Micro Irrigation Engineering
Prof. Kamlesh Narayan Tiwari
Department of Agricultural and Food Engineering
Indian Institute of Technology – Kharagpur

Lecture – 59
Precision Agriculture

Hello, participants. We are now starting Lecture 59. This is another interesting lecture and here we will be talking about precision agriculture. It is one of the important upcoming areas of research and application in the field and particularly, when we are talking of improving agricultural productivity. And then, giving precision amount of irrigation precision amount of other inputs like fertilizers, nutrient based on considering the field variability in a large area or even in a small area, if there are there is any field variability it exist.

So, here, we will talk about the precision agriculture. What are the different components of precision agriculture? How micro irrigation has relevance in precision agriculture? So, these are the topics which will we will discuss in this, particularly on precision agriculture.

Now, why precision agriculture? You see when we are talking about sun as a source of energy which is responsible for photosynthesis of the crop, so, irradiation of sun, natural water supply, the soil properties and the demand of the market these are all not just uniform at all. So, if this is varying, we need to make changes. So, even within the small regions or within a farm, soil properties and its quality in terms of the nutrient status, in terms of the availability of moisture content, in terms of the other physical parameters and the slope of the field, these can be different.

So, to in order to get sustainable and economical farming operations it requires precise adaption of natural and economic conditions. So, permanent and precise adjusting to the varying site-specific soil-crop condition in the field can address environmental needs much better and ensure greater yield. This is the rationale for site-specific precision farming or precision agriculture.

Managing irrigation throughout the field in a short duration, this is the, another important aspect which requires precision agriculture or precision farming. Within a single field in a site-specific way allow reduce nutrient quantity needed while maintaining the yields thereby improving the nutrient use efficiency. Means, when there is a variability and instead of giving uniform amount of nutrient all throughout the field, one can take decision after getting the data and smaller amount, when you are applying as compared to the uniform amount of nutrient application all throughout field. We will be improving the nutrient use efficiency of the crop. So, site-specific fertilizing relies either on the removal of nutrients by preceding crops means previous crop or on the supply in the soil as well as growing plant needs.

So, site-specific control in application of, say fungicides means, other chemicals, and fungicides would be the requirement that can be based on spatial difference of the crop biomass or on infected loci. Means, wherever there is a location where there is a problem, exactly at that particular location, fungicide application can be given. So, precision farming technique comply to a spatial, temporal and the rate at which various farming operations fulfill their function, to do with right thing, at the right place, and at the right time. So, there are 3 R's here. Right thing means exactly what is to be done exactly at that particular location. So, at appropriate location and at appropriate time, this is important when we are talking about precision farming or precision agriculture.

So, precision agriculture or precision farming it involves application of technologies and principles to manage spatial, temporal variability associated with all aspects of agricultural, horticultural, aqua cultural production for improving crop performance and environment quality through efficient management of resources using location specific hi-tech interventions. We will discuss, what is the meaning of here hi-tech interventions?

Means, we will use the sensor technologies where and then apply exactly at the appropriate location. So, sensor, GIS, GPS all these things we will be coming to this part. So, when we call of that precision agriculture or precision farming, it means these are the commonly used terms. Site specific farming, SSF, this is also one term which is used. We also sometimes we use site specific management. It is not the same management. Or, same specific operations are to be done uniformly to the whole farm or whole field which was in practice. Still, we are

using. But, what I am telling when we talk of precision agriculture means we need to apply exactly what is the, at that particular location, particular management practices are to be adopted. Farming by foot means step by step you just go there and then do.

And so, whole field at some place means we need to give lower quantity of water, smaller quantity of water somewhere moisture content is very low. Suppose, whole field it is of various soil texture. Now, the whole field of 100 acre farm and you may find that 25 acre has got one type of soil another 25 acre has got another type of soil means there are 4 types of soil, it has got different texture.

It has got different nutrient requirements, different crops, and different types of diseases. So, naturally, variable rate technology is required to make the agriculture to happen precision way. So, this particular diagram when you see, this diagram, precision agriculture, it requires the data acquisition. This is the one very important component that is the data acquisition where the crops, soil, terrain, climate, all these data which are to be collected by using the precision instruments.

These precision instruments could be sensors. And then, they are to be put up in a data logger or in a server it is brought. And then, this information which is extracted from the server are stored in this. Then, it needs the processing. So, these data are processed or mapped properly at which place this particular information it is there. So, we will be using the data which will be ancillary data, data analysis. It is a geospatial data means your geo-statistical programming. And then, we will take appropriate decision. So, support system, we will apply the decision support system which will be economical. And then, a specific operations or management such as your irrigation, fertilization, crop production, such type of things which will be done. And then, so, all these operations which are involved as per the, depending on the, site specific condition that is a precision agriculture.

It involves as I told you it involves lot of things and the government of India is supporting for the digitalization of the information. So, digital agriculture, the precision agriculture is also known as a digital agriculture. Means, we are getting information, digitize the whole field what are the information it is available. So, digital technologies it has future. It can play a

very important transformation role in modernizing and organizing how rural India performs in agricultural activities.

So, this will involve artificial intelligence, this will involve the Big Data Analytics. It will involve Block-chain Technology. It will involve 3D Printing, IoT and other as they are developed. So, these information which were being used earlier in the industries or in other operations, now, in agriculture, these technologies have got importance. So, appropriate and time of operation, such technologies can lead to smart and the sustainable farming.

So, there exist various similar technologies where sample from the field gets converted into digital information, is promptly analyzed to provide accurate results, which then allows farmers or any crop growers to take decision best suited to the land they farm on. Means, where they this cultivation is being done. So, it has a very important role. Now, digitization program, digitizing rural areas, villages, this has come a very big way in modern agriculture. And, this should be utilized so as to the productivity can be increased and then resources can be effectively utilized.

So, what are the different steps involve in precision agriculture or precision farming? There is one part is that is whole field is to be monitored. Means data will be collected through assessing the variability, how much variability means, assessing the variability and reporting simultaneously with space and time. That is a variable assessment.

So, data are to be collected and how a small piece of land data are being collected and that is with space and time. So, spatial variability and temporal variability can be monitored. Managing variability, action according to the variability means, if there is a variation from the nutritional point of view whether how about the fertility point of view, how about the crop, and infestation it has got the pest infestation. Or, there is a deficiency due to soil moisture content. So, we need to take appropriate action. The success of precision farming or precision agriculture, it depends upon how precisely, soil fertility, pest information, crop management with respect to biotic and abiotic variables and water are managed in the field and also how accurately the corrective actions have been taken as a part of variability noticed in the field.

The basic purpose is this one we are assessing but we need to take appropriate action. Simply collecting data will not help. So, evaluation, once we are doing, we need to evaluate whether it is economically viable. So, assessment in terms of economic viability, maintenance of environment. That is one part means every time we cannot think say that it is not economically viable. There are indirect benefits that it comes in terms of environment.

So, one cannot notice when the over irrigation is being done and you are saving water. So, you have used some kind of irrigation system means the side effect are overuse of water or fertilizer that is polluting the water and that might one cannot think of that how it is dangerous. So, economic part may not be evaluated properly but environment point, social health point of view, and the water quality point of view. So, this needs to be another maintenance of environment that should be evaluated. Feasibility of technology transfer and benefit to the market mechanism needs proper evaluation then only we can say.

Now, there are several components which are you know our facilitator for implementation of precision agriculture. So, several components are there, different technologies which have come and this needs to be applied. Now, you can see here remote sensing. The remote sensing data means the data are being collected from the land surface by using satellite. Now, there could be normal means for operating data, getting data, we use polar orbiting satellites where the data are being collected in terms of the spatial point of view. That how small means spatial resolution point of view and then data are being collected. Temporally, how quickly we are getting the data and then second part is that what kind of the data we are looking for.

So, spectral resolution will give us information that the particular crop and then taking those digital data in different bands. And, analyzing these data by using appropriate remote sensing data processing technique is to be applied. Image processing technique will be applied. So, drones, you can see here the drones is being used for precision farming and then site specific management.

So, drones, sensors, one is the sensors which are already there in the platform, in the satellite or aerial, but there are sensors which could be on the ground. So, ground sensors as well as monitoring from the remote place. Those are the sensors which will be use. Then getting data

in different that is from the geospatial point of view. How the data are there making different themes different layers using the geographical information system and global positioning system that at what place what kind of action is to be taken that is by using the satellites..

There are 24 satellites which are there in the space for monitoring the position. So, location point of view, the type of data or information being collected. Then auto analyzer that is another thing. That computer and internet these are the facilitator. Means data will be analyzed and then we will transport the data, so internet, computer facilities, variable rate applicator and then getting data in different bands, analyzing them. So, Big Data Analysis, IoT that is Internet of Things, connecting things from one to other devices. That is Internet of Things. And then, Artificial Intelligence means using the techniques of mathematical techniques to analyze those data by using AI, robots for taking action. So, there are huge amount of the technologies which are in means associated with the precision agriculture and not all will be means I am prescribing. But, yes, these are the components which are being used for the precision agriculture.

So, let us try to know the different component. I told about the remote sensing. It is giving synoptic area that overall view of the whole field with the data could be in the form of spatial, multi spectral. So, this is one advantage that is for the different spatial resolution. Means, different sizes of the field and how small one can view that will reflect with the spatial data. Smaller pixels sizes that will give this from this spatial point of view. And then, multi spectral, getting data in multi spectral, multi band, multi spectral range. So, maybe data we need from the reflectance point of view. We may be interested to get data emitted point of view means temperature data. How? So, infrared data, when we are collecting infrared temperature data, you are getting, that would be another way.

So, it has got a good promise of precision farming or precision agriculture. Remote sensing measures data as I told you that in a multi spectral band, so, it could be visible or invisible properties of the field. And then, the information this is spatial information at what place what kind of a thing it exists. There are large number of now satellites in the space. Those are being used. These are our Indian satellites.

There are high precision and then low spatial resolution satellites are available which is now we are getting data in the order of less than a meter. Such data are available. So, these are the older satellite where these resolution was up to the order of 4 point means, the 23 meter P6 when we are talking that 23 meter. But now, the, there are satellite where the information is available up to 4 less than a meter. LANDSAT, which this is an American satellite and SPOT, is the satellite from this France; so, these satellites data are being used. And then, we also did work in the year 2009. Where it is given that should such work, it has been done and we will discuss in the coming lecture.

So, the drones, application of drones in precision agriculture, this technology has changed over time. And now, these drones are available means when I was telling about the spatial resolution, so, these are capable of collecting information up to the order of you can see 0.5 centimeter or as 5 millimeter to 10 centimeter resolution. So, each and every bit of the field information can be collected. So, this application of drone we call it as a UAV. That is unmanned aerial vehicle where the, this cameras of multi spectral bands are mounted on this particular thing and data are being collected. This is what you are seeing here. The data can be collected. And also, site specific application of the nutrient or chemical can be done at appropriate location instead of giving uniformly to all the fields.

So, drone can be used for conducting aerial survey. This is what I was telling you that yes data on the crop health, data on the soil nutrient, plant, and all kinds of information that can be collected. So, the difference in the land use, what is the crop loss? Or, what is the health of the crop? That image can be made. And then, we can integrate with the geographical information system in order to take the decision. Now, drones are being, it has got multi spectral data where thermal, visual as well as other sensor data it can be loaded in the drones and then data can be collected. Now, drones have been used for application of the chemical particularly pesticide as and where it is required. So, depending upon the sensors employed on the drone, various data can be captured to monitor the plant health index.

To monitor the plant counting means up to this level because I was telling you that up to 10 centimeter resolution means 0.5 to 10 centimeter resolution. So, one can find out, how many number of plants available there? What is the plant height measurement? Whether there is a

water shortage means chlorophyll measurement, nitrogen content, drainage mapping, and weed. How much is the weed infestation? Such type of data it is possible.

Sensors is the another means there are devices which are used to monitor the soil moisture content, soil temperature. GIS is the, another system where we can one can link the different layers can be made, soil, crop, weather, field history. There could be several models that can be used. And, this support the several components particularly GPS guided machines and GIS is used for precision farming.

GPS to find out the exact location in the field, where we are there and what kind of information it is available or a particular device it is taken. Tractor is taken. And then, one can apply the fertilizer or those things that is possible.

Now, information database, that information database, it could be on soil, it could be on crop and it could be on climate. So, there are several things which are there. So, you can see data analyzer, the land means it will be auto analyzer. It will give the information that, what is the land elevation? What is the soil moisture content? What is the nutrient status? What is the plant water? All kinds of this data, so, by auto analyzer, information can be generated.

This is a minimum thing which is needed when we are talking of digital agriculture. So, personal computer and internet these things are there. Variable rate applicator, this already I have explained you that this is the variable rate applicator. It means this is the instrument or it is the device which will be applying the particular chemical or giving the information that how much amount of water, how much amount of nutrient it can be given or herbicide can be given. So, basically, this is the information where this we will be getting based on the information we got from the GPS.

Big Data, as the name it says that there is a huge quantity of data from agriculture. We are being we are getting. So, data analytics provide the opportunity to systematize the large amount of widely dispersed data that is generated from agriculture or other allied activities. So, these data are to be integrated when after the analysis.

IoT as the name is says that Internet of Things. And basically, it means that internet interconnectivity of all the connectable things. So, this is important thing that it will connecting between people to people that is by IoT we can do, people to device and device to device. So, this is all involved in the IoT. So, this allows the things to digitally interact to trigger, take a particular action on the basis of usable information or predetermined flags.

AI that is the Artificial Intelligence, so, sensors provide data that can be used to automate a specific task on the triggers provided. So, AI it takes automation to another level by incorporating analysis and learning on the basis of the past and current data. So, there is a needs a several algorithms to be developed for taking decisions. So, this support the decision making process using the machine or digital learning processes. So, here, it involves data collection. Say, and then, it is brought say image processing. These data which is collected from using a specific device whether the multi spectral camera loaded on the drone the data are brought where the Artificial Intelligence will be applied to take decision.

So, human intelligence can take long or assimilate to stimulate the understand react to all the complex variables that comprise the uncertainty that agriculture is subject to. So, there are certain Artificial Intelligence, it helps to make better sense of inherent fuzzy data and rapidly put out answers from the extremely complex input. So, these are the operations which are performed. Then, robots and sensors, these are the other things which are used in agriculture. It has come in the in a big way in agriculture also. And particularly, in greenhouse operations, these are done.

Now, precision farming in context to irrigation water management. So, some work which has been done at Precision Farming Development Center, which there were 22 centers, which were supported by Ministry of Agriculture. And, being coordinated or monitored by the National Committee on Plasticulture Application in Horticulture and Ministry of Agriculture and Farmers Welfare, was funding these projects. So, here the work which has been done in this field, some of the results related to precision agriculture and it is related to application of micro irrigation for giving appropriate amount of water and fertilizer. This has been presented here.

So, Precision Farming Development Center as I told you, these centers are located in varied agro-climatic regions, ICAR, say at IIT Kharagpur which I was heading this particular center and then State Agricultural Universities. So, altogether, there were 22 centers. By using the long time research experiments, they establish the water requirement as well as fertigation requirement of various crops. So, the studies which has been carried out at IIT Kharagpur on these crops, we establish the water requirement under drip irrigation system of Mango, Guava, Pineapple, Banana, Cabbage, Cauliflower, Tomato, Okra and so this is the variation in the water requirement from the early stage to the peak growth stage. These values are useful when we are applying precision farming technologies.

Similarly, we also established the month wise or weekly in fact daily values were estimated. And then, we got the results. And then, the results which gave best output, only that particular amount of water it has been digitalized and then given to this crop. So, you can see Banana is a 1 year crop. And, these are the values of amount of water to be given in different months. That is the daily amount of water in liter to be given. Similarly, for the Pineapple, Tomato, these are the vegetable crop. Tomato, Okra, Potato, and Cabbage. And then, Guava and Mango, these are the fruit crops. So, we established water requirement of these crops.

Then, we also, means, these studies were carried out by these centers for the variety of crops. Only few crops we are listing here where the fertigation dose say Broccoli which was irrigated by using the drip irrigation and fertigation was given. This study was carried out at PFDC, IARI in New Delhi. And then, these are the recommended doses and that every 15 days after the transplanting which give the best result. And, this particular crop was planted in October to March. Then, another crop that is a fruit crops. This study was carried out at IIT Kharagpur. And then, we also carried out, recommended the dose of fertilizer by using the drip irrigation system. So, this is the, another precision farming technology has been applied.

Then, the other crop you can see here. It is a Carnation. The study has been done at MPKV, Rahuri. The crop it took about 24 to 36 months. And here, the NPK values, that is nitrogen, phosphorus and potassium, these values, their doses has been recommended and these were given. So, another study it is carried out on the Capsicum crop by Central Institute of

Agricultural Engineering, Bhopal located in Bhopal for the drip irrigation and fertigation. So, there also, the, this recommendation has been given.

So, the purpose of giving you this information that one can apply water as well as fertilizer based on the requirement in the field. So, if this field is having the differential amount of nutrient status and soil moisture status then drip irrigation or micro irrigation, it will be applied and depending on the requirement.

The, another study which we did at Tarafeni South Main Canal command where normally irrigation it is being done uniformly. So, here, our purpose was to establish the spatial variation because the crop means farmers they do not sow the crop at the same time. There will be difference maybe 15 to 20 days or even to a, sometime it is 1 month in the delay. So, the amount of water to be given, it will have the different values. So, this particular study was carried out by Dr. N. K. Gontia. So, here, it is done at Tarafeni Main Canal command of Kangsabati River. We tried to found out from the spectral data NDVI that is Normalized Difference Vegetation Index and the Soil Adjusted Vegetation Index by using the satellite data.

The data were from IRS P6 where the 4 means wide field sensor WiFS data of the different months during winter season. This period it was done. And then, from those data, the Kc as well as the NDVI values relationship was established. So, between the NDVI and the crop coefficient established by FAO that is Food and Agriculture Organization, they have recommended the values. So, we established and then established relationship. This was using the NDVI. This is using the SAVI value.

So, you can see here. These are the monthly distributed spatially distributed crop coefficient. So, for December, this is for January. This is for February. Like this, and then, March. So, when we are getting the values of the crop coefficient which is changing with space, so, this is the spatially distributed crop coefficients. So, it means, if ETo is same for the whole area, then we can find out the ETc. So, that will be the spatially distributed ETc, similarly, SAVI also. So, NDVI as well as for SAVI, we establish. Then, we establish the ETc. As I told you that we establish ETc by that is ETc is your evapotranspiration requirement of the crop. So,

the monthly spatially distributed actual crop evapotranspiration that is Kc based on the SAVI values. That maps of the wheat crop, the study was published in the year 2009 in the journal. So, this information generated was used to supply appropriate amount of water at different locations of irrigation command as per the actual the crop water requirement.

A considerable amount of water that could be saved besides application efficiency of the canal system. So, similarly, fertilizers and other input resources can be applied which can save the water. So, similar kind of studies for the horticultural crops can be also done where the spatial variability of evapotranspiration requirement, fertilizer requirement can be done.

So, this is the entire detail of the data which we analyzed that how much amount of water that can be estimated that can be planned. So, you can see here the ETc value for the whole year means crop season. That is from December to the March. And then, the amount of water that total amount of water that can be estimated.

So, when we are talking about the precision agriculture, it has some no doubt there are some constant it be particularly from Indian context. We have a small land holding. And then, our socio economic status of the farmers Indian farmers is not that strong. But, it has lot of potential that can be applied because, now, there are several farmers they are interested to work together. They are farming cooperative. So, using the cooperative, such technologies these are possible to apply. Lack of success stories, this is another part that farmers can be convinced when we are giving the Benefit Cost Ratio. Knowledge and technology gap, there is, then the crop, farmer they do not grow same crop in the whole area so, that heterogeneity in the cropping system.

That is another part to implement precision agriculture. Lack of market when the produce is coming of very high quality, then market they do not get. So, there are some local and technical expertise that is also lacking. And then, the lack of data availability in terms of quality and cost and so. These instrument when we are talking, it will be useful for them.

So, these are the references one can use for this particular topic to refer for getting more detail.

So, in this particular lecture, we discussed about precision agriculture. We discussed about different components of precision agriculture and then the importance of digital farming technologies and how micro irrigation is relevant in precision farming or precision agriculture. In forthcoming lecture, we will be concluding this particular course of Micro Irrigation Engineering. So, we will discuss in the forthcoming lecture. Thank you very much.