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Review Article

Meteorological Aspects of Pest Control[1]

T. S. GOVINDASWAMY

INTRODUCTION

Crops are liable to the attack of various pests and diseases; their incidence and intensity being dependent on certain pre-disposing weather conditions. With the advent of the monsoon the invasion of insect pests and diseases on crops gathers momentum. They annually inflict a loss of millions of rupees on our farmers. The control of pests and diseases of plants is an essential part of modern farming.

The influence of meteorological elements like temperature, humidity, light, etc., on insects has been described by Uvarov (1929). Each insect has a definite range of temperature in which it thrives. Temperature plays an important part in the metamorphosis of insects. Developmental processes are accelerated at higher temperatures within the optimum limits. Low temperatures lengthen the larval life. In some insects light regulates the feeding time, while in others the period of egg laying. Foister (1929) has described the relation of weather to plant diseases. Dew is often responsible for creating favourable conditions for various fungi. Spores of fungi and bacteria are carried away by air currents and diseases spread. Smith (1953) observes that a minimum temperature above 10°C and a relative humidity of greater than 75 per cent lasting for a continuous period of 48 hours indicate favourable conditions for the occurrence of potato blight some 7-21 days later. Burke (1957) illustrates how synoptic weather analysis may be used to investigate the major favourable and unfavourable situations to the progress of the disease in each growing season. Rainey (1963) has brought out vividly the applications of synoptic meteorology in locust control.

All India Co-ordinated Crop Weather Scheme :

The scientific study of the influence of weather on crops is one of the main activities of the Agricultural Meteorology Division, Poona. Under the Crop-Weather Scheme, in addition to systematic obervations on weather and crops, quantitative observations on the incidence of pests and diseases are also being recorded on one or more of the five important crops of the country, viz., paddy, wheat, *Jowar*, cotton and sugarcane at about 50 Agricultural Experimental Farms. Besides these, qualitative observations on pests and diseases are also recorded at a network of about 140 stations. Table 1 gives the names (popular and scientific) of major pests and diseases of the five crops mentioned above.

Micro-climatological studies :

The study of microoclimate (the climate of the air layers near the ground surface) is very important in knowing the favourable conditions for the out-break of pests and diseases as well as in the fight against pests and diseases. Under the Crop-Weather Scheme micro-climatic observations are recorded regularly both in the open and inside crops Ramdas (1951).

[1]Contribution from the Meteorolgical office, Poona.

Table 1—Major pests and diseases affecting crops

Crops	Pests	Diseases
Paddy	1. Paddy stem borer (*Schoenobius incertellus* W.)	1. Blast disease (*Piricularia oryzae*).
	2. Paddy bug (*Leptocorisa varicornis* Dist.)	2. Leaf spot (*Helminthosporium oryzae*).
	3. Swarming Caterpillar (*Spodoptera mauritia* R.)	
	4. Paddy grass-hopper (*Hieroglyphus banian* FbP.)	
	5. Paddy Case-worm (*Nymphulla depunctalis* Guen.)	
	6. Paddy gall-fly (*Pachydiplosis oryzae* W.)	
Wheat	1. Wheat stem borer (*Sesamia inferens* W.)	1. Black rust (*Puccinia graminis*).
	2. Wheat plant-lice (*Taxoptera graminum* R.)	2. Orange rust (*Puccinia tritici*).
	3. Grass hopper (*Chrotogonus trachypterus* B.)	3. Yellow rust (*Puccinia glumerum*).
	4. White ants (Termites).	4. Smut (*Ustilago tritici*). 5. Bunt (*Tilletia tritici*).
Jowar	1. Jowar stem borer (*Chilo zonellus* Swinh.)	1. Loose smut (*Sphacelotheca cruenia*).
	2. Earhead bug (*Calacoris angustatus* L).	2. Grain smut (*Sphacelotheca sorghi*).
	3. Jowar mite (*Paratetranychus* sp.)	
Sugarcane	1. Top borer (*Scirpophaga nivella* F.)	1. Mosaic (Virus disease).
	2. Stem borers (*Argyria sticticraspis* H, *Diatorea Venosata* Walk and *Sesamia inferens* Walk.)	2. Smut (*Ustilago sacchari*).
	3. Root borer (*Emmalocera depressella* S.)	3. Red rot (*Colletotrichum falcatum*)
	4. Sugarcane leaf-hopper (*Pyrilla* spp.)	
	5. White-fly of sugarcane (*Aleurolobus barodensis* W).	
	6. White ants (Termites).	
Cotton	1. Pink boll-worm (*Platyedra gossypiella* S.)	1. Wilt (*Fusarium vasinfectum*).
	2. Spotted boll-worm (*Earias* Spp.)	
	3. Cotton stem weevil (*Pempheres affinis* F.)	

The surface of the ground is the seat of warming by insolation by day and of cooling by radiation at night and how these tendencies are propagated upwards into the air layers and downwards into the soil layers is shown in Fig. 1. The diurnal range of temperature is maximum at the ground surface. It decreases very rapidly with depth being negligible at a depth of about one foot. Coming to the air layes, high lapse rates exist very close to the ground and the diurnal range of temperature falls very rapidly in the first few inches above the soil surface and more and more gradually at higher levels. After sunset the ground begins to cool and the air layers begin to stratify. It is interesting to note that a remnant of unstable air still persists during night and the coldest air is found not at the ground surface but at about one foot above it.

The micro-climate of crop shows significant deviations from the conditions in the open space. Each crop develops a typical climate of its own. The deviation of the phytoclimate from the open depends upon the density of plants, height of the plants, foliage, etc. The micro-climate of sugarcane (Fig. 2) is of special interest. It is interesting to note inside the crop, the lowering of air temperature, the inversion layer even during day and the increased humidity.

From simultaneous observations at a number of selected points inside a sugarcane field, Gadre (1951) has shown that the micro-climate of the open changes quickly into the characteristic phytoclimate within about six feet as one enters the crop.

Estimation of the incidence and intensity of pests and diseases :

Insects mentioned in Table 1 may be grouped into (i) Boring insects; (ii) Sucking insects; and (iii) Chewing insects.

In the case of borers and chewing insects the damage is conspicuous. Incidence of shoot borers can be judged by the formation of 'dead hearts'. In the case of leaf eating insects, the plants will be partially or wholly defoliated. The damage is not conspicuous in the case of sucking insects. They gradually lower the vitality of the plants.

The diseases mentioned in Table 1 may be grouped into :

(i) Diseases whose symptoms are found in the crown as affected earheads (e.g. wheat and jowar smuts), (ii) diseases whose symptoms are shown by the leaves (e.g. rusts, lead spots, etc.), (iii) diseases whose symptoms are shown by the stem (e.g. red rot of sugarcane), and (iv) diseases whose symptoms are found at the root zone and collar region of the plant (e.g. wilt of cotton).

Under the All India Co-ordinated crop-weather scheme the estimation of the incidence and intensity of pests and diseases is done according to random sampling technique. The observations are recorded once a fortnight. To avoid selective bias, the sampling is done afresh each time. Usually two varieties of crops are under observation with six replications at the crop-weather stations. The size of the plot being 1/100 acre for paddy, 1/80 for wheat, 1/40 for *Jowar* and cotton and 1/20 for sugarcane. Three samples are taken from each half of a plot thus giving 36 samples for six replication of each variety.

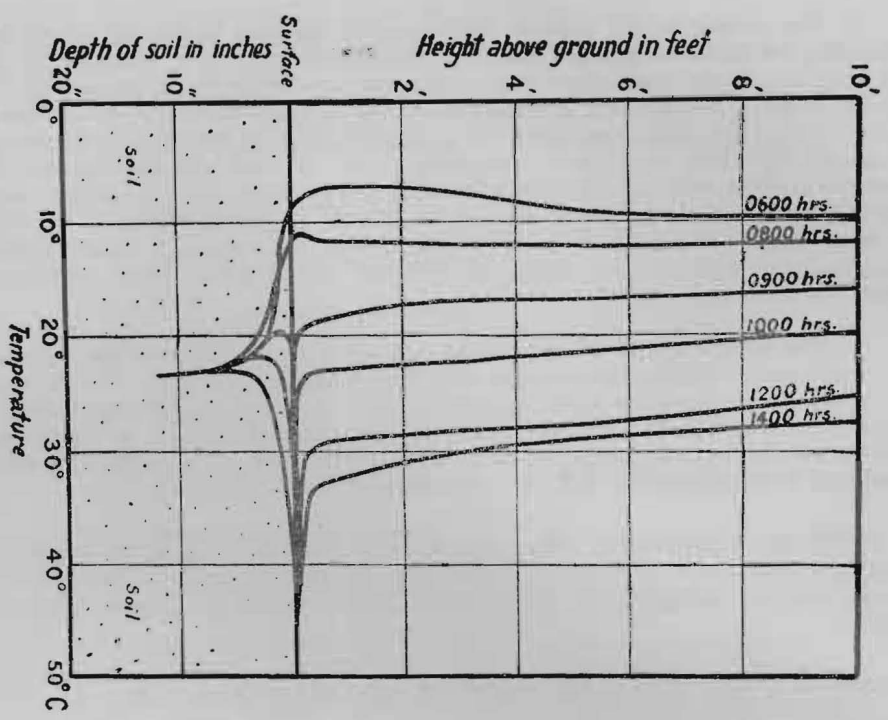

Fig. 1. Diurnal variation of temperature in the soil and air layers near the ground surface (on a typical winter day at Poona).

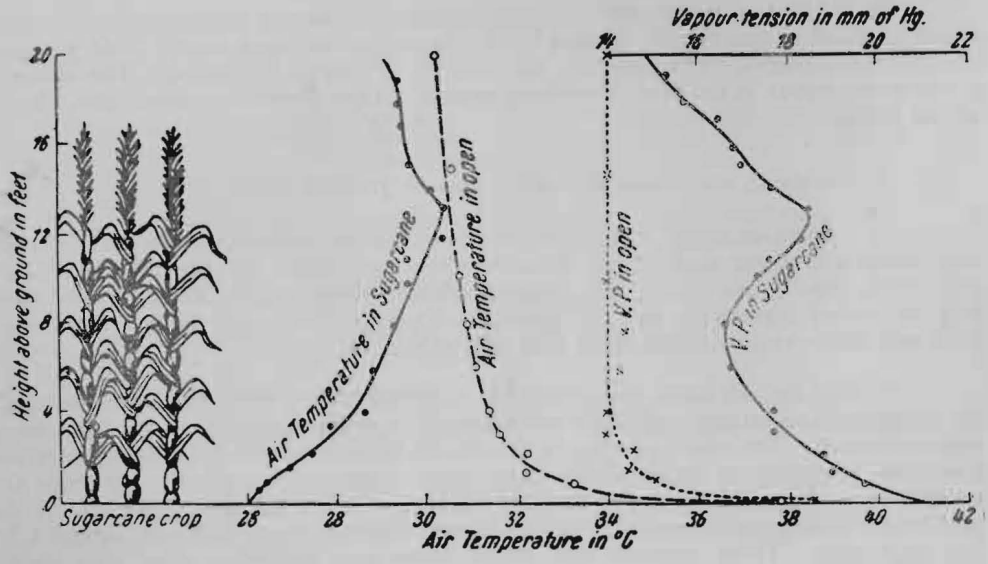

Fig. 2. Micro-climate of sugarcane.

The size and structure of the 'sampling unit' for different crops are given below :

Paddy : The sample consists of six bunches as indicated :

1st row O X X X O X X X O X X

2nd row X X O X X X O X X X O

O means bunch under observation

X means bunch not under observation

Wheat : The sampling unit is a 4ft. length consisting of four parallel one foot lengths in adjacent rows.

Jowar and Cotton : The sampling unit is a 8 ft. length made up of two parallel 4 ft. lengths in adjacent rows.

Sugarcane : The sampling unit consists of 8 ft. length.

In all cases the end plants in the sampling unit are examined for estimating the incidence and intensity of pests and diseases.

Boring insects : The plants falling under the sample are uprooted (1) to examine whether the shoots contain the borers and (2) to note the actual number of borers present. The number of shoots infected to the total number of shoots in the sample gives an estimate of the percentage of plants affected. The number of borers per plant gives an estimate of the intensity.

Sucking insects : The number of shoots infected to the total number of shoots in the sample gives an estimate of the percentage of plants affected. For the intensity of attack, (i) when the attack involves only a few insects, the actual number of insects in the two nearest leaves of the tallest cane of the end clumps of the sampling unit in the case of sugarcane and in the two top-most open leaves in the case of other crops are recorded and (ii) when the attack involves a large number of insects (e.g. pyrilla, aphids), the fraction of the area of the two leaves under observation covered by the insects including egg-masses is estimated to the nearest tenth.

Chewing insects : The method is the same as for sucking insects. The intensity of attack is judged by the fraction of the leaves under observation left unaffected.

The procedure for estimating diseases is more or less similar to that adopted for insects. The total number of shoots and the number of affected shoots in the sample gives an estimate of the percentage of plants attacked, while the fraction of leaf or earhead affected gives an estimate of the intensity of the disease.

Meteorological aspects in the control of pests and diseases :

Methods of control depend mainly on the life habit of each insects. Stomach poisons are generally applied against chewing insects while contact poisons against sucking insects. Dust is applied generally for soil infecting insects. Enclosed spaces like storage bins for preserving grains are fumigated. In resorting to control

measures like spraying, dusting, fumigation, etc., it is essential to try these operations under favourable meteorological conditions. How weather conditions affect the use of chemicals is briefly indicated as under :

Wind : Wind often limits the application of insecticides and fungicides. Strong winds interfere with spraying and blow away considerable quantities of dust deposited on the plants causing loss. Turbulence decreases vapour concentration. For killing the pest, the chemical has to stay on the plants for a certain minimum length of time. The day for spraying should be chosen after taking into consideration the meteorological situation of the area.

Humidity : The correlation of the incidence of plant diseases with prolonged wet and dry spells has long been recognised. The moisture present in the atmosphere very near the ground surface may make itself visible as mist, fog or dew. They occur generally during night or early morning and denote stable conditions which are favourable for dusting. The morning dew helps the powder to stick to the foliage and prevents it from being blown away. Low temperatures and moist grains adversely affect the efficacy of fumigants.

Rain : Rain constitutes one of the greatest obstacles to successful spraying. It washes away the poisons and necessitates repeated spraying. Here again, the choice of the day for such operations taking into consideration the meteorological situation is very important.

Soil temperature : The locust lays eggs in moist soil at a depth of 5-10 cm. The duration of egg stage varies greatly with soil temperature from ten weeks at a soil temperature averaging 19°C at a depth of 10 cm to two weeks at a corresponding temperature of 34°C. A knowledge of soil temperature in locust affected area is very important as it enables us to calculate the expected date of the appearance of the hoppers and thus to determine the time for starting control operations.

RESUME'

Climate determines the type of insects that exist in any given locality. It is the weather that determines when and under what conditions the insects can become an epidemic. Considerable research has been conducted in Europe on potato blight as weather is the dominant factor in the appearance and spread of potato blight. In the "Potato blight warning Service" of Ireland use is made of the weather maps.

The formation of desert locust swarms and their movements are closely associated with weather conditions. The swarms produced during winter in the Middle East usually fly eastwards into Pakistan and India, where they breed from June to September during the monsoon. Long distance swarm movements are observed in association with active Mediterranean depressions, while quasi static swarm distribution in association with the position of the Inter-Tropical Convergence Zone.

Information on temperature, rain and wind is especially important to the farmer when controlling pests and diseases. The farmer can decide what insecticides or fungicides he needs and keeps a reasonable supply of them on hand. He can also time his operations rationally both from the point of view of effectiveness and economy.

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