SECTION IV

GENERAL DISCUSSION
Drugs vs Mycelial Growth

In all 19 homoeopathic drugs were employed. Many of them proved to be potent antifungal agents on the basis of their effects on the mycelial growth of the pathogenic fungi. Similar antifungal properties of homoeopathic drugs have also been reported earlier (Khanna and Chandra, 1976; Singh and Gupta, 1981; Dua and Atri, 1983; Shrivastava and Kushwaha, 1984). Further, drugs exhibited specificity in their action since some of them were effective against certain pathogens while others against certain other pathogens, e.g., Arsenicum album, Blatta orientalis, Cina, Lycopodium clavatum and Thuja occidentalis were effective against *A. solani*, *Apis mellifica*, Arsenicum album, Blatta orientalis, Chenopodium anthelminticum, Sulphur and Thuja occidentalis against *B. theobromae* and *Apis mellifica*, Arsenicum album, Chenopodium anthelminticum, Lycopodium clavatum and Thuja occidentalis against *R. nodosus*. However, Thuja occidentalis and Arsenicum album were effective against all the pathogens under study. Antifungal properties of Thuja occidentalis and Arsenicum album against several viral and fungal pathogens *in vitro* and *in vivo* have already been appreciated (Khurana, 1968, 1980; Khanna and Chandra, 1976, 1977 a, b, 1978; Goswami and Das, 1980; Singh et al., 1980).

A number of cases were recorded where drugs presented more than one optimum (a range of potencies showing marked
activity). Such a phenomenon is rare with conventional compounds (Dimond et al., 1941; Montgomery and Shaw, 1943). Dimond et al. (1941) recorded two optima with Thiram, one corresponding to the action of undissociated molecules of Thiram and the other to that of the ionized form of the compound. Horsfall (1956) related the two peaks with different mode of action. Same appears to be true for the drugs showing more than two optima. Since growth of the pathogen is a concerted effect of a number of activities, its inhibition may be achieved in a number of ways each involving suppression of a specific activity. Possibly some of the drugs inhibiting pathogenic growth possess more than one mode of action. Results of the present investigations related to the effect of drugs on different activities connected with the growth of the pathogen support such a possibility. In such cases, each optimum of the drug may be taken to represent a particular mode of action of the drug. Occurrence of more than one optimum so often observed in the present study appears to be rather a rule with homoeopathic drugs as it has been noticed by many other workers dealing with homoeopathic drugs (Verma et al., 1969; Khanna and Chandra, 1976, 1977 a, b; Dua and Atri, 1983) and is consistent with the observations recorded in Hahnemann's Materia Medica Pura and in Allen's Encyclopaedia of Pure Materia Medica. This can be explained as homoeopathic drugs are qualitatively different from rest of the drugs in the
sense that here drug preparation involves a process of dilution alternated with potentization. Whereas, in conventional drugs, different concentrations of the substance are produced simply by the process of dilution. In diluted condition, irrespective of the degree of dilution, the drug can at best exist either in ionized form or in unionized form. Thus, the possibility of a substance occurring in varied forms is extremely limited. Homoeopathy overcomes this limitation through a process of drug preparation, which is unique to it. In the homoeopathic process of drug preparation, the drug is not only diluted but is also potentized and this way drugs of higher and higher potencies are prepared. This is said to unmask the deepseated remedial virtues at newer and unforeseen planes corresponding to the varied forms in which the drug molecules come to exist, that the process of trituration or potentization has generated.

**Drugs vs Disease Control**

With a view to devise appropriate control measures to combat the soft rot of tomato, apple and brinjal fruits caused by their respective pathogens, 10 homoeo drugs for each were selected on the basis of their *in vitro* efficacy. Their efficacy in preventing or curing the fruit diseases was then evaluated by applying them in Pre- and Post-inoculation treatments.
Drugs showing marked reduction in percentage rot in both type of treatments could be regarded as most efficacious since they appeared to possess the ability not only to guard the fruit from fresh infections but also to mitigate the infections already present. These were, Arnica montana 4 (84% prevention and 82% cure), Arnica montana 201 (88% and 69%), Chimaphilla umbellata 4 (78% and 86%) and Thuja occidentalis 201 (100% and 80%) in case of tomato; Blatta orientalis 4 (94% and 100%), Blatta orientalis 201 (74% and 70%) and Thuja occidentalis 201 (100% and 89%) in case of brinjal and none in case of Botryodiplodia infected apples. Possibly these drugs persisted on the fruit surface for sometime and made the conditions unfavourable for the growth of the pathogen, thus, protecting the fruit from any infection. In addition, they are possibly absorbed by the fruit where they check the infection from further spreading in the host.

Although their in vivo efficacy to prevent or check a disease should be directly related to their ability to inhibit the mycelial growth, cases were recorded where a drug failed to put up a good performance in in vivo evaluation, despite its fungitoxic potential in in vitro. Such cases can be described in two categories (a) where drugs could not check the disease due to their therapeutic failure (b) where drugs could not prevent the disease due to their prophylactic failure. Drugs that fall in category (a) were - Arnica montana 7, Arsenicum album all potencies;
Blatta orientalis 4, 7, 13, 201; Cina 1, 201; Ipecacuanha 7;
Lycopodium clavatum 7 and Thuja occidentalis 1, 7, 31 in case of
Alternaria rot of tomato, Apis mellifica 7, 13, 31;
Blatta orientalis 31, Chenopodium anthelminticum 7, Sulphur
4, 7, 13 and Thuja occidentalis 1, 7, 13 in case of
Botryodiplodia rot of apple and Apis mellifica 13, 201 and
Thuja occidentalis 4 in case of Rhizopus rot of brinjal.
The drugs that fall in category (b) were Apis mellifica 31,
Calendula officinalis 13, 31, 201; Cina 31, 201; Lycopodium
clavatum 31, 201 and Thuja occidentalis 4 in case of
Alternaria rot of tomato, Apis mellifica 7, 13, 31;
Arsenicum album 31, 201; Blatta orientalis 31, Sulphur 4, 7
and Thuja occidentalis 1 in case of Botryodiplodia rot of
apple and Apis mellifica 4, 31 in case of Rhizopus rot of
brinjal.

On the other hand, a number of such cases were also
recorded where the drugs proved quite effective in prevent-
ing or checking the disease, although they performed poorly
against the pathogen in vitro. Examples cited are Arnica
montana 4, Ipecacuanha 13, Calendula officinalis 1 in case of
Alternaria rot of tomato, Euphrasia officinalis 7 in case of
Botryodiplodia rot of apple, Blatta orientalis 7, 13;
Chimaphilla umbellata 201, Cina 1, Sulphur 13 and Thuja
occidentalis 201 in case of Rhizopus rot of brinjal.

Failure to repeat the performance of the in vitro
condition under in vivo condition by the drugs might have
been due to the specific 'microenvironment' in the infection court which the drugs and the pathogens have to face. 'Strong' drugs failed to express their fungitoxicity as effectively because either the host environment was unconducive to them or the fungicides induced resistance in the treated host. 'Weak' drugs were able to check or prevent the disease in other cases probably because certain host factors increased their fungitoxicity towards the pathogen.

However, Arnica montana 31, Arsenicum album 31 and Thuja occidentalis 201 appeared to be 100% successful preventives against A. solani - tomato rot as the fruits treated with them did not develop any sign of rot, but the therapeutic control of tomato rot has not been so successful. Drugs failed to exert successfully in preventing or checking disease in case of apples, though significant control could be achieved with certain drug potencies. Most satisfactory protection against A. nodosus was, however, promised by Apis mellifica 201, Arsenicum album 31, Blatta orientalis 7, 13; Chimaphilla umbellata 31 and Thuja occidentalis 201 in case of brinjals. A few drugs such as Arsenicum album 4, 7, 201 and Chimaphilla umbellata 7 could also be employed as therapeutics in successfully checking the brinjal rot. These facts indicated that homoeopathic drugs acted better as preventives rather than as curatives. Khanna and Chandra (1977 a, 1978) while devising homoeopathic control measures for Pestalotia psidii rot of guava and Pestalotia mangiferae
rot of mango have also arrived at the similar conclusions.

**Drugs vs Cell Wall Degradation Enzymes**

Since all the three fruits, under study were found to develop severe soft rot symptoms within a few days following infection caused by their respective pathogens, involvement of cell wall degrading enzymes, particularly pectolytic and cellulolytic ones, appeared imperative in the pathogenesis. When a pathogen comes in contact with a susceptible host, it is first confronted with a complex cell wall barrier composed of polysaccharides. The pathogen has evolved the means to recognize the chemical structure of this barrier and elaborates the appropriate enzymes to decompose it. While dealing with the phytopathogenic diseases and devising a suitable control measure for them, this aspect of pathogenesis is to be dealt with seriously. A perusal of literature in this regard will reveal that chemical control measures found successful in combating the phytopathogenic diseases have often been found to inhibit or inactivate the cell wall degrading enzymes also. Consequently, a few homoeodrugs, were also employed to study their effect on the production and activity of certain cell wall degrading enzymes, to ascertain their role in fruit rot control.

A comparison of the data with regard to the production and activity of enzymes in culture media and extracts of diseased tissues respectively indicated that
considerable amount of PG, PMG and Cellulases (Cx) were produced in the culture media of all the three pathogens, a lion's share being enjoyed by cellulases (Cx) at least in *A. solani* and *R. theobromae*. The secretion of cellulases (Cx) by *R. nodosus* was lesser in comparison to the pectolytic enzymes. Since activity of these enzymes were found to increase considerably in *R. theobromae* and *R. nodosus* infected hosts, their involvement in pathogenesis seemed obvious. However, in case of *A. solani* - tomato system, a decline in enzyme activity was recorded, particularly cellulase activity was retarded most. It appeared that certain host factors inhibited the synthesis of these enzymes *in vivo*. Thus virulence of a pathogen can not always be correlated with its *in vitro* ability to synthesize enzymes. Harter and Weimer (1921) found the saprophytic species of *Rhizopus chinensis* and *R. microsporus* producing more amount of enzymes in comparison to the pathogenic species of *R. nigricans* and *R. atrocarpi*. Norrall et al. (1972) likewise, also did not observe any correlation between *in vivo* synthesis of cell wall degrading enzymes and the virulence of *Sclerotinia*. Bateman and Millar (1966) have also conceived these enzymes as one of the complex factors involved in pathogenesis which may be the principal factor in certain diseases while in others they are apparently of little or no importance.
Results compiling the effects of 10 homoeodrugs each in 6 potencies, selected on the basis of their in vitro performance, on the in vitro production and in vivo activity of PG, PMG, Cx in *A. solani* - tomato, *B. theobromae* - apple and *R. noddus* - brinjal systems have already been discussed in preceding chapter and clearly indicate that although most of the drug potencies were found to be more or less inhibitory, none could cause significant reduction in enzyme production or activity. On comparing their in vitro and in vivo efficacy, it is further clearly revealed that they proved more inhibitory against the production rather than the activity of enzymes. This might well be due to the presence of certain components in the host tissues which did not permit homoeodrugs to exercise their full inhibitory potential whatsoever.

Taking together the results of their effects on mycelial growth and those on the enzyme production and activity together it will be difficult to establish any correlation between the two. Drug potencies that have shown remarkable antifungal activity in in vitro have failed repeating the same performance against cell wall degrading enzymes. A few instances were also recorded where a drug potency inhibited the enzyme production or activity despite its failure as a fungicide in vitro.
Drugs vs Respiration

For the growth and development of the pathogen, energy is required. This energy is principally supplied through the process of respiration, hindrance of which would mean the impairment of organism's growth. Consequently, in order to explore the mode of action of a fungicide, its effect on the respiration of the pathogen is often investigated. Present investigation, therefore, incorporates the effect of drugs on the respiration of the pathogen in terms of oxygen uptake.

A number of fungicides are known to interfere with the respiration of the pathogen, either specifically or non-specifically. Specific action involves inhibition of respiration due to upsetting the electron transport system or uncoupling the oxidative phosphorylation. The non specific action has been attributed to the disturbances in permeability or chemical reactions with sensitive enzymes in the respiratory chain.

If we take into account the effects of drugs on the mycelial output and the rate of respiration together, their action may be categorized as follows:

(a) Where drugs produced marked effects on both the processes, e.g., Arsenicum album 1, 4; Blatta orientalis all potencies, Cina 7, 13, 20; Ipecacuanha 7, Lycopodium clavatum 1 and Thuja orientalis 1, 4, 7
in case of *A. solani*: Arsenicum album 31, 201; Blatta orientalis 7, 13, 31; Sulphur 7 and Thuja occidentalis 1, 7, 13, 31, 201 in case of *R. theobromae* and Arsenicum album 7, Lycopodium clavatum 4, 201 and Thuja occidentalis 4 in case of *R. nodosus*. These drugs appeared to inhibit mycelial growth through inhibiting the mycelial respiration.

(b) Marked inhibition of the mycelial growth but no marked effect on the rate of respiration e.g., Lycopodium clavatum 7, 13 in case of *A. solani* and *Apis mellifica* 31, 201; Chenopodium anthelminticum 201, Lycopodium clavatum 7, 201 in case of *R. nodosus*. These drugs appeared to inhibit mycelial development by upsetting some activity other than respiration. No such cases were however, noticed with *R. theobromae*.

(c) Marked reduction in the rate of respiration but no marked effect on the mycelial development, e.g., Calendula officinalis 13 and Cina 201 in case of *R. theobromae* and Arsenicum album 13, Lycopodium clavatum 1 and Thuja occidentalis 1 in case of *R. nodosus*. In these cases, pathogen might have tapped energy from some source other than normal respiration for its growth.

Thus, we have studied a few homeopathic drugs in relation to their antifungal activities and also their
bearing upon plant disease control. We have also taken a few parameters in order to try to provide a rationale of their (drugs) working. And what we have come across? We have seen drugs behaving and performing in total bewilderment and a bizarre manner; drugs performing well against the pathogen but failing as a therapy or a prophylaxis, drugs failing against the pathogen but succeeding in bringing about excellent disease control. Drugs have curtailed oxygen uptake drastically in a pathogen but the pathogen has remained unaffected, or else the pathogen is found butchered under in vitro treatments but the drugs refuse to interfere with the respiration of the pathogen or with the synthesis of enzymes and then execute moderately in preventing or curing the fruit rot. In vitro performances are not repeated under in vivo conditions and vice versa. And then there are several instances, the thesis is replete with, where a drug has been found to be strong enough against the pathogen in in vitro and has also superbly controlled the rot therapeutically or prophylactically but alas! the drug executing successfully against the pathogen in in vitro is not the same one potency-wise which has provided disease control.

Notwithstanding the unintelligibility of the situation encountered while scanning through the corpus of data and interpreting them grudgingly, certain facts of observations remain worth underscoring and are presented here as gist.
There is sufficient amount of evidence to state that the \textit{in vitro} fungitoxic performances as displayed by so many drug potencies which in turn result from their antienzymatic (?) or antirespiratory (?) abilities at least in a few cases, have generally been found to be greatly altered under \textit{in vivo} conditions. It seems therefore, likely although precise mode of their operation remains to be ascertained, that the drugs have influenced the host therapeutically or prophylactically to act upon the pathogen in order to be effective against the disease by virtue of their power to repress the pathogen which in turn comes from their ability to impair a number of metabolic activities apart from those included in the present study. This is clearly suggestive of the multiple site action of the homoeopathic drugs. Inconsistencies in the action of the drug potencies as revealed throughout the course of investigations can be understood in light of the multiple site action concept of homoeopathic drugs. Accordingly, the inconsistencies in the behaviour of drug potencies could be due to the reason that most of the drugs presented more than one optimum and sometimes as many optima as there were potencies, each representing a particular mode of action. As a corollary of this, another significant point that emerges is that the principal focus of homoeopathic drug action is the host and not the pathogen, that is to say, the drug exercises its influence on the pathogen principally via the host. Lastly, it should also be mentioned that the drugs act better as preventives rather than as therapeutics.