

Practical Manual
B. Sc. (Hons.) Agriculture
Geoinformatics and Nanotechnology for Precision Farming
Course Code: ASAG3110
Course Credits: 2(1+1)
Semester: 5th



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Shaping Lives...
Empowering Communities...

Department of Agronomy and Agroforestry
M. S. Swaminathan School of Agriculture
Centurion University of Technology and Management, Paralakhemundi
www.cutm.ac.in

June, 2022

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Certificate

Certified that this is a bonafide record of practical work done by

Mr./ Ms. _____

Regd. No. _____ in B. Sc. (Hons.) Agriculture degree programme,

***Course No. ASAG3110 entitled “Geoinformatics and Nanotechnology for Precision
Farming” during 5th semester of the academic year 2022-23.***

Date:

Faculty In charge

Evaluation System
Geoinformatics and Nanotechnology for Precision Farming
Course Code: ASAG3110

Sl. No.	Marks distribution*	Total marks	Marks obtained
1	Record	5	
2	Attendance	5	
3	Field performance	15	
Total (25 marks)			

Signature of Faculty In-charge

List of Experiments

Exp. No.	Date of Exp.	Date of Submission	Title	Page No.	Signature	Remark
1			Introduction to GIS Software, Spatial Data Creation and Editing			
2			Visual and digital interpretation of remote sensing images			
3			Generation of spectral profiles of different objects			
4			Supervised and unsupervised classification			
5			Multispectral remote sensing for soil mapping			
6			Creation of soil fertility map using GIS			
7			Creation of productivity and management zones			
8			Fertilizer Recommendation using STCR			
9			Fertilizers recommendations based of Variable Rate Technology			
10			Crop stress (biotic/abiotic) monitoring using geospatial technology			
11			Use of GPS for agricultural survey			
12			Formulation and characterization of nano-particles			
13			Applications of nanoparticles in agriculture			
14			Project Formulation and Execution Related to Precision Farming			

Introduction to GIS Software, Spatial Data Creation and Editing**1.1 Aim**

To gain basic understanding on QGIS software and handling of spatial data.

1.2 Introduction

Quantum GIS (QGIS) is a user friendly Open Source GIS application licensed under the GNU General Public License. QGIS is an official project of the Open Source Geospatial Foundation (OSGeo). It runs on Linux, Unix, Mac OSX, Windows and Android and supports numerous vector, raster, and database formats and functionalities. Like all GIS applications, QGIS provides a graphical user interface allowing display of map layers and manipulation of data for analyses and map-making. A Geographical Information System (GIS) is a collection of software that allows you to create, visualize, query and analyze geospatial data. Geospatial data refers to information about the geographic location of an entity. This often involves the use of a geographic coordinate, like a latitude or longitude value. Spatial data is another commonly used term, as are: geographic data, GIS data, map data, location data, coordinate data and spatial geometry data.

1.3 Installation of QGIS software

- 1) Open your browser and reach the official QGIS website using the link given below (<https://www.qgis.org/en/site/forusers/download.html>)
- 2) Select “**All Releases**” tab present on the interface of QGIS webpage
- 3) Click on “**Previous releases of QGIS are still available here**” and then select the version of QGIS as per your choice
- 4) Prefer the latest version QGIS 3.10.9 “A Coruna”
- 4) You browser will download the file to the browsers default download directory.
- 5) Hit the run button to start the installation process and follow the prompts. There is no need to install the data sets suggested by QGIS.
- 6) Please go through the license agreement and click on the button> I agree and proceed with the installation as shown in the screen.

7) As the software is very heavy it is advisable to install it in the different drive other than the windows drive. As per our example, we will be installing in QGIS folder on D:\ drive and create a desktop shortcut for easy access

8) After browsing the folder click the Next button and proceed with the installation

11) By default QGIS component is selected. Do not install any other data set at this point. Click Install to proceed with installation.

12) You will see the progress of the installation on the screen.

13) Please reboot your machine once the installation is completed. Click finish to complete the installation

14) After machine is restarted, type QGIS on Run and open QGIS Desktop 3.10.9.



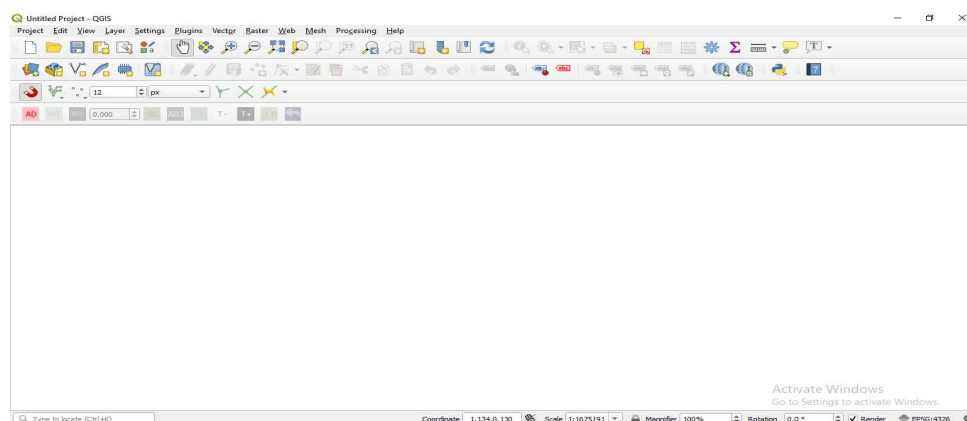
1.4 Opening an installed QGIS

1) Open the QGIS 3.10.9 folder on your desktop

2) Select QGIS Desktop 3.10.9. and open it by double clicking.

3) Open “New empty project”

4) QGIS user interface is given in the figure below



- 5) Select View>>Panels>>Layer
- 6) Select View>>Panels>>Browser
- 7) After selecting both layer and browser panels the QGIS workspace is ready to use

1.5 Steps to create a new Shapefile layer

- 1) Select “layer” tab from the menu bar
- 2) Go to Create layer>>New Shape file layer
- 3) The interface consists of File name, File encoding, Geometry type and New field
- 4) Browse the folder where you want to store the created shape file as File name
- 5) Select the File encoding as UTF-8 (Unicode Transformation Format)
- 6) Select the geometry type (point/multipoint/polygon/line)
- 7) Select the world geodetic system of your region
- 8) Add fields to the shape file by providing the name, type of data and length of characters
- 9) Select ok
- 10) To edit new geometry feature in the QGIS workplace click on “Toggle editing”
- 11) Then select the geometry feature to be added
- 12) Add the geometry feature and enter the data under the respective fields created

1.6 Steps to download spatial data

- 1) Visit <https://www.diva-gis.org/>
- 2) Select “Free spatial data”
- 3) Click on “country level data”
- 4) Select your country and add your subject of interest
- 5) Click on “ok”
- 6) Extract the data downloaded as a zip file into a folder

1.7 Symbology and Labeling

- 1) Browse the downloaded shapefiles of our country
- 2) Add the shape files as layers
- 3) Select the layer where you want to add labels and do symbology
- 4) Right click on that layer
- 5) Go to attribute table and identify the name of column based on which labeling and symbology is planned
- 6) Now go to properties option from a drop down menu appeared by right clicking the layer again
- 7) Labelling>>Single labels>>value (select the column name from the attribute table)>>ok
- 8) Symbology>>Categorized>> value (select the column name from the attribute table)>>Classify>>ok

1.8 Observations

1.8.1 Enlist the steps to create a shape file with point feature?

1.8.2 Enlist the steps to create a shape file with line feature?

1.8.3 Enlist the steps to create a shape file with polygon feature?

1.9 Conclusion:

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Visual and digital interpretation of remote sensing images.**2.1 Aim**

1. To intercept remotely sensed image data visually
2. To intercept the remotely sensed image data digitally

2.2 Introduction

Image processing and interpretation can be defined as the act of examining images for the purpose of identifying objects and judging their significance. Image analyst study the remotely sensed data and attempt through logical process in detecting, identifying, classifying, measuring and evaluating the significance of physical and cultural objects, their patterns and spatial relationship.

Interpretation is the processes of detection, identification, description and assessment of significant of an object and pattern imaged. The method of interpretation may be either visual or digital or combination of both. Both the interpretation techniques have merits and demerits and even after the digital analysis the output are also visually analysed.

The ability of human to identify an object through the data content in an image/photo by combining several elements of interpretation. There are two types of extraction of information from the images/photographs namely:

1. Visual interpretation
2. Digital interpretation

2.3 Visual interpretation

Analysis of remote sensing imagery involves the identification of various targets in an image, and those targets may be environmental or artificial features which consist of **points, lines or areas**. Targets may be defined in terms of the way they reflect or emit radiation. This radiation is measured and recorded by a sensor, and ultimately is depicted as an image product such as an **air photo or a satellite image**. Indeed, interpretation benefits greatly in many applications when

images are viewed in stereo, as visualization (and therefore, recognition) of targets is enhanced dramatically. Viewing objects from directly above also provides a very different perspective than what we are familiar with. Finally, we are used to seeing only the visible wavelengths, and the imaging of wavelengths outside of this window is more difficult for us to comprehend. Recognizing targets is the key to interpretation and information extraction. Observing the differences between targets and their backgrounds involves comparing different targets based on any, or all, of the visual elements of **tone, shape, size, pattern, texture, shadow and association**. Visual interpretation using these elements is often a part of our daily lives, whether we are conscious of it or not. Examining satellite images on the weather report or following high speed chases by views from a helicopter are all familiar examples of visual image interpretation. The nature of each of these interpretation elements is described below, along with an image example of each.

The basic elements are shape, size, pattern, tone, texture, shadows, location, association and resolution

Shape: The external form, outline or configuration of the object.

Size : This property depends on the scale and resolution of the image/photo. Smaller feature will be easily indented in large scale image/photo.

Pattern: Spatial arrangement of an object into distinctive recurring forms.

Shadow: Indicates the outline of an object and its length which is useful in measuring the height of an object. The shadow effect in Radar images is due to look angle and slope of the terrain. Taller features cast larger shadows than shorter features.

Tone: Refers to the colour or relative brightness of an object. The tonal variation is due to the reflection, emittance, transmission or absorption character of an objects. This may vary from one object to another and also changes with reference to different bands. In General smooth surface tends to have high reflectance, rougher surface less reflectance.

Infrared imagery: Healthy vegetation reflects Infrared radiation much more stronger than green energy and appears very bright in the image. A simple example is the appearance of light tone by vegetation species and dark tone by water. Particularly in thermal infrared images the brightness tone represents warmest temperature and darkness represent coolest temperature.

Radar Imagery : Smooth surfaces reflect highly and area blocked from radar signal and appear dark. Bridges and cities show very bright tone, on the contrary calm water, pavement and dry lake beds appears very dark tone.

Texture: The frequency of tonal change. It creates a visual impression of surface roughness or smoothness of objects. This property depends upon the size, shape, pattern and shadow.

Location Site : The relationship of feature to the surrounding features provides clues to words its identity.

Resolution: It depends upon the photographic/imaging device namely cameras or sensors. This includes of spectral and spatial resolutions. The spectral resolution helps in identifying the feature in specific spectral bands. The high spatial resolutions imagery/photographs is useful in identifying small objects

2.4 Digital interpretation using Semi-Automatic Classification Plugin in QGIS

In today's world of advanced technology where most remote sensing data are recorded in digital format, virtually all image interpretation and analysis involves some element of digital processing. Digital image processing may involve numerous procedures including formatting and correcting of the data, digital enhancement to facilitate better visual interpretation, or even automated classification of targets and features entirely by computer. In order to process remote sensing imagery digitally, the data must be recorded and available in a digital form suitable for storage on a computer tape or disk. Obviously, the other requirement for digital image processing is a computer system, sometimes referred to as an image analysis system, with the appropriate hardware and software to process the data. Several commercially available software systems have been developed specifically for remote sensing image processing and analysis.

In this section digital interpretation using Semi-Automatic Classification Plugin in QGIS has been explained in brief

2.4.1 Installation of Semi-Automatic Classification Plugin in QGIS

- Open QGIS software
- Select plugins from the menu bar
- Select manage and install plugins from the drop down menu
- Search for semi-automatic classification plugin and Install

2.4.2 Image clipping

- Drag and drop Landsat 8 images (Band1 to 7) from browse panel
- Open SCP plugin
- Select band set from the drop down menu
- Click on refresh button to load all the bands present in layers button
- Select all the bands loaded and add them to band set
- To crop the region of interest go to pre-processing tab
- Select an option “clip multiple rasters”
- Select input band set
- Click and select “set area in the map”
- Then select the ROI from the map and tap on run button
- Designate a path to store these clipped images

2.4.3 Pre-processing of images based on reflectance

- Open clipped bands in the layers panel
- Open SCP and refresh the band set with clipped band and them to the band set after deleting the previous bands by resetting
- Select the Landsat 8 OLI from the quick wavelength settings
- Select the pre-processing tab from SCP and select Landsat
- Select the directory containing Landsat bands
- Select MTL files from the original folder where Landsat images are downloaded
- Apply DPS 1 atmospheric correction
- Click on RUN

- Remove all the clip bands from the layers panel and transfer the reflectance bands created into the SCP bandset

2.4.4 Image composite selection

- Select the band combination as per our requirement
- This creates a virtual band set

Composite Name	Bands
Natural Color	4-3-2
False Color (urban)	7-6-4
Color Infrared (vegetation)	5-4-3
Agriculture	6-5-2
Healthy Vegetation	5-6-2
Land/Water	5-6-4
Natural with Atmospheric Removal	7-5-3
Shortwave Infrared	7-5-4
Vegetation Analysis	6-5-4

2.7 Observations

2.7.1 Enlist the steps involved in downloading Landsat 8 images?

2.7.2 Write down the importance of image pre-processing in Image analysis?

2.8 Conclusion

Signature of Faculty In-charge

Generation of spectral profiles of different objects

3.1 Aim

To extract spectral signatures of different objects using SCP plugin in QGIS

3.2 Introduction

Every natural and artificial object reflects and emits electromagnetic radiation over a range of wavelengths in its own characteristic manner, according to its chemical composition and physical state. The reflectance values for different objects, over a range of wavelengths, may be plotted for comparison. Such plots are called “spectral response curves” or “spectral signatures.” Spectral signatures can be defined as emittance and unique reflectance properties of target for various conditions. Differences among spectral signatures of landscape features are used to help classifying remotely sensed images, since the spectral signatures of similar features have similar shapes.

Multispectral imagery is a powerful tool for distinguishing different types of materials and features in the landscape. Natural and man-made materials often have unique spectral signatures that can be used to identify them quantitatively. Spectral profile charts allow you to select areas of interest or ground features on the image and review the spectral information of all bands in a chart format. A spectral profile consists of geometry to define the pixel selection and an image with key metadata from which to sample.

3.3 Steps to generate spectral profiles

- Install SCP plugin
- Browse the reflectance bands created in experiment 2 from its respective folder
- Add the reflectance bands to the layers panel
- Open SCP plugin and add the reflectance bands to the band set
- Close the SCP plugin
- Open SCP Dock
- Create new training input by designating a path to store the input

- Select create a ROI (region of interest) polygon and define various objects in the image to form a temporary ROI
- Define macro-class and class for every object selected
- Select save temporary ROI to training input to create a permanent ROI
- Highlight the ROI with same macro class and class ID merge their highlighted spectral signatures obtaining the average signature
- Highlight all the objects in the training input created and click to calculate signatures for highlighted items
- Add highlighted signatures to spectral signature plot

3.4 Conclusion

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Supervised and unsupervised classification

4.1 Aim

To learn image classification using QGIS

4.2 Introduction

Different landcover types in an image can be discriminated using some image classification algorithms using spectral features, *i.e.* the brightness and colour information contained in each pixel. Classification procedures can be “supervised” or “unsupervised”.

In unsupervised classification, the computer program automatically groups the pixels in the image into separate clusters, depending on their spectral features. Each cluster will then be assigned a landcovers type by the analyst.

In Supervised classification, the spectral features of some areas of known landcovers types are extracted from the image. These areas are known as training areas. Every pixel in the whole image is then classified as belonging to one of the classes depending on how close its spectral features of the training areas.

4.3 Unsupervised classification in QGIS

- Install SCP plugin
- Add band data set of landsat image to layers panel
- Go to SCP and select show plugin
- Perform layer stacking and create a raster of the bandset by clicking on “RUN”
- The QGIS program automatically groups the pixels in the image into separate clusters
- This can be viewed by selecting different band combinations for different types of landcover

Composite Name	Bands
Natural Color	4-3-2
False Color (urban)	7-6-4
Color Infrared (vegetation)	5-4-3
Agriculture	6-5-2
Healthy Vegetation	5-6-2
Land/Water	5-6-4
Natural with Atmospheric Removal	7-5-3
Shortwave Infrared	7-5-4
Vegetation Analysis	6-5-4

4.4 Supervised classification in QGIS

- Install SCP plugin
- Add band data set of landsat image to layers panel
- Go to SCP and select show plugin
- Perform layer stacking and create a raster of the bandset by clicking on “RUN”
- Open SCP Dock and click on training input
- Designate the path to store the training input
- Select “Create ROI polygon” to pick training sites from the picture and name them
- Merge all the similar training sites of the same macro class, if desired
- Select classification tab and choose minimum distance algorithm and “RUN”
- Provide the path to save the classified product
- The colours assigned can be changed by making changes in the image symbology

4.5 Conclusion

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Multispectral remote sensing for soil mapping

5.1 Aim

To get well acquainted with use of multispectral remote sensing for soil mapping

5.2 Introduction

Remote sensing involves the acquisition of visible, near infrared and short wave infrared images in several broad wavelength bands and differentiating materials by their spectral reflectance signatures. Different materials reflect and absorb differently at different wavelengths. As such, it is possible to differentiate among materials by their spectral reflectance signatures as absorbed in these remotely sensed images.

5.3 Multispectral imagery

Multispectral imaging captures image data within specific wavelength ranges across the electromagnetic spectrum including light from frequencies beyond the visible light range, i.e. infrared and ultra-violet. In general, Multispectral imaging measures light in a small number (typically 3 to 15) of spectral bands.

An example of a multispectral sensor is **Landsat-8** which produces 11 images with the following bands:

- **COASTAL AEROSOL** in band 1 (0.43-0.45 μm)
- **BLUE** in band 2 (0.45-0.51 μm)
- **GREEN** in band 3 (0.53-0.59 μm)
- **RED** in band 4 (0.64-0.67 μm)
- **NEAR INFRARED (NIR)** in band 5 (0.85-0.88 μm)
- **SHORT-WAVE INFRARED (SWIR 1)** in band 6 (1.57-1.65 μm)
- **SHORT-WAVE INFRARED (SWIR 2)** in band 7 (2.11-2.29 μm)
- **PANCHROMATIC** in band 8 (0.50-0.68 μm)
- **CIRRUS** in band 9 (1.36-1.38 μm)
- **THERMAL INFRARED (TIRS 1)** in band 10 (10.60-11.19 μm)
- **THERMAL INFRARED (TIRS 2)** in band 11 (11.50-12.51 μm)

5.4 Factors that influence the reflectance behavior of the soil

- **Soil colour**
- **Mineral Content**
- **Organic matter: Less decomposed OM has high reflectance in NIR**
- **Particle size**
- **Soil texture**
- **Soil Structure and roughness**

5.5 Observations

1. Explain in detail the role of multispectral imagery in preparation of digital soil maps?

2. Enlist open source multispectral sensors?

5.6 Conclusion

Signature of Faculty In-charge

Creation of soil fertility map using GIS

6.1 Aim

To provide hands on experience in creating a soil fertility map

6.2 Introduction

The digital soil map is a raster-based map composed of 2-dimensional cells (pixels) organized into a grid in which each pixel has a specific geographic location and contains soil data. Digital soil maps illustrate the spatial distribution of soil classes or properties and can document the uncertainty of the soil prediction. Digital soil mapping better captures observed spatial variability and reduces the need to aggregate soil types based on a set mapping scale

6.3 Acquiring soil map data

- Open browser
- Search for FAO digital soil map (<https://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/faounesco-soil-map-of-the-world/en/>)
- Select digital soil map of the world
- Download Digital Soil Map of the World - ESRI shapefile format, PDF format and KML file
- Open QGIS software
- Go to layer menu and add Digital Soil Map of the World in ESRI shapefile format
- Save the added shapefile by selecting save features as from the drop down menu and indicate its CRS (WGS 84)

6.4 Customizing the data for our region of interest

- Open attribute table
- Select features using an expression to select ROI
- Open fields and values
- Select country of interest
- Right click on the layer
- Save selected features only

- Provide file name and run
- Select properties of the customized shapefile
- Go to symbology and classify based on the soil type

6.5 Creation of soil map

- Go to project
- Select new print layout
- Right click on the blank sheet and select page properties
- Select add map from the drop down menu produced by clicking on add item
- Add labels and select add legends from the add item tab
- Click on save and go to layout to export the map

6.6 Conclusion

Signature of Faculty In-charge

Creation of productivity and management zones

7.1 Aim

To create productivity zones to assist in future management decisions

7.2 Introduction

Productivity zones are areas in a field with different yield history. The area with the highest harvest in the field for several seasons is considered a high productivity zone. There are also low and moderate productivity zones.

They are mainly needed to assess field homogeneity, to implement variable rate technology and to identify problems in the field.

7.3 Steps to create a land productivity map

- Open QGIS
- Install a plugin trends.earth
- Open calculate indicators
- Select land degradation indicator
- Select “use customized date-productivity”
- Change NDVI data set to MODIS13Q1
- Go to advanced tab in the menu bar
- Select trajectory indicator as NDVI trend and designate starting and ending year
- Check performance and designate starting and ending year
- Check state and designate initial and comparison period
- Go to area tab
- Select region/city/point/area from file
- Then go to next tab “options”
- Enter the file name and click on continue
- Select “view google earth engine taks”
- Then click on refresh list
- Select the file name entered in the options tab of calculate indicators
- Click on download file
- Land productivity map is created

7.4 Conclusion

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Fertilizer Recommendation using STCR**8.1 Aim**

To prescribe fertilizer doses for a given crop based on soil test values to achieve the “Targeted yields” in a specific soil agro-climatic region considering the efficiency of utilization of soil and added fertilizer nutrient by the crops.

8.2 Introduction

STCR approach is aiming at obtaining a basis for precise quantitative adjustment of fertilizer doses under varying soil test values and response conditions of the farmers and for targeted levels of crop production. These are tested in follow up verification by field trials to back up soil testing laboratories for their advisory purpose under specific soil, crop, and agro climatic conditions.

The STCR concept was developed by Ramamoorthy and his co-workers in 1967. STCR provides the relationship between a soil test value and crop yield.

8.3 Essential Parameters to develop fertiliser prescription equations**1) Nutrient requirement (NR) kg/q**

$$\text{NR (kg/q)} = \frac{\text{Total uptake of N or P2O5 OR K2O}}{\text{Grain yield (q/ha)}}$$

2) Per cent contribution of nutrients from soil to total nutrient uptake (Cs)

$$\text{Cs (\%)} = \frac{\text{Total uptake of N or P2O5 or K2O in control plot}}{\text{Soil test value for available N or P2O5 or K2O in control plot}} \times 100$$

3) Per cent contribution of nutrients from fertilizer to total uptake (Cf)

$$\text{Cf (\%)} = \frac{[\text{Total uptake of N or P2O5 in treated plot}] - [\text{Soil test values in treated plot} \times \text{Cs}]}{\text{Fertilizer N or P2O5 or K2O applied in treated plot}} \times 100$$

4) Percent contribution of nutrients from organic manure to total uptake (Co) Percent contribution from FYM (Cfym)

$$\text{Cfym (\%)} = \frac{[\text{Total uptake of nutrients in FYM treated plot}] - [\text{Soil test value for available NPK in FYM treated plot} \times \text{Cf}]}{\text{Nutrient added through FYM}} \times 100$$

Fertilizer Prescription Equations

1) Fertilizer Nitrogen (FN)

$$\text{FN (kg/ha)} = \frac{\text{NR}}{\text{Cf}/100} \text{T} - \frac{\text{Cs}}{\text{Cf}} \text{SN} - \frac{\text{Cfym}}{\text{Cf}} \text{ON}$$

2) Fertilizer phosphorus (FP2O5)

$$\text{FP2O5(kg/ha)} = \frac{\text{NR}}{\text{Cf}/100} \text{T} - \frac{\text{Cs}}{\text{Cf}} \times 2.29 \times \text{SP} - \frac{\text{Cfym}}{\text{Cf}} \times 2.29 \times \text{OP}$$

3) Fertilizer potassium (FK2O)

$$\text{FK2O(kg/ha)} = \frac{\text{NR}}{\text{Cf}/100} \text{T} - \frac{\text{Cs}}{\text{Cf}} \times 1.21 \times \text{SK} - \frac{\text{Cfym}}{\text{Cf}} \times 1.21 \times \text{OK}$$

where, FN, FP2O5 and FK2O are fertilizer N, P2O5 and K2O in kg/ha , respectively; NR is nutrient requirement (N or P2O5 or K2O) in kg/q , Cs is per cent contribution of nutrients from soil, Cf is per cent contribution of nutrients from fertilizer, Cfym is percent contribution of nutrients from FYM, T is the yield target in q/ha ; SN,SP and SK respectively are alkaline KMnO4-N, Olsen-P and NH4OAc-K in kg ha-1 and ON, OP and OK are the quantities of N, P and K in kg/ha supplied through FYM.

Problem 1

8.4 Conclusion

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Fertilizers recommendations based of Variable Rate Technology**9.1 Aim**

To recommend fertilizers based on variable rate application (VRA)

9.2 Introduction

Variable rate application is a method of applying varying rates of inputs in appropriate zones throughout a field. The goals of VRA are to maximize profit to its fullest potential, create efficiencies in input application, and ensure sustainability and environmental safety. There are a variety of VRA technologies available that can be used with or without a GPS system. The two basic technologies for VRA are: map-based and sensor-based.

9.2.1 Map based VRA

Map based VRA adjusts the application rate based on an electronic map, also called a prescription map. Using the field position from a GPS receiver and a prescription map of desired rate, the concentration of input is changed as the applicator moves through the field.

9.2.2 Sensor based VRA

This requires no map or positioning system. Sensors on the applicator measure soil properties or crop characteristics “on the go.” Based on this continuous stream of information, a control system calculates the input needs of the soil or plants and transfers the information to a controller, which delivers the input to the location measured by the sensor

9.3 Steps to apply fertilizers through map based VRA

To develop a plan for variable-rate fertilizer application in a particular field, the map-based method could include the following steps:

- Perform systematic soil sampling (and lab analysis) for the field
- Generate site-specific maps of the soil nutrient properties of interest
- Use some algorithm to develop a site-specific fertilizer application map

- Use the application map to control a variable-rate fertilizer applicator

A positioning system is used during the sampling and application steps to continuously know or record vehicle location in the field. Differentially-corrected Global Positioning System (DGPS) receivers are the most commonly used positioning devices.

9.4 Advantages of Map-Based Variable-Rate Application

- Systems are already available for most crop production inputs
- The user has a database that can be useful for a number of management-related activities
- The user can employ multiple sources of information in the process of formulating a variable-rate application plan
- The user has significant control regarding the function of such systems because of the involvement in application rate planning
- Field travel speeds need not be reduced

9.5 Steps to apply fertilizers through Sensor based VRA

- The sensor-based method utilizes sensors to measure the desired properties, usually soil properties or crop characteristics
- Measurements made by such a system are then processed and used immediately to control a variable rate applicator
- This method neither requires the use of a DGPS system nor extensive data analysis prior to making variable-rate applications

9.6 Advantages of Sensor-Based Variable Rate Application

- Pre-application data analysis time requirements can be eliminated
- Sensors produce far higher data resolution than traditional sampling methods
- No time delay between measurement and application with real-time systems
- Systems are self-contained

9.7 Conclusion

Signature of Faculty In-charge

Crop stress (biotic/abiotic) monitoring using geospatial technology**10.1 Aim**

To get acquainted with geospatial technology for crop stress

10.1 Introduction

The spectral characters of the vegetation are governed primarily by scattering and absorption characteristics of the leaf internal structure and biochemical constituents, such as pigments, water, nitrogen, cellulose and lignin. Pigments are the main determinants controlling the spectral responses of analysis of crop condition assessment using geospatial technique.

Chlorophyll pigment content is directly associated with photosynthetic capacity and productivity. Reduced concentration of chlorophyll is indicative of plant stress. Consequently, healthy vegetation shall have higher NDVI value.

$$\text{Normalized Difference Vegetation Index (NDVI)} = \frac{\text{NIR} - \text{RED}}{\text{NIR} + \text{RED}}$$

10.2 Steps to calculate NDVI of Landsat Image

- Download Landsat image bandset from USGS earth explorer
- In Landsat image “Band 5” represents “NIR wavelength” and “Band 4” represents “Red wavelength”
- Select Raster in the menu bar
- Open up the Raster calculator from the drop down menu
- Fit the NDVI formula in the Raster calculator expression
- Specify the output layer
- Click OK
- Classify the NDVI image layer by selecting the properties
- Further, select symbology and choose single band pseudocolour
- Apply and click OK

10.3 Conclusion

Signature of Faculty In-charge

Experiment No. 11

Date: _____

Use of GPS for agricultural survey.

11.1 Aim

1. To learn about functioning of GPS
2. To learn how to use GPS in agricultural survey

11.2 Introduction

The availability of reliable estimates of crop area is an important requirement agricultural statistics system of any country as this variable is an important parameter for estimating the production, along with crop yield. These three variables area, yield and production are the minimum set of key indicators required for planning, monitoring and evaluating agricultural and rural development programmes necessary to achieve food security.

Different methods are currently used for collecting crop area data viz., field reporting system, eye estimation, interviewing of the farmers, objective measurement methods etc. However, all these methods have their limitations in terms of reliability of crop area data, but the objective method of measuring areas is considered to be the most reliable method. The major limitation in area measurement is shape of the fields, which is not always polygonal but often a curvilinearly closed. This to be reduced to a polygon with a small number of sides (e.g. less than 20) of an equivalent area. Measuring errors, the another drawback either introduced by the surveyor or inherent to the equipment used can be overcome by using tools like GPS.

The use of handheld geo-referencing devices (Global Positioning System) is also emerging as an effective means of reducing the cost of crop area data collection and improving crop area data quality.

11.3 Global Positioning System

In most of cases, land parcels and crop fields, have irregular boundary lines which are not straight lines. With the emergence of the new handheld geo-positioning and mapping devices such as the Global Positioning System (GPS) new perspectives exist as viable alternative to cumbersome distance and angle measurement.



The Global Positioning System (GPS) is a satellite based radio navigation system formed by a constellation of 24-29 satellites and ground based stations, which can be used to locate positions anywhere on the earth by measurement of ranges to the satellites. GPS provides continuous (24hours/day), real-time, 3-dimensional positioning, navigation and timing worldwide in any weather condition.

11.4 Working principle of GPS

The GPS system consists of three segments:

11.4.1 Space segment: The space segment consists of 24 satellite vehicles with six orbits. Each orbit has four satellites at the altitude of approximately 20200 km. These six planes are approximately inclined at 55 degrees with respect to the earth's equatorial plane. Due to this configuration, 4 – 12 satellites are visible to any place on the earth at any time.

11.4.2 Control Segment: The control segment is having five control stations which are capable of tracking all GPS satellites. The Master control station contacts each satellite regularly and synchronizes the atomic clocks on board and also applies orbital model corrections.

11.4.3 User Segment: The user community who uses GPS as a tool includes civilians and military users with their antennas, receivers and other processors.

The kinds of GPS devices commonly used are: Garmin 12 xl (G12), Garmin 72 (G72), Garmin 60 (G60) Garmin-trex10, Garmin e-trex20, Garmin e-trex30, Magellan Explorist 400 (M400). Garmin Etrex.

11.5 Over view of Garmin eTrex device:

There are six buttons on your eTrex 10,20, or 30 which are

1. The Power/ Backlight Button
2. The Click-Stick Button
3. The Back Button
4. The Zoom-out Button
5. The Zoom-in Button
6. The Menu Button



Figure 2: The Garmin e Tex 10

- The Power button is the button that turns GPS receiver on and off.
- The Click-Stick (mouse): The Click-Stick is very similar to a computer mouse. The Click-stick will enable to navigate to different menu options by pushing the click-stick in a direction (left or right; up or down). Furthermore, use the Click-Stick as a button to activate highlighted selections.
- The Back button is used to quit a menu or page.
- The Zoom-out button: From the map Page pressing this button will enable to zoom out on the map.
- The Zoom-in button: From the map Page pressing this button will enable to zoom in on the map. From any other page, press to scroll or move a highlighted slider down.
- The Menu button: Press and release once to view the options menu for a page or press and release a second time to display the Main Menu from any page.

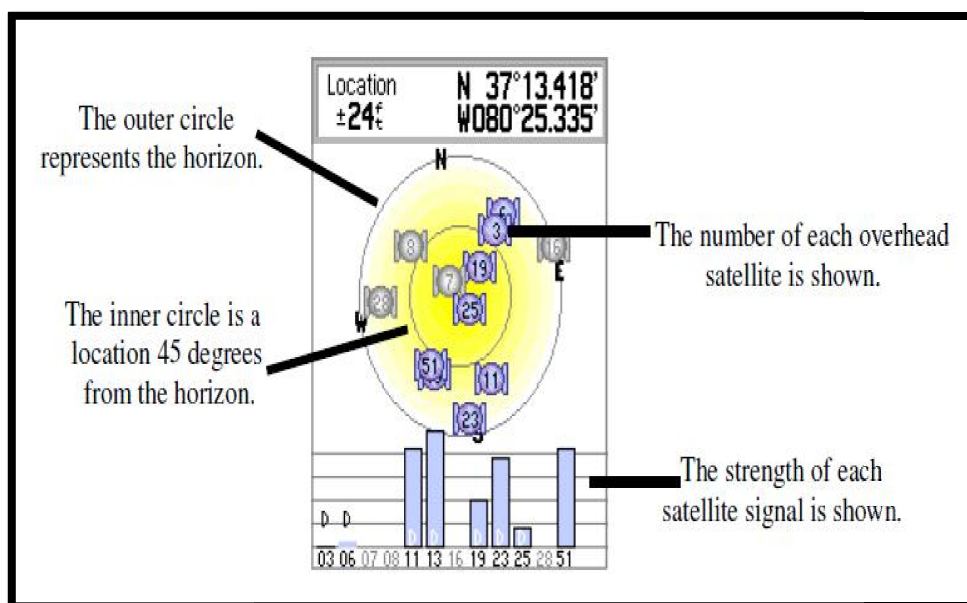


Figure 3: Location and satellite page of e-Trex 10

Turn on GPS receiver by pushing the power button. Use the menu button to go to the main menu and then select the satellite option to view current satellites. The satellite page can be seen at any time by going to the menu page and selecting *Satellite page*. After the GPS receiver is ready to navigate, a location (x, y coordinates) and error ($\pm 24\text{ft}$) for the location will appear in the upper section of the satellite page. Thus, GPS receiver has now been initialized, and is ready for estimation of agricultural area

11.6 Estimating Area Measurements

There are two methods for calculating an area estimate:

1. Area Calculation tool on the GPS unit (uses Tracks)
2. The Route method

11.6.1 Using the Area Calculation Tool:

- (i) First clear the current active track log just before begin laying tracks by. Go to: Main Menu > Track Manager > Current Track > Clear Current Track.
- (ii) Next go to Main Menu > Area Calculation, to start a fresh
- (iii) The Area Calculation page will have a Start option at the bottom; click Start using the click-stick.

- (iv) Begin walking around the perimeter of the area that has to be calculated. The screen displays your progress. The GPS will “connect the dots” and link your recorded track points in an attempt to estimate the enclosed area. View the saved track screen to decide whether or not the integrity of the track was maintained.
- (v) After returning to starting point, click on Calculate to get the area calculation. To change units of area highlight and click on the Change Units option to bring up a selectable list of choices (square feet, square yards, square meters, hectares, square miles, etc.
- (vi) If this area calculation is needed to refer to later, select Save Track. A page will open that will allow you to re-name the track if necessary.
- (vii) To view all of saved tracks, go to: Main Menu > Track Manager> Archived Tracks.

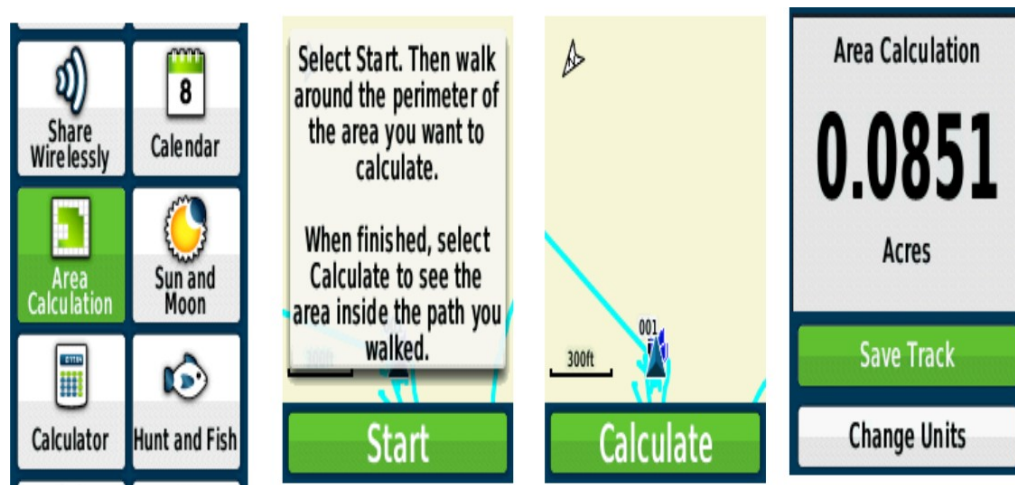


Figure 4: Area calculation using area calculation tool

11.6.2 The Route Method:

First, mark and save waypoints of all important corners of the area to be calculated.

From the GPS unit, go to Main Menu >Route Planner.

(iii) Select Create Route, and on the next screen, click on Select First Point. This takes to the category selection menu.

Go to Way points, and see a list of waypoints to choose from. Select the way point that marks the first corner of the area you want to calculate by clicking straight down. After seeing the map of this way point, click on Use.

Now select more waypoints, in order, to complete the route by repeating steps 3 and 4.

After adding all the waypoints to route, go back to Main Menu > Route Planner. From the Route Planner Menu, see the name of route (usually Route 001 if it is the first route saved to your device). By selecting the Route name, can edit the Route (add more points or delete points), rename, etc.

Once returned to the office, download route using the free software of GPS Utility (see previous page). To view the resulting area calculation, view your routes and select the View menu and then Reports. This will bring up a report detailing each leg of route, total distance and the area enclosed by the route.



Figure 5: Area map using route method

11.7 Conclusion:

Signature of Faculty In-charge

Formulation and characterization of nano-particles

12.1 Aim

To know about formulation and characterization of nanoparticles.

12.2 Nanotechnology

The American physicist Richard Feynman lectured, “There’s Plenty of Room at the Bottom” at an American Physical Society meeting at Caltech on December 29, 1959, which is often held to have provided inspiration for the field of nanotechnology. The solid colloidal microscopic particles with size ranging between 10-1000 nm are known as nanoparticles. Nanotechnology is science of manipulating materials at nano-scale. Among the latest technological advancements, nanotechnology occupies a central position. It has many applications in all stages of production, processing, storing, packaging and transport of agricultural products. The reduced use of herbicides, pesticides and fertilizers with increased efficiency, controlled release and targeted delivery will lead to precision farming. Dream of automated, centrally controlled agriculture can become reality now. They can be defined as system which contain active ingredient dissolved, encapsulated or adsorbed in matrix material which are used as target delivery system. Eukaryotic or prokaryotic cells had been founded to be larger in size than nanoparticle but for comparisons of their size they belong. During the designing of nanoparticle some control has to take in.

12.3 Formulation Preparation of nanoparticle

In the preparation of nanoparticles different types of matrix material are used such as polysaccharides, synthetic polymer and proteins. Various factors are involved in selection of matrix material to be used in preparations which are:

- (i) Required nanoparticle size.
- (ii) Permeability and surface charge of nanoparticle.
- (iii) Level of biodegradability and biocompatibility must be optimum.
- (iv) Material must not be toxic.
- (v) Solubility profile and stability of drug should not be affected.
- (vi) It should show desired drug release profile.
- (vii) Must not be immunogenic.

Following are methods which are used in formulation of nanoparticles

1. Dispersion of preformed polymers.
2. Polymerization method.
3. Coacervation or ionic gelatin method.
4. Supercritical fluid technology

12.3.1 Dispersion of preformed polymers

For the preparation of biodegradable nanoparticles from polymers such as poly (lactic acid) (PLA); poly (D, L-glycolide), PLG; poly (D, L-lactide-co-glycolide) (PLGA) and Poly-(cyanoacrylate) (PCA), dispersion of preformed polymer method is used. This technique can be used in various ways as described below.

a) Solvent evaporation method

In this method, there is conventional formation of emulsion between a partially water miscible solvent containing the polymer and the drug, and an aqueous phase containing the stabilizer. In this polymer is dissolved in an organic solvent such as dichloromethane, chloroform or ethyl acetate. Oil in water (o/w) emulsion is prepared by emulsification of drug and polymer mixture in aqueous solution which contain emulsifying agent, which result in formation of stable emulsion. After that by using pressure reduction method or continuous stirring, organic solvent is evaporated. Usually high speed homogenizer or ultrasonication had been used to reduce the size of nanoparticle to an optimum size.

b) Spontaneous emulsification or solvent diffusion method

This is also known as modified version of solvent evaporation method. In this method, two phase solvent is used, one is water miscible and other is water immiscible i.e. organic in nature which act as oil phase. In this method interfacial turbulence is created, by immediate diffusion between two solvents (which are differing in phase) which lead to the formation of small particles. A reduction in particle size can be gained by increasing the concentration of water miscible solvent both the above described method and can be used for preparation of hydrophilic and hydrophobic drugs.

c) Salting out

It is one of commonly used method used for preparation of nanoparticle. This method involves the mixing of saturated aqueous solution of polyvinyl alcohol (PVA) into an acetone solution of the polymer under magnetic stirring resulting in the formation of o/w emulsion. The precipitation

of the polymer occurs when sufficient amount of water is added to external phase to allow complete diffusion of the acetone from internal phase into aqueous phase.

12.3.2 Polymerization method

Polymerization of monomers in an aqueous solution forms the basis of this method. Two different techniques are used for the preparation in aqueous solution.

- a) Emulsion polymerization: This method involves emulsification of monomer in non-solvent phase.
- b) Dispersion polymerization: This method involves dispersion of monomer in non solvent phase. Incorporation of drug in nanoparticle can be achieved either by dissolving the drug in polymerization medium or by adsorption onto nanoparticle. Suspension of nanoparticles is formed, which contain surfactants and stabilizers that are used in polymerization which has to be removed by method like ultracentrifugation or by suspending them in isotonic medium which is free of surfactant. Polybutyl-cyanoacrylate or poly (alkylcyanoacrylate) nanoparticles are been prepared by this method. The polymer particle size had been affected by concentration of stabilizer and surfactant involved in preparation.

12.3.3 Coacervation or ionic gelation method

Chitosan, sodium alginate and gelatin are hydrophilic biodegradable polymers which are used for the preparation of nanoparticles by coacervation method. Preparation of hydrophilic chitosan nanoparticles by ionic gelation was developed by Calvo and Co-worker. This method involves a preparation of two aqueous phases, of which one is the polymer chitosan, poly-block co-polymer ethylene oxide or propylene oxide (PEOPPO) and the other is a polyanion sodium tripolyphosphate which are mixed, due to mixing positively charged amino group of chitosan interacts with negative charged tripolyphosphate to form coacervates with a size in the range of nanometer. When electrostatic interaction take place between two aqueous phases coacervates are formed, and when two molecules interact due to ionic force, resulting in transition from liquid phase to gel phase at room temperature this is known as ionic gelation method.

12.3.4 Production of nanoparticles using supercritical fluid technology

Various conventional approaches like solvent diffusion, solvent extraction-evaporation and organic phase separation require the use of organic solvent are hazardous to the environment as well as the physiological systems. Supercritical fluid technology thus has been invested as an

alternative to prepare biodegradable micro and Nanoparticles. Solvent which remain fluid in a single phase regardless of pressure above critical temperature are known as supercritical fluid. Super critical CO₂ is the most widely used supercritical fluid. The most common processing techniques involves supercritical fluids are supercritical Antisolvent (SAS) and rapid expansion of critical solution (RESS). Formation of hydrophilic drug Dexamethsone phosphate by the use of modified SAS. RESS diffuse from SAS process in that its solute in dissolved in super critical fluid. Thus with solvent power of super critical fluid the solute is eventually precipitated.

12.3.5 Characterization of nanoparticles

To understand synthesis and application of nanoparticle, characterization of nanoparticle is necessary. Size determination is the primary parameter for characterization of nanoparticle. Various techniques had been used for this purpose. Particle size Most of the properties of nanoparticle like drug loading and release pattern, in vivo distribution, tissue targeting, toxicity and biological fate are concerned with the size and size distribution of Nanoparticles so they had become an important parameter in characterization of product. It has been reported that micro particles are less effective drug delivers than particle having size ranging in between nanometers for e.g nanoparticles having size range greater than 230 nm acquire in the spleen shown by body distribution studies. A nanometer is one billionth of a meter. Overall nano refers to a size scale between 1 nanometer (nm) and 100 nm in at least one dimension, and involves developing or modifying materials or devices within that size. In more technical terms, the word “nano” means 10⁻⁹, or one billionth of something. For comparison, the wavelength of visible light is between 400 nm and 700 nm. A leukocyte has the size of 10000 nm, a bacteria 1000-10000 nm, virus 75-100 nm, protein 5-50 nm, glucose 1nm, deoxyribonucleic acid (DNA) ~2 nm (width), and an atom ~0.1 nm, . In this scale, physical, biological and chemical characteristics of materials are fundamentally different from each other and often unexpected actions are seen from them.

Nano materials are composed of components with very small size, and these components have impacts on the properties of materials at the macro level. Nano particles can serve as “magic bullets”, containing herbicides, chemicals, or genes, which target particular plant parts to release their content. Nano capsules can enable effective penetration of herbicides through cuticles and tissues, allowing slow and constant release of the active substances. This convergence of technology with biology at the nano level is called nano biotechnology.

Method of determining particle size is by

1. Photon-correlation spectroscopy.
2. Dynamic light scattering.
3. Brownian motion and light scattering properties
4. Scanning or transmission electron microscopy

12.4 Conclusion

Signature of Faculty In-charge

Applications of nanoparticles in agriculture**13.1 Aim**

To know about different applications of nanotechnology in agriculture

13.2 Nanotechnology and nano-particles

Nanotechnology is a powerful technology allows us to have a look at the atomic and molecular level and able to create nanometer-scale structures. Nanotechnology in agriculture and food production, causing the agricultural land returned to its normal position, greenhouse construction with high performance and productivity, prevent extinction and destruction of plants and animals species, and overall nanotechnology provides the efficiency of the agriculture for higher population. In the agricultural sector, nanotechnology research and development is likely to facilitate and frame the next stage of development of genetically modified crops, animal production inputs, chemical pesticides and precision farming techniques.

Nanotechnology is an interdisciplinary field that has been entered in different range of applied sciences such as chemistry, physics, biology, medicine and engineering. Targeted research and development, for understand, manipulate and measure at the materials with atomic, molecular and super molecules dimensions is called nanotechnology. In other words, nanotechnology is the manipulation or self-assembly of individual atoms, molecules, or molecular clusters into structures to create materials and devices with new or vastly different properties. Nanotechnology can work from the top down (which means reducing the size of the smallest structures to the nanoscale e.g. photonics applications in nano electronics and nano engineering) or the bottom up (which involves manipulating individual atoms and molecules into nanostructures and more closely resembles chemistry or biology).

13.3 Advantages of nanoparticles

- 1) They are suitable for different routes of administration.
- 2) Carrying capacity of nanoparticles is high.
- 3) Shelf-stability of drug increases.
- 4) Ability to sustain and control drug release patterns.

- 5) Suitable for combination therapy where two or more drug can be co-delivered.
- 6) Both hydrophobic and hydrophilic drug can be incorporated.
- 7) System increases the bioavailability of drugs.
- 8) Imaging studies can be done by utilizing them.
- 9) It is used for targeted drug delivery of drugs.
- 10) Development of new medicines which are safer.

13.4 Disadvantages of nanoparticles

- a) Manufacturing costs of nanoparticle are high which result in overall product cost
- b) Solvents are toxic in nature which is used in the preparation process.
- c) Can start immune response and allergic reactions in body.
- d) Extensive use of poly (vinyl alcohol) as stabilizer may have toxicity issues.
- e) Nanoparticles are difficult to handle in physical form because particle-particle aggregation occurs due their small size and large surface area.

13.5 Observations

13.5.1 What are the applications of nanotechnology in agronomy?

13.5.2 What are the applications of nanotechnology in pest and disease management?

13.5.3 What are the applications of nanotechnology in agriculture and food industry?

13.6 Conclusion:

Signature of Faculty In-charge

Project Formulation and Execution Related to Precision Farming**14.1 Aim**

To understand the philosophy of precision farming and its basic components and to get knowledge about formulation and execution at field level

14.2 Scope

Precision farming is a management strategy that employs detailed site specific information to precisely manage production inputs. This concept often called as precision farming, prescription farming or site-specific management. The main objective is to know the soil heterogeneity and crop characteristics variation and to optimize the production inputs within small portions of the field. The main philosophy behind Precision farming is need based application of production inputs (seed, fertilizer, chemicals etc.). Precision farming (PF) is a holistic management approach that originated in the early 1990s with the goal of optimising profitability and productivity while minimising the adverse environmental impacts in each spatial unit of the field. It is centred on sound use of agronomic principles, and involves variable application of external inputs and other cultural practices to match varying soil and crop conditions. Practical implementation is dependent on technological developments to collect, manage, analyse and utilise vast amounts of site-specific data. Rapid advances in both remote sensing sensors, hardware (positioning and sensor technologies, yield monitors, variable rate applicators, etc.) and software (data collection, geographic information systems [GIS] coupled with the availability of low-cost powerful computers has made PF a reality today.

Precision Farming can be used for

- Land preparation
- Seeding
- Chemicals application
- Fertilizer application
- Crop monitoring
- Nutrient auditing

- Soil and leaf testing
- Pest management
- Conservation practices
- Automation

14.3 The basic components of PF:

PF basically depends on measurement and understanding variability, technology-enabled, information and decision focused. The components include RS/ soil and plant sensors, GIS, GPS, soil testing, Yield monitors and grid sampling and variable rate technologies (VRT), Internet of things (IoT), Machine learning (ML), and Artificial Intelligence (AI).

14.3.1 Global positioning system (GPS) is a navigation system based on a network of satellites that helps users to record positional information (latitude, longitude and elevation) with an accuracy of between 100 and 0.01 m. GPS allows farmers to locate the exact position of field information, such as soil type, pest occurrence, weed invasion, boundaries and obstructions. There is an automatic controlling system, with light or sound guiding panel (DGPS), antenna and receiver.

14.3.2 Soil and plant Sensor technologies is an important component of precision agriculture technology and their use has been widely reported to provide information on soil properties and plant fertility/water status. A comprehensive list of current sensors as well as desirable features for new sensors to be developed in the future. One of the most popular ways to characterize soil variability is surveying the field with soil apparent electrical conductivity (ECa) sensors that collect information continuously when pulled over the field surface. Because ECa is sensitive to changes in soil texture and salinity, these sensors provide an excellent baseline to implement site-specific management.

14.3.3 Geographic information system (GIS) Computerized GIS maps are different from conventional maps and contain various layers of information (e.g. yield, soil survey maps, rainfall, crops, soil nutrient levels and pests). GIS is a kind of computerized map, but its real role is using statistics and spatial methods to analyse characters and geography. A farming GIS database can provide information on field topography, soil types, surface drainage, subsurface drainage, soil testing, irrigation, chemical application rates and crop yield. Once analysed, this information is used to understand the relationships between the various elements affecting a crop

on a specific site .In addition to data storage and display, the GIS can be used to evaluate present and alternative management by combining and manipulating data layers to produce an analysis of management scenarios.

14.3.4 Grid soil sampling and Variable-Rate Technologies (VRT) application Variable-rate technologies(VRT) are automatic and may be applied to numerous farming operations. VRT systems set the rate of delivery of farm inputs depending on the soil type noted in a soil map. Information extrapolated from the GIS can control processes, such as seeding, fertilizer and pesticide application, herbicide selection and application at a variable rate in the right place at the right time. VRT is perhaps the most widely used PFS technology in the United States. Grid soil sampling uses the same principles of soil sampling but increases the intensity of sampling. Soil samples collected in a systematic grid also have location information that allows the data to be mapped. The goal of grid soil sampling is a map of nutrient needs, called an application map. Samples may be collected for more than one area of a field which fall in to the same range of yield, soil colour, etc. and thus the same zone. Grid soil samples are analysed in the laboratory, and an interpretation of crop nutrient needs is made for each soil sample. Then the fertilizer application map is plotted using the entire set of soil samples. The application map is loaded into a computer mounted on a variable-rate fertilizer spreader. The computer uses the application map and a GPS receiver to direct a product-delivery controller that changes the amount and/or kind of fertilizer product, according to the application map.

14.3.4 Crop management Satellite data provide farmers a better understanding of the variation in soil conditions and topography that influence crop performance within the field (intra field variation). Farmers can, therefore, precisely manage production factors, such as seeds, fertilizers, pesticides, herbicides and water control, to increase yield and efficiency.

14.3.5 Precision irrigation in pressurized systems are being released for commercial use in sprinkler irrigation by controlling the irrigation machines motion with GPS based controllers. In addition to motion control, wireless communication and sensor technologies are being developed to monitor soil and ambient conditions, along with operation parameters of the irrigation machines (*i.e.* flow and pressure) to achieve higher water application efficiency and utilization by the crop. These technologies show remarkable potential but further development is needed before they become commercially available.

14.3.6 Software Applying precision agriculture technologies will frequently require the use of software to carry out diverse tasks such as display-controller interfacing, information layers mapping, pre and post processing data analysis and interpretation, farm accounting of inputs per field, and many others. The most common are software to generate maps (e.g. yield, soil); software to filtering collected data; software to generate variable rate applications maps (e.g. for fertilizer, lime, chemicals); software to overlay different maps; and software to provide advanced geostatistical features. All are excellent options for precision agriculture farm management and record keeping to keep up with the needs of modern, information-intensive farming systems. There are a few companies that operate world-wide and provide integrated software packages from generating all different types of maps, having statistical analysis tools and also record keeping.

14.3.7 Yield monitors are a combination of several components. They typically include several different sensors and other components, including a data storage device, user interface (display and key pad), and a task computer located in the combine cab, which controls the integration and interaction of these components. The sensors measure the mass or the volume of grain flow (grain flow sensors), separator speed, ground speed, grain. In the case of grains, yield is continuously recorded by measuring the force of the grain flow as it impacts a sensible plate in the clean grain elevator of the combine.

14.3.8 Internet of things (IoT) can also be applied in precision farming. It refers to every things or devices embedded with electronics, software and sensors to the Internet and enabling them to collect data, exchange data without human-to-human or human-to-computer interface. Usually the farmer pumps the water more or less to cultivate the land. This may result in wastage of water or insufficient to the crops. IoT sends an alerting message to the farmer when the moisture level increases or decreases. Often Farmers' hard-works are destroyed by Pests that results in loss to farmers. IoT has a system that detects the motion of pests using PIR sensor (Passive Infrared Sensor). This information can be used by the farmers to reduce damage done by the pests. With Precision agriculture farmers generate data via sensors and analyze the information to evaluate current practice and make improvement for greater efficiency and effectiveness. This allows farmers to monitor livestock, vehicles and other farming resources in remote areas. IoT connected Devices detect water and nutrients timely for good production.

14.4 Precision farming on arable land

The use of PA techniques on arable land is the most widely used and most advanced amongst farmers. CTF is a whole farm approach that aims at avoiding unnecessary crop damage and soil compaction by heavy machinery, reducing costs imposed by standard methods. Controlled traffic methods involve confining all field vehicles to the minimal area of permanent traffic lanes with the aid of GNSS technology and decision support systems. Another important application of precision agriculture in arable land is to optimize the use of fertilizers, starting with the three main nutrients Nitrogen, Phosphorus and Potassium. In conventional farming these fertilizers are applied uniformly over fields at certain times during the year. This leads to over application in some places and under-application in others. The environmental cost is directly related to over-application which allows nitrogen and phosphorus leaching from the field into ground- and surface waters or to other areas of the field where they are not desired. With the use of precision agriculture methods, fertilizers can be applied in more precise amounts, with a spatial and temporal component to optimize the application. The technology that allows the farmer to control the amount of inputs in arable lands is the Variable Rate Application (VRA), which combines a variable-rate (VR) control system with application equipment to apply inputs at a precise time and/or location to achieve site specific application rates of inputs. VRs are decided on the basis of prior measurement, e.g. from remote sensing or machine mounted sensors.

14.5 Conclusion:

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