

## MOULDS, METABOLITES AND TISSUES\*

**W**ITHIN the last quarter of a century, experimental plant pathology, particularly, dealing with pathogenic fungi and their host plants has shot up into great prominence. Physiology of fungi, *in vitro*, and the physiology of the host tissue under the influence of products of metabolism of these tiny microscopic forms, now termed collectively, as toxins or antibiotics, have been studied intensely in many centres of research. Many fungi have been screened for antibiotic production and those of interest to us are the wilt toxins.

### TOXINS AND ANTIBIOTICS

An important wilt toxin known to affect cotton plants in India is fusaric acid which is a pyridine-carboxylic acid with a molecular weight of 179 and the unsaturated dehydro-fusaric acid with a close enough molecular weight of 177. Both these forms are known to occur inside plant tissues when they are invaded by several species of the common soil organisms of the genus *Fusarium*. It is, however, not known if these two fractions are produced independent of each other, although it has been noticed that the unsaturated dehydro-fusaric acid is produced earlier than the saturated fusaric acid molecule. Fusaric acid is known to be produced notably by *Fusarium lycopersici* (the tomato wilt pathogen), *F. vasinfectum* (the cotton wilt pathogen), the non-specific *F. heterosporum* and quite recently, much higher quantities are shown to be produced by a weak parasite, *F. orthoceras*. Another genus *Gibberella fujikuroi* is also known to produce fusaric acid, dehydrofusaric acid and two substances of the Gibberellin group that are known to have the character of growth substances. The *in vitro* requirements of these fungi in the shape of carbon and nitrogen for optimum production of the antibiotic have been worked out and the main factors contributing towards this are the form and sources of carbon and nitrogen and the pH of the substratum.

### RHIZOSPHERE AND FUNGAL METABOLISM

There is great deal more to learn about pathogenic fungi and their behaviour in the region of the root (rhizosphere). For instance, the cotton wilt fungus, *Fusarium vasinfectum* which takes a heavy toll of this crop plant in many cotton-growing areas in India, has been estab-

lished by us as a typical soil inhabitant of these soils, and, indeed, as many as fourteen species of this genus are now known to be present in such soils. There seems little doubt that they are primary decomposers of cellulose in the soils. We have also noticed the occurrence in soils of two other species, *F. lateritium* and *F. scirpi* known to produce wilt of tomato. The typical organism causing tomato wilt in other parts of the world is *F. lycopersici* through its wilt toxin fusaric acid and *F. lateritium* and *F. scirpi* recorded by us as potential pathogens of the tomato are not known to produce this toxin. Quite recently we have succeeded in showing that a weak parasite *F. orthoceras* could produce considerable quantities of fusaric acid, far in excess of what the cotton wilt pathogen *F. vasinfectum* can produce.

In the rhizosphere, many organisms, pathogens and saprophytes, have been noticed and, in fact, they have been quantitatively assessed. These organisms obviously depend on the root exudates that can afford an unfailing substrate of energy material in the form of sugars, vitamins and amino acids. The pathogenic forms of the soil have been shown by many workers to produce *in situ* antibiotics and these remain stable in many cases for considerable periods. We have been able to show that *F. vasinfectum* in sterilized soils amended with stable organic matter like green leaf and oats produces the equivalent of fusaric acid upto 2.9 and 7.9 µg./g. of soil respectively. Our work has also indicated that this organism can be induced to produce mutants under ultraviolet irradiation of 2537 Å with a total energy less than  $24.73 \times 10^{-7}$  ergs and some of these mutants are capable of synthesizing greater quantities of fusaric acid *in vitro* than the parent culture.

### ENERGY SUBSTRATES

One of the heavy metals required by *F. vasinfectum* for normal production of fusaric acid *in vitro* is zinc and as far as we can determine, using stringent bioassay methods, fusaric acid is not formed with concentrations of the metal below 0.08 mg./l., the optimum being 0.24 mg./l. and levels higher than 0.4 mg./l. inhibit the production of the antibiotic. This work has direct bearing on the field problem of wilt as we have been able to show that in soils where cotton wilt by *F. vasinfectum* occurs freely, there is lower level of Zn than in those that harbour the pathogen but yet show no typical wilt and, indeed, these soils have much higher content of this metal.

\* Abstract of the Presidential Address by Prof. T. S. Sadasivan to the Section of Botany of the 45th Indian Science Congress, Madras, 1958.

## SOIL CONDITIONS AND HOST PHYSIOLOGY

It is obvious that the wilt fungus requires *in vivo* metals, pectins and presumably a good source of nitrogen. We have examined both resistant and susceptible varieties of cotton plants for their nitrogen source and find that their protein nitrogen and non-protein nitrogen contents differ very widely and the susceptible varieties make available large quantities of non-protein nitrogen *in vivo* upon which the fungus toxin development largely depends. This is borne out by *in vitro* tests where the fungus has been shown to depend upon non-protein nitrogen sources for elaboration of toxins. Similarly, *in vivo* pectin source is greater in the roots of the susceptible, than in the resistant varieties tried by us and possibly is another *in vivo* energy source on which the pathogen depends for developing its twin enzyme systems, the pectin methylesterase and pectin galacturonase without which the organism could not synthesize the toxin.

## ENVIRONMENT, TOXAEMIA AND TISSUE RESPIRATION

One of the *in vivo* causes of resistance to the cotton wilt pathogen we have ascribed, over and above what has been stated already, is the presence of cystine only in resistant plants. There are two ways, as far as we have data, of inducing susceptible plants to produce cystine and create an artificial barrier of resistance. This can be done by zinc amendments to soils where these plants are grown or by growing susceptible cottons at a temperature of 37.5° C.

The possibility of the fusaric acid molecule splitting at the high temperature of incubation

of 37.5° C. and being utilized for respiratory purposes of the plant tissue suggests itself as an alternative explanation. It could also indicate the *in vivo* chelation of heavy metals with cystine thus withdrawing these metals which are vital for potentiation of the toxin fusaric acid. One of the effects of Zn amendment appears to be that of retarding tissue respiration of susceptible cotton plants grown in Zn amended infested soils and bringing it down to the normal level of the healthy control. This is interesting, because increased respiration of tissues of cotton grown in infested soils seems to be the major change with onset of toxæmia and the role of Zn in nullifying these effects has to be further explored.

## WILT AND IONIC DERANGEMENT

Some of the newer results in our investigations on the uptake of ions and their derangement in wilted susceptible cotton plants indicate that apart from loss in K and an increase in Mn *in vivo*, there is strong evidence of the appearance of ionized calcium during pathogenesis. Although the resistant plant also shows ionized calcium lines nearly as strong as the susceptible plant under toxæmia, the healthy susceptible plant shows very weak ionized calcium lines. Therefore, Ca ionization is essentially ascribable to the possible dissociation of the fusaric acid molecule *in vivo* and the consequent changes it could have brought about in the respiration and in the ionization of the neutral calcium. This evidence is suggestive of a poisoning effect of the tissues resulting in major ionic derangement *in vivo*.

## A GEOCHEMICAL HYPOTHESIS OF THE EARTH'S STRUCTURE

THE view that the Earth is zonal in its structure, with each zone characterised by certain dominant elements has long prevailed in geochemistry. These views in recent years have been examined and it is considered that a chemically homogeneous non-zonal globe is much more probable.

The hypothesis is based on the fact that the behaviour of matter would be totally different from that observed on the crust of the Earth. In the interior where the pressure is hundreds of thousands of atmospheres, the outer electrons are forced into the lower quantum levels. At a depth of 2,900 Km. the pressure is of the order of 1,400,000 atoms, and

calculations show that at the high pressure prevailing at this depth, all atoms will become identical, in respect of their chemical behaviour. Thus, it is assumed that at the high pressure prevailing at this depth, called the 'centrisphere' all atoms will be in a 'metallised' state, in which matter will be made up of atomic nuclei immersed in a homogeneous electronic plasma, having a high electrical and thermal conductivity. This geochemical hypothesis of the structure of the Earth finds support in certain thermodynamic considerations and seems to agree with the seismological data. (A. F. Kapustinsky, *Nature*, 1957, 180, 1245.)