Soil Science and Technology
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Lecture – 44
Wind Erosion and Tillage Erosion

Welcome friends to this fourth lecture of week 9 of Soil Science and Technology. And in this lecture, we will be trying wrap up this conservation tillage topic and then we will be starting up the Wind Erosion and as well as Tillage related erosion.

And in the last lecture, we talked about different aspects of conservation tillage and what are the six different process, six different types of conservation tillage, we talked about no till, we talked about zero till, we talked about vertical tillage, we talked about ridge tillage practices and then so on so forth.

And then, we talked about, we know, zero tillage and how we are maintaining the crop residues using the zero tillage and how this air pollution, we know, also, we have discussed about this vertical or turbo tillage system and what are their advantages what are their drawbacks. And then, we talked about this happy seeder and how the happy seeder is helping us to control the air pollution which is basically created due to the burning of crop residues.

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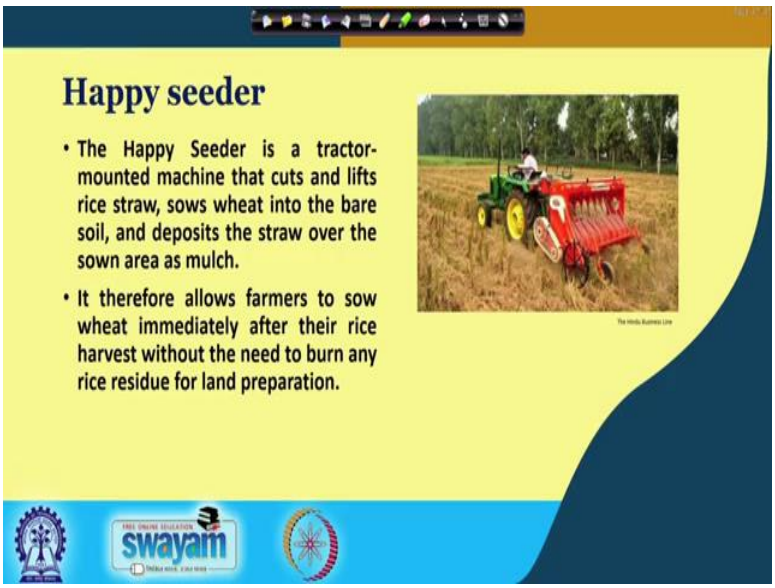

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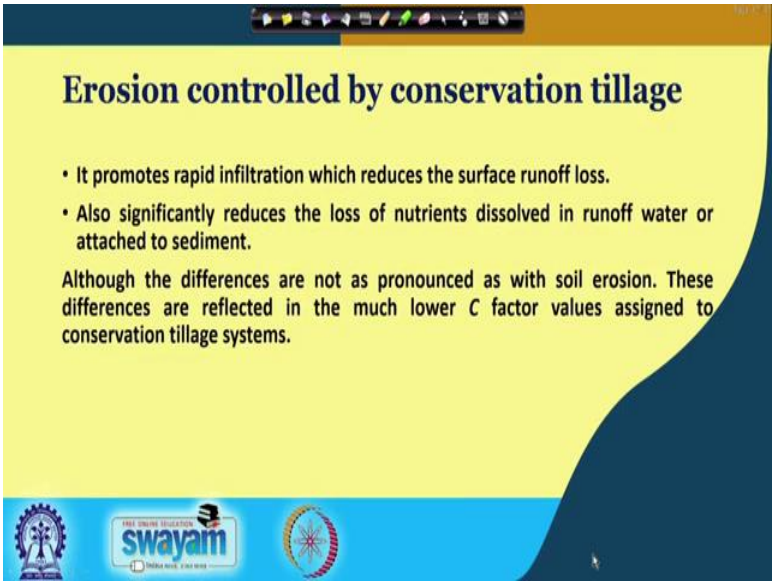

So, in this lecture we will be talking about, we will be talking about different erosion different aspects of conservation tillage and we will be talking about different soil properties which are, you know, being affected because of some conservation tillage. So, let us start with the erosion control by conservation tillage.

So, remember that, in case of conservation tillage, it promotes rapid infiltration which reduces the surface runoff losses because since one of the major criteria or major assumption or major criteria for conservation tillage is to maintain at least 30 percent of the cover crop cover over, the, you know, over the soil surface and minimum disturbances of the soil.

So, that helps in, you know, aggregation in the soil, you know, less decay of organic matter, less decomposition of organic matter and as a result of more binding of soil particles. And when there is a mould binding of the soil particles, more aggregate formation that will facilitates the water infiltration and when there will be more water infiltration; obviously, there will be less chance of water runoff. Not only that, due to the binding action of these roots of the plant as well as the binding action of organic matter, these soil particles are having less chance to carried away from, you know, erode away from one place to another place along with the flowing water or runoff.

So, that is why obviously, these when we are maintaining these conservation tillage, we are actually, you know, encouraging the, you know, encouraging the more aggregate

formation or beneficial aggregate formation in the soil and it promotes the rapid infiltration which reduces the surface runoff losses. And also, it significantly reduces the loss of nutrient dissolve in runoff water or attached to sediments and that also maintains the inherent fertility of the soil. So, although the difference are not as pronounced as with soil erosion, these differences are reflected in the much lower C factor. If you remember that C factor, which you consider in the calculation of universal soil loss equation. So, these differences are reflected in much lower C factor values assigned to conservation tillage systems.

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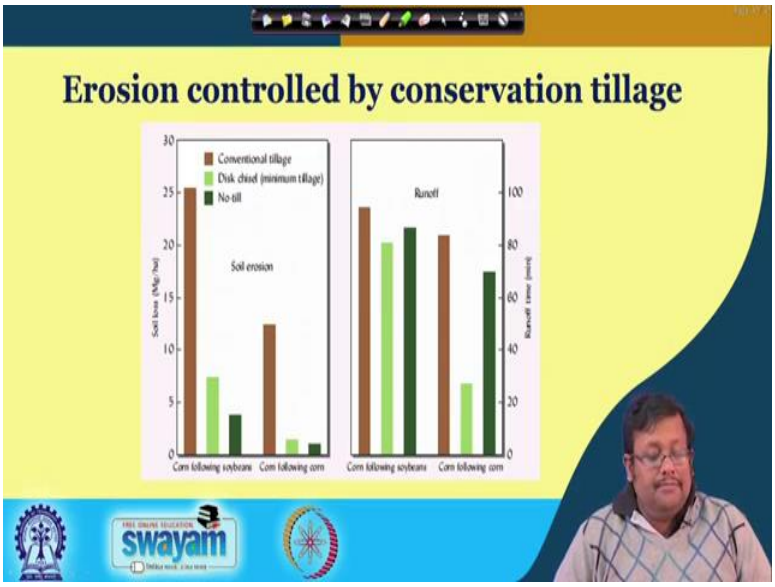

So, erosion control, let us see the trends if erosion control by conservation tillage. You can see here in the conserve, you know you know, there is a corn followed following the soybeans and here you can see corn following the corn and obviously, in the conservational tillage, soil loss is high in both the systems and followed by disk chisel with minimum tillage and in the lowest soil loss, you can get in case of this no tillage system.

And obviously, in both the systems, the runoff is highest in case of obviously, conventional tillage followed by no till system and then disk chisel system and the similar trend you have found in case of corn following corn system also.

So, basically that shows that the importance of conservation tillage for controlling the soil loss and also reduction of the runoff. So, again, we know, it is always recommended

to use the no till or disk till which will disk chisel with minimum tillage to maintain the soil health.

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So, what are the effects on soil properties? This is very important aspects. So, you know, these conservation tillage has different effects on soil properties which has got physical, you know, it has got impact on physical properties of the soil, it has got impact on chemical properties of the soil and it has got impact on biological properties of the soil.

So, as per as the physical properties of the soil loss are concerned, it increases the, you know, bulk density, it increases the infiltration, it increases the water holding capacity, it increases organic matter into the soil, it we know and also the residue cover soil are generally cooler because sometime it is detrimental for. However, sometime it is detrimental for the seed germination this cooler temperature.

And as far as the chemical properties are concerned obviously, it increases the nutrient mineralization, it increases the cation exchange capacity, but also may increase the denitrification sometime because of the, we know, less inversion or less air movement sometime and it also decreases the decomposition rate. So, maintaining the organic matter in the soil, sequestering more carbon in the soil or enhancing the carbon sequestration. And also as mixing of soil does not takes place, so, there is a chance of developing acidifying agent due to decomposition.

So, in that case, we need lime application as you know that we are applying we or we generally need to apply lime in case of acidic condition. And third one is biological properties. Obviously, the abundance activity and dive, you know, and the diversity of soil organism tend to be greatest in term in case of conventional tillage as compared to the, you know; obviously, these are high in case of conservation tillage as compared to come conventional tillage.

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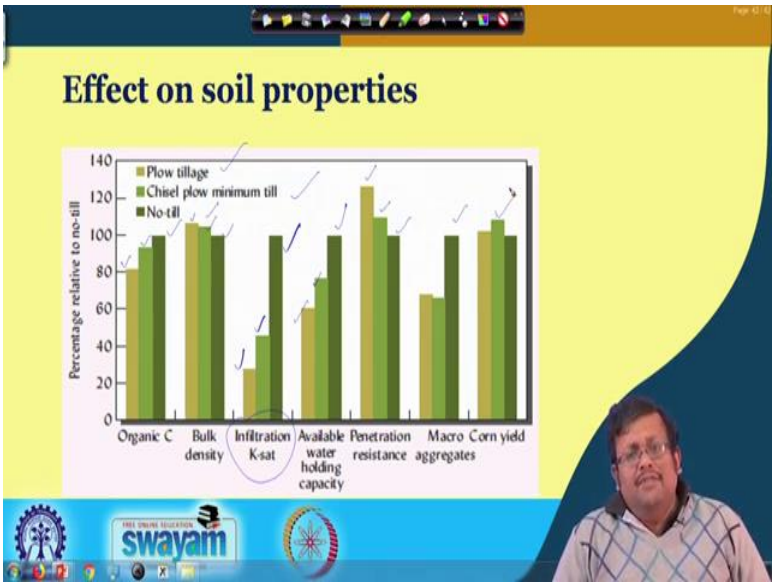

So, effect on soil properties; obviously, we can see here different effects on soil property. Let us see here three different types of tillage system; one is Plow tillage, another is Chisel plow or minimum till and then no till. So, you can see organic carbon; obviously, it is lowest in case of Plow tillage, followed by Chisel plow, no till. And in the no till system or Chisel plow, minimum till and no till system. Bulk density bulk density is always highest in case of Plow tillage followed by chisel Plow and followed by no till system. So, when there is a high bulk density; obviously, there will be compactness and as a result of that, water movement will be restricted or water infiltration will be restricted.

When the water infiltration is restricted there is; obviously, increased chance of surface runoff. Infiltration, you know, this hydraulic conductivity is also increased in case of no till system followed by the minimum till system and in case of Plow tillage the infiltration rate is lowest. Available water holding capacity is highest in case of no till

followed by minimum till and then Plow tillage. Penetration resistance will be always highest in case of Plow tillage just like, you know, it will be much more compact. And then, chisel Plow minimum followed by Chisel Plow minimum till and then lowest will be in case of no till system. Macro aggregates will be highest in case of no till system and obviously, the, you know, corn yield will be highest in case of minimum till with the chisel Plow.

So, you can see, all the beneficial effects of soil properties can be obtained by using this conventional tillage by using the conservation tillage practice instead of conventional tillage practice because conventional tillage practice reduce the organic carbonate increases the bulk density, increases the penetration resistance, it increases the, you know, it decreases the available water holding capacity.

So obviously, from this, you know you know, if you see there is always increase in beneficial soil properties as compared to all. There is always increase in beneficial soil properties in conservation tillage practices as compared to conventional tillage.

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So, let us move ahead and see ok. So, this shows the picture of the same soil. You know, we are having, you know, both this picture are showing the same, you know, of, you know, soil which are affecting the, which are affected by conservation tillage practices. So, the left picture shows the soil condition in a no till system. You can see it is darker in colour because of high amount of organic matter. And similarly, you can see the left the

right picture; it shows the same soil and the no till system and via versus conservation conventional tillage system.

So, you can see this soil is under no till system and this soil is under conventional system. Now obviously, from the from the visual, you know, effect, it can be identified that this no till system soil are having high amount of organic matter then that of the conventional tillage practices. So obviously, the beneficial effects of soil will be much more, we know, in this no till system soil. However, in this conventional tillage system, you know, reduces the organic matter here. So, that basically shows the effect of this alternate conservation tillage practices in different beneficial soil properties.

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And also, you can see some other effects, you can see due to the convention conservation tillage practices, there is a dense growth of nitrogen fixing vetch within a zero tillage rotation. So obviously, these dense growth of nitrogen fixing plant helps in more anchoring the soil much more, helping prevention of the helping preventing the movement of soil particles to runoff. And also, you can see development of porous soil architecture beneath a grass crop in rotation. So, this soil architecture helps in more water movement reducing the chances of runoff.

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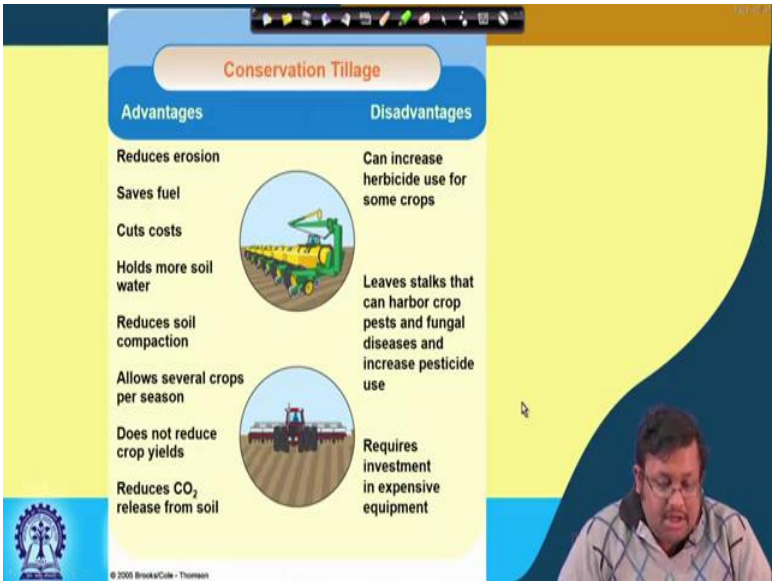

So, these are other beneficial effects as I have already mentioned. So, let us discuss in the final slide. So, let us discuss what is the advantages and disadvantages of Conservation tillages. So, conservation tillage; obviously, the advantages are reduced erosion; obviously, this one of the major thing and then it saves then it saves the fuel of implement different implements and then cut cost of maintenance of the field and also tillage operation.

It holds more soil water, it reduces the soil compaction, it allows several crops per season and also it does not reduce crop yields and it reduces carbon dioxide release from the soil, thereby reducing the green house effect. What are the disadvantages? Obviously, this has, you know, conservation tillage are also having some disadvantages. It can use increase the herbicide use for some crop because we are maintaining the ground cover.

And obviously, there will be chances of weed infestation and also leaves stalks that can harbour crop pests and fungal diseases and increases pesticide use for those for those diseases and also requires investment in expensive equipments, just like I told you about the happy seeder. However, irrespective of these things, you know, there is a great prospect of conservation tillage for maintaining, for maintaining the soil quality and reducing the soil erosion and specifically in country like India, require this type of practice for maintaining their inherent soil fertility and also to prevent the continuous soil degradation.

So, guys I hope that now several things are clear to you and about the conservation tillage practices and how it is beneficial and so, we are finishing this conservation tillage lecture topic.

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And in the next topic, will be discussing this wind erosion and tillage erosion and the concepts which will be covering are reasons of different wind erosion and then mechanisms of wind erosion, then prediction of wind erosion, then what is tillage erosion and finally, prediction of tillage erosion.

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So, let us start with the reasons of wind erosion. Obviously, you can see this is a worldwide map of vulnerability to wind erosion and you can see different colour coding for low, moderate, high and very high. Obviously, you can see here India, in Indian condition there is always high and very high chances of wind erosion you can see most of the areas are vulnerable. Specifically, these areas are vulnerable to moderate to high to very high wind erosion, except these western Indian parts.

So, so wind erosion is an important aspect of wind erosion, we know, important aspect of soil erosion. So obviously, what are the different reasons for wind erosion; overgrazing of the fragile land of arid and semi arid areas and also dry regions with strong wind and no wind and no obstacles. So, region vulnerable to both wind erosion includes the Sahel area in Africa and the pacific coast of South America and the Loess plateau in China. So, all these areas are very very susceptible to wind erosion.

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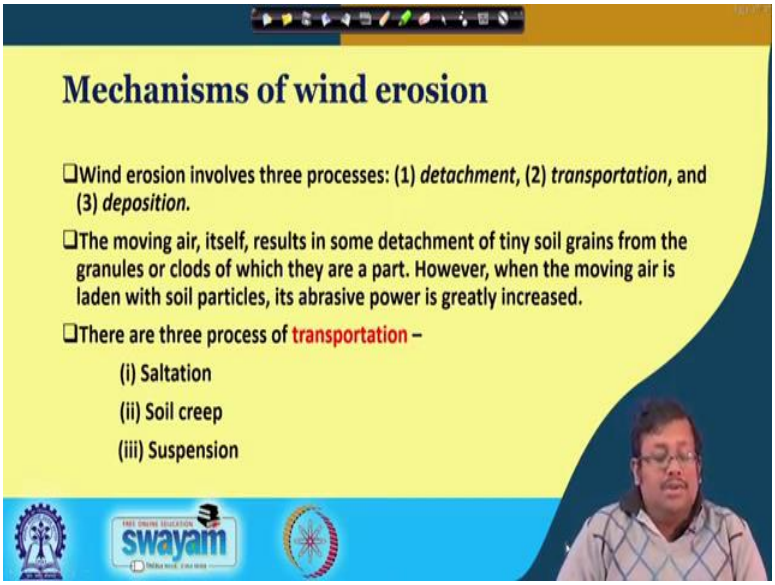

So, let us move ahead and see mechanics of wind erosion. So, wind erosion involves three basically, three basic processes; just like in case of water erosion, it is basically combination of detachment and then movement and depositions; similarly detachment transportation deposition. So, similarly wind erosion is also involve also involves three basic processes. These are basically detachment transportation and deposition.

So, the moving air, you know, itself results in some detachment of tiny soil grains from the granules or clods of which they are a part. And however, when the moving air is

laden with, you know, soil particles it is abrasive power is greatly increased. So, there are three processes in transportation; one is called saltation, another is soil creep, another is suspension. We will discuss all of these. So, transportation is mediated through these three processes; one is again saltation, then soil creep and suspension. So, let us discuss what are these.

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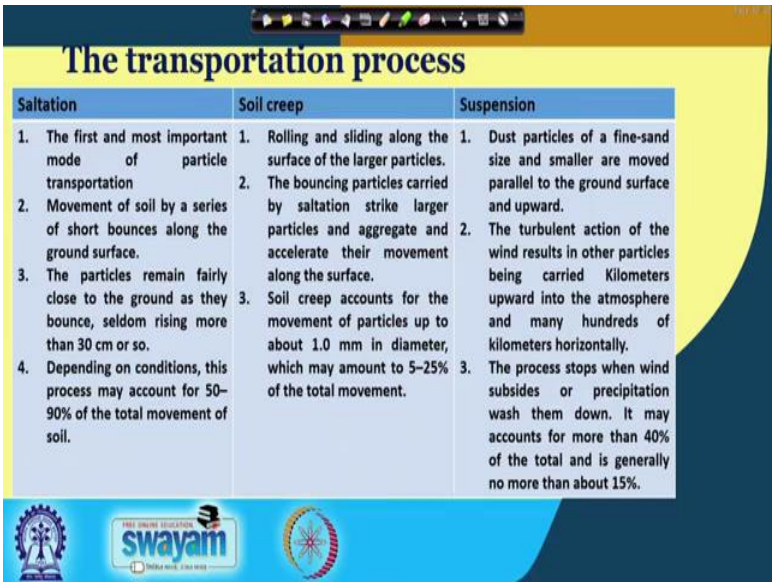

So, saltation is the first and most important mode of particle transportation. Remember, this movement of soil by a series; series of short bounces along the ground forces called Saltation and the particles remain fairly close to the ground as they bounce and seldom raise more than 30 Centimetre or so. And depending on the condition, this process may account for 50 to 90 percent of the total movement of the soil. So, this saltation process is the major process which accounts for the lion's share of the wind transfer, wind based transportation process.

The second important transportation process is soil creep. Soil creep is basically rolling and sliding along the surface of the larger particles and the bouncing particles carried by saltation strike larger particles and aggregates and accelerates their movement along the surface and finally, soil creep accounts for the movement of particles up to about 1 millimetre in diameter and which may amount, you know, to 5 to 25 percent of the total movement. So, this is how soil creeps and finally, suspension.

Suspension is when the dust particles of a fine sand size and smaller are moved parallel to the ground surface and upwards that is called suspension. Obviously, again remember that these dust particles and fine sand size and smaller particles are moved parallel to the ground surface and upwards that is called suspension. And the turbulent action of the wind results in other particles being carried kilometres upward into the atmosphere and many hundreds of kilometres horizontally.

So, that is why, the winds basically carry the soil particles from one place to another place which are far apart from each other. And the process stops when wind subsides or precipitation wash down them and it may accounts for more than 40 percent of the total and is generally no more than about 15 percent.

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So, this is the saltation process, I mean these are transportation process which shows different types of movement. So, you can see, this is much clearer. So, this is saltation process, so, so saltation process slow bounces of this; so, just like as the definition of the saltation, we saw if we go back, this is a movement of soil by series of short bounces. So, similarly we can see the saltation process shows the movement of soil particles in short bounces as we can see short bounces.

Whereas, the soil creep is basically rolling of the soil particles and the suspension is, you know, it is a movement through the air, moving air. So, again here it is a saltation and it is the soil creep and saltation site particles and aggregates, in case of soil gives it is 0. 1

to 0.5 millimetre, and it allows basically suspension size dust are generally less than 0.1 millimetre. This very important again.

Saltation size particles and aggregates generally ranges between 0.1 to 0.5 millimetre. Whereas, in case of suspension, size of the dust should be less than 0.1 millimetre and in the suspension, it moves along with the, you know, wind and this allows the wind, you know, these allows basically indicates a relative wind speeds. So, you can now differentiate between these three processes of transportation wind based transportation.

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So, again this light area shows, you know, where the top soil has been eroded and deposition of the top soil along the fences. So, this an example of, you know, wind based erosion where wind is carried away from with the blowing, I am sorry, the soil is carried away with the blowing wind and deposited in an area which is far apart.

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And let me show you some examples of wind based erosion. You can see these are the different pictures of Dust Bowl which occurred in US in 1920's to 30's. So, this is an extensive movement of dust across the great plains and, you know, up to the New York and all this, you know, washing and other places when and basically disrupts the daily life, you know, daily life of this United States in particularly during 1920 to 30 and these dust bowl basically resulted from a severe wind erosion.

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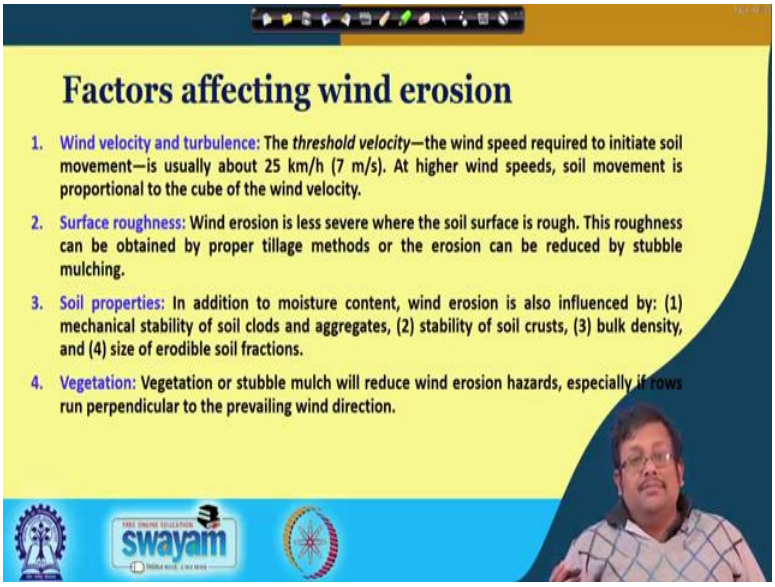

So, what are the different factors, which effects the wind erosion? Obviously, wind velocity and turbulence is one of the important factor, then surface roughness is another important factor, then soil properties and vegetation the threshold velocity. Remember that the wind speed requires to initiate the soil movement is usually 25 kilometre per hour or 7 meter per second.

At higher wind speed, obviously, soil movement is proportional to the cube of the wind velocity. In case of surface roughness; obviously, wind erosion is less severe when the soil is rough. So, this roughness can be obtained by proper tillage methods of the erosion which basically can, you know, reduce the, and which can be reduced by stubble mulching. Soil properties in addition to moisture content, wind erosion also influenced by mechanical stability of the soil clods and aggregates and the stability of the soil crust, bulk density and size of the erodible fractions, you know that and vegetation.

Obviously, vegetative or stubble mulch will reduce the wind erosion hazard especially if rows run perpendicular to the prevailing wind direction.

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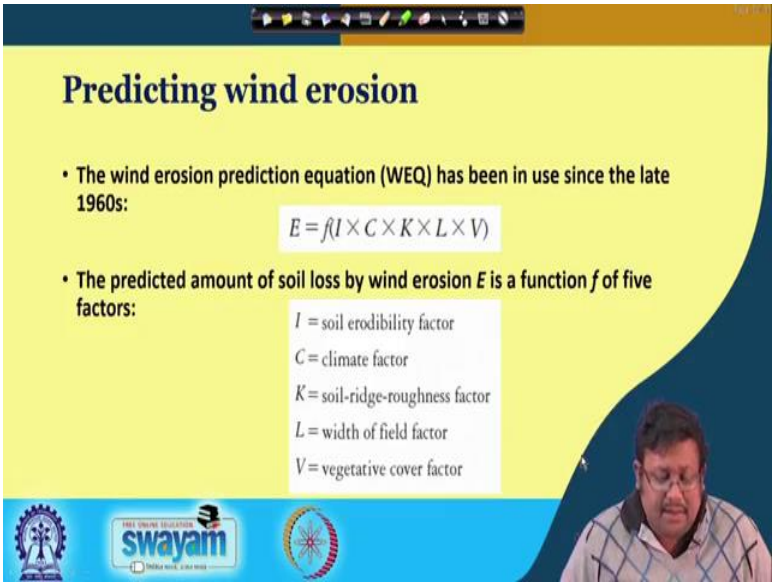

So, how we can predict the wind erosion? The wind erosion predict equation are WEQ has been you in used in the since late 1960 and the formula of this wind erosion of this equation is E equal to where E is basically function of I C K L and V where this E is basically the amount of soil loss by wind erosion. It is a function of these five factors. I is basically soil erodibility factor. C is basically climate factor and K is basically soil ridge

roughness factor, L is basically width of the field factor and V is basically vegetative cover factor.

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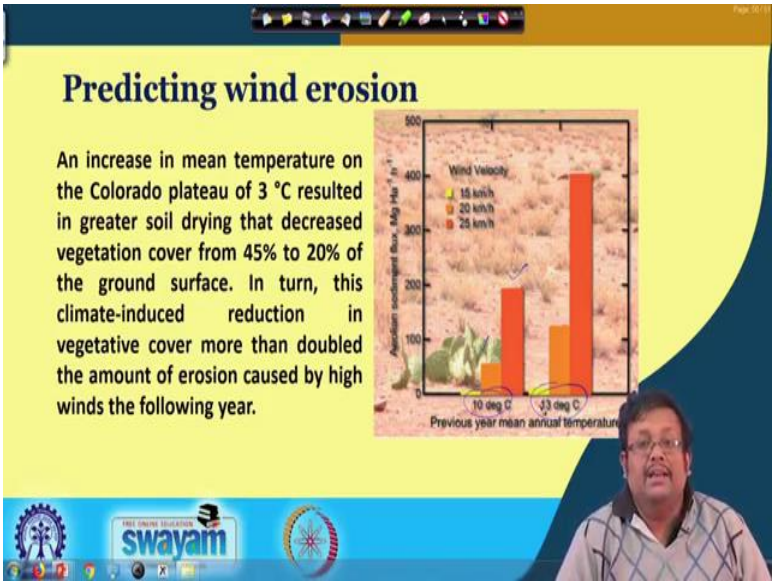

So, let us discuss these factors. So, predicting wind direction, we know, predicting wind erosion ; obviously, an increase in mean temperature on the these these these graph basically shows the increase, you know, a trend where there is a mean, when there is a there was a mean increase in temperature in the Colorado plateau of United State. And this mean temperature increase with 3 degree centigrade which basically resulted in greater soil drying that decreases the vegetative cover from 45 percent to 20 percent.

So, as a result of increase in, you know, increase in the mean temperature, there is a greater drying and as a result of that the vegetative cover reduce from 45 percent to 20 percent of the ground surface. And as a result of that, you know you know, this climate induced reduction in vegetative cover more than doubled the amount of erosion caused by high winds the following year. So, you can see previous year mean annual temperature. So, it was 10 degree centigrade and the next year it was 13 degree centigrade. So, you can see, we know, this basically represent 15 kilometre per hour winds speed, 20 kilometre power, 20 kilometre per hour wind speed and this basically represent 25 kilometre per hour wind speed.

So, in the following year all these amounts of Aeolian sediment flux or the amount of material carried away through wind erosion, almost doubled because vegetative cover

was reduced from 45 to 20 percent. So, that shows the importance of vegetative cover for maintaining the or to prevent the wind based erosion ok.

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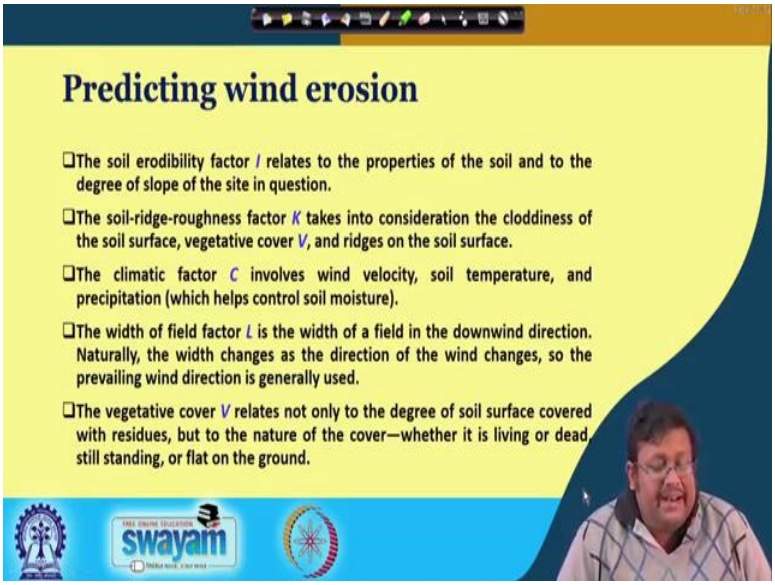

So, so predicting the wind erosion. So, let us consider all the factors, the soil erodibility factor I relates to the properties of the soil and to the degree of slope of the site in question and in the soil ridge and soil ridge roughness factor K takes into consideration the cloddiness of the soil surface and the vegetative cover V and the ridges on the soil surface. And the climatic factor C involves wind velocity, soil temperature and precipitation which helps controlling the soil moisture.

And the width of the field factor that is L is the width of a field in the downward direction. Naturally, the width changes as the direction of the wind changes. So, the prevailing wind direction is generally used and the vegetative cover factor V basically relates not only to the degree of soil surface covered with residues but to the nature of the cover whether it is living or dead or still standing or flat on the ground.

So, not only it not only cover the degree of soil surface covered, but it also covered it also, it also considered the nature of that cover whether they are dead, whether they are alive, whether they are actively growing, whether they are I mean flat or, you know, flat on the ground, what is the standing condition. So, all these are considered and you can see that total amount of wind erosion is basically inter related for, you know, basically, you know, basically can be considered as a inter play of all these important factors ok.

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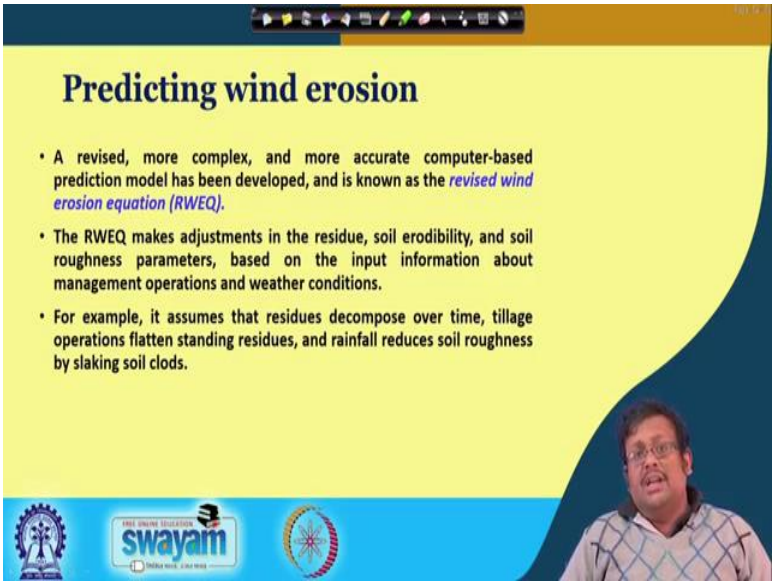

So, so, a revised more complex and more accurate computer based prediction model has been devised and it is known as a revised wind erosion equation or R W E Q and this R W E Q make adjustment in the residue in soil erodibility and soil roughness parameter, based on the input information about the management operations and weather conditions.

For example, if it assume that residue decomposes over time, tillage operation flatten standing residues and rainfall reduces the soil roughness by slaking the soil clods. So, you can see guys, you know, while we are considering these wind based, you know,s erosion and different types of wind based of factors, these are also very much important.

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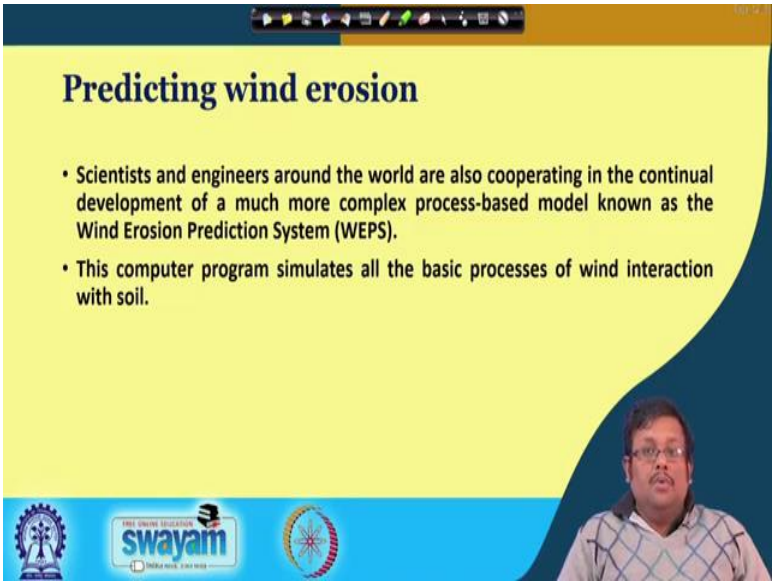

And scientist and engineers around the world are also cooperating in the continual development of a much more complex process based model known as the Wind Erosion Prediction System on W E P S and this computer program simulates all the basic processes of wind interaction with the soil.

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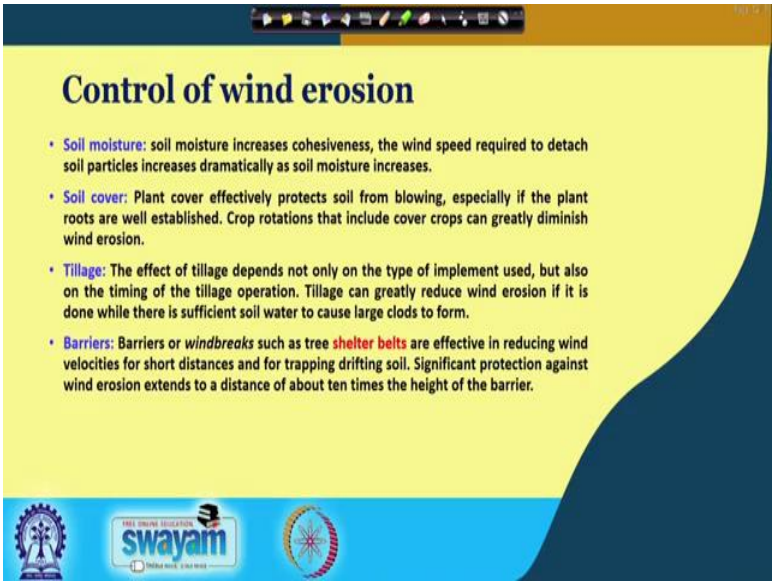

So, you know, guys let us wrap up here. And I hope that you have learned some new aspects of wind erosion in this lecture and in the next lecture or in the 5th lecture of this week 9, we will be trying to cover the aspects of different controlling measures of wind

erosion and then we will be talking about different organic pollutants which are present in the soil and how they are polluting the environment. And thank you and let us meet in our next or fifth lecture of week 9 of soil science and technology.

Thank you.