https://doi.org/10.29321/MAJ.10.A04309

Recent Developments in the Chemotherapy of Plant Diseases*

by

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Introduction: The search for chemical substances to control plant and animal diseases started as soon as the microbial nature of the diseases was established early in the nineteenth century. At present several chemical substances, both inorganic and organic, are being used for combating these diseases. But the study of plant chemotherapy i. e. the treatment of plant diseases with chemicals which act within the host plant is a relatively recent subject and more and more attention is being paid to it at present in the United States of America and in England. An attempt is made here to bring together the latest developments and findings in plant chemotherapy.

Mode of action and the method of application of chemotherapeutants: It is generally understood that the symptoms of plant diseases are brought about either by the direct action of the pathogen on the host or from the host's reaction to the toxins produced by the pathogen. As a general rule the food supply available inside the plant tissue does not meet the specific requirements of the pathogen and so the establishment of the organism inside the host is prevented unless the host is susceptible to the specific organism. But in some cases the presence of fungistatic and fungicidal chemicals within the host tissue offers a natural resistance for the plant. The presence of protocatechuic acid in the scales of onions is a ready example. The object of chemotherapy is to introduce into the plant system some chemicals which can bring about the resistance or in other words immunize the plants against certain phytopathogens. These chemicals are known to act at least in two different ways; (1) by direct action on the pathogen and (2) by antidoting the toxins produced by the pathogen. Again, there are more than one way by which these effects are brought about by these chemicals. Some of them like hydrogen sulphide and hydrogen cyanide gases when applied externally are known to penetrate deep inside the host tissue and check the spread of the pathogen after it had entered the host. In this case the chemical is known to be a topical chemotherapeutant. When the chemical, applied to one part of the plant, diffuses to the other parts and arrest the pathogen or antidotes the toxins produced by it, it is known as a a systemic chemotherapeutant. In a few cases the chemical may change the degree of resistance of the host to the pathogen by bringing about a change in the metabolic activity of the plant.

* Paper presented for the 1954 College Day and Conference Symposium on "Recent Advances in Agriculture".

There are several ways by which the chemotherapeutants are introduced into the plant system of which injection and translocation, soil treatment and root absorption and foliage application and leaf absorption are the important ones. Injection of the chemical into the stem was one of the common methods used by earlier workers, but in recent years the other two methods are reported to be more useful. In the case of Dutch elm disease it was found that when 8-quinolinol benzoate was applied to the roots, there was better control than when injected into the stem, the chemical injected into the stem was translocated readily in the longitudinal direction, but the radial and tangential transmission was very poor (Dimond *et al* 1949). Similar results have been reported for the bacterial blight of beans and X-disease of peach. There is enough evidence to show that the chemicals applied to the leaf surface are absorbed by the leaf and transmitted systematically, but the degree of absorption may vary with the chemical as well as the plant. Perhaps soil application of the chemical is the easiest and the best method but it has been found that many of the chemicals are less stable in the soil, thus warranting a serial application at periodical intervals. It is also known that certain chemicals and antibiotics lose their activity inside the plant which may be due to slow break down or dilution of the chemotherapeutant due to the effect of the growth of the plant. So the treatment in such cases may have to be repeated at closer intervals.

Most of the chemothrapeutants are known to be quite effective even in very small doses and it is more so with antibiotics which are effective at doses below I: 10,000. Some of them have been reported to be phytotoxic at higher levels, but the nonphytotoxic dosage, the time and frequency of treatment etc., are details to be worked out for a given set of conditions.

Organic Compounds as Chemotherapeutants: Several organic and inorganic compounds have been tested for their chemotherapeutic value in plants against fungal, bacterial and virus diseases but only a few of them were found to be effective. Some of the important diseases which have been successfully treated by the chemicals other than antibiotic substances are listed in Table I.

Antibiotics as Chemotherapeutants: Of the more than one hundred antibiotics so far reported to have been isolated from microorgaisms, only a small number has been tested in plants and among them only a few have been reported to be useful as chemotherapeutants. The action of antibiotics against plant viruses is at present a controversial topic as some workers believe that the virus principle is inactivated by the antibiotic as indicated in the *in vitro* experiments and others believe that they bring about a change in the host tissue resulting in the resistance of the plant to virus infection. The important fungal, bacterial and virus diseases of crop plants controlled by antibiotic chemotherapy are given in Table II.

TABLE I

Some of the important plant diseases controlled by chemotherapy

No.	Name of the disease	Casual agent	Chemotherapeutant	Authority	
I	**Fungus Diseases :**				
1.	Dutch elm disease	*Ceratostomella ulmi*	(i) 8-quinolinol benzoate (ii) 2-carboxymethyl mercaptobenzo-thiazole salts	Dimond *et al* Dimond and Davis	(1949) (1952)
2.	Wilt of tomato	*Fusarium lycopersici*	(i) 8-quinolinol sulphate (ii) Na and K 2-benzothiazolyl-thio-glycolates	Stoddard and Dimond Dimond and Davis	(1951) (1953)
3.	Wilt of carnations	*Fusarium* sp.	4-chloro-3, 5-dimethylphenoxye-thanol; 2-norcamphane metha-nol; 8-quinolinol sulphate	Stoddard and Dimond	(1951)
4.	Wilt of greenhouse stock (*Matthiola incana*)	*Rhizoctonia* sp.	8-quinolinol sulphate	Stoddard and Dimond	(1951)
5.	Root-rot of Vanda orchids	*Fusarium* sp.	T. M. T. D.	Murakishi	(1953)
6.	Wilt of egg plants	*Verticillium* sp.	2-carboxymethylmercapto-benzo-thiazole salts	Dimond and Davis	(1953)
7.	Oak wilt	*Chalara quercina*	Disodium ethylene bisodium car-bamate + 2-mercaptobenzothia-zole; 8-hydroxyquinoline etc.	Hoffman	(1952)
8.	Early blight of tomato	*Alternaria solani*	(i) 4-nitrosopyrazoles (ii) 2-carboxymethylmercapto-benzo-thiazole salts (iii) 1-p-sulfamylphenyl-3, 5-dime-thyl-4-nitrosopyrazole; 2, 4, 6-trichlorophenoxy acetic acid	McNew and Sundholm Dimond and Davis Stubbs	(1949) (1952) (1952)

No.	Name of the disease	Casual agent	Chemotherapeutant	Authority
9.	Chocolate leaf spot of beans	*Botrytis cinerea* and *B. fabae*	(i) Aryloxyaliphatic acids (ii) 2, 4, 6–trichlorophenoxyacetic acid	Crowdy and Wian (1951) Crowdy and Elizabeth (1952)
			(iii) Mono–, di–, and trichloro–beta–naphthols	Byrde *et al* (1953)
10.	Stem rust of wheat	*Puccinia graminis tritici*	(i) Calcium sulfamate (ii) Sulphdiazine; 3–sulphanilamile–6–methyl pyridazine	Livingston (1953) Hotson (1953)
II	**Bacterial Diseases:**			
1.	Bacterial blight of beans	*Xanthomonas phaseoli*	Salicylic acid; Auamine	Dimond and Stoddard (1948)
2.	Crown gall of fruit trees	*Bacterium tumefaciens*	Sodium dinitro-o-cresylate	Ark (1941)
III	**Virus Diseases:**			
1.	X-disease of peach	virus	Quinhydron; hydroquinone; 8–quinolinol sulphate; p–nitrophenol; p–amino-benzene sulphamide	Stoddard (1947)
2.	Leaf roll of potato	virus	2, 4–dichlorophenoxyacetic acid 2–methyl–4–chlorophenoxy	Lock (1948) Limasset *et al* (1948)
3.	Potato virus X and Y	virus	acetic acid	
4.	Tobacco mosaic	virus	(i) 4–chloro–3, 5–dimethylphenoxy ethanol (ii) Thiouracil	Davis (1952) Nichols (1954)

TABLE II
Plant diseases controlled by antibiotic chemotherapy

No.	Name of the disease	Causal agent	Chemotherapeutant	Authority	
I	**Fungus Diseases:**				
1.	Early blight of tomato	*Alternaria solani*	Grisoofulvin	Brian	(1952,
2.	Late blight of potato	*Phytophthora infestans*	Terramycin	Bonde	(1953)
3.	Seedling blight of oats and barley	*Helminthosporium victoriae*	Helixin B	Leben *et al*	(1953)
4.	Wilt of tomato	*Fusarium oxysporum* var. *lycopersici*	Thiolutin	Gopalakrishnan & Jump	(1952)
5.	Stem rust of wheat	*Puccinia graminis tritici*	Actidione	Livingston	(1953)
6.	Mildew of oats and barley	*Erysiphe graminis*	Griseofulvin	Brian	(1952)
II	**Bacterial Diseases:**				
1.	Crown gall of fruit trees	*Bacterium tumefaciens*	Penitalin	Repert & Hawas	(1951)
2.	Gall on tomato	*Agrobacterium tumefaciens*	Aureomycin	Blanchard	(1951)
3.	Bacterial blight of beans	*Xanthomonas phaseoli*	Streptomycin	Mitchell *et al*	(1952)
4.	Leaf drop of fruit trees	*Xanthomonas pruni*	Streptomycin; Terramycin	Dunegan *et al*	(1953)
III	**Virus Diseases:**				
1.	Tobacco necrosis	virus	(i) Terramycin (ii) Trichothecin	Leben & Fulton	(1952)
2.	Tobacco mosaic	virus	Trichothecin	Bawden & Freeman	(1952)
3.	Tomato bushy stunt	virus	Trichothecin	Bawden & Freeman	(1952)

Discussion: Though the chemotherapy of plant diseases is known to be one of the most important methods of plant disease control particularly so for systemic diseases, comparatively little attention has been paid to it so far. Perhaps this is due to want of sufficient knowledge on the chemotherapeutic agents and also phytotoxic nature of those known to be antimicrobial. Further the translocation of the chemicals introduced into the plant is brought about mostly by osmosis and is very slow as compared to the translocation in the blood stream in animal which is more conducive and effective in combating pathogens. With the increasing knowledge on the chemotherapeutic value of some of the organic substances and the etiology of the disease more and more attention is being paid to overcome the obstacles observed in previous years. Moreover it has been recently observed that some of the chemicals which did not show much antimicrobial property *in vitro* proved to be quite useful as chemotherapeutic agents. Davis and Dimond (1953) found that the plant growth regulators, 2,4-D, α-naphthalene acetic acid and indol-3-acetic acid, which had relatively low fungitoxicity *in vitro* when applied to the tomato plants four to ten days prior to inoculating with *Fusarium oxysporum*, the wilt disease was reduced or prevented. A change in the host metabolism showing reduced sugar content of tissues was recorded. The longer the interval between treatment and inoculation the more potent was the chemotherapuetic effect. Gupta and Price (1952) obtained similar results when the culture filtrate of *Trichothecium roseum* was tested against Southern bean mosaic. These findings have opened a new line of approach in chemotherapy of plant diseases, wherein it is required to test all chemicals for activity irrespective of their antimicrobial property *in vitro*. In this connection one important precaution to be observed is to see that the quality of the produce is not adversely affected by the chemotherapeutants. It is hoped that a vigorous approach from the biological as well as chemical aspects of these complicated problems is bound to yield better results.

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