month of peak ET crop.

So if these are the conditions you will find the, when the availability of the moisture becomes very low then the difference in the peak ET crop and the mean monthly value that will be very large, so you can apply that correction…these are basically the corrections which can be

applied over and about the K c factors, so these corrections are can be useful corrections to be applied on the K c factors which you are using for converting the ET naught into ET crop values. Is that clear? Similarly the other 2 curves are for mid-continental climates with variable cloudiness and mean ET crop of 5, number 3 is for 5 millimetres per day and number 4 curve is for 10 millimetres per day, okay. Main thing to understand that this stage is that is not with the with the availability of K c values that is not the end of the whole problem you will have to take into account the local conditions if you want to utilise your information which you are computing in the form of ET crop in a proper manner in a realistic manner.

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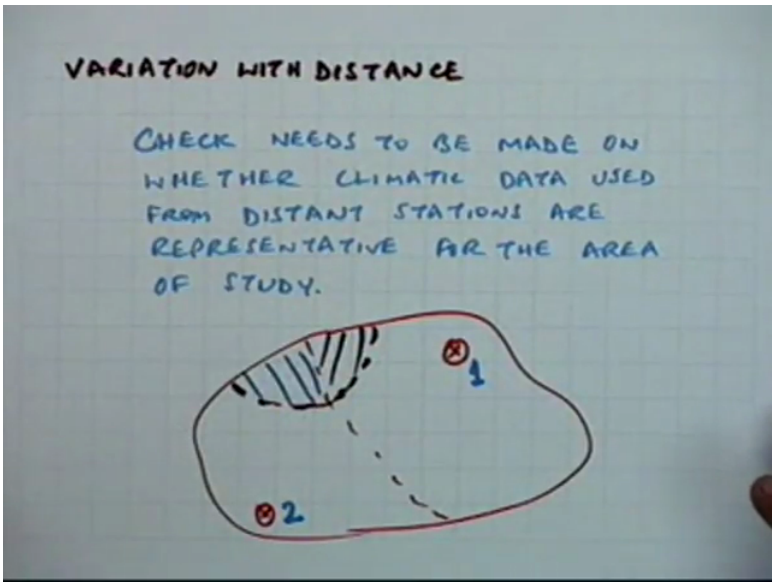

Then the next factors the variation with distance, the climate also varies with distance we have considered that suppose this is your area, now in this area you have 2 places where you are observing the climatic data each place is supposed to have its area of influence which station should be used or which station is the representative station for any area, if you are interested in this area, let us say that this is your area of interest, now this is the area where your irrigation project is and you have these 2 stations the climatic data is available at these 2 stations, they will always be the point station because you will have the density of these climatic stations which are being maintained by IMD they are very few in number if you look at the total country as a whole and most of the time you will find that there is only one station this is available.

Now the question comes that is that station representative of the conditions where you are applying that data, if it is not then it is bound to give you results which are different than what should have been obtained if had the data been available. Even in this situation if you are

using, if you are having these 2 stations it is better to look at what is the area of influence of this station and use this station for this area and use the other station, the station number 2 for this area, so these variations with distance can be incorporated, those can be avoided or they can be taken care of if you have, if you have the proper look at the what is the representativeness of those stations so it is an important factor before you transfer the data or you use the data from a very distant station.

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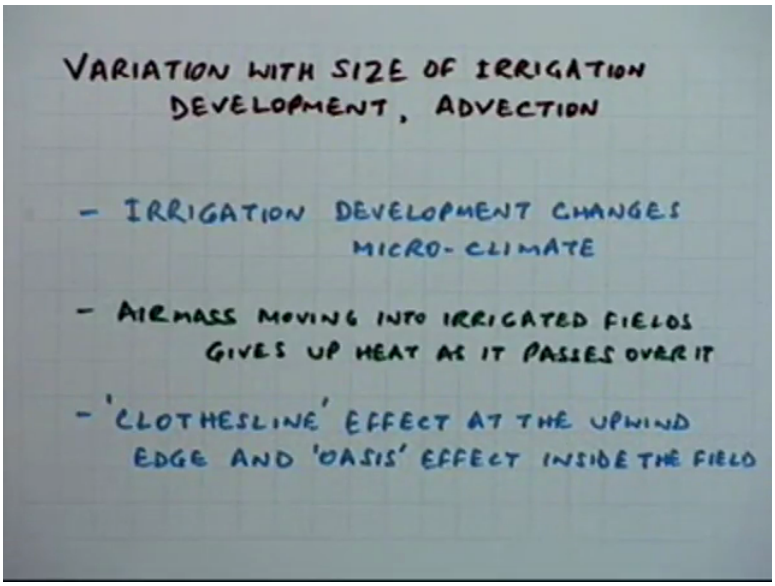

Then the variations with size of irrigation development, there is another factor which is very important. What happens in the actual situation where you want to go in for a new irrigation project and you want to find out what others are the irrigation requirements, so what is the obvious thing you will like to look at the data you will use the data which is made available from some observatory and that data you have used in arriving at what will be the what will be the irrigation requirements or what will be the ET crop to start with that is what will define the irrigation requirements. Now this ET crop you have found by making some actual observation some data is being observed in actual practice wherever you want to go in for a new irrigation project.

You might install some instruments there or if an observatory is already there then you have a long series of data otherwise you might install some of these points all those parameters which are needed you might start taking those parameters and collect some data for a reasonable length of period of time. What happens in this process? The climate which you are considering or let us not say climate but environment basically, the environment in which in which under which you have taken the data which you have under which you have observe

the data that environment might be entirely different than the environment under which you are going to implement that those results which you have obtained for example if you have found out that ET crop requirement for a specific crop.

When you change the conditions, when you start irrigating the area previous data was collected when there was no irrigation facilities available. You were only using natural rainfall as the available input of moisture, now with the irrigation becoming, irrigation water becoming available the micro climate has changed, the value of soil moisture is different now than it was before when we had collected the data, so those factors those changing the Micro climate will make some impact on the K c values which you are considering. If you are using the same old K c values they will not be any more relevant they want be any more appropriate. This is basically looked at in the form of the 2 effects which it causes what is one is called the 'clothesline effect' the others 'oasis' effect. What are these 2 effects? What happens is that when the air mass moves over the irrigation fields, what happens?

That air mass loses some latent heat of evaporation, it will reduce its temperature if it is passing over the irrigated fields that effect is called the clothesline effect because from the irrigation areas the evaporation activities is much more predominant than from the areas which are dry area, is not it? If it is an irrigated feel the evapotranspiration activity will be much higher, now when the evapotranspiration activity for that activity to the carry on the moisture which is being lost, that moisture…the losing process need some energy which is known as latent heat of evaporation. Now that if it is available in the air mass that will be extracted from the air mass, so if the irrigation is prevalent and you will find that the clothesline effect will be there whereas the same thing happens in the case of when you put the clothes for drying they will reduce the temperature of the air mass which is in then which is just passing over it that is why it is called clothesline effect but the same time the as far as the field is concerned it is having an oasis effect.

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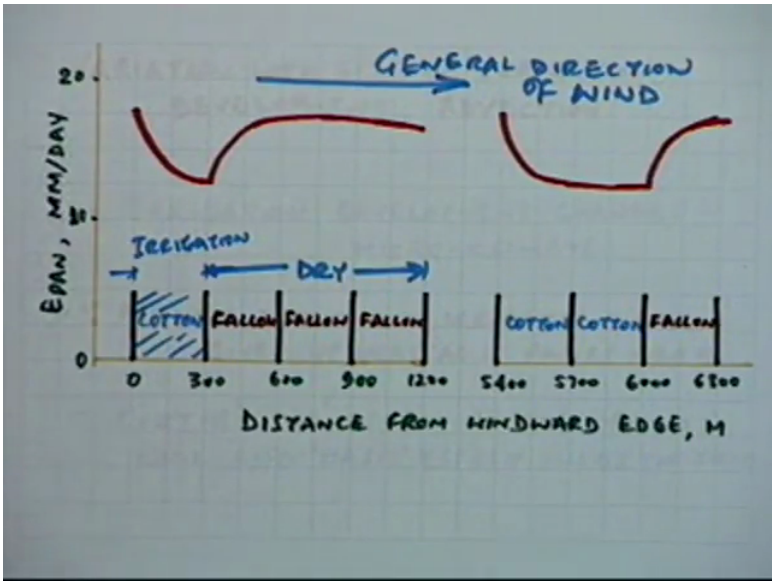

That is depicted very well here using a particular crop, cotton crop this is the data of experimental setup where a pan data was observed, the E pan data in millimetres per day has been observed under the conditions under different conditions were in one case in the 1st case you have the cotton and you have the irrigation over this field, in this field you have the irrigation, okay and this is the fallow area this is dry area, what happens to ET pan? The pan evaporation it changes drastically. This is the general direction of the wind, this is the wind direction, so as soon as the wind passes over cotton field which is irrigated field you will find that the because of the clothesline effect its E pan value will reduce and then immediately after the end of the field again the value increases to its previous value.

If you have the irrigation over a larger size field you will again find that the effect is there. Now this effect, the extent of this effect will be basically dependent on how you are utilising your areas and the total area which is under irrigation you might not be irrigating all the fields simultaneously, how much is the area which is which is under irrigation, how much is the fallow area because if you have the total area under irrigation then it will it will have the impact which will be a global impact and once it goes down because all the areas are irrigated areas then you will have the permanent effect of E pan or the evapotranspiration activity coming down, whereas if the area is different than the effect whether it is oasis effect or the clothesline effect will be a function of how much area is under irrigation, so that has to be looked at along with.

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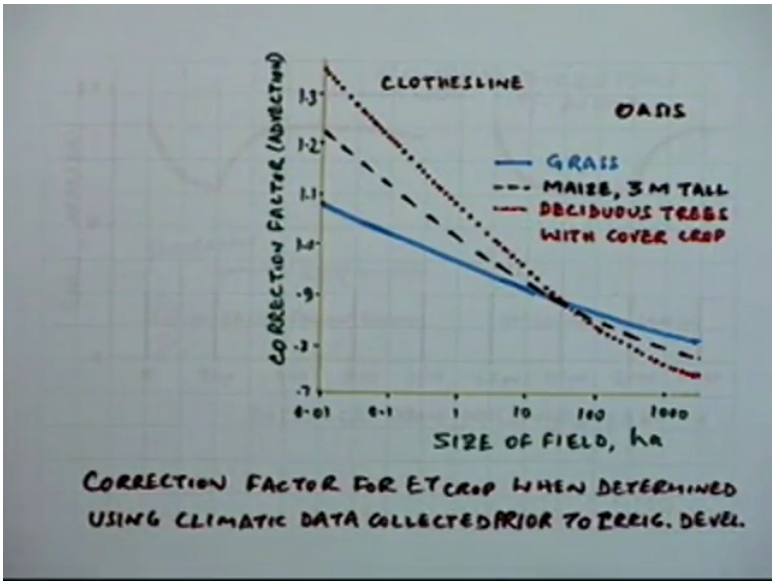

Now this is the depiction of that, the combined effect with respect to the size of the field, if the size of the field is very small you will have the clothesline effect and if the size of the field is very large then you have the oasis effects and accordingly and this also varies to extend with respect to which crop you are using because it is also dependent on what are the crop characteristics for example in this case this is for grass the blue line, for maize the black line is the one which presents the maize variation with respect to the size of the field and there is a correction factor to be applied and the correction factor in the case of grass is very small whereas in the case of maize it is quite large and in the case of deciduous trees is again is still more pronounced. Simultaneously if you look at the size of the field, if the size of the field is more than around 20 hectares you will have the effect, oasis effects if the size is less than this level then the factors the clothesline factor accordingly the correction factor can be used for arriving at a proper value of K c. Any question at this level? So will stop here today.