AGROMETEOROLOGY

Mirza Hasanuzzaman, PhD
Associate Professor
Department of Agronomy
Sher-e-Bangla Agricultural University

Meteorology: Meteorology is the interdisciplinary scientific study of the atmosphere. It is a branch of applied science which deals with the details of the atmosphere and its effects.

Agrometeorology: Agro-meteorology implies that it is the study of those aspects of meteorology which have direct relevance to agriculture, in its various forms, to help the sensible use of land, accelerate production of food and to avoid the irreversible abuse of land resources.

Weather: The state of atmosphere that prevails at a particular locality at a particular time/moment is called weather of that locality for that time/moment. The state of atmosphere means the situation developed by temperature, pressure, humidity etc.

Climate: Climate may be defined as the mean weather of a locality for a long period of time. The branch of science that deals with climate is called climatology. The long time means a period of 25-30 years.

Macroclimate: Climate of a large area. Valid weather yard measures it. The macro climate extends up to 40-50 km area surrounding the weather yard.

Microclimate: Climate of a lower scale. It determines the climate of a surroundings a plant, leaf even stomata etc.

Local climate: The climate between macro and micro climate such as the climate of a field, a tree or a house etc. What crops should be grown in a field, it depends on macro climate. The production depends on mainly local climate. The micro climate is necessary for research.

Major elements of climate:

1. Atmospheric temperature
2. Precipitation
3. Sunlight
4. Relative humidity
5. Atmospheric pressure
6. Wind
7. Cloud

Comparison between weather and climate

Weather	Climate
• Atmospheric condition of a particular day	• Average weather condition of a particular period of years.
• Vegetation does not depends on weather	• Climate greatly influences on vegetation
• Daily agricultural operation depends on weather.	• Climate determines the seasonal cropping
• Weather influences on agricultural production	• Climate determines the types of crops on location
• Natural hazards (insects, diseases etc.) influenced by weather.	• Initial information is given by climate
• No influence on soil formation, soil reaction.	• Temperature, rainfall has influenced by it.
• Weather changes rapidly	• Climate does not changes rapidly
• Measured by thermometer, raingauge barometer etc.	• Climate cannot be measured by any instrument

Weather instruments

The weather measuring instruments which are used or setup at the metrological station are enlisted below:

- ***Maximum and minimum thermometer*:** It is used in recording maximum and minimum temperature of a particular day of a particular place.
- ***Hygrometer*:** It is used in measuring the atmospheric humidity of a particular day of a particular place.
- ***Rain Gauge*:** Amount of rainfall is measured by this instrument.
- ***Barometer*:** It is used to measure the atmospheric pressure.
- ***Anemometer*:** Wind speed is measured by this instrument.
- ***Wind vane*:** This instrument is used to detect the direction of wind.
- ***Sunshine recorder*:** This instrument is used to record sunshine hours.

TEMPERATURE

Influence of temperature in agriculture

Distribution of Plants: Plants can grow only within certain limit of temperature. For each species and variety there are not only optimal temperature limits, but also optimal temperatures for different growth stages and functions, as well as lower and upper lethal limits. Temperature determines which species can survive in a particular region.

Table 1. Classification of vegetation based on temperature

Class	Temperature requirement	Crops
Megatherms	High temperature throughout the year	Tropical crops like rubber, Cassava, Varieties of rice, etc.
Mesotherms	High temperature alternating with low temperature of winter	Sub-tropical crops like maize, sorghum, etc.
Microtherms	Low temperature	Temperate crops like wheat, oats, potato etc.
Hekistotherms	Very low temperature	Pines, spruce, etc.

Germination: Temperature greatly influences germination of seeds Optimum temperature activates enzymes for proper seed germination. Different seed requires different range of temperature.

Table 2. Cardinal temperature of different crop's seed germination:

Crop's Seed	Temperature (°C)		
	Minimum	Optimum	Maximum
Rice	11	32	41
Maize	9	33	42
Wheat	4	25	32
Soybean	9	30	41
Barley	4	22	36

Photosynthesis: The effect of temperature on the rate of photosynthesis is little than on other processes. Very high and very low temperatures affect the photosynthetic rate adversely. The rate of photosynthesis increases with the rise in temperature from 5° to 37°C beyond which there is a rapid fall. Between 5° to 37°C, the rate of photosynthesis is doubled for every 10°C increase in temperature. C_4 plants (maize, sugarcane) require high temperature (30° to 45°C) and C_3 plants (rice, wheat, mustard, potato) require relatively low temperature (10° to 25°C) for optimum temperature.

Respiration: The rate of respiration increases with the rise of temperature up to a certain level, but beyond the optimum limit the respiration rate shows marked decrease. The rate of respiration becomes doubled at the increase of 10°C above the optimum temperature provided other factors are favorable.

Transpiration: Stomata open at 0 to 30°C temperature. Higher transpiration occurred at high temperature. At >30°C stomata will closed.
Flower Initiation: In many crops (such as sugar beet, wheat) low temperature is required for flower initiation. The phenomenon of acquisition or acceleration of the ability to flower by chilling / low temperature treatment is termed as vernalization.

Induction of sterility: The occurrence of various cytological abnormalities in meiosis during the formation of the generative cell has been thought to constitute the primary cause of spikelets sterility. These abnormalities due to cold injury at the boot stage of rice plant. Sterility can also occur due to loss of stickiness of stigma and consequently failure of fertilization. Rice yield decrease due to sterile of spikelets caused by low temperature at booting stage.

Yield: Soil temperature is important for the vegetative growth of crops. Soil temperature is more important than air temperature to plant growth. Optimum soil temperature for potato is 17°C, Tuber formation is practically absent above 29°C. Corn yield increases almost linearly as soil temperature rises from 15 to 27°C. The mid day high temperature accelerates photosynthesis and ripening of fruits. The production dry matter occurs when temperature ranges between 20 to 30°.

Life span: Life span of same crop differs in Rabi and Kharif season due to temperature variation.

Morphology of plants: In cotton, more vegetative growth occurs in Kharif due to high temperature

Quality of products: Less quality due to very high temperature.

Disease and insects' infestation: Disease infestation higher in high temperature. But at > 50°C no diseases and insects are observed.

Weed attack: Higher in high temperature.

Evaporation: Higher in high temperature

Processing of industrial crops: 26 to 30°C air temperature is required for tea curing and for jute retting 34°C water temperature is required.

RELATIVE HUMIDITY

Humidity

The absorption of water vapor to the atmosphere is called humidity. It is measured by hygrometer. The amount of water vapor that can retain the atmosphere depends on temperature. It is increased with increasing temperature.

Absolute humidity

The amount of water vapor per unit volume of air is called absolute humidity. It is expressed as g m^{-3}. It is used in air conditioning.

Relative humidity

The ratio between the amount of water vapor present per unit volume of atmosphere with constant temperature and atmospheric pressure and the amount of water vapor required saturating that volume with that temperature and pressure is called relative humidity. It is expressed as percentage.

Influence of relative humidity on agriculture

Distribution of crops: The demand of relative humidity is different in different crops. Hence relative humidity regulates the crop distribution, e.g., young tealeaves are the industrial raw materials, and hence high relative humidity is for succulent young leaves.

Transpiration: Low relative humidity increases transpiration.

Evaporation: Low relative humidity increases evaporation and thus the irrigation demand is higher.

Fruit setting: Lower relative humidity affects fruit setting. It dries the stigma and reduces the pollen viability.

Disease infestation: Less disease infestation with low relative humidity e.g., with relative humidity 90-100% the late blight of potato infestation is so high that the whole field may be damaged within 2 to 3 days, but no infestation with lower relative humidity.

Insect infestation: Higher infestation with high relative humidity.

Processing of industrial crops: Specific relative humidity is required in different steps for processing different industrial crops. It reserves the quality e.g., Yellowing of tobacco leaves in flue curing requires 80-90% relative humidity and for colour fixing, it requires 20% RH.

Preservation and transportation of vegetables and fruits: Relative humidity favor preservation and transportation of fruits and vegetables. It is better to maintain 90-95% relative humidity during preservation and transportation.

Curing of under ground crops: It is required to curing ½ weeks for underground crops like, potato, sweet potato, onion, garlic, ginger etc high relative humidity is required for their curing. E.g., for potato curing 85−95% relative humidity is required.

Seed drying and preservation: It is require to lower relative humidity for preserving seeds

PRECIPITATION

Precipitation is any type of water that forms in the earth's atmosphere and then drops onto the surface of the earth. When the atmospheric temperature less than 10°C then it water vapour come down from the atmosphere as precipitation.

Types of Precipitation

According to its appearance precipitation are of two types:

A. Liquid precipitation

When the temperature is higher than freezing point then it comes down to the atmosphere as liquid form like dew, fog, rainfall etc.

1) **Rain:** drops of liquid water (> 0.5 mm in diameter).
2) **Drizzle:** droplets (<0.5 mm in diameter).
3) **Dew:** condensation of water vapour onto a cool surface.
4) **Fog-drip:** accumulation of fog droplets on vegetation and other obstacles (horizontal interception.)

B. Solid precipitation

When the temperature is lower than freezing point then it comes to the atmosphere as solid form like snow fall

1) **Snow flakes:** solid equivalent of rain.
2) **Snow grains:** small crystals of ice; solid equivalent of drizzle.
3) **Ice Crystals:** Also called diamond dust. They are small ice crystals that float with the wind.
4) **Sleet:** Rain and snow mixed, snow that partially melts as it falls.
5) **Hail:** dense precipitation of ice that is at least 5 millimetres in diameter.

Rain or rainfall

Precipitation of liquid drops of water. Raindrops generally have a diameter greater than 0.5 mm (0.02 inch). Amount or volume of rainfall is expressed as the depth of water that collects on a flat surface. Rainfall is classified as light if not more than 2.5 mm (0.10 in) per hr, heavy if more than 7.50 mm (more than 0.30 in) per hr, and moderate if between these limits.

Causes of rainfall variations

- **Proximity of sea:** Higher rainfall near sea areas and low rainfall to the long distance from the sea.
- **Wind flow:** When the wind flows above the water sources, then it carries more water vapour as a result more rain fall.
- **Presence of hills:** Higher rainfall to the one side of hill but less rainfall towards the opposite side of the hill.
- **Presence of higher plants:** Only 1-3% absorbed water is assimilated by the plants, other 97-93% water is released from the plants through transpiration. More rainfall with the presence of maximum plants.
- **Rate of evaporation:** Higher rainfall to that area, where maximum water sources for evaporation is available.
- **Temperature:** More rainfall to the high temperature areas due to more evaporation. Hence the maximum rainfall occurs in the tropical region and minimum in the arctic region.
- **Latitude:** More rainfall in the axis and minimum to the poles.

Different regions in the world due to rainfall variation

The world is divided into 5 regions on the basis of annual average rainfall.

1) **Arid region:** Low rainfall (<25.4 cm). One third area of the world is under this region. Drought is the main characteristics of this region such as Saudi Arabia, Sudan, Egypt, Libya etc. under this region.

2) **Semiarid region:** Annual average 25.5 to 50.8 cm. Hyderabad of India, part of Pakistan, and part of Iran are semiarid region.

3) **Sub humid region:** 50.8 to 101.6 cm rainfall. Brazil, Chile are in this region.

4) **Humid region:** 101.6 to 203.2 cm rainfall. Uganda, Argentina are in this region.

5) **Wet region:** >203.2 cm rainfall. Small area under this region such as Cherapunji of Asam, India and Bangladesh.

Influence of rainfall in Bangladesh agriculture

Distribution of crops: Rice and jute require more rainfall. Tea requires maximum rainfall (Annually >150 cm) and more or less rainfall about 5 cm in each month is require. Joar, Cheena, Kaon sorghum grow in low and less rainfall areas.

Germination: Wheat seed requires 56% water absorption compared its weight for germination. But mustard requires less water absorption. Broadcast Aman and jute seeds require more rainfall. Chilli and potato seeds damage with higher moisture.

Supply of water according to plant requirement: Only 1 to 3% absorbed water by the plants is utilized by assimilation and rest 97 to 99% absorbed water is released from the plants as transpiration. For 1 g dry matter production around 50 mm water in coniferous crops (Thuja, Pine) but it is 2500 mm for leafy vegetables. The mean water requirements are is 300 to 1000 mm

Addition of N to the soil: Atmospheric nitrogen added to the soil through rainfall ranges between 6 to 28 kg N/ ha/ year.

Addition of S to the soil: Sulpher added to the soil as H_2SO_4 which is formed by the SO_2 and H_2O (rainfall). Small amount of H_2SO_4 addition is helpful for the crops but it is detrimental with higher amount.

Tillage and other intercultural operations: Rainfall has great influence on it as--

- It is difficult to cultivate the land if there is no rain for hardiness of the soil. It is found in the early summer in Bangladesh.
- Due to heavy rainfall 'Zoe' condition is delayed and hence ploughing, weeding, etc operations hampered.
- Heavy rainfall also hampered harvesting and processing of crops.
- Liquid form of fertilizers, insecticides, fungicides etc application in the leaf will be meaningless if it is rains immediate after spraying.
- Heavy rainfall may create water logging. Hard soil crust may be creates on the upper level of soil when dries after rainfall that hampered the proper aeration to the drops.

Leaching loss of nutrients: Nutrients like N, Ca, Mg etc. leached from the soil due to heavy rainfall and this hampered yield, make the soil acidic due to Ca losses. In moist area the rate of $CaCO_3$ and $MgCO_3$ losses per year per hectare is 112 kg and 22 kg, respectively.

Soil erosion: The erosion loss of soil is higher both excessive rainfall and it is also higher in open field.

Disease infestation: The rainfall transmits disease organisms through runoff and rainfall etc.

Weed infestation: Weed seeds also transmit with runoff and also favours to germination due to excessive moisture.

Waterlogging: Excessive rainfall creates water logging and this hampered roots, nutrients uptake etc.

Quality of products: Heavy rainfall in rainy season is the main cause for sourness of grapes.

- Boll formation of cotton is hampered due to heavy rainfall.
- Shattering loss of mustard
- Disturb in pollination.
- Rainfall creates problem in drying of crop products.
- Decrease the quality of tuber crops.
- Creates problem in decomposition green manuring

INFLUENCE OF WIND ON AGRICULTURE

Lodgings: With heavy wind, Crops lodged e.g., rice, jute, sugarcane, etc. Destroy increases with higher wind speed. e.g., > 50-60 km / hour.

Transpiration and evaporation: More transpiration and evaporation with high wind speed It is not changed above 20 km/hour speed (Devlin, 1976)

Soil erosion: Wind has direct relationship with soil erosion. Soil fertility decreased with soil erosion. Photosynthesis also hampered by dust particles on leaf surface.

Pollination: Wind is must for anemophilous plants. e.g., maize, palm etc.

Disease spreading: Wind spreads diseases organisms from one place to another. The diseases organisms of stem rust of wheat come from Himalayas through wind during winter.

Insects spreading and control: Insects spread from one place to other through wind. Anti direction of wind speed also controls insects spreading. Insects also died with higher speeded wind

Weed dissemination: Weed seed dispersed from one place to another through wind. This hindered to control weeds.

Isolation distance of seed production: Pollens move from one place to another. Hence for better seed production proper isolation distance should be maintained.

Indirect influence: Wind spread clouds from one place to other and occurs rain Saline water may sometimes enter in to the crop field with higher wind speed

SUNLIGHT

Plant utilizes solar energy in photosynthesis Each and every living organisms depend on plants for their food.

Green plants utilize only 1% solar energy. Other 99% are utilized in another way. Sugarcane and Sugarbeat can utilize 2% solar radiation. The spectral range (wave band) of solar radiation from 400 to 700 nanometers that photosynthetic organisms are able to use in the process of photosynthesis is called photosynthetically active radiation or PAR.

Sunlight is discussed in different ways:

1. Photoperiod
2. Total sunshine hour
3. Intensity
4. Wave length
5. Light direction

1. **Photoperiod:** Period from sunrise to sunset is called photoperiod. It is sometimes also termed as Potential sunshine hour in a particular day at a particular time. The photoperiod varies in different axis.

2. **Total sunshine hour:** The bright sunshine hour in a day is called total sunshine hour. It is measured by Sunshine Duration Recorder.

3. **Intensity:** Intensity is measured by different units as feet candle, meter candle, photon, LUX etc. The intensity in a cloud free sky is around 10000 ft candle. But it varies due to cloud, branch and canopy in a plant, planting distance, shadow of plants etc.

4. **Wave length:** The sunlight comes to the earth as electromagnetic wave. The visible spectrum is white. It is formed by 7 monochromatic light known as VIBGYOR which is developed by Sir Issac Newton in 1666. The atmosphere heated more when the short wave length increases.

5. **Direction of light:** The sunlight comes to the earth on the Northern hemisphere from southern side and Southern hemisphere from the northern side.

Influence of sunlight on agriculture

Sunlight is more essential for different physiological activities of the plants in the following ways

Breaking of seed dormancy: Plants can be divided into 3 ways due to light importance in breaking dormancy.

a) Light germinating plants: Light is most necessary for germination e.g., All epiphytic plants

b) Light favor germinating plants: Germination may also take place in dark but favored or enhance in light e.g., Tobacco, Lettuce, Grasses Coniferous plants.

c) Dark germinating plants: Light inhibit germination e.g., *Allium*, Amaranth etc

Photosynthesis: Presence of sunlight is must for photosynthesis. For maximum photosynthesis 1200 ft candle sun light is necessary. For maximum utilization of sunlight plant can be grown with optimum distance and hence pruning is essential

On the basis of sunlight requirement plants can be divided in to two groups

a) **Heliophilous plants**: These plants require bright sunlight for their photosynthesis. e.g. Rice, Wheat etc.
b) **Heliophobis plants**: Photosynthesis occurs in low and shaded sunlight, e.g. Tea, Coffee, Bettle vine Ginger, Turmeric, Aroids, Lemon, Tobacco etc.

Transpiration: Sun light effects on transpiration in two ways: a) due to stomata opening in sunlight, more transpiration occurs in more sunlight and b) more transpiration due to temperature increase.

Plant Movement: Light influence on plant movement. Roots always avoid light such tendency is known as Geotropism. But shoot always move towards light. This movement is called phototropism. The movement towards in sun is called Heliotropism.

Color of plants: Light control color of the Plants due to lack of sunlight, plants become yellowish and chlorophyll formation starts on potato stolon when receives light.

Flower development: The day length has influence on flower development this is called photoperiodism. The duration on photoperiod without which plants cannot flowers is called “critical photoperiod”. Plants can be broadly classified into 2 groups on the basis of day length and photoperiod.

a) **Day neutral plants**: No relationship between flower formation and day length. E.g. Tomato, Brinjal, BR 3 rice variety, Soybean, Maize, Cotton, Sunflower, Banana, Papaya etc.

b) **Photosensitive plants:** Flower formation directly related with day length. It is again divided into:

   i. **Short day plants:** Short day i.e. long night required for flower production. Critical photoperiod is 11-12 hours e.g. Jute, Sugarcane, Aman rice, Tobacco, Sweet potato, Coffee. The plants that flower below critical photoperiod called short day plants, e.g. the critical photoperiod of jute is 11.5 hours hence jute can flowers only when the day length is 11.5 hours or bellow.

   ii. **Long day plants**: Long day that is short night required for flowering. Critical photoperiod is 12-14 hours, e.g. Cabbage, Potato, Lettuce, Radish; etc plants flower above the critical photoperiod is called long day plans. e.g. Spinach flower above 13 hours day length or more but not less.

Pest control: Short wave length ultra violet rays destroy many causal organisms of fungus and bacteria and hence it is suggested to keep the land open after ploughing on sunlight for some days.