**Soil Fertility and Fertilizers**
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**Lecture – 50**
**Biofertilizers and Management of Fertilizers and Manures in Soil (Contd.)**

Welcome friends to this 50th lecture of NPTEL online certification course of soil fertility and fertilizers. And in this lecture, we are basically right now at week 10, where we are discussing biofertilizers and management of fertilizers and manures. And in this lecture we are going to discuss the topic of fertigation. Now, in our previous couple of lectures we have discussed about we have discussed about biofertilizers, how we can develop biofertilizers, how we can what are characteristics of biofertilizers. And also we have discussed what are the benefits of using bio fertilizers? In the second lecture, we have discussed about biocha; why it is important for enhancing the soil fertility.

In the third lecture, we have discussed about mulching and why mulching is important; and what are the different types of mulching like organic mulching, inorganic mulching we have discussed in details. In the fourth lecture we have discussed about nano urea, which is an important addition in the fertilizer market; and which can improve the nitrogen use efficient by the crop. So, we have discussed all these 4 topics so far in this week. Now, in the last lecture of this week, that is 50th lecture we are going to discuss the fertigation.

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Now, these are the concepts which we are going to cover in this lecture. First of all, what is fertigation? Then, why fertigation is necessary? Then, what are the different types of fertigation? And then, effect of drip irrigation on yield, water use efficiency and economics; and also we are going to discuss the benefits of fertigation. So, these are some major concepts, which we are going to discuss in this lecture. These are some of the keywords which you are going to use in this lecture fertigation, drip irrigation, fertilizer tank, water productivity, and water use efficiency.

So, to begin this lecture we should remember that fertigation is a way for sustainable nutrient, water and crop management, where there is a water scarcity, where there is nutrient reduced

nutrient use efficiency. We can use fertigation to improve both the nutrient use efficiency and water use efficiency.

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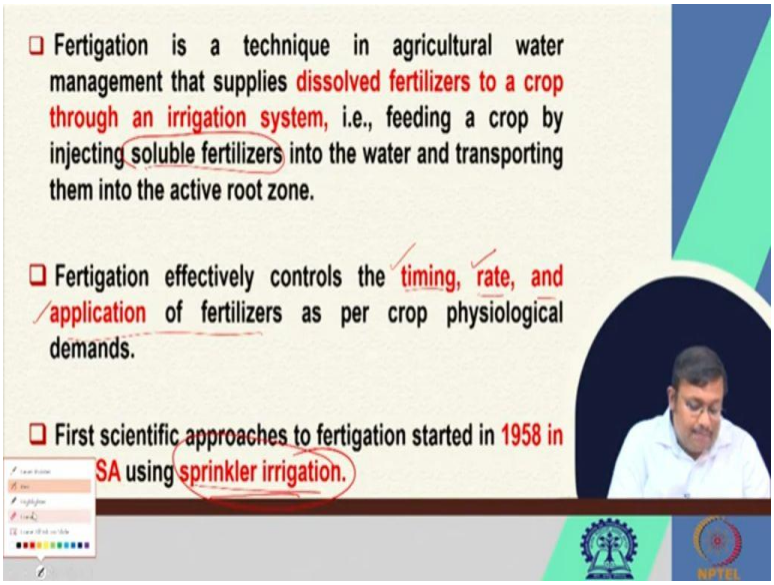


Now, let us discuss what is fertigation? So, fertigation is a technique in agricultural water management that supplies dissolved fertilizers to your crop through an irrigation system; that is feeding a crop by injecting soluble fertilizers into the water and transporting them into the active roots zone. So, here one thing is very important as you can see, that is soluble fertilizers. So, this fertigation system always deals with these soluble fertilizers into and basically this fertigation system feed the crop by injecting the soluble fertilizers into the water, and transporting them into the active root zone, so that they can be up taken by the plant.

Now, remember that fertigation effectively controls the timing, rate and application of fertilizer as per crop physiological demands. So, essentially using fertigation, we can give the fertilizer as well as irrigation application at proper time, proper rate and so proper method of application as per the crop physiological demands. First scientific approaches to fertigation started in 1958 in the USA using sprinkler irrigation; so we are going to discuss this sprinkler irrigation later on in this lecture. But, remember that the first application of this fertigation started in the United States.

So, if we go back and if we just move ahead and see the next important topic or important aspect that is why fertigation is necessary.

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Now, this is a picture of a fertigation; you can see the fertigation is being applied to the plant in the field. Now, why fertigation is necessary? So, the incessant population pressure generally brings down per capita water availability by 41 percent in Indian condition of course, where the irrigation sectors consume the lion's share; that is 83 percent of the present water utilization. So, you can see that although there is high percentage of the present water utilization is accounted for irrigation sector, the per capita water availability is continuously decreasing.

Now, India is fast approaching a water scarce country and decreasing per capita water availability in India. So, the consumption, at the same time the consumption of fertilizer namely Urea, DAP, MOP, NPK complex, and SSP increased from 1991 to 1992 to 2014 to 15, by 118 to 68, and 67, 157 and 26 percent for all these fertilizers in just 23 years. So, you can see the fertilizer consumption has drastically increased. But, at the same time the the the water availability per capita water availability has been decreasing since long time; and we are quickly approaching it to a water scarce condition.

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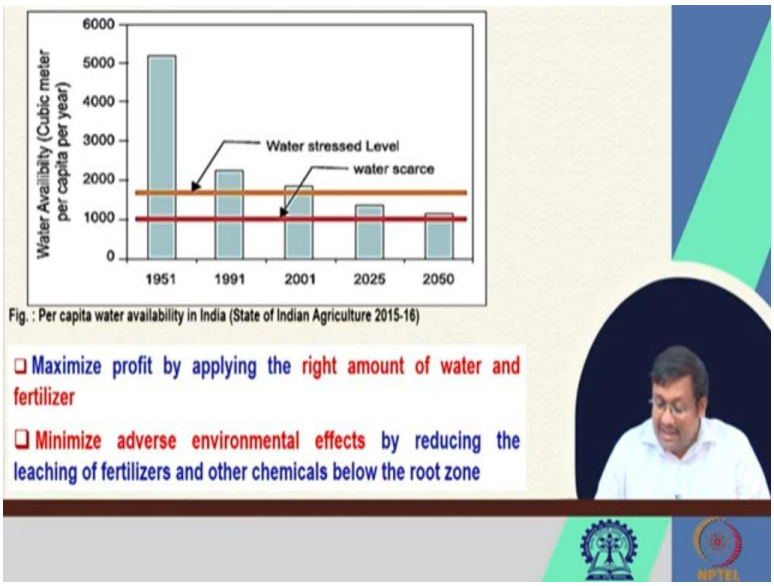


Now, if we see the scenario of per capita water availability in India, we will see that starting from 1951 where our per capita water availability was quite high. There is a gradual decline in per capita water availability; and you can see by 2050 we will basically reach towards these red line or threshold of water scarcity. Right now, in this zone we belong to this zone that is somewhere in between water stress level and water scarcity. However, we are fast approaching towards water scarcity, and by 2050 we will be reaching towards water scarcity threshold.

So, by applying this fertigation that is application of fertilizer with irrigation, we can maximize the profit by applying the right amount of water and fertilizer; so, this is the most important thing. The second is we can minimize the adverse environmental effects by reducing the leaching of fertilizer and other chemicals below the root zone. So, now we know that several fertilizers are very much susceptible to leaching losses, specifically nitrogenous fertilizers. So, if we apply these fertilizer in the judicious rate, according to the crop physiological demand through fertigation, we can reduce the fertilizer application; and also we can ensure that there will be no leaching of fertilizer materials. So, these are some of the impacts of fertigation.

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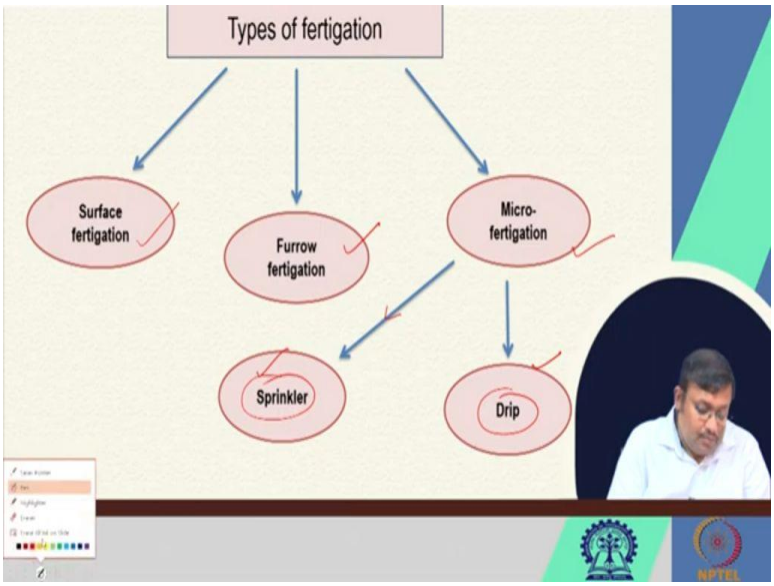


Now, if we see what are the different types of fertigation? First of all, there is surface fertigation. Then, we can see, first of all, we can see surface fertigation; then, we can see also furrow fertigation, and third category is micro-fertigation. Now, the micro-fertigation can be also divided into 2 category; one is sprinkler irrigation, another is drip irrigation. Now, in this lecture we are going to first discuss the drip irrigation or drip fertigation, then we will discuss the sprinkler irrigation. So, let us go ahead and see the micro-fertigation.

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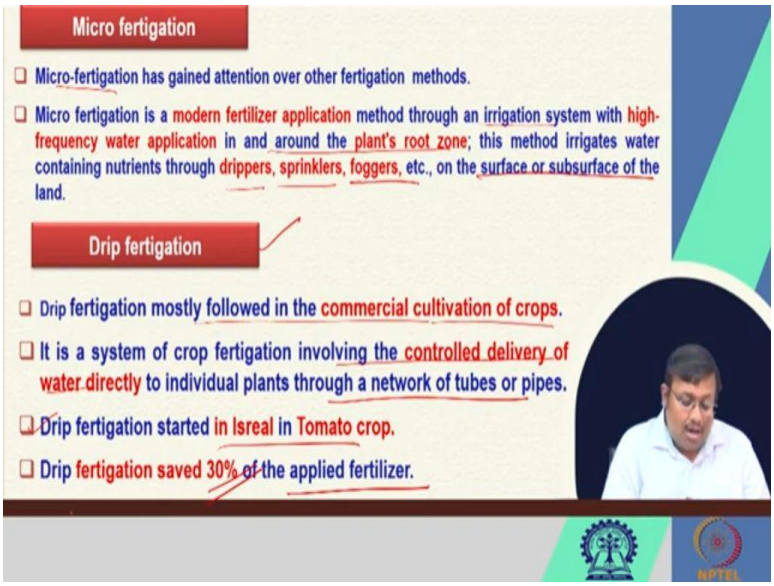

Now, micro fertigation has gained attention over other fertigation methods. Now, what is micro fertigation? Micro fertigation is a modern fertilizer application method through an irrigation system with high frequency water application in and around the plant's root zone. So, both these drip irrigation and sprinkler irrigation comes under there, come under the category of these micro fertigation. And in the micro fertigation method, we are ensuring that we are applying the irrigation water in high frequency in and around the plant's root zone. And this method of micro fertigation irrigates water containing nutrients through drippers, sprinklers foggers et-cetera.

We are going to see on the surface or subsurface of the land. Based on the requirement, we can apply the fertilizer as well as irrigation at proper place. The second important thing with, I mean the first category of micro fertigation or is drip fertigation and drip fertigation mostly followed in the commercial cultivation of crops. So, all the commercially cultivated crops they are suitable for drip irrigation. Now, it is a system of crop fertigation involving the controlled delivery of water directly to individual plants through a network of tubes and pipes. So, in this drip irrigation using a network of tubes and pipes we can apply the fertilizer in a controlled way.

And drip fertigation started in Israel in tomato crop and drip fertigation save 30 percent of the applied fertilizer. So, drip fertigation is known to save 30 percent of the applied fertilizers. So, this is the benefit of deferred drip fertigation.

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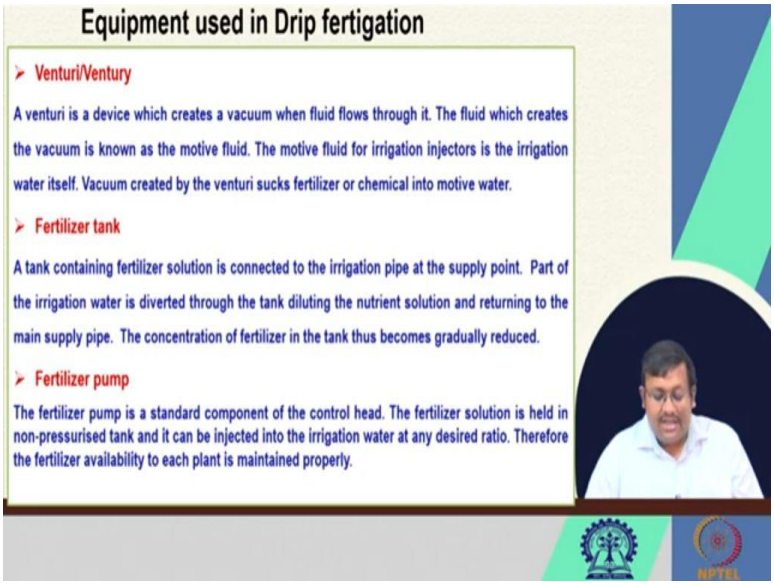

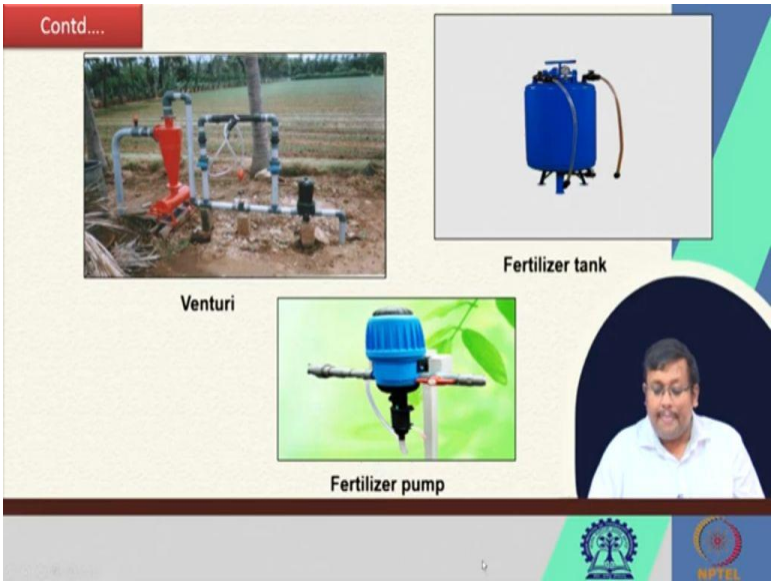


Now, so let us discuss what are the equipments which are used in drip fertigation? So, the first one is Venturi or (Ventu) v, e, n, t, u, r, i or v, e, n, t, u, r, y; both of them are correct, so you can use either of them. So Venturi is a device which creates a vacuum when fluids flows through it. So, the fluid which flows through it, creates a vacuum is known as the motive fluid; and in motive fluid is basically the irrigation water itself. So, when the irrigation water creates a vacuum that sucks the fertilizer or chemical into the motive water; and ultimately that gives that fertilizer mix water to the plant. Second important component is a fertilizer tank. So, it is a tank containing fertilizer solution which is connected to the irrigation pipe at the supply point.

Now, part of the irrigation water is diverted through the tank diluting the nutrient solution, and returning to the main supply pipe. And the concentration of fertilizer in the tank thus becomes gradually reduced. The third important component is fertilizer pump. So, the fertilizer pump is a standard component of the control head. Now, the fertilizer solution is held in non-pressurized tank and it can be injected into the irrigation water at any desired ratio. Therefore, the fertilizer availability to each plant is maintained properly. So, these are different equipments which are being used drip fertigation. You can see this Venturi; this is a fertilizer tank and this is a fertilizer pump.

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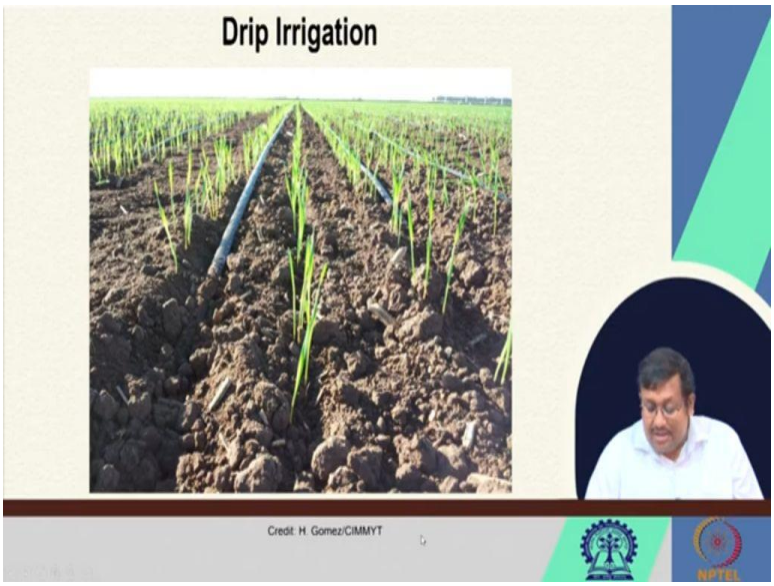


Now, this is an example of drip irrigation. And you can see the drip irrigation can give or supply the fertilizer mixed water, irrigation water to the exact plant root zone. And thereby, supplying the required quantity of the fertilizer as well as water without wasting; and thereby increasing the water use efficiency or the nutrient use efficiency.

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The second type of micro fertigation is can be mediated through sprinkler irrigation. Now, what is sprinkler irrigation? Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall. Now, you can see this is an picture or image of sprinkler irrigation. So,

in this sprinkler irrigation water is distributed through a system of pipes usually by pumping. Now, it is then sprayed into air through sprinklers, so that it breaks up into the into small water droplets which fall on the ground.

Now, the pump supply system sprinklers and operating condition must be designed to enable a uniform application of water. So, this is a sprinkler irrigation system; and we can apply the fertilizer to sprinkler irrigation also.

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Now, let us see what are the crops which is suited for fertigation. If we see the field crops, we can see aerobic rice, wheat, maize, cotton pulses are very suitable for fertigation. In case of vegetables tomato, chilly, capsicum, cabbage, cauliflower, onion, okra, brinjal, bottle gourd, cucumber these are suitable for fertigation. Or, in the orchard crops, we can see grape, banana, pomegranate, orange, citrus, tamarind, mango, fig, lemon, custard apples, suppota, guava, pineapple, coconut, cashew nut, papaya et-cetera; these are suited for fertigation. In case of flowers rose, carnation, gerbera, jasmine, marigold these are suited for fertigation.

In case of plantation crop tea, rubber, coffee, coconut are important for fertigation. In case of spices turmeric, cloves, mint are important for fertigation. In case of oil seeds, sunflower, oil palm, and groundnut can be irrigated by fertigation. And in case of forest crops teakwood, bamboo can be can be maintained or managed by fertigation. So, these are the crops which are suited for fertigation.

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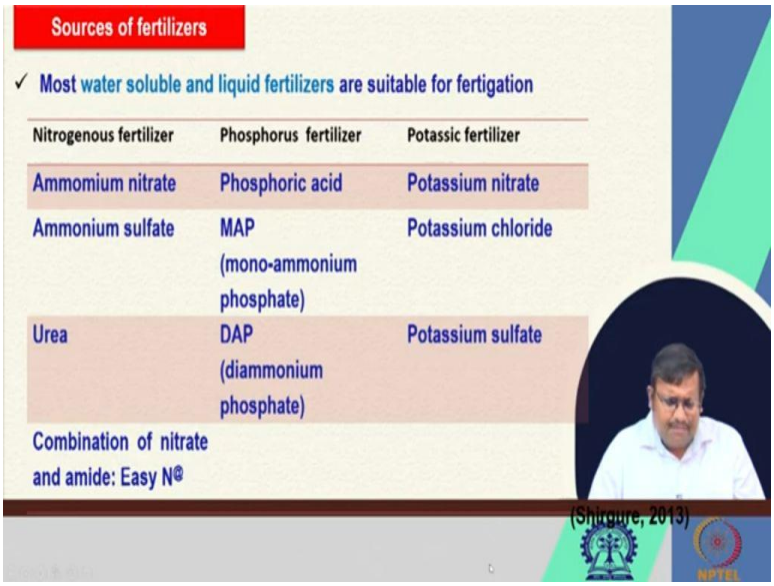


Now, let us see what are the sources of the fertilizers? Now, as I have mentioned that one of the major criteria of fertigation is the use of water soluble fertilizer. So, most water soluble and liquid fertilizers are suitable for fertigation. What are those water soluble fertilizers? So, we can see that ammonium among nitrogenous fertilizer, we can see ammonium nitrate, ammonium sulfate, urea, and combination of nitrate and amine which is known as easy nitrogen or easy N can be also utilized in fertigation. In case of phosphorus fertilizer, phosphoric acid, mono-ammonium phosphate, di-ammonium phosphate; so, these are important soluble fertilizers which you can use for fertigation method.

The third most important primary nutrient is potassic fertilizer. And in case of potassic fertilizer, potassium nitrate, potassium chloride, and potassium sulfate are water soluble and liquid fertilizer, which is suitable for fertigation. So, these are different types of soluble fertilizers which you can apply as we can apply for fertigation.

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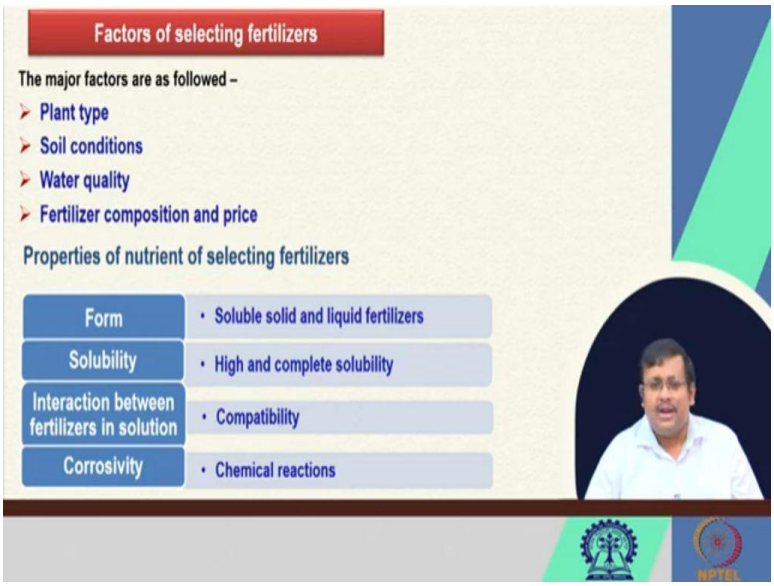


Now, what are the factors which can control the selection of fertilizer for fertigation? So, the major factors are basically plant type, then soil conditions, water quality, and fertilizer competition price. So, these 4 to 5 factors are the controlling or determining factors for selecting the fertilizers for fertigation method. Now, what are the properties of nutrients which are important for selection of the fertilizer? First of all, form; this is the most important property. Whether that form is a soluble form or liquid form; these these are important factors for selecting the fertilizer.

Secondly, whether they have high solubility or low solubility that is also an important consideration when we select the fertilizer for fertigation. And also interaction between fertilizers in solution; there should have complete compatibility. Otherwise, there will be we cannot use that fertilizer for fertigation; and fourth important point is corrosivity. So, it should have minimum chemical reactions to to interact with the materials which are present in the fertigation system; so, that there should not be any salt buildup or there should not be any corrosion.

So, these are important factors which are which are one should remember before selecting the proper fertilizer, before the fertigation purpose.

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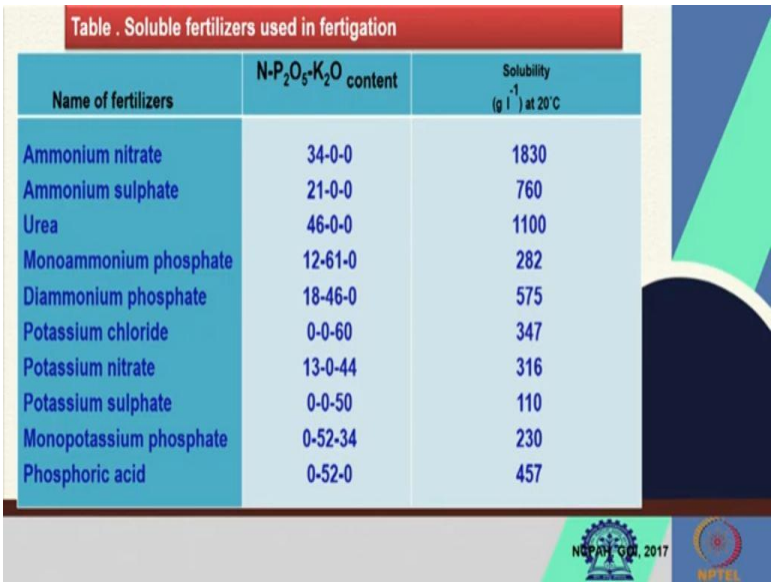


Now, if we see the soluble fertilizers used in fertigation, we can see ammonium nitrate which contain 34 percent nitrogen; and has a solubility of 18 hundred 30 gram per liter at 20 degrees centigrade. Ammonium sulfate has 21 percent nitrogen and it has a solubility of 760. Urea has 46 percent nitrogen and 1100 gram per liter solubility; monoammonium phosphate 12-61-0 and 282. And you can see for other fertilizers also like diammonium phosphate, we can see it has 18 percent nitrogen and 46 percent P2O5; and it has 575 gram per liter solubility.

So, it is, this is a list of the fertilizers which can show there; and also which are suitable for fertigation and we can see their responding solubility also.

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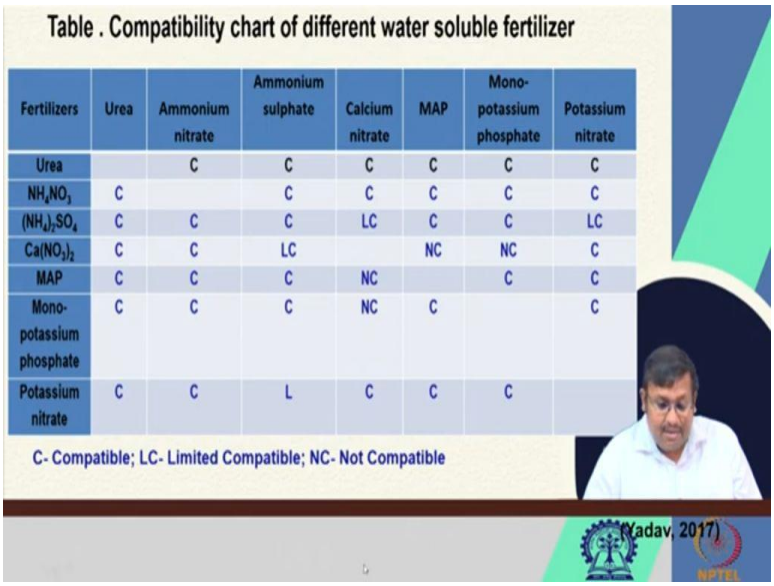


Now, if you see the compatibility chart of different water soluble fertilizers. So, we can see that urea is compatible with ammonium nitrate, ammonium sulphate, calcium nitrate, and then monoammonium phosphate, mono potassium phosphate, and potassium nitrate. However, the calcium nitrate he has no compatibility with monoammonium phosphate and mono potassium phosphate. Similarly, monoammonium phosphate has no compared not compatible with calcium nitrate; and mono potassium phosphate is not compatible with calcium nitrate.

And limited compatibility we can see between calcium nitrate and ammonium sulphate, and also calcium nitrate and ammonium sulphate. So, this table helps us to see whether we have, I mean what should be the ideal combination of different soluble fertilizers which we use for fertigation purpose.

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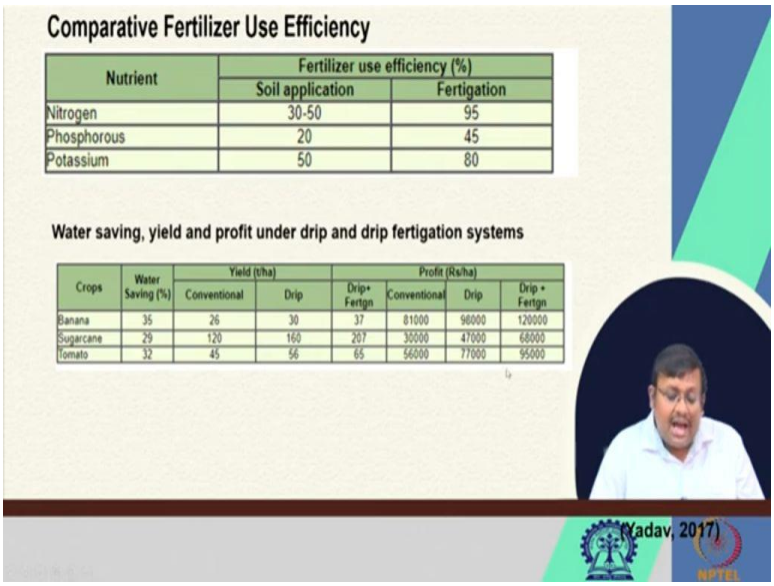


Now, if we want to see the comparative fertilizer use efficiency; in case of nitrogen, in case of soil application, the fertilizer use efficiency varies from 30 to 50 percent. However, in case of fertigation, we get 95 percent water fertilizer use efficiency. In case of phosphorus, we get 20 percent for soil application. In case of fertigation, we get 45 percent for soil application. In case of potassium, we get 50 percent for soil application; however, in case of fertigation, we get 80 percent for fertigation. Now, water saving, yield and profit under drip and drip irrigation fertigation systems; so you can see in case of banana, water saving 35 percent. And in case of conventional that should be the yield will be around 20 ton per hectare; whereas, in case of drip the yield will increase.

And in case of sugarcane and tomato also, you can see the water savings will be 29 percent, 32 percent; in all the cases there will be increase in the yield. And if you see the profit, the drip plus fertigation will give you profit for all the 3 conditions. And so this is the profit chart which you can see or compare. So, in case of conventional, it is 81000; and 98000, in case of drip. But, when you combine both drip and fertigation, you will get 120000. In case of banana: in case of sugarcane will get 68,000; in case of tomato, you will get 95,000 when combining drip fertigation.

So, these are different types of water saving yield and profit under drip and drip fertigation systems.

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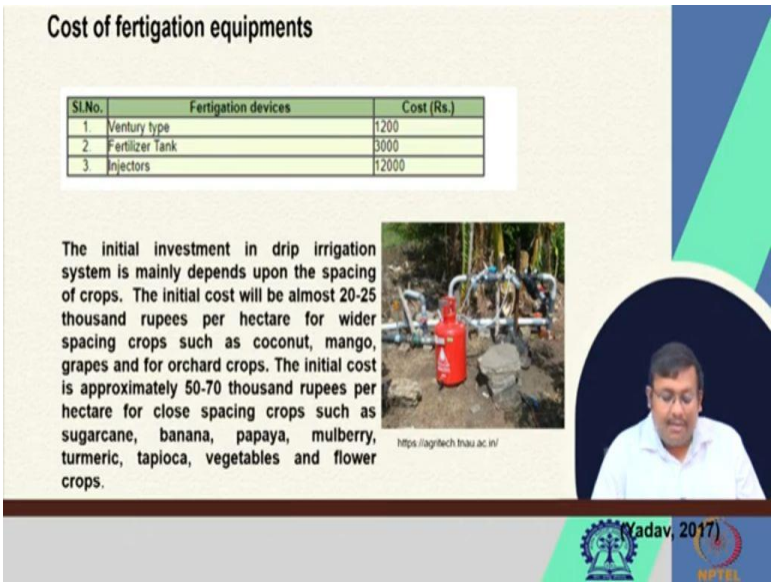


Now, if you see the cost of fertigation equipments, we have already discuss. So, the Venturi type is around 1200. In case of fertilizer tank, it is 3000; in case of injectors, these are 12,000. So, the initial investment in drip irrigation system is mainly depends upon the spacing of the crops. So, the initial cost will be almost 20 to 25 thousand rupees per hectare for wider spacing crops such as coconut, mango, grapes and for orchard crops. And the initial cost is approximately 50 to 70 thousand rupees per hectare for close spacing crops such as sugarcane, banana, papaya, mulberry, turmeric, tapioca, vegetables and flower crops.

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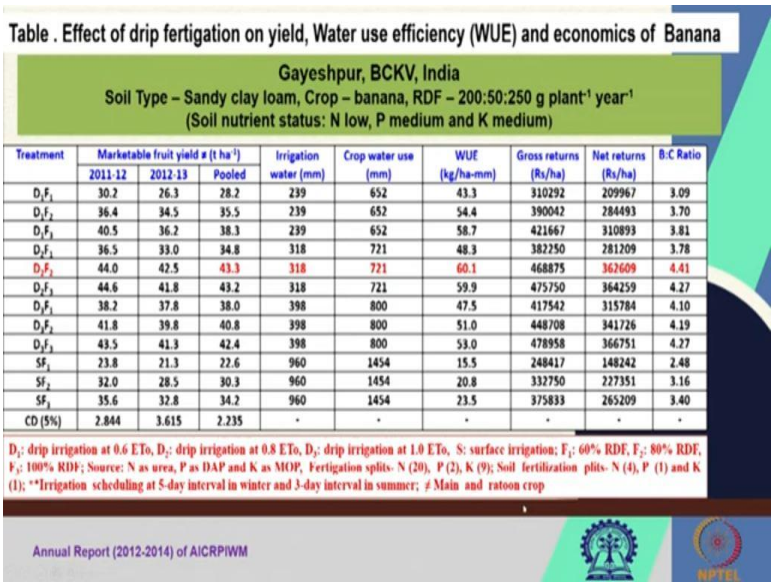

So, if you see the effect of the fertigation on yield, and water use efficiency and economics of Banana, you can clearly see that when there are different treatments; so D2F2 stands for D2F2 stands for the drip irrigation with at 0.8; it is 0 and F2 stands for the 80 percent of the recommended for dose of fertilizer. So, in this combination, we can see that marketable fruit yield is increasing among all the treatments. So, the marketable yield is highest in this treatment and also irrigation water. If you see it is 318 millimeter, and crop water use you can see also it is quite high.

And also water use efficiency if we compare, these can show the highest water use efficiency of 60 around 60 kg per hectare 1 millimeter. So, this water use efficiency is 60 kg per hectare millimeter. And you can see also net returns is also increasing. So, you can see this is an example of effect of drip fertigation on yield water use efficiency and economics of Banana.

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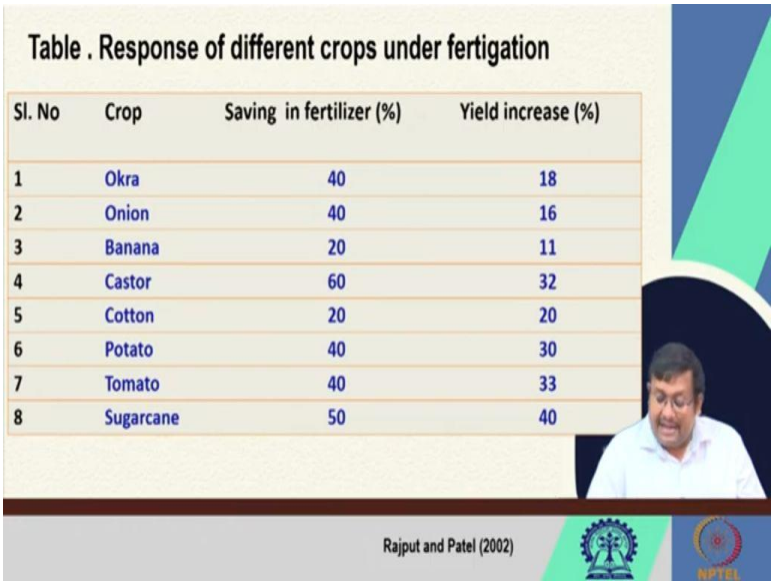


Also if you see the response of different crops under fertigation, we can see that saving in fertilizer for different crops, we can see from which varies from 20 to 60 percent; so, 20 percent in cotton and 60 percent in castor. And also we can see the yield increase percent yield increase varying from 11 to around 40 percent. So, that shows that use of fertigation can not only save the fertilizer, but also simultaneously it can increase the yield.

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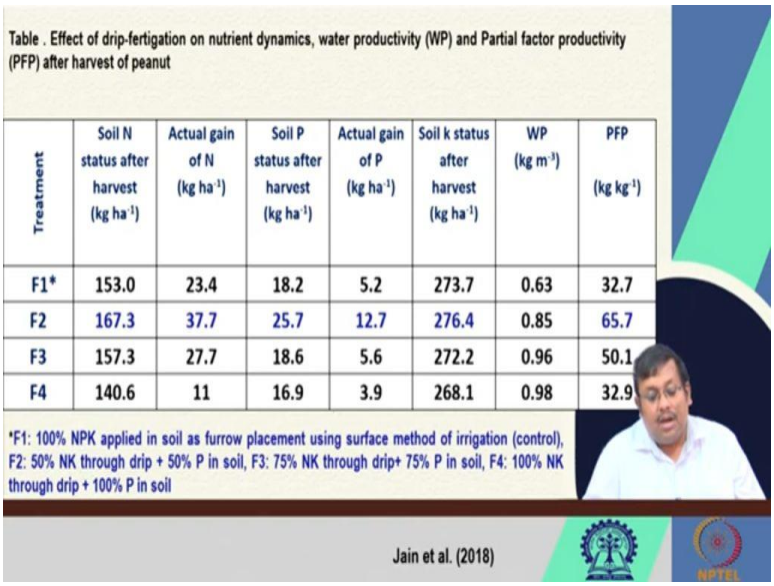


Also if you see the effect of drip irrigation on nutrient dynamics, water productivity and partial factor productivity, we can see these F2 treatment which is basically 50 percent of nitrogen and potash; and also plus 50 percent of phosphate in soil. We can see the soil nitrogen status after harvest, actual gain of nitrogen, and soil phosphorus status after harvest, actual gain of phosphate or phosphorus; and then soil potassium status after harvest. And also, the partial factor productivity is highest in case of this F2 treatment. So, that shows the importance of the fertigation for a drip irrigation on fertilizer use efficiency by different crops.

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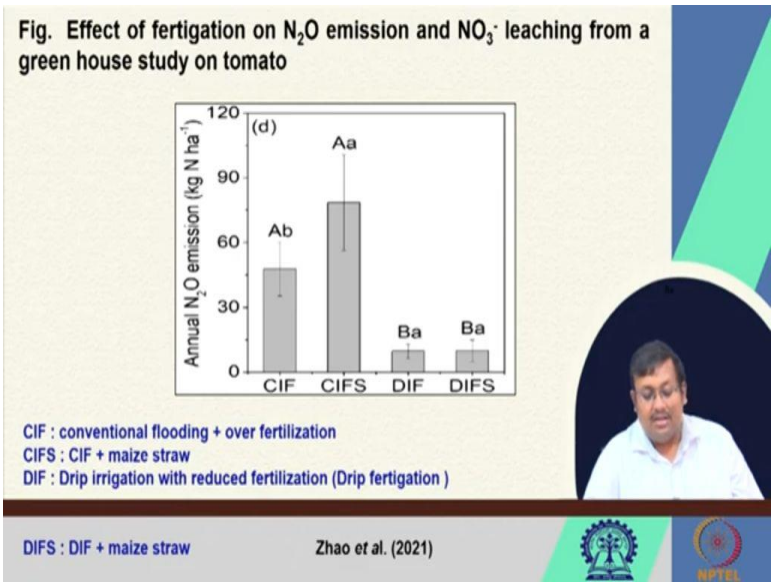

Also, if we see the effect of fertigation on nitrous oxide emission and nitrate leaching from a greenhouse study on tomato, published by Zhao et al 2021. We can see that when there is a combination of drip irrigation with reduced fertilization, or drip fertilization in other words and drip irrigation or drip fertigation with maize straw, there is significant decrease in nitrous oxide emission. Simultaneously, we can see that there are reduction in nitrate leaching when we use the drip fertigation process.

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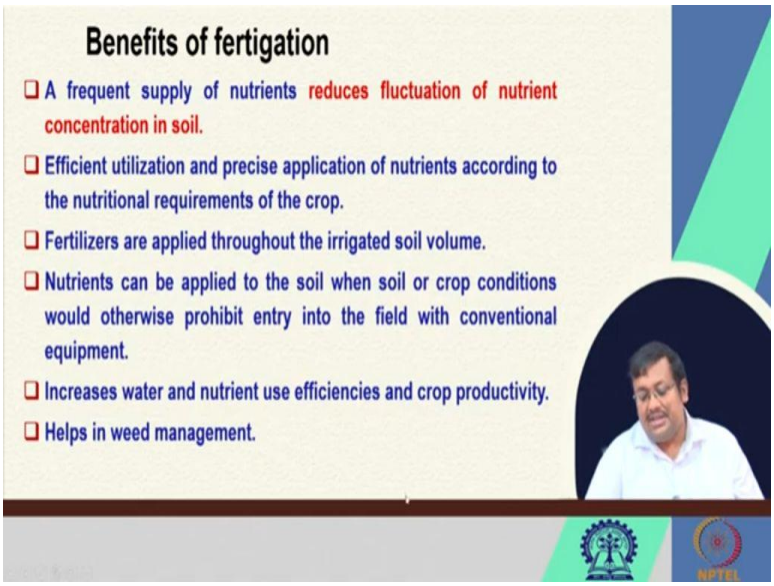


So, what are the benefits of fertigation? So, a frequent supply of nutrients uses fluctuation of nutrient concentration in soil; and then efficient utilization and precise application of nutrients according to the nutritional requirement of the crop. Fertilizers are applied throughout the irrigated soil volume; and the nutrients can be applied to the soil when soil or crop condition would otherwise prohibit the entry of field, entry into the field with conventional equipment. And then it also increases water and nutrient use efficiencies and crop productivity; and also finally it helps in weed management.

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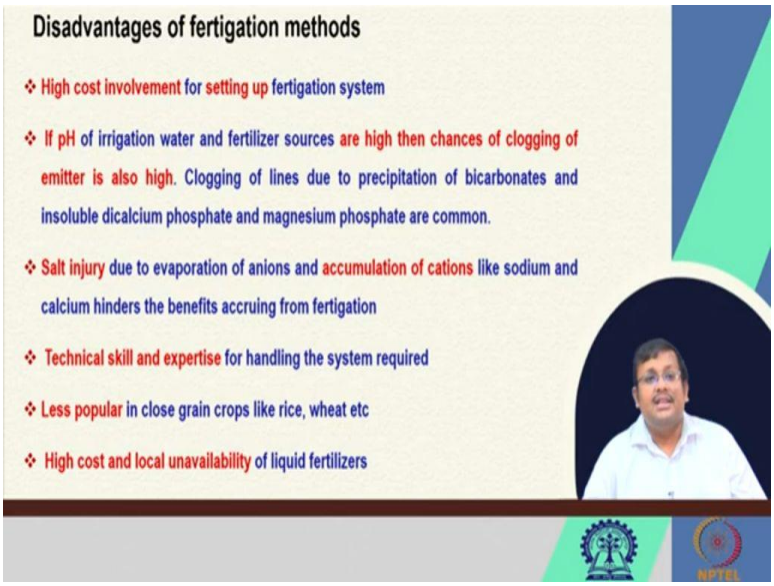


However, at the same time, there are several disadvantages of fertigation methods also. For example, high cost of involvement for setting up the fertigation system. And if the pH of irrigation water fertilizer sources are high, then there is chances of clogging of the emitters. There are certain salts like bicarbonates and insoluble dicalcium phosphate, magnesium phosphates, which can precipitate; and clog the fertigation system that could be salt injury due to evaporation of anions and accumulation of cations like sodium and calcium. Which can hinders the benefits accruing from fertigation; and there are it requires technical skills and expertise for handling the fertigation system.

It is less popular in close grain crops like rice, wheat et-cetera. And then also high cost and local unavailability of the liquid fertilizers are also important disadvantages for fertigation methods.

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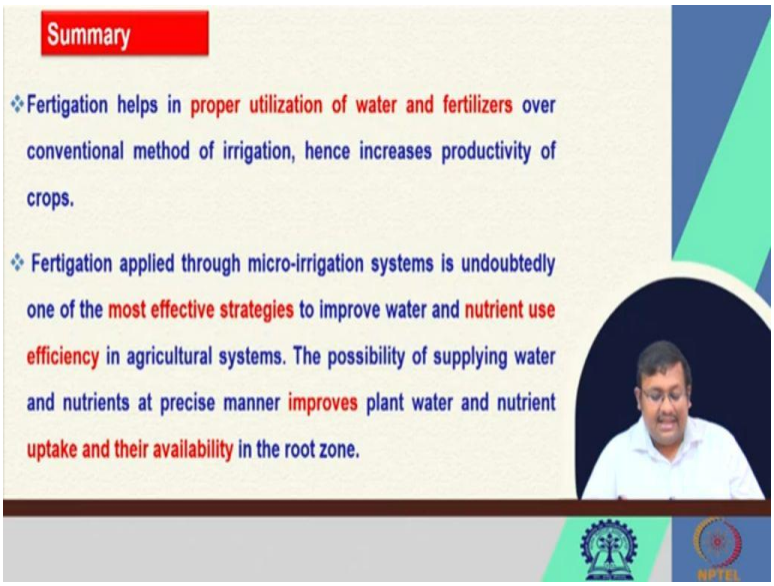



So, to summarize this fertigation, fertigation helps in proper utilization of water and fertilizers over conventional method of irrigation; hence increases the productivity of the crops. And then fertigation applied through micro-irrigation system is undoubtedly one of the most effective strategies to improve water and nutrient use efficiency in agricultural systems. The possibility of supplying water and nutrient at precise manner improves plant water and nutrient uptake and their availability into the root zone. Among different methods of fertigation, drip fertigation is mainly used in the agriculture field.

And this seems beneficial among other methods to optimize the resource use efficiency by enhancing the uptake of nutrient, and reducing the leaching loss of nutrient and water uses. And besides enhancing the resource use efficiency, it also provides economic return by reducing the wastage of nutrient and water. And all these positively influence the economic and environmental sustainability of agricultural activities.

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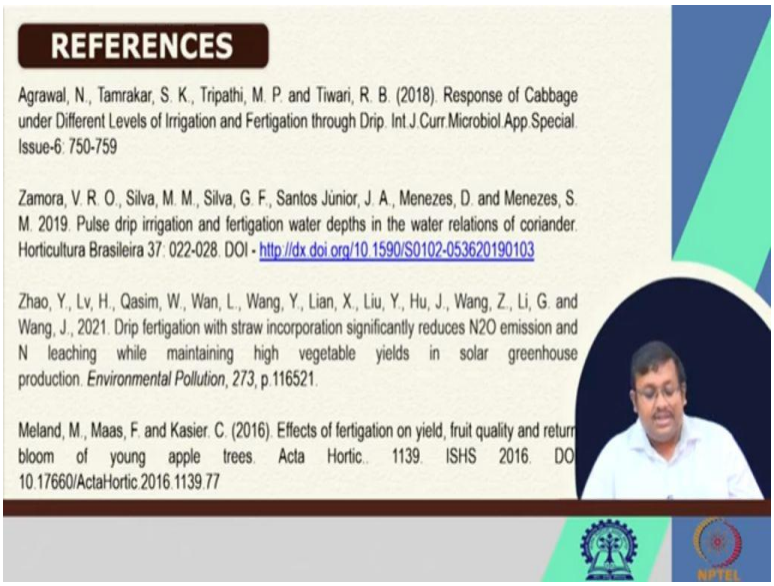


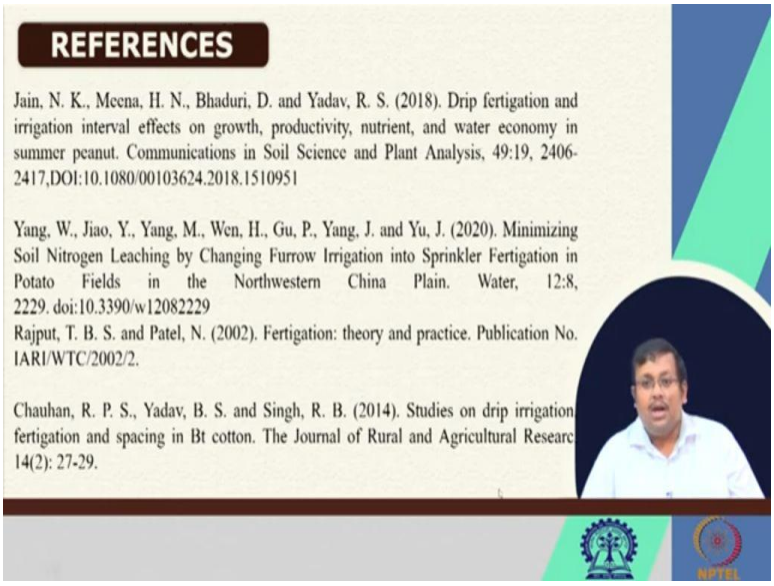


So guys, by this we have wrapped up this this lecture; and these are the references which I have used. So, please go through these references for getting more knowledge on fertigation. And if

you have any questions, please let me know so that I can answer your queries. Let us meet in our next week of lectures to discuss other aspects of soil fertility and fertilizers. Thank you.