Meteorology And Meteorological Instrumentation

CHAPTER 4

METEOROLOGY AND METEOROLOGICAL INSTRUMENTATION

This chapter covers general informations about the meteorology, meteorological parameters, meteorological station and types of available instruments. The chapter also covers influence of meteorology on crop water use.

4.1 METEOROLOGY

4.1.1 There is hardly any sector of human activity which is not influenced by environment considerations. The physical state of the aerial part of the environment with which the science of meteorology is concerned is the prime factor which influences not only the physical and physiological behavior of the living organisms but also a large number of areas which directly or indirectly have a bearing on human life in general. Meteorology is the science of the atmosphere which is an envelop of air surrounding the earth differentially heated and adhering to the earth during its motion of rotation about its axis and revolution around the sun.

4.1.2 The physical state of the atmosphere in respect of the radiational regime, thermal regime, moisture regime, dynamic regime and the state of sky at any place at any instant of time is termed weather. Weather refers to relatively smaller area of space and only an instant of time. This evidently means that weather is not static but dynamic.

4.1.3 Climate on the other hand is the normal or generalised weather as occurring or observed over a relatively large period of time such as a month or a season over a larger region. Information on climate of a region is deduced from accumulated weather informations for the region over a period of time, usually a considerably large number of years.

4.1.4 Role of meteorology is increasing day by day, among the areas with which human life is most concerned viz: Agriculture, Public health, Transportation, Recreation, sports, etc. Agriculture and irrigation engineering are the fields where meteorology plays a vital role. For designing any irrigation project or irrigation system basic data of meteorology, or the informations generated from such data are necessary. Rainfall is the important parameter to decide flood for any spillway. And on the other hand capacity of the reservoir and its canals can not be determined without the evapotranspiration rates. Thus a well established weather station is required in the catchment area as well as in the command area of a project.

4.1.5 Meteorology science is not only helping the engineers during planning and designing stage, but it is continous source of informations for operation maintenance and management process. A weather station on dam site, along periphery of reservoir or in catchment area is useful as under:

- To estimate the incoming flow to reservoir-based on rainfall data
- To estimate total evaporation losses from the reservoir

Looking to the low irrigation potential and small water resources of the state it is to be kept in mind that utilisable water resources, if used conventionally will be exhausted and there may remain no additional water for harnessing. Hence it is necessary to see that water must be used economically and efficiently by adopting new and modern methods of irrigation and latest methods of determination of water requirements of crops and proper management practices. The knowledge of optimum weather conditions specific to a given phase or stage of growth of a crop, coupled with the knowledge of how weather has behaved in the past over a number of years, helps to characterise the growing season. The knowledge of the crop characteristics and the weather characteristics, as inferred from past records combined, enable an agricultural, meteorologist and irrigation engineer to formulate ecological crop planing. Thus meteorology does play a significant role in irrigation management, It is therefore necessary to establish meteorological observatories at dam sites, in catchment area, and in the command areas.

4.2 METEOROLOGICAL STATION

4.2.1 In order to understand the interrelationships between weather and life, precise assessment and characterisation of weather or this physical state of the atmosphere is necessary for which the meteorological observatory is needed. Climate is of utmost significances in the planning of several activities affecting life. The climate of a region just cannot be known unless the bulk of meteorological data is built for several places in the region over several years. This evidently established the need for a network of meteorological observatory.

4.2.2 Requirements at meteorological stations: Authority and observer

The work 'authority' is used to denote the organization responsible for the maintenance of the station. The 'observer' is the person to whom is assigned the actual duty of making and recording the observations.

The observer need not have a high scientific qualification, but should be a person of sufficient intelligence and education to carry out instructions in a satisfactory manner. He should be capable of developing a real interest in the weather, if he does not possess it already, and must be dependable. Observations often have to be made under conditions which entail some personal discomfort and thus make real demands on the observer's zeal and sense of responsibility. His occupation should be such that he has opportunities of taking note of the weather between the fixed hours of observation.

There should also be a deputy observer capable of taking over the observer's duties in the later's absence. It is a good plan to arrange for the deputy to take spells of duty periodically so that his knowledge of the procedure does not become rusty from disuse.

4.2.3 Selection of site

To ensure that the observations are representative of the place and sufficiently comparable with those made at other stations to permit their use in national or regional climatological studies, the following basic requirements are laid down for climatological stations:

(i) Outdoor instruments are usually installed on a level piece of ground about 10 m by 7 m covered with short grass and surrounded by open fencing to exclude unauthorized persons. A suggested layout is shown in Figure 4.1.

(ii) The plot should be upon generally level ground, there should be no steeply slopping ground in its vicinity and the site should not be in a hollow. If these conditions are not met with, the readings of temperature and amount of precipitation may show peculiarities of entirely local significance.

(iii) The site should be well away from trees, buildings, walls or other obstructions. The distance of any such obstacle (including the fencing) from the rain-gauge must be at least twice the height of the obstacle.

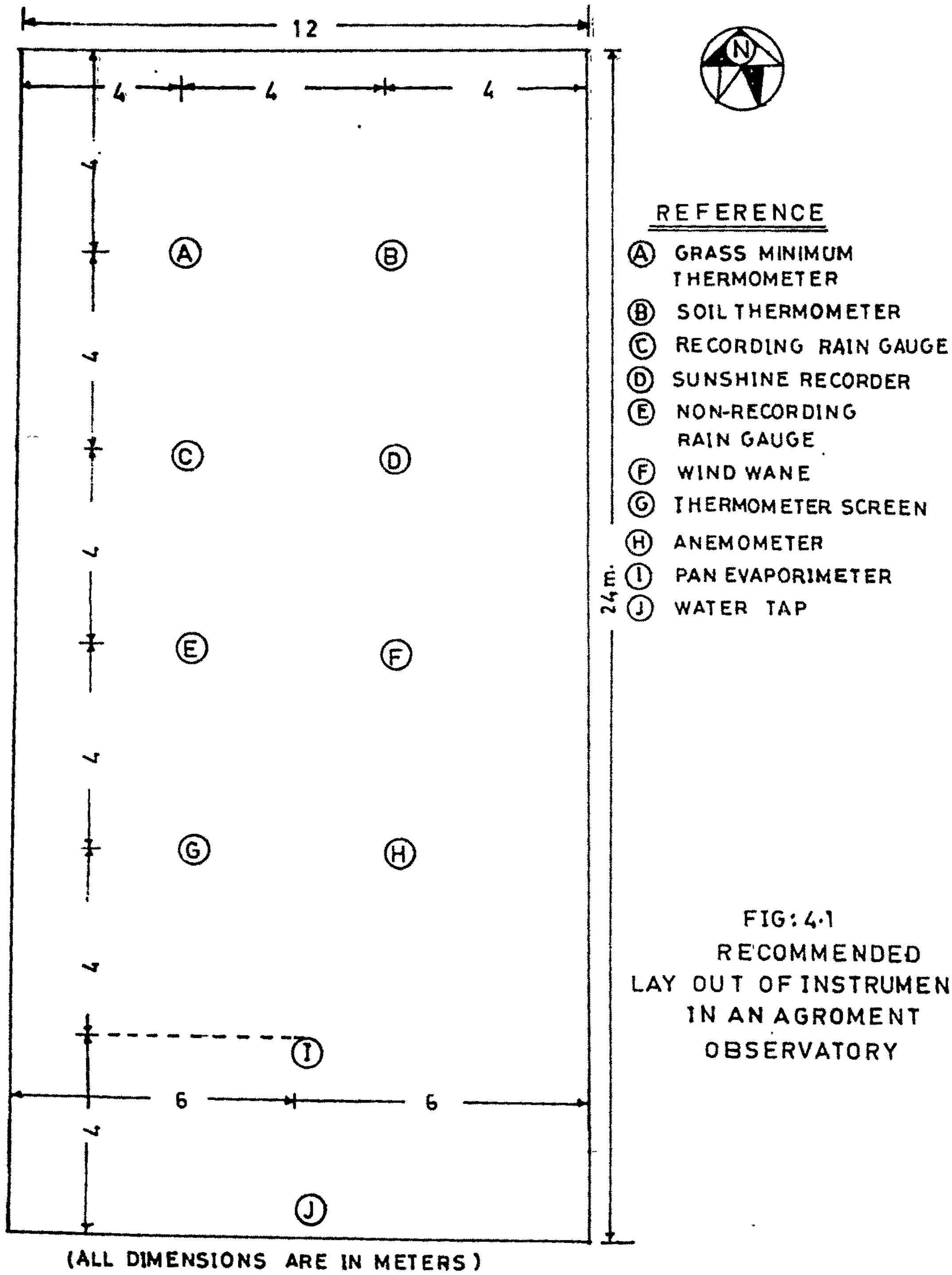


FIG: 4·1
RECOMMENDED
LAY OUT OF INSTRUMENTS
IN AN AGROMENT
OBSERVATORY

(iv) The sunshine recorder, rain-gauge and wind vane should be on sites with exposures that satisfy their requirements and they need not be on the same site as the other instruments.
(v) The enclosure may not be the best place to estimate the wind speed and direction; another observation point, more exposed to the wind, may be desirable.
(vi) Very open sites which are satisfactory for most instruments are unsuitable for rain-gauges. For such sites the rainfall catch is reduced in other than light winds and a measure of shelter is needed.

In selecting a site the future should be considered as well as the present. A good site may become a bad one because of the growth of trees or the erection of buildings on adjacent plots. It should preferably be sited on a scheduled open space, and the layout of the remainder of the open space should be such that the exposure will remain unimpaired for many years.

4.2.4 Co-ordinates of the Station

For record and other purposes the position of a station must be accurately known. The 'co-ordinates' of a station are:

(i) the latitude to the nearest minute,

(ii) the longitude to the nearest minute, and

(iii) the height of the station above MSL , i.e. the altitude of the station, to the nearest tenth of a meter if possible, although usually quoted to the nearest meter.

These co-ordinates refer to the plots on which the observations are taken, and are not usually the same as those of the town,village or airfield after which the station is named. The latitude and longitude can be read from the appropriate sheet of the one-inch Survey map. The position of the station may be even more closely identified by a grid reference for the site and this should also be given. The altitude of the station is defined as the height above mean sea level of the ground on which the rain-gauge stands. The level of the barometer is separately specified.

The determination of the altitude of the station involves leveling from the nearest GTS bench mark or from the nearest point the altitude of which is accurately known. In fairly flat country, observers should be able to determine the altitude of the station without much difficulty by reference to a large-scale map on which many altitudes are shown. In more difficult situations it is better to carry out surveying.

4.2.5 Orientation

For the determination of wind direction, and for some other purposes, it is necessary to know the exact direction of true north from the station and the true bearings of selected conspicuous objects. Several alternative methods are available for doing this, but the following appears to be best.

True north may be obtained from the position of the sun at noon, local apparent time is indicated by the direction at this time of the shadow thrown by a stick, carefully adjusted to the vertical pole or flagstaff.

Alternatively the orientation of a station can be accurately determined by the magnetic compass, provided that careful precautions are taken. A compass needle does not point to true north but diverges to west or east of north by an amount, known as the 'declination', which differs from place to place and in any one place varies slowly from year to year. All directions determined by compass bearing must be corrected by the amount of the magnetic declination, which may be obtained by consulting the Survey of India. True bearings are obtained from magnetic bearings by subtracting a westerly declination or adding an easterly one. A serious source of error in the determination of direction by means of a magnetic compass is the disturbing effect produced by the proximity of iron or steel or of electric currents. Even the presence of such small objects as iron nails in the support on which the compass is placed, a knife or keys in the observer's pocket, may cause serious errors of unknown magnitude. The observer must satisfy himself that all such possible sources of disturbance are absent before a compass reading can be accepted as reliable.

4.3 METEOROLOGICAL PARAMETERS

Periodical measurements on meteorological factors such as atmospheric pressure, wind velocity and wind direction, temperature,humidity, radiation, sunshine, precipitation and evaporatrion are essential in understanding the atmospheric phenomena. Though it is generally difficult to make short term weather predictions, observations over a period of time would render long term predictions on a statistical basis. A brief description of meteorological elements is covered under this para.

4.3.1 Atmospheric Pressure

The pressure exerted by the atmosphere is a very important characteristics of the atmosphere. This is usually measured by barometer consisting of an inverted U tube filled with mercury kept in a cistern, or an anoroid barometer which consists of a diaphragm deflected by the atmospheric pressure. Barograph records pressure continuously with time. Curve joining points of equal pressure is known as isobar. Atmospheric pressure is always expressed in millibars.

4.3.2 Wind Velocity

Air in motion is called wind. The horizontal component of the air movement parallel to the earth's surface is generally referred to as wind and the vertical one as air currents. Wind velocity is measured by cup anemometers.

4.3.3 Temperature

Temperature is measured usually in degree celsius (°C) with mercury in glass type thermometer. Four thermometers are placed in the stevensen screen for maximum, minimum, wet and dry temperatures. A continuous record of temperature with time can be obtained by an automatic recording instrument called the "thermograph".The mean daily temperature is computed as the arithmatic average of the maximum and minimum temperatures recorded that day, observations over 30 year period called the normal temperature.

4.3.4 Radiation

The source of energy for all atmospheric activities is solar radiation, usually measured in calories per square centimeter per minute (Cal/cm^2 /min). The unit cal/cm^2 /min is known as langley (ly). The energy of 2 ly/min (solar constant) reaches at the outer limit of the atmosphere out of 107050 ly/min radiated by sun. The soler radiation received by a unit area on a horizontal surface is called insolation. It depends on the declination of sun, the latitude of the place and the position of sun at that time. A major portion of the insolation is scattered and absorbed in the atmosphere or reflected from clouds and earth's surface, after which about half of the insolation reaches the earth's surface. Part of this is again reflected to the atmosphere and the rest is absorbed by the earth.

The duration of the bright sun shine in a day is recorded by an instrument called the sun shine recorder. The sort wave radiation both direct and diffused reaching earth's surface is measured by "Pyranometer" as referred by WMO.

4.3.5 Humidity

Water vapour is one of the regular constituents of the atmosphere, although at a time very small amount may be present. It has considerable influence on temperature. It is fact that this moisture is the precipitation and also materially controls the rates of evaporation from land and water surfaces. The pressure exerted by the vapour in a saturated space is called the saturation vapour pressure. Relative humidity is the percentage ratio of the actual to the saturation vapour pressure, and is therefore a ratio of amount of moisture in a given space to the amount the space could contain if saturated.

Relative humidity or simple humidity is usally measured by the "Psychrometers". It consist of two glass thermometers, dry and wet bulb thermometers. The vapour pressure and humidity can be calculated from equations and tables using observed data of dry and wet bulb temperatures. The continuous recording of the humidity with time is done by an automatic recording instruments called the "Hygrograph".

4.4 METEOROLOGICAL EQUIPMENTS

4.4.1 Type of equipments required for meteorological observatory depends on its purpose of utilisation. A meteorology established in a catchment area and a station in command area both will have to generate some special data. However in general the essential instrumental equipments of a climatological station comprises following equipments

(1) Thermometers : Maximum and Minimum

(2) Thermometers : Dry bulb and Wet bulb

(3) Thermometer Screen

(4) Rain gauge

(5) Anemometer and Wind Vane

(6) Sun shine recorder

(7) Evaporimeter

Anemometer, wind vane and sun shine recorders are essential at an agromet station.

4.4.2 Other instruments desirable for a climatological station are as under

(1) Grass minimum thermometer

(2) Earth and soil thermometers

(3) Recording rain gauge

(4) Barometer

Desirable addition to this equipment includes the following

(1) Barograph

(2) Thermograph

(3) Hydrograph

(4) Soil moisture equipments

(5) Lysimeters (essential at agromet stations)

4.4.3 A brief introduction of important equipments is as under :

(1) The measurement of soil temperature is of great importance in meteorological and agricultural studies, and is made with the thermometer bulbs kept on the surface of the soil and at various depths up to 100 cm. The standard depths for soil temperature measurements are 5, 10, 20, 50 and 100 cm. Soil thermometers at depth 5, 10 and 20 cm. are part of standard equipment at agricultural observatories in India. IS 6592-1972 covers about types, immersion, ranges, materials, construction, gradation, figuring, testing and inspection of soil thermometers.

(2) A set of four thermometers, a wet bulb thermometer, a dry bulb thermometer, a maximum thermometer and minimum thermometer is generally used at meteorological observatories for routine temperature and humidity measurements. These are exposed in wooden louvered thermometer screens which support

the thermometers, shield them from direct radiation from outside sources and from precipitation while allowing free circulation of air around them, and prevent accidental damage. Two types of screens are in use, the small screen, originally known as Stevenson screen for shielding meteorological thermometers and the large thermometer screen for shielding recording thermograph and Hydrograph in addition to thermometers. IS: 5948-1970 covers about the types, material, dimension, general requirements about screen, sketches inspection and packing.

(3) For general meteorological work, measurements of temperature and humidity of air are made with a set of four liquid in glass thermometers. One maximum, one minimum and two ordinary, the bulb of one of which is covered by a layer of thin wet cloth. They are produced with wooden mounts for extra strength and robustness and exposed in louvered thermometer screens. The thermometers shall be of the liquid in glass, solid stemtype with enamel back as follows:

(a) Maximum thermometer - Mercury in glass having a range from -35°C to +55°C.

(b) Minimum thermometer - Alcohol in glass having a range from -40°C to +50°C.

(c) Ordinary thermometer (wet and dry bulb) - Mercury in glass having a range from -35°C to +55°C.

IS:5681-1983 covers other details viz.: Requirements of liquid, construction, graduation, figuring, ranges accuracy, dimensions, marking, test inspection and sketches.

(4) The sunshine recorder is an instrument for accurate measurement of the duration of bright sunshine at a place. There are different types of instruments available for this purpose, but the Campbell-stokes pattern which uses the focused heat radiation from the sun to burn a trace on a chart is widely used. IS: 7243-1974 covers the description, specifications, general requirements, sketches and type of cards for the tropical pattern sunshine recorders.

(5) The measurement of the amount of water evaporated from the soil and from free water surfaces is of great importance in agriculture and in irrigation and drainage system. Evaporation is generally measured at agrometeorological stations using a pan evaporimeter. IS:5973-1970 covers the specifications, description of pan, sketches and general requirements.

(6) The direction of wind is specified relative to the true north at the place of observation and is generally expressed as a bearing in degrees from the true north (in clockwise direction) or as a compass point using 8,16 or 32 points according to the accuracy required. The measurement of wind direction is of great importance in meteorological research. A windvane is used for indicating the direction from which the wind is blowing. IS:5799-1970 describes the properties, material and general requirements of windvane.

(7) The accurate measurement of wind speed is of great importance in meteorological research. The simplest and most common method of measuring wind speed is by the use of a cup counter anemometer in which the run of wind in kilometers and tenths is indicated directly on a revolution counter. Anemome-

ter consists of three (or four) hemispherical cups fixed in a horizontal plane to a sleeve which can freely rotate about a vertical axis. The rotation is transmitted through a guage, mounted under the cup, which counts the number of revolutions. The counter is so designed that the increase in the reading of the counter divided by the intervening time interval in hours gives the wind velocity directly in km/hr.IS:5912-1970 covers the description, general requirements, sketches, testing and inspection for anemometer, cup counter.

Remote indicating electrical anemometers and windvanes are also extensively used for the measurement of wind speed and direction at distant locations (IS:8754-1978).

(8) Atmospheric pressure is generally measured by means of a mercury or aneroid barometer. The requirements of mercury barometer are covered in IS:5798-1970. Specifications for aneroid barometers are covered in IS:5793-1970.

(9) In most recording meteorological instruments a pen rests lightly on a paper chart wrapped around a vertical cylindrical drum. The drum is rotated at a constant speed by a clock mechanism and as the element to be recorded varies the pen makes an ink record on the chart. The chart generally consists of a grid of lines printed on good quality paper. The scope, description, type of charts, sketches for various charts, dimensions, material and other requirements are given in IS:5947-1970.

(10) Accuracy in the measurement of rainfall is of great importance in almost all field of national economy and is of

special significations in agriculture. IS 4849-1968 covers specifications and general requirement of rain measures. IS 5225-1969 covers specification for raingauge, material, installation sketches and general requirements.

All forms of precipitation shall be measured on the basis of vertical depth of water. IS 4986-1983 covers the details regarding the installation of raingauge (non-recording type:IS 5225-1969), method of measurement and recording of precipitation.

IS 5235-1969 specifies the requirements for natural siphon type recording raingauge. IS 8389-1983 covers the procedure to be followed in the installation, use and recording of precipitation from the natural syphon type recording raingauges.

4.5 INFLUENCE OF METEOROLOGICAL PARAMETERS ON CROP WATER USE

Various factors operate singly or in combination in influencing the amount of irrigation water required by plants. Their effects may differ with locality and fluctuate from time to time. The more important factors which influence crop water use are climatic parameters, water supply, type of crop and plant growth characteristics. From above mentioned factors,the climatic parameters are predominating factors.

4.5.1 Temperature

The rate of evapotranspiration in any particular locality is affected more by temperature, which for long time period is a good measure of solar radiation. Abnormally low temperatures may retard plant growth and unusually high temperatures may produce dormancy. Consumptive use may vary even in years of equal accumulated temperatures because of deviations from the normal seasonal distribution. Transpiration is influenced not only by temperature but also by the area of leaf surface and the physiological needs of the plant, both of which are related to stage of maturity.

4.5.2 Latitude and Sunlight

Because of the earth movement and axial inclination, the hours of the day light during the summer are much greater in the higher latitudes than at the equator. Since the sun is the source of all energy used in crop growth and evaporation of water , the longer day may allow plant transpiration to continue for a longer period each day and to produce an effect similar to that of lengthening the growing season.

Clouds or dust in the atmosphere can reduce the amount of sunlight that reaches the plant. Elevation may also affect the amount of energy received since at higher elevations there is less absorption of energy by the atmosphere.

4.5.3 Humidity

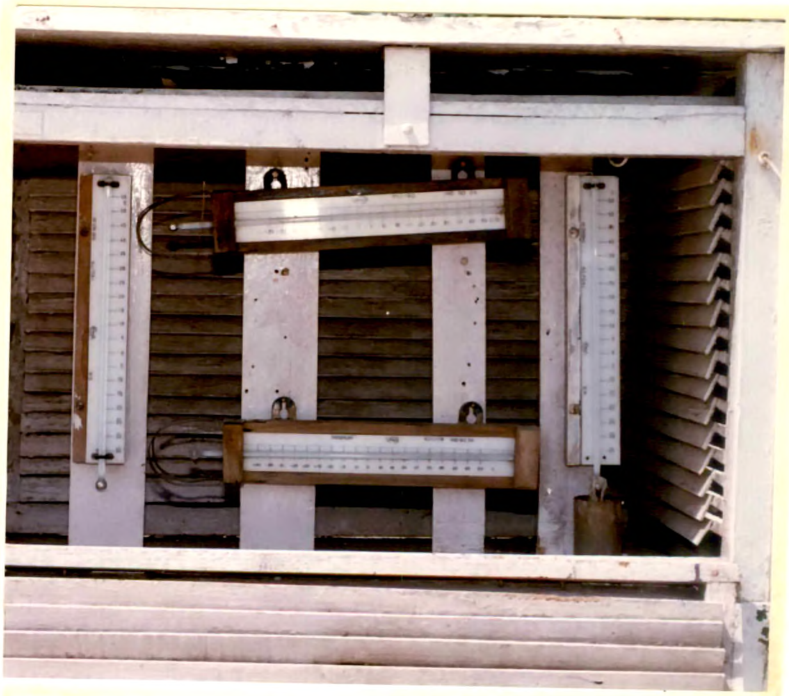
Evaporation and transpiration are accelerated on days of low humidity and slowed during period of high humidity. If the average humidity percentage is low during growing season, a greater use of water by vegetation may be expected.

4.5.4 Wind Movements

Evaporation of water from land and plant surface takes place more rapidly when there is moving air than under calm air conditions. Hot, dry winds and other unusual wind conditions during the growing period will affect the amount of water consumptively used.

4.5.5 Precipitation

The amount, frecuancy and intensity of precipitation has an effect on the amount of crop water use during any season. Frequent light showers may add little or nothing to the soil moisture for use by the plants through transpiration but do decrease the withdrawal from the stored moisture. Because the precipitation may be largely lost by evaporation directly from the surface of the plant foliage and from the land surface. When storm occure within a relatively short period after completion of an irrigation a high percentage of precipitation is lost due to surface runoff, deep percolation or both. Other storm may be of such intensity and amount that a large percentage of their precipitation will enter the soil and become available for plant consumptive use. Such a condition materially reduces the amount of irrigation water needed.



4.1 Temperature Equipments

Pan Evaporimeter

Anemometer

Sun Shine Recorder

Photo 4.2