Soil and Water Conservation Engineering
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Lecture - 05
Water Erosion Control Measures

Hello friends. Welcome back to NPTEL online certification course entitled Soil and Water Conservation Engineering. I am Rajendra Singh professor in Agricultural and Food Engineering Department, IIT Kharagpur and we are in last week that is lecture 5 of week 1 and the topic is Water Erosion Control Measures. Just to give you a reminder of the course content of this week, we started in lecture 1 with introducing the soil and water conservation, erosion etcetera.

In lecture 2 we went through causes and types of soil erosion, in lecture 3 we saw factors affecting soil erosion and effects of soil erosion. And lecture 4 we went through soil erosion mechanics and in today lecture we will see some of the control measures that can be adopted to control water erosion.

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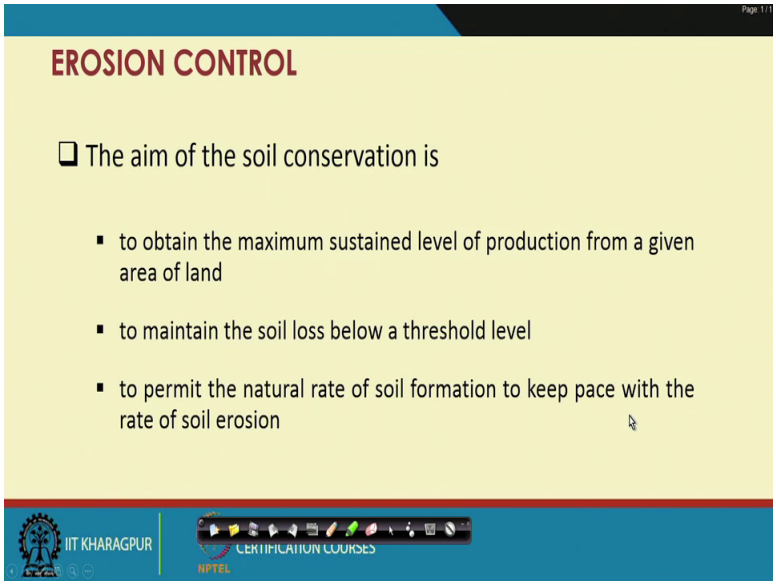

Now, erosion control is basically we want to control erosion or in other words we want to conserve soil. So, the aim of soil conservation is to obtain maximum sustained level of production from a given area of land. So, that is the that is the thing and for that you remember when we discuss about the when we discussed about the sheet erosion, we saw

that it is the top fertile soil that is primary carried away that is at that is transported during the erosion process. So, once with the fertilize soil is lost then obviously, the level of production will be affected and in order to get the maximum sustained level of production we must conserve our top fertile soil.

And of course, the second aim is to maintain the soil loss below a threshold level. And also third-one is to permit the natural rate of soil formation to keep pace with the rate of soil erosion. The ideal case is the case of geological erosion where the rate of soil formation and the rate of soil erosion, they are naturally balanced. In the case of accelerated erosion or manmade erosion, we know that the rate of soil erosion will always surpass the rate of soil formation because, rate for soil formation is a very slow process that we have already seen.

So, but it still we would like to keep the rate of soil erosion to be as close as possible to the rate of soil erosion and that is why we want to maintain the soil loss below a threshold level so, that so, that the soil formation page could be as close as possible to so, soil erosion bright.

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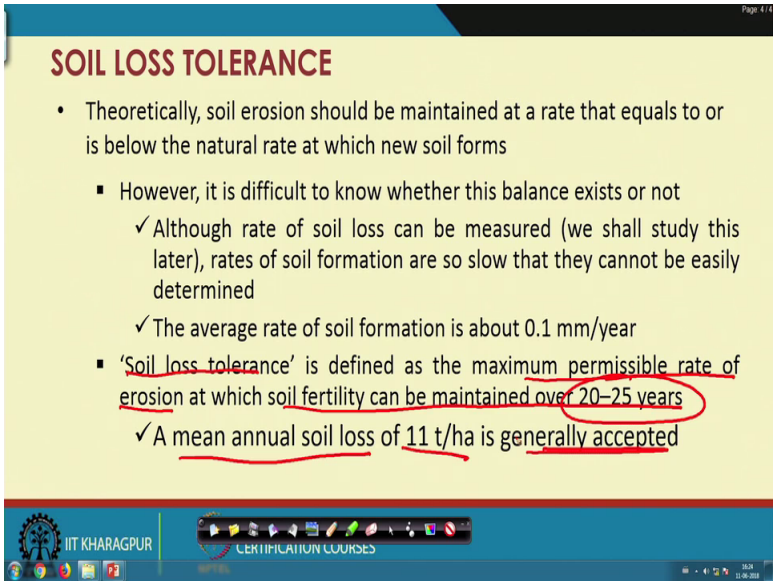

Now, coming to solve loss tolerance theoretically soil erosion should be maintained at a rate that equals to or is below the natural rate at which new soil forms, that is what basically happens. There is a balance between the soil formation and the soil erosion rate in the geological erosion and that is why that that we say that is a very slow process, we

cannot really notice that with our naked eyes. On the other hand when the soil erosion rate is much higher as compared to soil formation rate, then it is quite naturally noticeable and that is where we call it accelerated erosion or manmade erosion.

Now, it is difficult to know whether this balance exist or not means very difficult. Basic reason behind this is that though it is possible the rate of soil erosion the rate of though [FL] hello.

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However, it is difficult to know whether this balance exist or not and the reason is very simple that though, the rate of soil loss can be measured and wills we will spent 1 lecture entire lecture on in the coming week on how to measure soil erosion soil soil erosion of soil loss in the field conditions that will see. So, but let us assume that soil loss rate can

be measured at the moment with our knowledge, whatever knowledge we have that is that is possible. But, the rate of soil formation is so slow the natural rate of formation is so slow that it cannot be easily determined.

So, because one of them because we want to make a keep a balance between rate of soil loss some rate of soil formation and because, it is not possible determine one of them so, it is very difficult for us to know whether there is a balance between the soil formation rate and soil loss rate or not. And the average rate of soil formation as you can see the number it is 0.1 mm per year.

So, from this itself you can visualize that it is very very difficult really to be able to measure or know the rate at which soil is getting formed. Now, soil loss tolerance that is why we finally, defined a soil terms calls soil loss tolerance and then soil loss tolerance basically defined as the maximum permissible rate of erosion at which soil fertility can be maintain over 20 to 25 years. So, basically we want to keep the soil loss within a permissible limit which we are calling as soil loss tolerance so, that the soil fertility is maintained.

And for that we are what we are saying is that the soil fertility should be maintained over a period of 20 to 25 years. And based on the studies a mean involves soil loss of 11 tones per hectare is generally accepted as per as soil loss tolerance is concerned. That means, that simply means that if you are able to maintain annual soil loss below 11 tons per hectare for a given area, then it will be problem possible to maintain the soil fertility for few coming years may be 20-25 years or coming year; that is what we are interested in.

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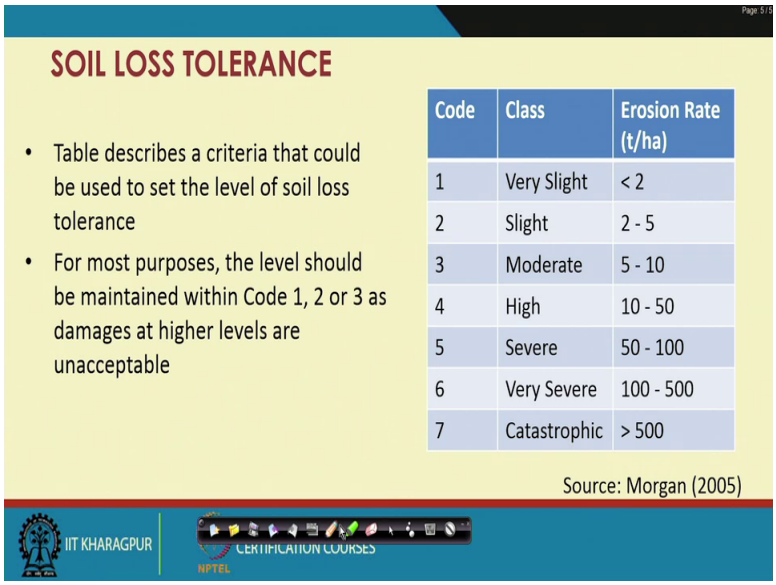

Now, this table basically describes a criteria that could be used to set the level of soil loss tolerance and this has been given taken from Morgan 2005. According, to this table the soil loss is divided into 7 different classes and 7 course are given 1 to 7; 1 is when the class referred to as very slight where the erosion rate is less than 2 2 tons per hectare to 7, when it is referred is catastrophic where the erosion rate is greater than 500 tons per hectare. And as we can see that for most purposes the level should be maintained within code 1, 2, 3; that means, this is the acceptable course. That means, the class should be between very slight to moderate and that simply means the erosion rate should be less than 10 tones per hectare.

And this probably will give an idea why the soil tolerance rate in the previous slides we saw that was taken as 11 tons per hectare because, then that simply means that we will be able to keep our soil loss within moderate levels. And that means, that will help us in maintaining keeping the soil productivity maintained for a long period of time.

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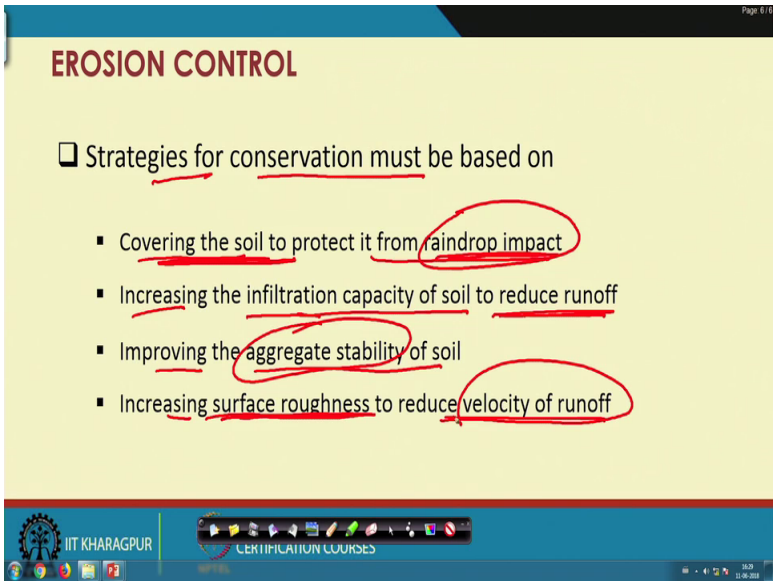

Now, coming to erosion control the strategies with could be adopted for conserving soil should be based on certain factors. And these are 4 major factors, the first one is covering the soil to protect it from raindrop impact. Second is increasing the infiltration and capacity of soil to reduce runoff. Third is improving the aggregate stability of soil and fourth is increasing surface roughness to reduce velocity of runoff.

In our previous class when we discussed about the water erosion mechanics, we saw that there are 3 processes involved detachment, transportation and deposition. Now, detachment about detachment when we discussed we saw that it is the raindrop impact effect or it is the flowing water that is responsible for detachment process. On the other when hand with come should transportation it is the runoff or the overland flow. That simply means if you want to check erosion, we have to keep a check on detachment and erosion processes transportation processes.

And that simply means that two agents which are responsible for these two processes that is raindrop impact and flowing water that has to be checked. And that is that is basically the concept behind the strategies which are adopted for erosion controller. If you look here covering the soil to protect it from raindrop impact. So, if we cover the soil obviously, we know we have seen the rain drop impact erosion that when the raindrop hits with its kinetic energy to the base soil surface that breaks down the soil aggregates and that causes detachment of soil particles.

So, if the soil is covered by some kind of plantation or some kind of grass then; obviously, that cover will absorb the kinetic energy of raindrop impact. That means, aggregate disaggregation of the soil mass will not be there that mean detachment will be limited. Similarly, if we call if the soil cover is there then; obviously, water will be whole for a longer period time on the soil surface and that will allow more of infiltration to take place. And that simply means as a result the total runoff that could be generated that will be reduced..

Then the third is improving the aggregate stability of soil and for that we have to add some kind of organic matter into our soil. And for that what are the steps, the what is done will see little later when we talk about the conservation measures. And, lastly if we increase the surface roughness that is by covering the soil then; obviously, the velocity of runoff will be conserved. That means, the kinetic energy of the flowing water will be less that means, the erosive capacity will be less and that means, erosion could be controlled. So, these are the sum of the strategies which are adopted for controlling erosion.

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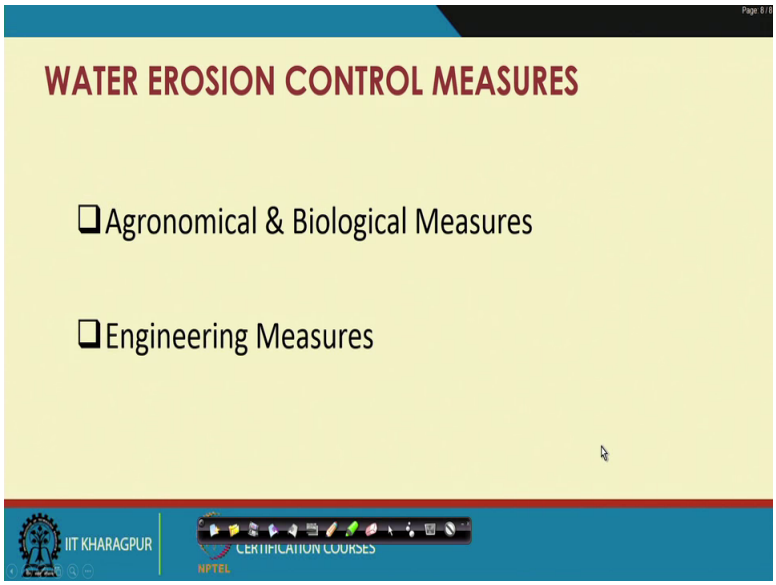

Now, coming to erosion control measures water erosion control measures; they are broadly classified into two groups: agronomical and biological measures and engineering measures.

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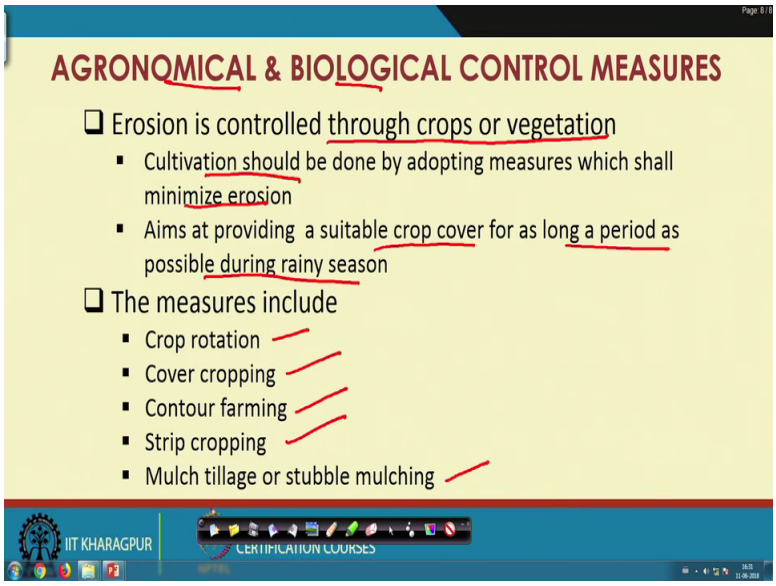

And we will discuss first about the agronomical and biological control measures and obviously, is the name itself suggest erosion is controlled through crop or vegetation. So, agronomical and biological the name itself suggests that is the crops or vegetation that are basically use for controlling erosion. And basically in that means that we need to do our cultivation in such a way which shall minimize erosion. And obviously, it aims at providing a suitable crop cover for as long period as possible during rainy season. That whenever, rain rainy is taking place if our soil surfaces is covered so; obviously, is our several lectures we have seen now, that that simply means that will observe the kinetic energy of the falling rain drops or it will offer resistance to the flowing water.

And the result the erosive capacity of either the raindrop or the flowing water will be less and that means, the detachment in transportation processes will be under control. And the measures typically which are adopted under agronomical and biological control measures are crop rotation, crop covering, contour farming, strip cropping and mulch tillage or stubble mulching. That these are the 5 different types of measures which are normally adopted under agronomical and biological control measures.

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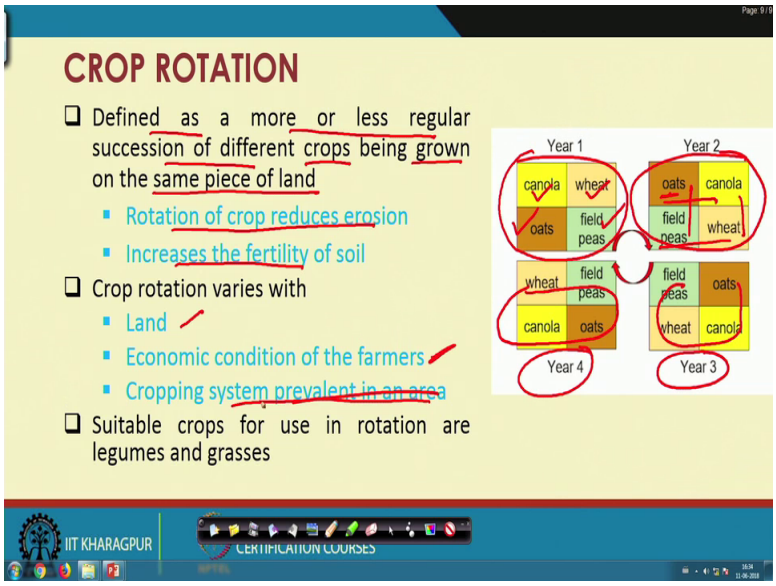

Now, let us start with crop rotation. So, crop rotation is defined as a more or less regular succession of different crops being grown on the same piece of land. And this is done because; rotation of crop reduces erosion and increases the fertility of soil. So, that simply means that as you can see here example there is a plot having 4 different fields. So, here one the crops chosen are canola, wheat, field peas and oats and when we go in to year 2, the same crops are being grown, but there are other fields are change. So, oats has come from this plot to this plot, field peas has come from here to here, canola has gone from here to here and wheat has so; that means, there is a circular rotation.

Similarly, if we go into year 3 then again the it is circularly rotated. So, oats comes here canola, wheat, field peas and year 4 again wheat comes here, wheat, field peas, oats, and canola. So, this is how the crops are rotated. So, that is crop rotation that is regular succession of different crops being grown on the same piece of land. And basically, this helps in two possible ways, one is that the different crops have different root root growth pattern and because the root growth pattern is different so, each plant or each crop has a tendency root take nutrients from a particular zone of the soil.

So, if you keep on changing the crop that simply mean the entire the root root zone of the soil it can be utilized and nutrients are extracted from different places. If we grows same crop year after year that simply means that the same portion of the root zone is being utilized by crops. And that means, the remainder of the portion whatever nutrients are

there they remain unutilized, where in the where it is being used that is you being used excessively and that means, there no nutrient left. So, that one advantage of of crop rotation.

And of course, it varies with land because all crops cannot be in everywhere. Economic condition of farmers because, if you have to change crop then obviously, you should have some cash in hand and cropping system prevalent in area this is very important point because, if our talk about say Bengal where IIT Kharagpur is located then farmers here have a tendency to grow paddy during the Kharif season, followed by paddy giving the Rabi seasons.

So, paddy and paddy is followed whereas, you can see that it is against the principles of crop rotation. If you go to North-India mostly you will find that paddy or rice is grown during the Kharif season, followed by wheat in the winter season or Rabi season. And then some kind of legume crops are taken in the (Refer Time: 18:23) or summer season.

So that means, there is a natural rotation being followed by farmers in Northern India and suitable crops are used in rotation are legumes and grasses. Basically, because these are nitrogen fixing crops; legumes especially are nitrogen fixing crops that means, they add nutrients or organic matter to the soil. So, this them they strengthen the soil from nutrient point of view and that means, the productivity or production will be it can be expected to be much higher from such soils which are healthy in nature.

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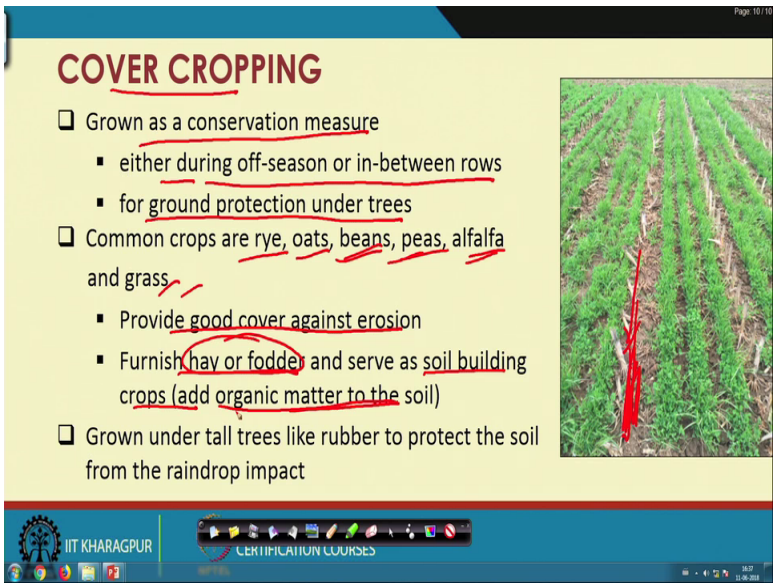

Then next measure is cover cropping at in the cover cropping it is grown as a conservation measure, either cover crops are cover crops are grown either during off-season or in-between rows and for ground protection under trees. So, in your previous class when we were talking about the ill effects of erosion or erosion then we saw in between rows if faulty agricultural pads in between rows.

If we allow bears soil then obviously, when raindrops hits there will be detachment and because, there will be flow velocity here without any kind of resistance so, the erosion will be much much higher. So, when we say cover cropping then in between rows certain crops are grown and that simply means that the soil area or the land between the rows crop rows is protected.

Then common crops are which are used for its cover crop are rye, oats, beans, peas, alfalfa and grass because of two reasons, one is there provide good cover against erosion. So, because they spread on the surface those say they provide the cover the soil surface the that is the purpose that is cover cropping and they furnish hay or fodder and serve as a soil building crops. So, if you grow alfalfa and grass so obviously, not only covering, but your also getting some hay or fodderanimals in the area. And if you go for beans, peas or leguminous crops then obviously, as already I mentioned that they are nitrogen fixing crop so, they add organic matter to the soil.

And of course, this cover crops are also grown under tall trees like rubber to protect the soil from the raindrop impacts. So obviously, if the if the surface below tall tree is if you can imagine in that from a tall tree if whatever water is intercepted it that falls the kinetic energy will be much much higher. So, if the soil surface is protected with some kind of covered then soil erosion will be minimized in that case. So, that is the second type of agronomical major that is cover cropping.

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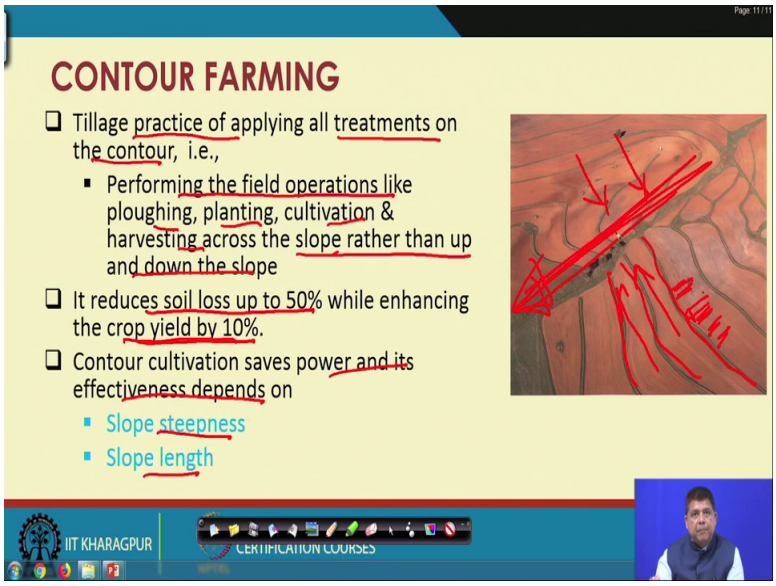

The third agronomical measure which is adopted is contour farming and in the contour farming it is defined as tillage practice of applying all treatments on contour. And I think you know contour what contours are, that is the points having same allegation they are referred to as contours. So, we identify that and we perform all the field operations like ploughing, planting, cultivation, harvesting across the slope rather than up and down the slope. So, if the slope is in this direction say for example of course, is very difficult to say from this person say for example, in this direction.

So, our all our agricultural operations we do across this slope, not along the slope. So obviously, in that case what is the what happens is that the flow path is broken and also the velocity of flow will be checked to a larger extent. And it is generally reported that contour farming reduces soil loss up to 50 percent, while enhancing the crop yield by 10 percent.

Because, we are allowed we do not allow water to flow away here so obviously, more soil more water is conserved in the soil; that means, more water is available crop production and that is why crop yield also is enhanced. Then contour cultivation saves power and its effectiveness depends on slope steepness and slope length. It has, if saves power because if you do cultivation practices along the slope then obviously, you can imagine that while traversing up the slope the energy consumed by farm implements we much much higher.

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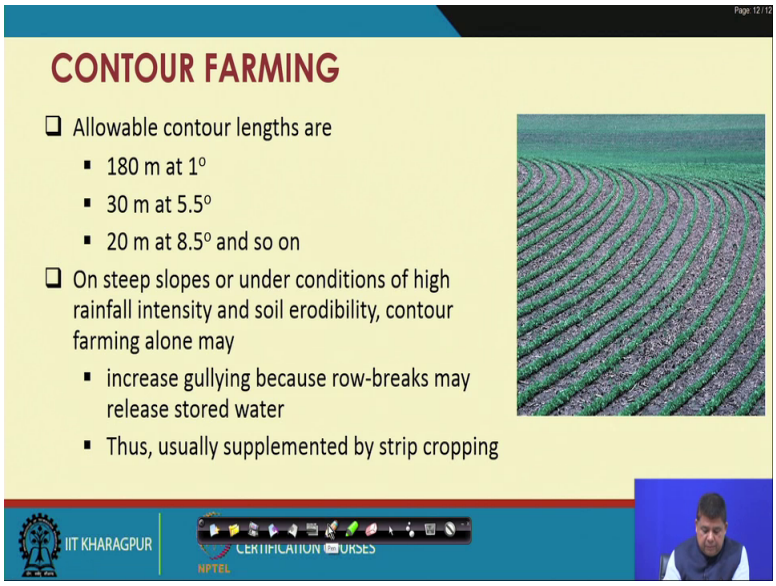

So, the allowable contour length because there are two things, one is length as well as slope. The allowable contour length are 180 meters at 1 degree, 30 meters at 5.5 degree and 20 meters at 8.5 degree and so on. So, larger the slope smaller will be this slope length which is quite obvious. And then there are certain specific cases like for example, on steep slopes or under conditions of high rainfall intensity and soil erodibility contour forming alone may increase gulling because, row breaks may release store water.

So obviously, there is always a danger because there is a slope and one of the, if any one of the each row they break that is simply means whatever, it store water is there that will have tendency; that will flow with a much higher velocity and much greater impact. And that means, it might result in row breakage and may cause gulling that is gully generation it might start. So, usually under such circumstances suggest specific circumstances they are supplemented by strip cropping which we will be seeing next.

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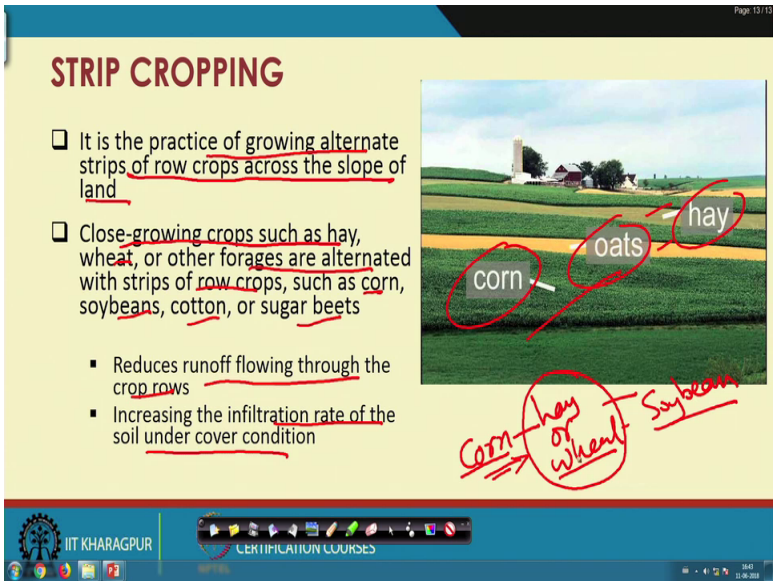

So, strip cropping is basically a practice of growing alternate strips of row crops across the slope of the land. So, that is why strip because, alternate strips of row crops are grown across the land. So, as you can see here for example, they are strips this was one strip, this is other strip, this is get another strip.

So corn, oats, and hay so, they are grown alternatively. And generally close growing crops such as hay, wheat or other forages are alternated with strips of row crops such as corn, soybean, cotton, sugar beets; which simply means that if you grow corn first then next close growing crops say for example, if season permits then hay or wheat could be grown depending upon the seasons.

And then again you could have another row crop that in means say for example, soybean. So that means, you have a row crop followed by a close growing crop and then again a row crop and what happens is it reduces runoff flowing through the crops rows. So, if this is a row crop so, whatever water is generated this close good in crops will erase that water that means, the flow velocity will be reduced.

And then it also increases the infiltration rate of the soil undercover conditions because, soil water is get arrested here. So obviously, this will had tendency to check the check or rather because water is store there so; obviously, the more water could in filtered into the soil because of these regions.

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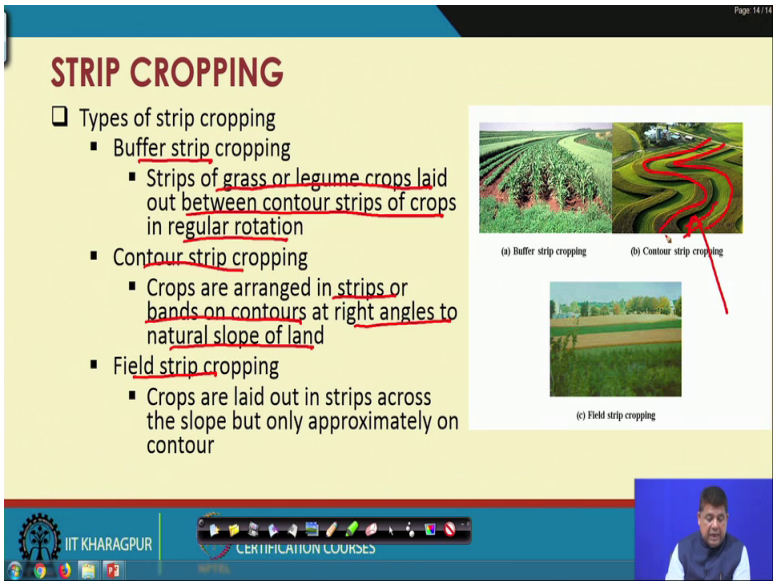

Then strip cropping could be of 3 different types: buffer strip cropping, contour strip cropping and field strip cropping. There are 3 types of strip cropping are possible. Let us see one of one after the other, buffer strip cropping means the strips are grass or legume crops laid out between contour strips of crops in regular rotation. So, whenever we have the regular crops grown in between that them the grass or legume crops are laid out, that is basically they are grown contour. The next is contour strip cropping where crops are arranged the strips or bands on contours at right angles to natural slope of land.

So, basically here as you can see the contour lines are being followed for cultivation. So, there are row crops and in between these row crops some alternate crop will be grown. So, grass or legume could be grown and third-one is the field strip cropping where the crops are laid out in strips across the slope, but only approximately on the contour. So, here the idea is same I mean idea is on 3 cases same that you first you have row crops and in between that you grow the strips of grass or legume crops in between.

And the only thing is that in this case it is the contour lines which are followed in (Refer Time: 28:12). Here contour lines are followed as close as possible where in this case contour lines are not so, strictly followed. So, buffer strip cropping, contour strip cropping or field strip cropping. So, here the buffer the grass or legume use as buffer crop wherein, the these cases the crops itself are being used for alternating.

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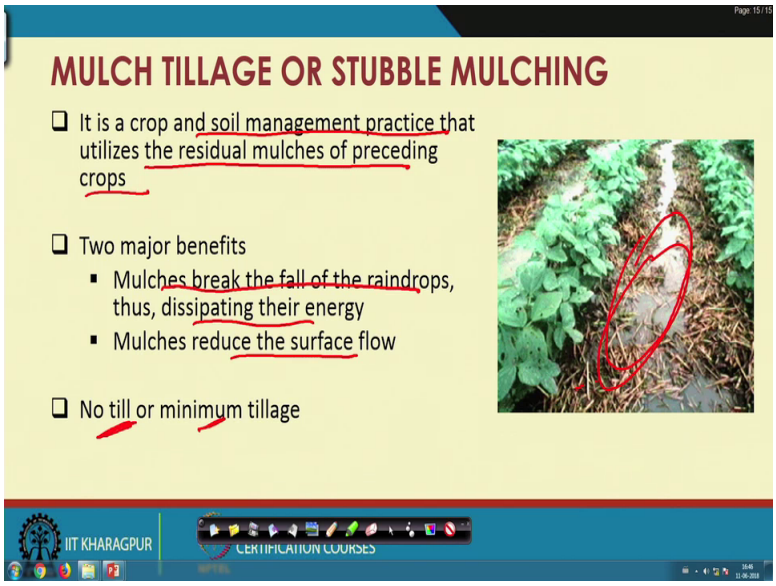

Then the last measure is mulch tillage or stubble mulching and obviously, it is a crop in soil management practices that utilizes the residual mulches of preceding crops. So, as you can see that if you when you harvest a crop then the stubble is left in the in the field itself and that is stubble is used as mulch. That means, in between the rows that that stubble is used to cover the soil and two major benefits these mulch as break the fall of the raindrops and thus, dissipating kinetic energy and reduce the surface flow.

And very similar to what cover cropping, but what we are doing instead of growing another crop we are using the stubble of the previous crop. And that this means that they will be of no tillage or very minimum tillage that will be required for this cover cropping kind of things. So, in case of mulch tillage so, that is that is the advantage, but very similar to the cover cropping these mulch; mulch a stubble use is used as mulch very similar to the concept of cover cropping.

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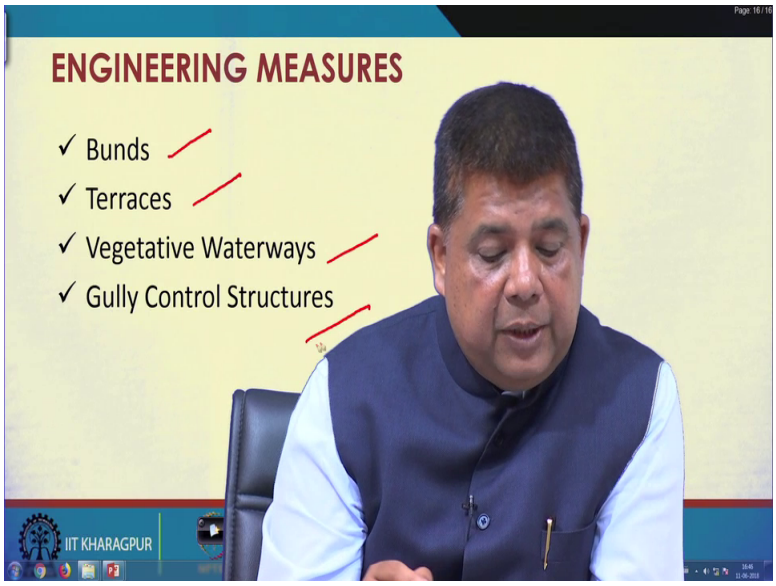

Then we come to engineering measures and there are 4 types of engineering measures which are normally are adopted bunds, terraces, vegetative waterways and gully control structures. And in on each one of them will be spending at least a minimum of 1 week. So, that is why I am not going to give you much detail today, but just to just a brief introduction about these topics.

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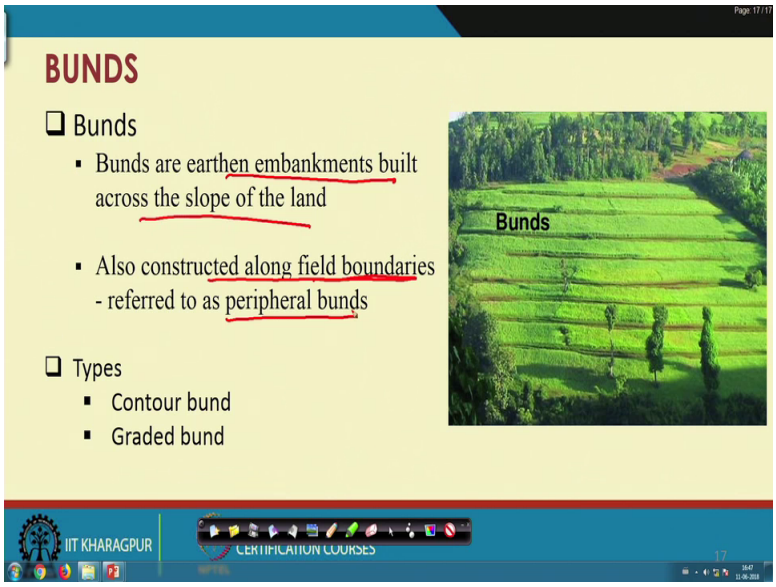

So, bunds are earthen embankments built across the slope of the land so, across this slops that is very important. And of course, bunds could be of different types and typically

there also along all field boundaries you will find bonds where, they are referred to as peripheral bunds. And two types of bonds which are commonly used for soil erosion purposes or water erosion purposes they are referred to as contour bund and graded bund. And week number 3 we will be spending entire week on the bunds, on discussing water bunds, how to design them and things like that.

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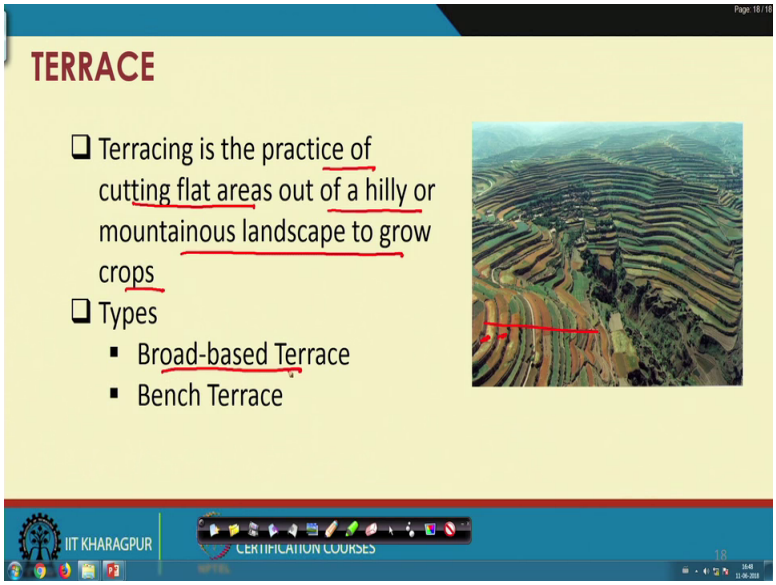

Then next engineering measure is terracing or terrace which is the practice of cutting flat area the out a hilly or mountainous landscape to grow crops. So, wherever you go to any of the hilly terraces you will find because there is a hill there is a steep slopes so, cultivation cannot take place. So, in order to facilitate cultivation the flat areas are cut and so, that some kind of steps kind of structures are there and so, the cultivation could take place.

And the types two types of terraces which are commonly adopted are broad base terraces and bench terraces. So, again week number 4 will be spent on terracing and designed of terraces.

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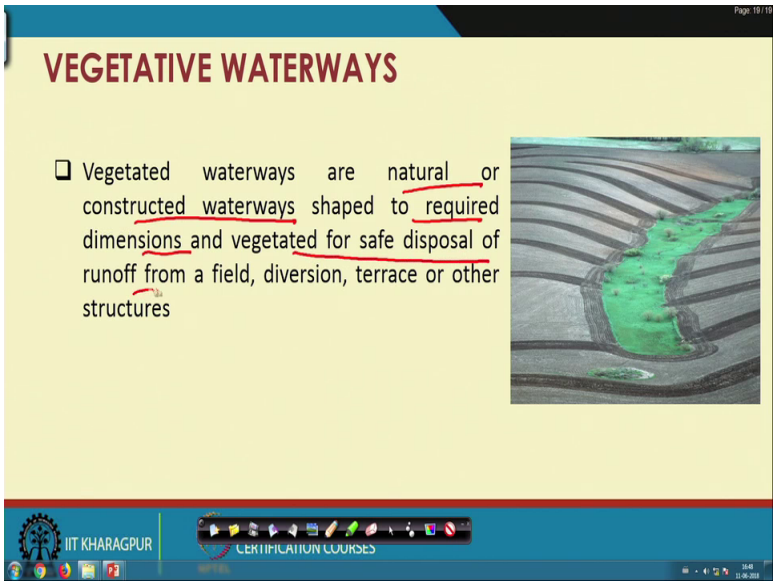

Next measure is vegetative waterways which are natural or constructed waterways shaped to required dimensions and vegetated for safe disposal of runoff from a field, diversion, terrace or other structure. So, they are nothing, but natural or constructed waterways or channels where some kind of vegetation is allowed to grow so, that the water could be taken away at a safe velocity or without causing any kind of erosion. And week number 5, will be spent on vegetative waterways and then we will see the details of how water there and how to design them.

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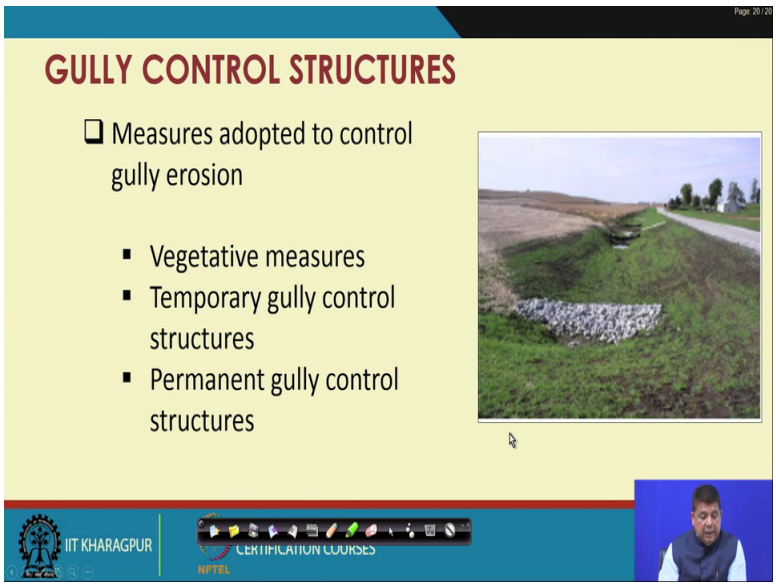

And they last engineering measure is gully control structures and gully control structures are adopted to control gully erosion. We have seen gully erosion already over this is most severe type of erosion. And the measures which could be adopted are vegetative measures, temporary gully control structures and permanent gully control structures. And again we will spend several weeks on seeing what are the gully control structures and how to design them in greater detail, if you remember that is what we have seen.

So, this was all about the water erosion control matter in brief. We spend more time on agricultural and biological measures, a little less on engineering measures because in coming weeks we will be spending a lot of time on engineering measures.

Thank you very much.