PESTS AND DISEASES.

METEOROLOGICAL CONDITIONS AND PLANT DISEASES.

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In its early stages, the study of plant diseases resolved itself into little more than a study of the parasites. Later, the study of the host plant received greater prominence, as the truth that disease is an indication of abnormal or disordered physiology became generally recognised. Still more recently has come the recognition of another truth, namely, that diseases caused by parasites are the manifestations of complex interactions of host and parasite under the influence of the conditions of a varying environment. Such conditions may be designated "environmental factors."

No observant person who watches the incidence of plant diseases can avoid noticing the marked influence of one group of environmental factors, those included in what is rather vaguely termed the weather, on the prevalence of many of these diseases. To give only one instance, the unusual prevalence of the powdery mildews (Erysiphaceæ) noticed in England in certain summers, such as that of 1921, is frequently ascribed to periods of dry, hot weather. At the same time, such a summer as that of 1921 was too dry for potato blight (*Phytophthora infestans*) to be severe in most parts of England. If these statements are true it is evident not only that disease is influenced by the weather, but also that different diseases are differently influenced by the same kind of weather.

Furthermore, if disease in any one country can vary from year to year under the influence of the annual fluctuations of the weather, we would expect to find that countries possessing different climates, that is different *average* weather conditions, would show still more marked variations in the prevalence of their plant diseases, owing to the greater amplitude of the variations between different climates than between those of the weather of any single climate.

It might be expected that comparison between the plant diseases of areas with different climates would be difficult because the host plants would not be the same. However true this may be for the wild plants, it is much less true in regard to the major cultivated crops. The latter have been subjected to long periods of artificial selection in such a way as greatly to extend their original range. Wheat and potatos, for instance, are grown under very considerable differences in climatic conditions. Their parasites, on the other hand, have not been subjected to the same human influence, and they have had to follow the hosts as best they could. In the larger continental areas, such as the United States and India, the wheat, sorghum, maize, and potato areas are much greater than the areas in which certain of their parasites are found.

Weather and climate depend on the same set of factors—the ordinary meteorological factors of temperature, humidity, light, wind, etc.—and if it is desired to understand the relationship between meteorology and disease, an attempt must be made to evaluate the influence of each of these factors on the interaction between host and parasite. Probably this influence is capable, in most cases, of exact evaluation, but the data are as yet somewhat scanty. Temperature, humidity, and radiation are the chief factors about which data exist, and the following discussion will be confined to them.

The most difficult case is undoubtedly the study of the influence on disease of variations in weather conditions from one year to another within the same area. These variations are of lesser amplitude and duration than those between different climates, and most frequently are not large enough to prevent the disease from appearing but merely influence its amount.

In India rust is present every year in probably every wheat field. Whether an epidemic outbreak occurs or not appears to depend entirely on the weather conditions of the year. These conditions were analysed by Moreland for 13 years in three selected districts in the mid-Gangetic Plain. He concluded that the deciding factor was the humidity of the air in January and February (the crop being sown in October and harvested about April), and that in the districts with the earliest harvest, the earlier part of this period was more important than the later. My own observations are in general agreement with these, except for the rather natural proviso that it is the humidity of the air within the crop that is of consequence. In a field at Pusa sown throughout with the same variety of wheat, rust (*Puccinia triticina* and *P. glumarum*) was severe in an area with a dense stand and almost absent towards the borders of the field where the growth was light. In the dense crop the air humidity was nearly 20% higher, four inches above the ground than in the light crop, as tested by an experiment lasting between 7 and 8 hours on a dull day. The temperature was about 3°C. lower in the dense crop. Soil moisture determinations showed that there was much more moisture under the dense crop, especially from the 3rd to the 6th foot, and this was really the cause of the good growth, as soil moisture is the chief limiting factor in wheat growing at Pusa.

Another disease, which at Pusa is dependent on humidity or rather on the deposition of dew is the die-back of chillies (*Capsicum*), due to *Vermicularia Capsici*). This disease appears at the flowering season about the beginning of October and may do very great damage. It ceases abruptly about 4 to 6 weeks later. This is because it is dependent on the heavy dews of this period, accompanied by a moderately high temperature. Artificial inoculations only succeed in almost saturated conditions. Plants growing under shade escape, as the deposit of the dew is slight. Later on, as the temperature falls and dew is less copious, the disease ceases. Observations during six years suggest that the relative air humidity requisite to cause an outbreak of this disease during the flowering period is over 85%. In three of these years, when it was below this figure in the second half of September there was no disease.

Potato blight (*Phytophthora infestans*) in the Gangetic Plain is influenced by a somewhat more complex group of factors. It is usually absent, and only two outbreaks have occurred in the last 25 years. Under certain circumstances a considerable portion of the seed used is brought down from the Himalayas where, at altitudes from about 4,000 to 7,000 ft., blight is endemic. If the Plains temperature is sufficiently high infected seed thus brought down becomes sterilized, as it is well known that *Phytophthora infestans* is easily killed by heat. In 1912 a large import of diseased seed occurred rather late in the season, which was unusually cool at sowing time (October). In late December there was much fog and cloud with a low temperature, and an epidemic was in progress in January 1913. Attempts to carry the fungus in culture over the following hot weather at Pusa failed and in the fields also there was no disease next year.

In localities where potato blight is endemic the problem is much more difficult and the meteorologic conditions that govern its intensity are by no means fully understood. It is one of the cases in which a good deal is known, thanks to the work of Melhus and others, of the conditions of temperature and humidity that influence the life history of the parasite. The optimum temperature for the germination of the spores is between 10° and 13°C. A frost sufficient to kill potato leaves will also kill the mycelium of the fungus. Its upper temperature limits are below those required to injure the tuber, as it will not survive even 4 hours at 120°F., and cannot long be kept alive in cultures maintained throughout at over 90°F. But its optimum temperature for growth is much higher than the germinative optimum, being about 24°C. Its moisture relations are not so exactly known, but like all its allies it requires a high humidity for successful germination; it cannot stand drying for long, and zoospores are formed as a rule only in drops or films of water. The period of motility of the zoospores is longer at low temperatures; they can swim for 20 hours at 5°C., but only for 1 hour at 20°C. If the meteorological factors that influence the disease acted only by influencing the parasite, we would expect to find outbreaks always occurring when a cool, damp period alternated with a warm period at a time of the year, say July, in England when there is usually some blight in most of the potato fields. The cool period would assist germination and prolong the life of the zoospores, thus aiding dissemination, while the succeeding warm period would stimulate the growth of the fungus in the tissues. If another cool, damp period followed when the new infections were in the sporting stage, we would get the process repeated in an accentuated degree, and several such oscillations would enormously multiply the attack. But it is not easy to find records of such a regular sequence of events, partly because the meteorological data are not sufficiently detailed but perhaps also partly because the influence of the weather factors on the potato plant itself have not been studied. It is known, however, that in at least certain areas in the United States an unusually cool summer is necessary for severe attacks. It is also almost confined to the north-east, being seldom found below 40°of N. latitude. In Europe it is prevalent north of 50°N. In all cases it is worst where the humidity is high. In localities like the Channel Islands and the west of Ireland the humidity conditions are usually suitable, and temperature is likely to be the controlling factor in most years.

Many other diseases caused by *Oomycetes* appear to be influenced by rather similar conditions, as most of the *Pernosporaceae* have similar temperature relations. In order to demonstrate the liberation of zoospores in the Phycomycetes it has been the custom in Pusa to use chilled water during the warmer parts of the year. The downy mildew of the grape, caused by *Plasmopara viticola*, appears to be an exception, as most observers consider that it is worst in relatively high temperatures.

It would appear that black rot of the grape vine, caused by *Guignardia Bidwellii*, is a similar case. It is stated that severe infection only occurs when there is a cold snap with rain, followed by a warmer period. Though the temperature relations of the fungus have not been worked out, so far as I know, this is very suggestive of their being similar to those just mentioned.

Another group of diseases that appears to be closely influenced by weather conditions is the powdery mildews (Erysiphaceae). It has already been mentioned that they are sometimes said to be worse in England in dry years. I have noticed the same thing in India with regard to the pea mildew, *Erysiphe Polygoni*. More exact observations are rare. Losch examined the prevalence of apple mildew in an orchard situated on the slope of a ravine in Wurtemberg. The slope faced S. E. The upper part was severely attacked but, as one descended, the mildew decreased until at the bottom it was insignificant. The rays of the sun struck full on the upper slope. They reached lower down later in the day and, at the bottom, shade remained all the forenoon. The upper part was very hot and dry, the bottom cool and moist. No evidence was obtained as to whether the host or the parasite was most influenced, nor whether different varieties of apple would be equally affected.

Oak mildew behaves in the same manner. It has been noted to be more severe in the upper levels of sloping woods, and also in exposed localities. Neger has found that it produces its conidia much more vigorously on shoots exposed to the light than on those in the shade. Exposure and sunny weather favour the disease, but the relative importance of the factors of drought and radiation have not been fully estimated.

In Italy it has been noticed that either a drying out of the soil or a sudden rise in temperature makes wheat susceptible to *Erysiphe graminis*. Rivera believes that this is due to a lessening of turgescence and is therefore a reaction of the host plant and not of the parasite. He says it is particularly marked in rich soils where the plants have a relatively restricted root development and would naturally suffer from shortage of water or excessive transpiration. A hot sun and dry conditions are inimical to certain species of *Oidium* and epidemics are only likely to occur when there is a rapid alternation of moisture and dryness.

In India, tobacco mildew *(Erysiphe Cichoracearum)* is practically confined to shaded plants and the cereal mildew is also worse under shade. Most experimenters with cereal cultures kept indoors, must have noticed the greater prevalence of mildew under such conditions than in the open. More diffuse light and the absence of air currents appear to be the causes, and exposure to light and air the remedy. The same has been noticed in regard to the vine *Oidium*, and those on strawberry and cucumber. These apparent discrepancies might disappear on more exact knowledge of the actions of the different factors. The latter have not been studied in detail as regards their effect on the host-parasite complex, but they appear to be sufficiently marked to permit of exact evaluation. It seems likely that their action on the host is of greater importance than on the parasite, contrary to what appears to be the case with the downy mildews.

All these are cases of parasites, primarily of the aerial parts of the plants. If we turn to those of the roots we find rather more exact knowledge. The problem is perhaps easier, as the environment is relatively more stable.

The earliest, and still one of the most complete, studies of the influence of temperature on a soil-dwelling parasite was made by Balls in Egypt, in 1905-6, on the sore-shin disease (*Rhizoctonia Solani*) of cotton. The damage done by this disease is usually restricted to the first stages of development of the seedling. Once cork-formation begins damage ceases. Cotton is sown in Egypt at different times between the end of February and May. The earlier sowings may take about 12 days to appear above ground, while in the middle of April the seedlings may be up in 5 days. Growth of the cotton root increases with a rise of temperature, in an accelerated curve which ceases rather suddenly at about 37°C. The parasite—a fungus universally present in Egyptian soils—has a similar growth curve, ceasing very abruptly at about the same point, 37°C. It was determined with considerable probability, especially in the case of the fungus, that inhibition of growth at the higher temperature was due to auto-intoxication, of much the same type as the well-known staling phenomenon in bacterial cultures. The toxin is produced even at the lower temperatures, but is too slowly formed to accumulate sufficiently to inhibit growth, unless the medium is scanty or the cultures are kept for longish periods, until the temperature approaches 37°. Then it is formed more rapidly than the fungus can stand, and growth ceases. When the fungus encounters the young tissues of the cotton seedling at a temperature of, say, 20°C., these are penetrated and the hyphae pass from cell to cell, destroying the tissues before the toxin has time to accumulate sufficiently to check their growth. But at temperatures approaching 33°C. auto-intoxication is more rapid and growth is delayed. At the same time, at this temperature (33°C.), the cotton plant has its vital activities near their optimum. Hence defensive cork-formation is vigorous and the parasite is checked after producing only a small scar. At 37°C. not even a scar is produced, growth of the fungus being entirely inhibited. Thus the late sown seedlings normally escape attack, but a cold spell of even a couple of days in May will cause the death of many of them. The seasonal prevalence of this disease in Egypt is therefore, practically, a purely temperature reaction, affecting chiefly the parasite.

We can now leave the discussion of the influence of seasonal variations of weather on the incidence of disease, after noting that in few cases has there been a successful attempt to evaluate the influence of the different factors exactly. When we turn to those wider and more prolonged variations that constitute different climates, we find that greater success in this direction has been achieved,

In India a rice disease of great severity occurs in part of the great rice-growing tract at the head of the Bay of Bengal. It is not due to a fuugus, but to a nematode worm *(Tylenchus augustus)*. Injury is confined to the parts of the plant above the water in which the rice is grown, and to reach these parts the worm must leave the water and climb up the plants. It is a pure ectoparasite, never entering the tissues. Experiments have proved that the worm is able to move on a dry surface, provided the relative air humidity is above some point between 90 and 95%, probably near 93. Above this point it has the power to condense water, and it moves in the film surrounding it by a snake-like method of progression. Neither feeding nor reproduction are possible under totally immersed conditions, but only in damp air between 90 and 100% relative humidity. Below 90% it can neither move, nor feed, nor reproduce. Hence the disease is confined to areas of maximum air himidity during the summer and autumn months. It has been possible to correlate the meteorological data from 6 reporting stations within the affected area, with the distribution of the disease and to forecast that the greater part of the rest of India, excluding parts of the Burma delta and some of the east coast districts, is not liable to become permanently infected.

The smuts of sorghum, particularly the grain smut *(Sphacelotheca Sorghi)* annually cause damage estimated at a million sterling in Western India. They are also prevalent in the Punjab and submontane districts, but are unknown in the eastern half of the Gangetic Plain. Kulkarni worked out the temperature relations of this disease. Sorghum has its optimum temperature for germination at about 37°C., at which temperature and suitable moisture the seedlings will be up in two days. At 20°C. they take about twice as long, and at 16°C. about three times. The spores of *Sphacelotheca Sorghi*, however, have their germinative optimum about 20° to 25°C., and germination falls off rapidly above 30°C., giving only 1 or 2% at 37°C. Infection is only possible during the earliest stage of seedling development. At high temperatures not only is this stage shortened, but the smut spores germinate feebly. In incubator experiments no infection occurred at 40°C., whereas at 25°C. there was 50 to 60°C. %. In Western India the main crop is sown at a time when the temperature is about 21° to 27°C. and naturally suffers severely. A second crop is often sown at a period when the temperature is over 30°C., and this suffers relatively little. At Pusa, in the eastern half of the Gangetic Plain, the temperature at sowing time ranges up to 38°C., and there is no natural sorghum smut, though by properly selecting the temperature at sowing time it can be artificially produced. In a comparative experiment seed grain was mixed with spores and divided into two lots. One sown at Jacobabad with an air temperature of 36° to 40°C. gave no smut. The other sown at Poona at 25°C. gave 65% infection.

Wheat bunt *(Tilletia tritici* and *T. levis)* in India is a similar case. It is prevalent in Kashmir and along the Punjab foot-hills, occurs in the Punjab plains, but not severely, and is unknown further east or south. Bunt spores have al ow optimum for germination (between 12° and 18°C.) and usually fail to germinate above 25°. In Central and Eastern India the temperature at sowing time is usually above 25°, while in North-western India the temperature at sowing time is below. In the latter case it is low enough to permit the spores to germinate and infect the seedling, but further east and south it is too high. Hungerford, under Idaho conditions, found that the maximum degree of infection was obtained with a temperature of 9° to 12°C. and fairly high soil moisture.

Maize smut (*Ustilago Zeae*) has much the same distribution in India as bunt, but its temperature relations in that country have not been worked out. In America it has been shown that the maximum for spore germination and the development of sporidia is between 36° and 38° C., so that it might be expected to be limited by high temperatures at sowing time in much the same way as sorghum smut, and its Indian distribution suggests that this is the case.

Thus there is a group of four of the major diseases of cultivated plants in India (potato blight, sorghum smut, wheat bunt, and maize smut) strictly limited in their normal distribution by the temperature relations of host and parasite, the influence on the parasite being the chief.

In the United States a great deal of information regarding the temperature and humidity relations of certain diseases has been accumulated during recent years. Only a few of the more striking cases, where a correlation with regional climatic conditions has been established, need be mentioned.

The seedling blight of maize and wheat caused by *Gibberella Saubinetii* is a severe disease in the United States, especially in the middle west. It was noticed that the southern part of the maize belt escaped this disease, as did also the northern part of the wheat belt. The temperature relations of the disease were recently worked out. Wheat and maize were grown in soil held constant at eight different temperatures from 8° to 36° C., and exposed to infection, with the result that the favourable soil temperatures for the infection of wheat were found to range from 12° to 28° C., the optimum being about 24°. Maize, on the other hand, was infected from 8 to 20° C., most severely from 12° to 16°. The reaction appears to be one of the host, not of the fungus. Like most soil *Fusaria* the latter has a relatively high optimum in culture (24° to 28° C.). At low temperatures in maize and at high temperatures in wheat, it was found that the cell-walls of the seedling long remained in an unthickened condition, easily penetrated by the fungus. At the higher temperatures in maize and at the lower temperatures in wheat, thickened cell walls, which resist the fungus, are rapidly formed.

The temperature relations of a good many soil-dwelling parasites have been worked out. In those attacking the potato, four species of *Fusarium* together with *Verticillium albo-atrum* have their growth optimum at about 25°, two species of *Fusarium* at 30° C. The latter two are the species that cause damage in the southern potato-growing region of the United States. *F. oxysporum* and *F. radicicola*. The cabbage yellow parasite, *F. conglutinans*, is one that requires a moderately high temperature to cause disease. At a soil temperature between 22° and 24° C., 97 out of 104 plants wilted, and between 10° and 16°, 1 out of 88. *Fusarium Lini* infects flax chiefly between 20° and 30° C., and like the last disease its geographical distribution in America is limited accordingly. The tobacco wilt *Fusarium*, *F. oxysporum* var. *Nicotianal*, is the same, 28° to 31° C., being its optimum for infection, while little infection occurs at 15° or 34°. This limits its natural range to certain areas or to exceptionally hot seasons in other areas into which it may be introduced.

In these and many other cases the temperature relations of both host and parasite have been determined only for the underground system. Recently, however, it has been suggested that the air temperature to which the above-ground parts of the plant are exposed may be of importance. This has been established in the case of the *Fusarium* wilt of tomato *(F. Lycopersici)*. As in the case of the sore-shin of cotton the growth curves of the parasite and of the roots of the host are similar, the optimum being about 28°C. If the air temperature is held constant at 27° to 33,° fatal wilt develops at a soil temperature of 27° but not at 17° or 36°C. There is no external symptom of wilt if the air temperature is at 17°, no matter what the soil temperature may be, nor if the soil temperature is below 20° or above 34°, no matter what the air temperature may be, although both the host and the parasite can grow at these temperatures. Hence the disease is chiefly found, in America, in the Southern States and in England, in the hottest part of the year.

Onion smut *(Urocystis Cepulae)* is a similar case. According to the soil and air temperature used, onions can be grown with from 100% to no smut as a result of inoculation. The reaction is believed to be chiefly one of the host plant. The seed will germinate over a wide range of soil temperature, from 10° to 31°C., but the best top growth is got with a soil temperature of about 20°C. Infection will occur at soil temperatures between 10° and 25°C., but little at 27°. At a soil and air temperature of 25° a great many plants will outgrow the attack but at an air temperature even as high as 30° to 33° infection can be got if the soil temperature is kept below 25°. In outdoor plantings infection was completely inhibited when the mean soil temperature reached 29°C. and increased steadily with lower temperature. This explains the geographical distribution of the disease in the United States, where it is absent from large areas in which onions are sown when the soil temperature is high.

Even mosaic diseases show definite temperature relations. In cucumber mosaic a high soil and air temperature favour the disease and the relations have been worked out in some detail by Doolittle. Johnson has given similar data in regard to the influence of air temperature on several mosaic diseases.

Humidity relations have not been worked out in so many cases in the United States.

In comparing oat rust *(Puccinia coronifera)* with mildew *Erysiphe graminis)*, Fromme found that he could get no infection with the rust below 80% relative humidity, and only 6% at 93, taking infection at saturation to be 100. With the mildew, on the other hand, he got infection at from 75 to 80% humidity.

Lauritzin found *P. graminis* on wheat still more restricted, as he got no infection at 92% humidity and only succeeded at from 95 to 100%. The same was required for *Colletotrichum Lindemuthianum* on beans, and nearly as high limits, 91 to 100% for *Ascochyta Fagopyrum*.

Except in a few marked cases, such as potato blight (where temperature plays also a great part) and black rot of the vine, there has as yet been relatively little work done on humidity in relation to regional distribution. This is partly due to the greater complexity of the apparatus required for exact work. Thus, though we may believe that humidity is an important factor in the distribution of a disease in different climatic regions (as it certainly is in regard to its intensity in a given region) there is as yet little exact proof of this.

Still less have the finer details of the humidity relations of the host-parasite complex been worked out. There is just enough known to indicate that methodical research in this direction may give results cf great interest. Thus Pantanelli has shown that infection of the vine leaf by *Plasmopara* is dependent on the condition of the stomata, being possible only when these are fairly widely open. Young leaves are immune because their stomata are too narrow. So also in older leaves infection fails if the soil moisture is below 15%, unless the air humidity is above 80%. If the soil moisture is above 20% the stomata open widely enough to permit infection at an air humidity above 40%.

I have so far confined myself to the action of the individual factors on particular cases of disease. It would take too much space to examine climatic influences as a whole on the general characters of the parasitic flora of a region, such as the relative scarcity of the Erysiphaceae in the tropics. But one or two cases indicating the interest of general studies of this nature may be quoted:

In Tripoli, Trotter has made observations on the character of the fungus flora. It is a hot, dry area, ranging from a region of relatively small rainfall restricted to October to February near the coast, to a region of no, or only accidental, rain inland. Of 83 Basidiomycetes, in the wide sense. 62 are parasitic rusts and smuts, and of the whole fungus flora about 70% are parasities. He suggests that the water requirements of the fungi have determined this altogether abnormal percentage of parasites, since the latter get their water from the host plants and are independent of the climatic shortage of water. Furthermore, species with a relatively short life-history predominate, especially the Deuteromycetes. Amongst the rusts an unusual number are short-cycle forms, and the same has been found for the Alpine rusts of Switzerland, the reason in both cases being the relatively short growth period that the climate permits.

Equally interesting data may be expected from ecological studies of the parasitic flora of different regions, a subject on which very little has been done. Dufrenoy examined from this point of view the Bareges valley on the north of the Pyrenees. He studied the influence of altitude on the parasites of a certain number of plants found at all altitudes on the valley slopes, from the bottom to 2,000 m. He found three groups. In one, the parasite was equally prevalent at all altitudes (most Ascomycetes), in another it was more severe at the lower levels or confined to them (some rusts, potato parasites), and in the third it was found chiefly at the upper levels (oak mildew and some rusts). He concluded that radiation was the most important factor in influencing the vertical distribution of the parasites. Temperature was of importance in fixing the seasonal periodicity and the amount of damage caused to the host but, had little effect on the presence or absence of the parasite. The effects of shade were studied in some detail, and the chief interest in the work is the high importance given to the intensity and actinic power of the sun's radiation in influencing leaf parasites.

The practical interest and importance of the study of the relation between meteorological conditions and disease scarcely needs emphasis. In France there has been for some time in operation a system of meterological notifications from a central station at Montpellier, fed by some 60 recording substations, of the dates on which vine diseases are likely to appear and thus when spraying or sulphuring may be necessary. The notifications are based on a knowledge of the conditions influencing germination and infection, incubation in the tissues and subsequent sporulation, and are controlled by field observations at the Station. It is possible to predict sporulation seven days in advance, which gives ample time for protective measures. In Italy a similar service is operated from Turin.

In Germany the Biologische Reichsanstalt in Dahlem, Berlin, has established a laboratory for meteorology and phenology and has commenced the collection of data by means of a system of report cards issued throughout the country. A limited number of characteristic diseases are selected, and an attempt will be made to correlate their incidence and regional distribution with the isotherms and other meteorological data and with the annual fluctuations of the seasons. A search is also being made for indicator plants which may be found to have a reaction to seasonal conditions parallel with that of the parasites. Hiltner has already claimed that he can find a strict relation between the date at which snowdrops bloom and the extent of the plague of field mice which occurs from time to time in Bavaria.

The United States Weather Bureau is carrying on a large investigation to determine the effect of current meteorological factors on the growth of vegetation. As a part of this, systematic meteorological and phenological records are being kept at a number of centres with a view to determining the critical periods in the growth of crops and in the development of injurious insects and fungous diseases. Though the data are not as yet sufficient to yield much information regarding the incidence of diseases, some interesting correlations have been obtained, such as that potato blight makes its most rapid development when the daily average temperature is about 72°F. We have already seen that the optimum temperature of the parasite for growth in the host plant is about 24°C. or 75°F.

The object of this paper, however, is rather to stress the importance of beginning at the other end—of first establishing the temperature and humidity relations of the parasite and host, singly and together, and only then, with the exact information thus gained, seeking the correlation with meteorological data.

The co-operation of the meteorological authorities will be required the moment it is sought to translate the results of such exact studies into practical application. Whether the meteorological data at present recorded are sufficient is doubtful. In India they are not, neither as regards temperature nor, still more, humidity. Even where the records are taken three times daily, a correction formula appears to be required. Several such formulas have been worked out for the mean temperature, but their application differ in different localities. For the purpose here indicated, not only the means but the duration of the daily extremes may be of the utmost importance, a low minimum, if sufficiently prolonged, being perhaps sufficient to start a parasitic attack, though it might not be revealed in the daily mean if counterbalanced by a hot day.

In this brief review many points of great interest, as, for instance, the fascinating problem of the overwintering of the cereal rusts, have been omitted. No attempt has been made to do more than give examples of various aspects of the influence of environmental factors on plant disease. Field observations on the seasonal and regional occurrence of diseases have, no doubt, a certain value, but the trend of recent work has been to show that definite conclusions cannot safely be drawn from such observations unless they are controlled and elucidated by the more exact methods of laboratory research.—International Review of the Science and Practice of Agriculture, Vol. III, No. 2.

FRUIT DISEASE ON OIL PALMS.

The following extract is taken from the Annual Report of the Mycologist of the Department of Agriculture, F.M.S. & S.S. for the year 1924.

A rather disturbing feature has become manifest on mature African Oil Palms. On the inside of the leaf bases of large numbers of Oil Palms, close to the junction with the stem, pinkish-white rhizomorphic strands are to be found, often bearing fruit-bodies, *i.e.* of a pink-capped Marasmius (?) sp. While commonly present, no damage is done if the fungus remains in its usual place on the leaf-bases. Recently one case has been observed where the fungus suddenly grew up over the mature fruit-bunches, and rendered them useless for oil-production. The common presence of this fungus on the palms and the possibility of the parasitic tendency becoming more common makes careful supervision necessary. It appeared that the trouble might have originated owing to the numerous, non-fecundated bunches being allowed to remain and disintegrate on the tree ; usually a few mature nuts are present in such bunches, and as the fungus under consideration appears to be the chief agent in the disintegration of the non-fecundated bunches, it was possible for this organism to get gradually accustomed to growing into and attacking the oil-bearing nuts. The suggestion to remove the non-fecundated bunches was made and carried out and there has been no further recurrence.