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SLM 401

Soil Fertility and Water Management

Module 1

SLM 405:
AGRICULTURAL METEOROLOGY

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Module 1

Agricultural Meteorology - Elements and Their Observations

1.0 Introduction

Observations of the physical and biological elements in the environment are essential in agricultural meteorology. Meteorological considerations are indispensable in assessing the performance of plants or animals because their growth is a result of the combined effect of genetic characteristics and their response to environment (nature). Without quantitative data, agro meteorological planning, forecasting, research and services by agro meteorologists cannot properly assist agricultural producers to survive and to meet the ever-increasing demands for food and agricultural by-products. Such data are also needed to assess the impacts of agricultural activities and processes on the environment and climate.

The physical elements of climate are observed in order to assist in the evaluation of actual and future land use potentials and of such constraints in agriculture as are caused by the environment. To meet these requirements, agricultural meteorology needs reliable, quantitative data on the relevant climatic elements.

Indispensable climatic elements in agricultural meteorology include those pertaining to geographical climatology and especially those permitting interpretation of physical processes in the lower layers of the atmosphere and the upper soil layers. These include Temperature, Sunshine and Radiation, Wind, Clods, Humidity, Rainfall, Soil temperature and soil moisture. Others include Dews, Fogs, Open water evaporation and Plant transpiration.

2.0 Objectives

- to identify the physical elements of climate.

- to identify the importance of these weather elements in relation to agriculture.
- to recognize the calibrations of these elements.

3.0 Main Contain

Procedure

a. Temperature, sunshine and radiation

Temperature is the condition of a body which determines its ability to communicate heat to other bodies or to receive heat from them. For meteorological purposes, temperature is referred to the Celsius scale (degree centigrade). 0 degrees centigrade is the normal ice point; 100 degrees centigrade is the normal boiling point of water. The relationship to the absolute thermodynamic Kelvin scale is given by: T degrees Celsius + 273.15= degrees Kelvin.

In agriculture, the spectral distribution of solar radiation especially in photosynthesis assessments is of great interest. Radiation fluxes to and from the earth's surface are most important meteorological elements for heat and energy balance assessments. Energy conversion from solar radiation mainly takes place on the surface of the soil and of plants. This phenomenon is of special interest in agricultural meteorology. The duration of sunshine (units: hr per day) allows for estimates of the energy available for physical and biological processes.

b. Rainfall, dews

The amount of precipitation, rain, snow, ice and dew which reaches the ground in a stated period is expressed as the depth to which it would cover a horizontal surface if there were no loss by evaporation, run-off or infiltration, or if any part of the precipitation falling as snow or ice were melted (liquid equivalent). As precipitation measurements should as much as possible, be representative for a larger area, the choice of site, the form and exposure of the gauge, the prevention against loss by evaporation as well as the effects of wind and splashing are important points which have to be observed.

The amount of precipitation is measured in millimeters, the readings being made to the nearest 0.2 mm; 10 mm should read to 2% of the total. Depth of snow is given in centimeters.

Ordinary rain gauges usually have the form of a collector above a funnel leading into a receiver.

c. Measurement of dew

Dew, being essentially a nocturnal phenomenon, and relatively small in amount, is nevertheless of much interest in arid zones. The amount of dew deposited on a given surface in a stated period is usually expressed in the same units as rainfall: mm depth of dew.

A direct method of measuring dew is to expose a weighted plate of hygrosopic material (gypsum, blotting paper) at sunset and re-weight it after sunrise. This method requires accurate weighing and protection at sunrise to prevent evaporation. Qualitative assessment of dew is obtained by exposing filter paper "sensors" with dew spots. When wetted by dew, the spots will spread to an extent which depends on both the duration and intensity of dewfall. Dew duration recorders operate to a far extent in the same way as the above mentioned wetness recorders.

d. Wind

In agricultural meteorology, the effects of the kinetic energy transfer of wind to the plant/soil system as well the effects of its mass transfer on the energy and water balance are of interest.

By its physical nature two magnitudes are required when describing wind: its **velocity** and the **direction** from which it blows.

- Windspeed is usually indicated in: m/sec, km/h, or knots (=
1 nautical mile/h), but occasionally the non-linear Beaufort scale is used, which refers "forces" from 0 to 12 to the effects of wind on smoke, trees or water surfaces.

- The direction from which the wind blows is either given in accordance with the geographical directions (e.g. N,E,S,W) or in degrees: 1 to 360 (90 degrees = East, 180 degrees - South, 27 degrees = West, 360 degrees = North; 0 frequently stands for Calms).

The Wind Vane (Direction) is a common instrument used in most weather stations

An assembly of a vane plate (which can have many shapes) and a needle is mounted on a vertical axis, which allows it to revolve freely. As a result of the mechanical action of the wind on the vane, the needle will be turned in the direction from which the wind blows. As the direction indicated by the vane, oscillates around the equilibrium point of the airflow (which can change direction rapidly over time), big efforts have been undertaken to minimize this drawback by different designs. The axis of the wind vane can be connected to a mechanical or electrical (contacts, potentiometer) device, which provide recording facilities and/or remote reading of the wind direction.

Advantages

1. To assist the management of agricultural activities - determining the time, extent and manner of cultivation and other agricultural operations (sowing, harvesting, planting, application of biocides and herbicides, ploughing, harrowing, rolling, irrigation, suppression of evaporation, design, construction and repair of buildings for storage, animal husbandry etc.) and different methods of conservation, industrial use and transportation of agricultural products.
2. To assess the performance of plants and animals in relation to climatic elements.
3. To assess the impact of agricultural activities and processes on the environment and climate.

Disadvantages

- Specialized and precision equipment are required for accuracy.

- Trained specialists are conditions for the management of a good weather station which is costly
- Interpretation of results may not necessarily follow the course of nature and so may be misleading

Recommendations

1. It is recommended that research institutes and study centres (schools and colleges) should have functional weather stations to serve their immediate community.
2. National annual weather forecasts should be taken seriously, while efforts should be made to have clientele weather forecasts and services.
3. Weather stations and their component parts should be periodically maintained to ensure accuracy and precision.

4.0 Conclusion

Weather elements and their observations are essential to agriculture and the environment. Our behaviour as humans is driven by the changing weather elements especially our farming operations. The physical elements of climate are observed in order to assist in the evaluation of actual and future land use potentials and of such constraints in agriculture as are caused by the environment. It is in light of the above that each community and educational establishments should have a functional weather station.

Work Assignment

1. If your thermometer reads 25°C, what is its equivalent in Kelvin?
2. What is the unit of measurement of sunshine?
3. What is the unit of measurement of rainfall?
4. List other sources of precipitation apart from rainfall.
5. Wind speed of zero signifies what.

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Crop Phenology and Climate Effects on the Objects of Agriculture

Introduction

The key atmospheric variables that impact crops are solar radiation, air temperature, humidity, and precipitation. The day-to-day variability of these across the landscape can be described as weather. Weather extremes at critical periods of a crop's development can have dramatic influences on productivity and yields. The long-term average temperature and humidity and the total solar radiation and precipitation over a crop's growing season can be described as the climate. It is the climate that, in the absence of any weather extremes, determines the realized yields for a given region.

Phenology is the study of periodic plant and animal life cycle events and how these are influenced by seasonal and annual variations in climate, as well as habitat factors (such as elevation).
Understanding crop phenology is fundamental to crop management, where timing of management practices is increasingly based on stages of crop development. This will facilitateplanning of operations, such as irrigation, the application of fertilizers and pesticides.

The response of crops to the different weather variables is quite complex and difficult to describe. Predicting the exact response of crops to the weather is, as a result, an inexact science, and one that contains great uncertainty. If one of the variables is limiting (for example, temperatures that are too hot or too cold), then the effects of solar radiation or precipitation do not greatly affect the crop. When none of the variables is limiting, the crop will respond to the variable that is farthest from the optimum for that variable.

2.0 Objectives

- To identify the effects of temperature changes on crop growth and development
- To identify moisture regimes for major crops
- To identify the effects of winds on crops and the need for cover crops development

3.0 Main Content

Procedure

1. Temperature

Other than planting, temperature is the main variable that determines when a crop will grow. It also determines, along with precipitation and solar radiation, how well a crop will grow and how fast it will develop. There are four temperature thresholds, called the cardinal temperatures, that define the growth of a crop: the absolute minimum, the optimum minimum, the optimum maximum, and the absolute maximum. The absolute minimum and maximum temperatures define the coldest and hottest temperatures at which a crop will grow. Temperatures between the optimum minimum and maximum define the range of temperature where the crop performs the best. For example, maize (Zea maysL.), for example, has an absolute minimum temperature of 50 °F (10 °C), an optimum minimum of 64 °F (18 °C), an optimum maximum of 91 °F (33 °C), and an absolute maximum of 117 °F (47 °C).

Heat stress affects plants because as temperature increases, respiratory reaction rates speed up, using more of the photosynthetic compounds manufactured in a day. Also, with elevated maximum temperature, especially temperatures that exceed 100 °F (38 °C), plants require more water to maintain optimum water content in their tissues.

If the soil cannot meet the additional water requirement, heat stress is compounded by an added water stress.

2. Precipitation

The type, timing, and amount of precipitation (rain, dew) received during the year play critical roles in crop productivity. Rain is generally more efficient in recharging the soil pro-file and thus is more available for crops. The efficiency of rain in recharging the soil depends on the rate or intensity with which the rain falls. Rain showers or storms that fall at rates greater than 0.5 inches an hour (12.7 cm/hr) are less efficient than lighter showers because the water forms ponds on the surface and runs off the fields into ditches and rivers, carrying along precious topsoil.

The timing of rainfall while crops are growing is critical. During seed germination and stand establishment, either too much or too little rain can influence yields. Too much rain, especially with cool temperatures, can result in seed diseases, causing poor stands, or can saturate the soil, causing poor soil aeration and poor germination and stands. Dry soils during germination and stand establishment can result in either poor seed germination or weak and small plants that may not withstand dry weather during the early growth of the crop, causing smaller plant leaf area. For corn, the critical time during the early growth lasts for approximately 30 days, from planting to tassel initiation, when the corn leaves are being initiated and beginning to grow.

Because the soybean crop continues to flower and fill pods from the start of flowering to almost the beginning of maturity, soybean requires adequate rainfall throughout the period of flowering to maturity. Failure to receive adequate rainfall during flowering and pod fill will result in fewer flowers and pods on the plants.

Wet soils during rainy season play an important role in determining how many days are suitable for field work. When soil moisture is normal or wetter than normal, even small rains will result in field work delays on all but the sandiest soils. Over saturated soils delays planting and seed emergence in addition to poor aeration. This underscores the importance of weather elements in crop production, thus crop phenology.

3. Solar Radiation

Plants use the solar energy from the sun to fix carbon dioxide from the atmosphere, in combination with water from the soil, into carbohydrates that cause plants to grow, reproduce, and provide the grain and vegetation used as food by humans and animals. The solar energy available to plants is a function of sunshine intensity and duration.

When the crop has a full canopy, leaf area index greater than 2.7 the rate of carbon fixation by maize results in an accumulation of approximately 0.14 bushels of grain per acre per megajoule-bu/A/MJ (8.8 kg/ha/MJ). An average heavily overcast day between May and August receives about 8.2 MJ of solar energy. Thus, if all the carbon fixed by photosynthesis were to go into the grain, the yield gain on a heavily overcast day would be 1.2 bu/A/day (75.5 kg/ha/day).

Advantages

Understanding crop phenology in relation to weather is fundamental to crop management, where timing of management practices is increasingly based on stages of crop development and occurrences of the elements of weather.

It facilitates planning of operations, such as irrigation, the application of fertilizers and pesticides.

Harvesting of crops, especially grains are synchronized to periods of highly reduced precipitation and humidity in order to hasten drying and storage.

Disadvantages

1. Weather forecasts are seldom accurate as the vulgaries of nature are unpredictable
2. Most weather forecasts are for regions and hardly could be applied to small geographical areas. A regional forecast cannot suffice for all farming areas.
3. Expertise is required to read and interpret data at weather stations

Recommendations

1. It is recommended that there should be proper study of the climate and weather components of your region/location before sitting your agricultural enterprise
2. Crop phenology studies of a region/location should be conducted before the commencement of commercial farming activities. These studies are necessary for appropriate crop type selection and management.

Conclusion

The response of crops to the different weather variables is quite complex and difficult to describe. Predicting the exact response of crops to the weather is, as a result, an inexact science, and one that contains great uncertainty. This notwithstanding, understanding crop phenology is fundamental to crop management.

Practical Exercises

1. What are the effects of water logging on farming operations and activities?
2. What are the likely consequences of prolonged cloud cover during the day time of our cropping season.

References

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Simple Lay Out Of Agro-Meteological Station

Introduction

An agro-meteorological station (weather station) is a facility, either on land or sea, with instruments and equipment for measuring atmospheric conditions to provide information for weather forecasts and to study the weather and climate. Weather stations range from simple analogue technology to digital technology

The measurements frequently taken include temperature, atmospheric pressure, humidity, wind speed, wind direction, and precipitation amounts. Weather stations sensors are used to take readings of the various weather elements, so the data collected can be analyzed using weather station software.

2.0 Objectives

- To identify areas suitable for sitting weather stations
- To identify sensors for weather elements
- To take readings of the sensors and interpret same.

3.0 Main Content

Procedure

Installation Guide

In order to report accurate weather information you must take care in deciding where to place your weather station. The process of deciding how and where to install your weather station is called "Siting". Siting is the single most important factor in ensuring accurate readings. In fact, sitting influences the accuracy of weather readings much more than the quality of the weather instruments themselves.

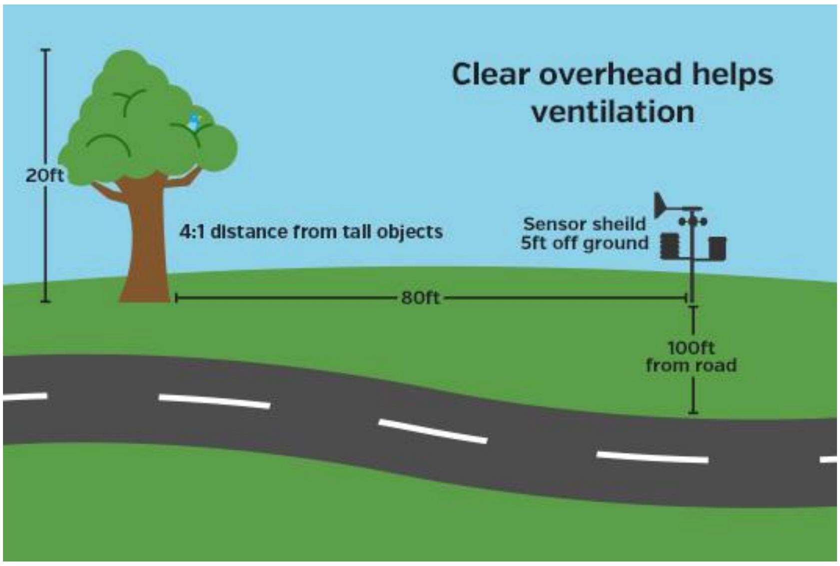
Temperature

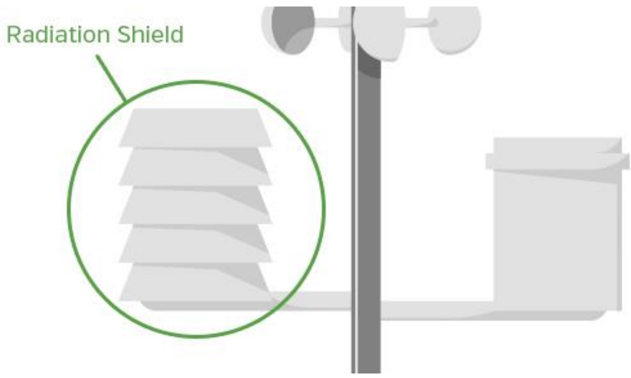
The most common error in installing a weather station is associated with misplacing the thermometer sensor. Meteorologists define temperature as the temperature in shade with plenty of ventilation.

When placing your weather station, make sure:

- The thermometer sensor never receives direct sunlight.
- The thermometer receives plenty of ventilation and is not blocked from the wind.
- If the thermometer is placed on a roof-top, make sure it is at least 5 feet above the roof-top.
- If the thermometer is placed above grass, again, it should be at least 5 feet above the grass surface.
- The thermometer is at least 50 feet from the nearest paved surface.

Suggestion - use a radiation shield for your thermometer. This way, your weather station can be placed in direct sunlight, with the thermometer located inside the radiation shield.





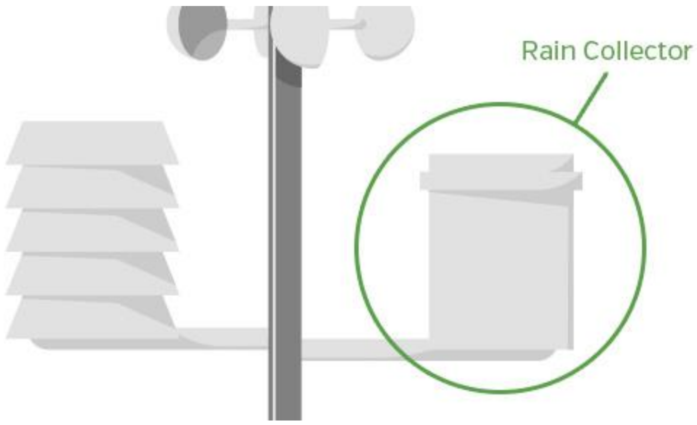
Humidity

Humidity measurements should reflect the humidity of the general atmosphere in your location. Plants and bodies of water influence humidity measurements. Hence, make sure the humidity sensor is at least 50 feet away from the nearest tree or body of water.

Rain Collector

You want the Rain Collector (or, Rain Gauge) to receive rainfall as if it were in the middle of a large field. Nearby buildings create "shadows". Imagine if there's a building nearby to the west, and it is raining with a west wind. In such an event, your station's rain collector is bound to miss a lot of falling rain because of the "shadow" cast by the building. As a rule of thumb:

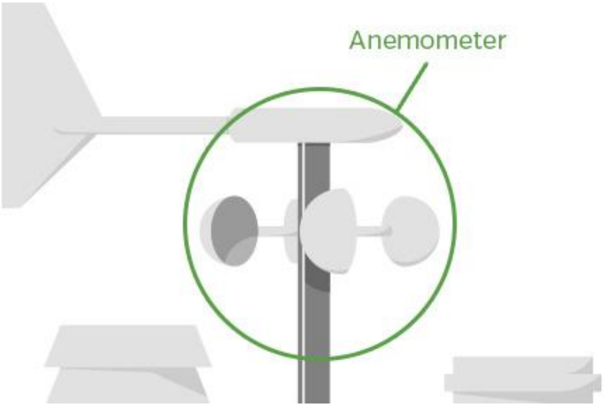
- The rain collector should be placed with at least 5 feet horizontal clearance from the nearest obstruction.
- If a nearby obstruction is just over 5 feet away, that obstruction should be no more than 10 feet tall.



Wind Speed and Direction

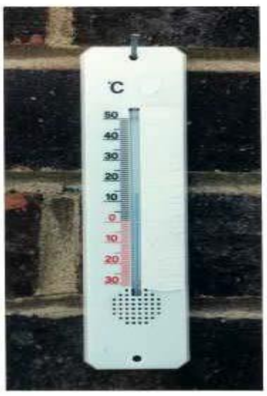
Similar to a rain collector, the anemometer should reflect the wind patterns as if the instrument was placed in a large field.

- The standard wind measurement should be taken at 10 meters (33 feet) above the ground. A roof-top works the best. Try to place the anemometer as high as is convenient.
- Try to make the anemometer the highest object around 7 feet or more above the surrounding obstructions is best.



Types of weather element sensors and their setting

Thermometer - A thermometer measures **temperature**. Some weather stations measure both the temperature indoors and outdoors, record highs and lows, show trends to indicate temperature rising or falling, and even predict short-term future temperature ranges.



Ordinary spirit-in-glass thermometer. This simple louvred thermometer screen is available as a kit

Hygrometer - A hygrometer measures **relative humidity**. Relative humidity is the quantity or percentage of water vapor (water in gas form) in the air. Humidity influences environmental factors and calculations like precipitation, fog, dew point and heat index.

Humidity is measured most accurately with a wet- and dry- bulb thermometer

Barometer - A barometer measures **atmospheric pressure**. A barometer can help to forecast upcoming weather based on the changes it measures in the atmospheric pressure. Some weather stations feature a barometric pressure history chart or pressure trend arrow so you can easily track changes, like a pressure drop.

A simple, clearly-marked, barometer

Anemometer - An anemometer measures how fast the wind is blowing, or **wind speed**. Some weather stations can display wind speed in MPH, KPH or knots, and record current, peak and average wind speed readings.

A simple home-made weather-vane

The ventimeter can measure wind speed and indicate wind direction

Wind Vane - A wind vane, or weather vane, is an instrument that determines which direction the wind is blowing**.**

Rain Gauge - A rain gauge measures **rainfall or liquid precipitation.** Some weather stations include rainfall alerts to notify you when a rain event has begun, or to alert you of potential flood conditions. The opening of the collector should have a receiving area of 200 to 500 cm2. (The most common standards are: 200 cm2, 324 cm2 (diam: 8 inch) and 400 cm2. However, in many countries 126 cm2 (diam: 5 inch), are still used. The rim of the collector should have a sharp edge and should fall away vertically inside and be steeply leveled outside. It should be designed to prevent rain from splashing in and out. The receiving water container should have a narrow neck and be protected from radiation to prevent loss of water by evaporation.

The rain measures, measuring glass or dip rod, have to be graduated to correspond to the relative areas of cross section of the gauge orifice. A measuring cylinder should be made of a clear material (glass or moulded plastic), have a low coefficient of expansion, and its diameter should not exceed 3 times of the gauge diameter. Graduation should be in units of rainfall and at least every 0.2 mm should be marked.

Dip rods are mainly used to measure rainfall in monthly or seasonal gauges. However, these measurements should be checked using cylinders as well.

A cheap plastic rain-gauge with funnel and measuring cylinder

4.0 Conclusion

The measurements and observations outlined in this chapter can form the basis of many interesting constructional and experimental instruments in the study of weather for agriculture. These simple sensors form the background to the understanding and use of the advanced versions.

5.0 Practical Exercises

1. Talk a walk to a weather station nearest to you and identify the available weather sensors
2. Where is the direction of the wind now. State date and time
3. List the damages that might be caused by excessive wind speed
4. What preventive measures are necessary to avert the damages listed in (3) above.

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Acurite weather station.com