MAHARASHTRA AGRICULTURAL UNIVERSITY EXAMINATION BOARD, PUNE

SEMESTER END EXAMINATION

B.Sc. (Hons) Agriculture

Semester	:	VI (New)	Term	:	Second	Academic year	: 2023-24
Course No.	:	ELE AGM 361	Title	:	System Simulation and Agro-advisory		
Credit	:	3(2+1)					
Day & Date	:		Time	:	3 hrs.	Total Mark	: 80

MODEL ANSWER

SECTION 'A'

Q.1 Write in details about different type of models and its application in agriculture.

Ans. TYPES OF MODELS (8M)

Depending upon the purpose for which it is designed the models are classified into different groups or types of them a few are:

1. Statistical models: These models express the relationship between yield or yield components and weather parameters. In these models relationships are measured in a system using statistical techniques.

Example: Step down regressions, correlation, etc.

2. Mechanistic models: These models explain not only the relationship between weather parameters and yield, but also the mechanism of these models (explains the relationship of influencing dependent variables). These models are based on physical selection.

3. Deterministic models: These models estimate the exact value of the yield or dependent variable. These models also have defined coefficients.

4. Stochastic models: A probability element is attached to each output. For each set of inputs different outputs are given along with probabilities. These models define yield or state of dependent variable at a given rate.

5. Dynamic models: Time is included as a variable. Both dependent and independent variables are having values which remain constant over a given period of time.

6. Static models : Time is not included as a variable. Dependent and independent variables having values remain constant over a given period of time.

7. Simulation models: Computer models, in general, are a mathematical representation of a real world system. One of the main goals of crop simulation models is to estimate agricultural production as a function of weather and soil conditions as well as crop

management. These models use one or more sets of differential equations, and calculate both rate and state variables over time, normally from planting until harvest maturity or final harvest.

8. Descriptive model: A descriptive model defines the behaviour of a system in a simple manner. The model reflects little or none of the mechanisms that are the causes of phenomena. But, consists of one or more mathematical equations. An example of such an equation is the one derived from successively measured weights of a crop. The equation is helpful to determine quickly the weight of the crop where no observation was made.

Application of modeling :

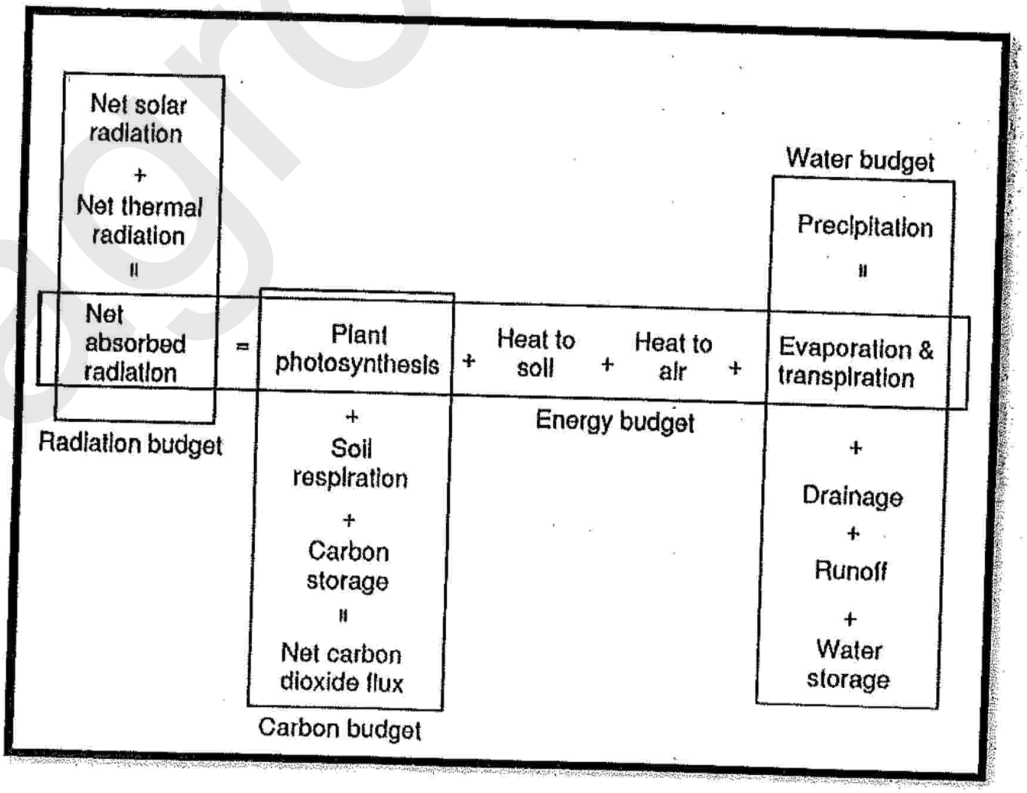
1. **Seed rate to be utilized :** Seed is costly input for small and medium farmer. Hence, he is always interested in knowing the optimum seed rate for a given variety. The model can calculate optimum yield under different plant population for given agro-ecological conditions by which he can immediately advise the farmer the optimum seed rate for maximum yield.
2. **Row spacing or crop geometry :** Farmer is very much interested in knowing the row spacing or crop geometry for a given crop. The modeler can calculate yield under different row spacing treatments and can recommended to the farmer best spacing.
3. **Fertilizer dose and application :** Fertilizer being a costly input farmer is very much interest in knowing optimum fertilizer dose and method of its application such as full dose or split dose, if split, the interval at which second dose is to be applied. Modeler can estimate the yield under different fertilizer doses and with variety of application. With the maximum of yield he can recommended the dose and its application. After calculating the benefit cost ratio he can modify the recommended dose.
4. **Irrigation and stage of application :** For *rabi* and summer crops irrigation is very important input. Similarly, for cash crops, vegetables, fruits and flower irrigation is primary need. Its quantum of application and benefit due to that can be calculated by a modeler and utility of irrigation in terms of monetary returns can be estimated. Thus, modeler can estimate the monetary returns of each irrigation and its time of application.

Q.2 Write in details about soil-plant-atmosphere continuum. (8M)

Ans. Soil-plant-atmosphere continuum :

- The soil-plant-atmosphere continuum (SPAC) is the pathway for water moving from soil through plants to the atmosphere.
- Continuum in the description highlights the continuous nature of water connection through the pathway.
- The low water potential of the atmosphere, and relatively higher (i.e. less negative) water potential inside leaves, leads to a diffusion gradient across the stomatal pores of leaves, drawing water out of the leaves as vapour.
- As water vapour transpires out of the leaf, further water molecules evaporate off the surface of mesophyll cells to replace the lost molecules since water in the air inside leaves is maintained at saturation vapour pressure.
- Water lost at the surface of cells is replaced by water from the xylem, which due to the cohesion-tension properties of water in the xylem of plants pulls additional water molecules through the xylem from the roots toward the leaf.

Two general principles are indispensable for studying the SPAC: (1) the conservation principles that take the form of mass and energy 'budgets,' and (2) the transport principles that relate the flow of some quantity to the difference or gradient of other quantities that influence or 'force' the flow and describe the 'state' of the exchange process.



Q.3 Define the crop growth model write principles of crop growth modeling and write the data required for calibration and validation of crop growth model. (8M)

Ans. Crop growth model :

Crop growth model or Agricultural models are mathematical equations that represent the reactions that occur within the plant and the interactions between the plant and its environment.

The model simulate or imitates the behaviour of real crop by predicting the growth of its components, such as leaves, roots, stems and grains. Thus, a crop growth model not only predicts the final state of total biomass or harvestable yield, but also contains quantitative information about major processes involved in the growth and development of a plant.

Principles of Crop Growth Modeling :

- A sound appreciation and understanding of the biological problem, though not necessarily including the most intricate details
- A realistic mathematical representation of the phenomenon
- Finding a solution, quantitative if possible, of the resulting mathematical problems
- A biological interpretation of the results, ideally giving biological insight and predictions

Data required for calibration of validation of CSM :

Input for CSM

1. Site description:
- Latitude and longitude, elevation, average annual temperature
- Slope and aspects of the site

2. Weather :
- Daily global soil radiation, daily maximum and minimum temperature, daily rainfall.

3. Soil :
- Soil type, soil depth (divided by n layers), soil texture, soil organic carbon, bulk density, soil nitrogen, pH

4. Initial condition of the system :
- Previous crop, residues left on the soil (if any), initial soil water and soil nitrogen

5. Crop and field management :
- Cultivar name and type, planting date and type, row space, plants per square meter, irrigation/nitrogen amount, method, dates of irrigation/fertilization, fertilizer type

Q.4 Define potential and achievable crop production. Describe the desirable attributes of models for estimation of potential and achievable crop production. (8M)

Ans.

- **Potential crop production** is the yield of a current cultivar "when grown in environments to which it is adapted; with nutrients and water non limiting; and with pests, diseases, weeds, lodging, and other stresses effectively controlled".
- **Achievable crop production** is defined as the yield of a cultivar when grown in environments to which is Limited by water, plant nutrients, weeds, diseases, pests and pollutants

Desirable attributes of models for estimation of potential and achievable crop production :

These include use of daily time step weather data, capacity to capture management practices that influence yield (e.g. sowing date, plant density, cultivar maturity), eco-physiological in structure, crop specificity, low requirement of cultivar specific parameters, proved performance through validation and peer-reviewed publications, full documentation of parameterisation, and user friendly interface.

Crop simulation models estimate different yield levels, depending on the assumptions and modelling approach. Crop models with typically daily time-step and sufficient detail of physiological principles can be used to estimate yield potential. This involves the assumptions of non-limiting water and nitrogen. Estimates using actual weather, and consequently a certain frequency and intensity of water stress, could be considered closer to water-limited yield. Indeed, modelled yield often reproduces the upper boundary of measured yield under water limiting condition.

Weather data for modelling crop yield :

The models commonly used to simulate potential and water-limited yield require a minimum data set of daily weather variables including incident solar radiation, maximum and minimum temperature, precipitation, and some measure of humidity, i.e. relative humidity, actual vapour pressure, dew point temperature. If measured solar radiation is not available (which is often the case), then simulations can be based on solar radiation data, or atmospheric pollution. More than 30 weather data sources have been used in agricultural research, but few have been used for simulating yields.

Q.5 Write the different Indigenous Technical Knowledge (ITK) use for weather forecasting. (8M)

Ans. Previously when there was no such technology available farmers based their prediction on many natural, cultural and social phenomena. Some of these are discussed below:

Visible spectrum around the sun and the *moon*

- People predicted weather after observing the visible spectrum around the sun or moon. If the spectrum around the sun had a greater diameter than that around the moon, they predicted rainfall after a day or two.
- Some people based their weather prediction on the nature of the solar halo, specifically: "if the spectrum around the sun has a larger diameter then rainfall is assured.
- All the photometers are a luminous phenomenon produced by the reflection, refraction, diffraction or interference of light from the *sun* or moon. The visible spectrum of light around the sun or moon is called halo, or carona according to its distance from the sun or moon. If the distance is more then it is called the halo phenomenon, which is caused by a layer of thin veil of cirrus clouds i.e. non rain bearing clouds. But if the distance is less, it is called corona phenomena produced by somewhat dense clouds which may cause rainfall. The accuracy of this indigenous observation can be as high as 50 per cent

Cloud and wind direction

- If there is an accumulation of clouds in the South-East direction in a layered form accompanied by winds blowing from the southern direction then it is claimed that there will be rainfall within a day or two.

Weather prediction through birds and other animals

Farmers also predict weather by observing closely the different activities of various birds, animals etc. The following are some indigenous beliefs:

- It is believed that on a hot summer day the cry of the bird called "Nialu" for water brings rainfall
- During the rainy season farmers observe the "Matilari" bird (House swift) and they predict heavy rainfall if the bird flies high in the sky
- If the Maina bird bathes in the water it indicates that there will be rainfall within one or two days
- During long hot days in summer if the cry of theapiha bird is heard then people

believe that God will quench her thirst and there will be rainfall after one or two days.

- A group of sparrows frolicking in the sand indicates that there will be rainfall that day or the next day and if they are observed to be playing in water then it is believed that the weather will be dry for some days to come.
- If the "Jonks" (Leechs) are immobile/stationary at the water surface (Pond) then dry weather is predicted but if they move rapidly in the upward and downward direction in water then rainfall is predicted.
- If the "Tatihari" bird (Lapwing) lays her eggs on the higher portion of the field then heavy rainfall is predicted during the coming rainy season but if the eggs are laid in the lower portion of the field then a drought is predicted. These birds never construct a nest but lay their eggs on bare soil. Further it is also believed that if a single egg is laid, then there will be rainfall only for one month out of four months of the rainy season. If two eggs are laid then rainfall will occur for two months and similarly four eggs indicate there will be rainfall during all the four months of the rainy season.
- If there is a swelling on the lower portion of the camel's legs then rainfall is predicted by the farmers. The swellings are probably caused due to higher relative humidity.
- If the "Tillbohara" (Dragon fly), which appears generally in the rainy season, are observed to swarm in a large group over a water surface (Pond) then dry weather is predicted but if they swarm over open dry lands or fields then early rainfall is predicted by the farmers.
- If the colour of the clouds is similar to the colour of the wings of the Titar bird (Partridge) i.e. grey or black-grey and strong eastern winds are also blowing then assured rainfall is predicted by the farmers. The clouds of a colour similar to that of the said bird are rain bearing clouds i.e. of cumulonimbus type.
- If centipedes emerge from their holes carrying their eggs in swarms in order to shift them to safer places (within the house) then farmers predict early rainfall The centipedes do this so as to avoid egg damage which can be caused by rain water.
- When spider nets are plentiful on grasses, sticks of tomato crop and on trench bean crop then it is estimated that the rainy season is over.

Q.6 Define the weather forecasting and write in details types of weather forecast based on validity period. (3M)

Ans. Weather forecasting :

Any advance information about the probable weather in future obtained by evaluating the present and past meteorological conditions of the atmosphere is called forecast.

Types of forecast based on validity period :

Weather forecasting on the basis of their validity periods or time scale are classified as follows.

1. **Now casting (few hours to one day) :** This type of weather forecasting is issued for less than 12 hours. It is closely related to local weather phenomena like thunderstorms, duststorms, cyclone and cold and heat waves.
2. **Short range forecast (SRF) (24 hours to less than 3 days) :** It comprises a forecast and warning of weather elements hazardous to agriculture is valid for 36 hours and an outlook for the subsequent 2 days. The short-range forecast includes cloud spread, rainfall distribution, heavy rainfall warning, maximum and minimum temperatures, head and cold waves, low-pressure areas, cyclone warning, hail or thunderstorm, duststorm, snow, frost and likelihood of maximum wind speed. The short-range forecast is issued twice a day on the basis of synoptic condition.
3. **Medium range forecast (MRF) (3-10 days) :** It is a forecast and warning of weather elements hazardous to agriculture which is valid for 3 to 10 days. This forecast includes cloud amount, rainfall, maximum and minimum temperature, average wind speed, wind direction and weekly cumulative rainfall.
4. **Long range forecast (LRF) (for more than 10 days, a month and for season) :** It is a forecast form more than 10 days, or month or season. The IMD started issuing the long range forecasting since 1988 onwards on total monsoon rainfall of the country by 25th May. The predicated and actual long period average of monsoon (June-September) rainfall of the country were in agreement. These forecast can be used for predicting likely trends in foodgrains production of India before the beginning of the kharif season, as foodgrains production depends mostly on the distribution and amount of monsoon rain across the country. The cultivable cropped area depends on monsoon rain and its distribution. These forecast can hold the foodgrain prices in check through buffer stock operations.

Q.7 Define the term remote sensing and its application in agriculture. (8M)

Ans. **Remote Sensing:** Remote sensing (RS) also called earth observation, refers to obtaining information about objects or area at the Earth's surface without being in direct contact with the object or area.

Applications of remote sensing in agriculture :

1. **Monitoring in-season agricultural operations :** All the farm operations like sowing, inter-cultivation, harvesting etc. is being monitored effectively by the remote sensing.
2. **Crop identification :** By using LISS II or III seasons crop identification on regional scale is possible.
3. **Crop acreage estimation :** By using stratified sampling methodology crop acreage estimation is done to the high level precision.
4. **Crop yield estimation :** The crop yields are estimated by analyzing satellite based vegetation indices which are transformation of reflectance in the near infrared portions of electromagnetic spectrum.
5. **Monitoring of crop phonology and stresses :** The crop condition is affected by several factors like deficiency of nutrients, acidic and salinity problems of soil, nutrient deficiencies, adverse weather conditions etc. all these can be detected by remote sensing.
6. **Damage estimation and command area management :** The damages due to floods, cyclones, water logged areas in command area etc. can be detected and managed effectively by using techniques like the multi-temporal remote sensing.
7. **Water availability and soil moisture estimation :** The surface and subsurface water availability for irrigation and the amount of moisture shored in the upper few centimeters of the soil can be found with a greater accuracy.
8. **Land degradation and watershed management :** The remote sensing technology is highly useful in identifying and delineating degraded lands. Also facilitates in delineation of the watershed areas.
9. **Drought detection and management :** The drought realistically and ways to mange the adverse effect is possible through remote sensing.
10. **Desertification :** Remote sensing provides information to identity the important indicators of desertification. Based on this, action can be taken by the planners at different levels.

Q.8 What is agro-advisory? Enlist broad activities covered in agro-met advisories. (8M)

Ans. Agro-advisory :

Farm decisions taken in response to changing weather. Farm decisions include agronomical, pest and disease, water and input managements. This agro-met advisory taken in response to past, current and future weather change. Basic considerations to prepare weather based agro advisories are weather sensitive crops, their weather sensitive stages and weather sensitive farm operations.

Broad Activities of Agro met Advisories

- Sowing/ transplanting of *kharif* crops based on onset of monsoon
- Sowing of *rabi* crops using residual soil moisture
- Fertilizer application based on wind condition
- Delay in fertilizer application based on intensity of rain
- Prediction of occurrence of pest and disease based on weather
- Propyl active measures at appropriate time to eradicate pest and diseases
- Weeding/ thinning at regular interval
- Irrigation at critical stage of a crop
- Quantity & timing of irrigation based on meteorological threshold.
- Advisories for timely harvest of crops
- Advisories are delivered to the end users without any delay
- Interactive tuning of advisories with the farmers / managers as frequently as possible
- It is disseminated in English and local languages

Q.9 Crop weather calendar write details for preparation of crop weather calendar. (8M)

Ans. Crop weather calendar :

Detailed information for each important crop on their dates of sowing, dates of commencement and duration of major cultural operations, important periods in their life cycle and their most probable weather requirements have in India been presented in a pictorial form called the "**Crop Weather Calendar**".

PREPARATION OF CROP WEATHER CALENDARS

These crop weather calendars consist of three parts: A, B and C (Fig 1).

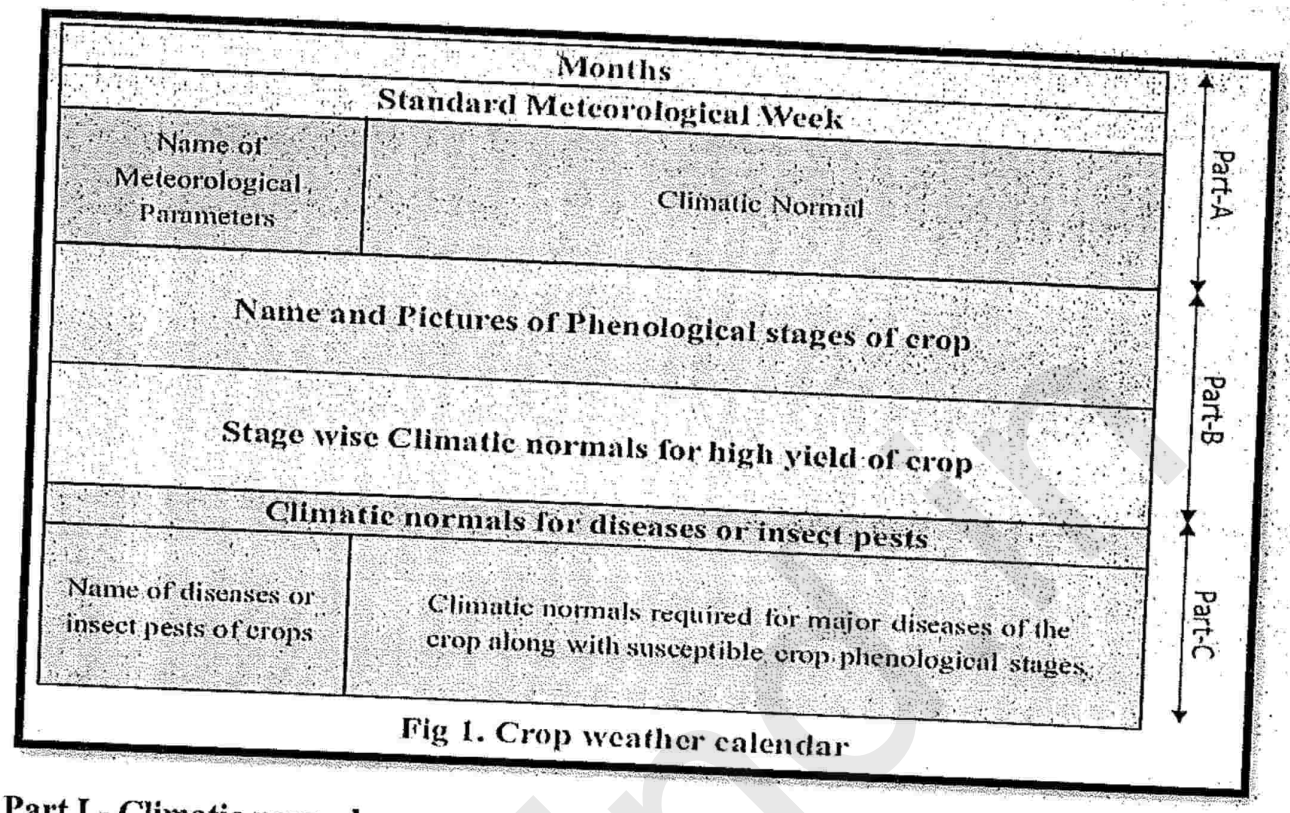


Fig 1. Crop weather calendar

Part I - Climatic normal :

The uppermost portion of calendar contains average meteorological data for different months and the respective standard meteorological weeks for the location / station for the entire growth period of the crop. Various meteorological parameters (eg. Maximum & Minimum temperature, rainfall, number of rainy days (rainfall 2.5mm), relative humidity (morning and evening), solar radiation / sunshine hours etc.) are given which can be computed from long term averages (at least 20 years data). The months and standard meteorological weeks are marked at the top of the calendar.

Part-II Phenological observations and Climatic normal for high yield of crops :

The middle part shows the typical life history of the crop in the form of a diagram. Important "growth phases" relevant to the crop species like sowing, germination /emergence, transplanting (in case of crops like rice), vegetative growth, flowering, grain formation and maturity period etc. are indicated. These "phases" cover certain time intervals indicated by horizontal bars, which depend on variations in crop variety, sowing date from place to place and from year to year and the nature of the crop itself. In addition to the above information, the middle part of crop weather calendars indicates the favourable meteorological conditions for the crop (stage-wise or whole crop growth period) which will lead towards high yield of the crop.

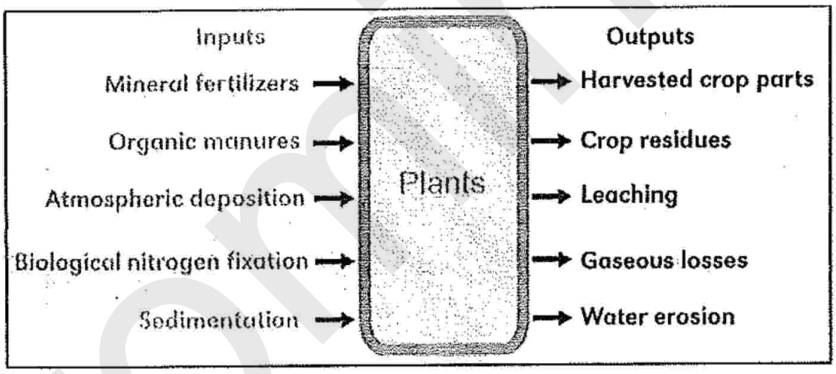
Part-III Climatic normal favourable for incidence of major pest of rice crop :

The bottom portion of the calendar consists of meteorological conditions conducive for incidence of pests and diseases and the nature of the weather warnings that can be given. The horizontal bars indicate the susceptible periods of the crop during which if the weather is conducive and disease inoculum / insect is present, then, the incidence of that disease / pest may occur. According to this information an agrometeorologist can issue weather-based agromet advisory for control of disease / pest in the crop.

Q.10 Write short notes (Any two) (8m)

a) Soil nutrient balance sheet :

Ans. Soil Nutrient Balance Sheets An assessment of nutrient additions, removals, and balances in the agricultural production system generates useful, practical information on whether the nutrient status of a soil (or area) is being maintained, built up, or depleted. A simplified depiction of nutrient additions and removals is given in Fig.



Nutrient balances provide information about environmental pressures. A nutrient deficit (negative value) indicates declining soil fertility. A nutrient surplus (positive data) indicates a risk of polluting soil, water and air. The nutrient balance is defined as the difference between the nutrient inputs entering a farming system (mainly livestock manure and fertilisers) and the nutrient outputs leaving the system (the uptake of nutrients for crop and pasture production). Inputs of nutrients are necessary in farming systems as they are critical in maintaining and raising crop and forage productivity. However, a build-up of surplus nutrients in excess of immediate crop and forage needs can lead to nutrient losses, representing not only a possible cause of economic inefficiency in nutrient use by farmers, but also a source of potential harm to the environment, through water pollution or air pollution, notably ammonia or greenhouse gas emissions. This indicator is presented for the two main nutrients, nitrogen and phosphorus, and is measured in

tonnes of nutrient and in kilograms of nutrient per hectare of agricultural land.

b) Crop weather diagram

Ans. It give season-wise information on crop husbandry (tillage to harvest), actual weather and normal weather month- or week-wise, and information on pest and disease incidence. It may help in understanding favourable weather conditions that are responsible for better crop yield and vice-versa, if they are prepared continuously for number of year. Using the crop weather diagrams, attempts can be made for obtaining better crop yields through agronomic manipulation and one can also predict crop yields qualitatively on the basis of weather conditions. It is also possible to select a suitable variety for given location based on crop weather diagrams.

The main difference between crop weather diagram and crop weather calendar is that the former indicates the current state of information on crop and weather, while the latter indicates the mean state of information on crops and weather – including forewarnings and the periods during which they are to be issued. The crop weather diagram can be tool to assess the crop condition and its yield in relation to weather, while the crop weather calendar is a tool for weather forecaster for providing efficient weather service. The crop weather calendar and crop weather diagram are handy and useful in agro-advisory, which helps to improve crop yields through better agronomic practices

c) Weather map

Ans. Weather maps simply and graphically depict meteorological conditions in the atmosphere. Weather maps may display only one feature of the atmosphere or multiple features. They can depict information from computer models or from human observations. Weather maps are found in newspapers, on television, and on the Internet.

On a weather map, each weather station will have important meteorological conditions plotted. These conditions may include temperature, current weather, dew point, cloud cover, sea level air pressure, wind speed and direction. On a weather map, meteorologists use many different symbols. These symbols give them a quick and easy way to put information onto the map.

Q.11 Do as directed (8M)

1. Write full form of AMFU.

Ans. Agro Meteorological Field Unit

2. Write full form of DSSAT.

Ans. Decision Support System for Agrotechnology Transfer

3. The agro-advisory service is based on **Medium Range** weather forecast.

4. Write full form of NWP.

Ans. Numerical Weather Predication

5. The **geostationary** satellites that monitors atmospheric conditions over the world.

6. Write full form of RADAR.

Ans. Radio Detection And Ranging

7. The number of degrees the maximum daily air temperature is above the heat stress threshold times the number of days is called as **heat stress unit**.

8. The **Deterministic** models estimate the exact value of the dependent variable..

Q.12 Define the following terms (8M)

1. **Growth** : Growth is defined as an "Irreversible increase in size and volume and is the consequence of differentiation and distribution occurring in the plant".
2. **Simulation model** : Crop Simulation Models (CSM) are computerized representations of crop growth, development and yield, simulated through mathematical equations as functions of soil conditions, weather and management practices.
3. **Crop** : Crop is defined as 'aggregation of individual plant species grown in a unit area for economic purpose'.
4. **Theoretical yield** : Theoretical yield is the maximum crop yield as determined by biophysical limits to key process including biomass production and partitioning.
5. **Model** : A model is a schematic representation of the conception of a system or an act of mimicry or a set of equations, which represents the behaviour of a system.
6. **Surrogate Variables** : Those variables that are calculated by the model and used to estimate value of another quantity that the model does not directly calculate is called as surrogate variables.
7. **Simulation** : A simulation is the manipulation of a model in such a way that it operates on time or space to compress it, thus enabling one to perceive the

interactions that would not otherwise be apparent because of their separation in time or space.

8. **Antitranspirants :** Antitranspirants are materials which decrease water loss from leaves by reducing the size or number of stomatal openings leading to decreased rate of water vapour diffusion from leaf surfaces.

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