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CHAPTER

Management of Seedborne Diseases

Seedborne diseases were among the first plant diseases to be investigated by scientific methods. More than hundred years ago classic studies were conducted by De Bary (1886), Hellwig (1699), Prevost (1807) and Tillet (1937) to prove that diseases like ergot, bunt and smut were not only caused by fungi that affected seed but also get transmitted through seed. It was Roffredi (1775) who demonstrated that the nematode *Anguina tritici* is associated with the seeds of rye and barley. Similarly, Kühn (1857) proved that the seed, pappus and other parts of *Dipsacus fullonum* is responsible for the transmission of the nematode *Ditylenchus dipsaci*. *Xanthomonas phaseoli* in bean is transmitted through seeds (Halsted, 1893). Tobacco mosaic virus infects the seeds of tobacco was demonstrated for the first time by Allard (1915). Transmission of bean common mosaic virus through seeds was shown by Reddick and Stewart (1919).

According to Browning (1972) it is possible to keep a particular disease under check through various chemical, physical and cultural practices. However, all these measures aim at complete control of the disease, but any management strategy hardly achieve complete control. Moreover, the complete control results in resurgence of target pest and outbreak of resistant pest strains. Hence the concept of pest management, which aims not to completely control a pest but only to manage it at the economic threshold level was coined at the California University (Stern et al, 1959). Broadly, the basic category of tactics available to manage seedborne pathogens are exclusion, eradication, protection or therapeutic measure and host resistance. Tactics of each category potentially could be useful in seedborne disease management, but each has its own inherent strengths and weaknesses. Depending upon the types of pathogens and disease in question, one or a combination of control measures have to be adopted to reduce the effect of diseases on crop yield. The exclusion of inoculums through

quarantine and seed certification has been dealt in chapter 12 and 13 respectively while the eradication with chemicals has been discussed in chapter 10. So in this chapter we will restrict our discussion to only protection or therapeutic measures.

8.1 CHEMICALS IN DISEASE MANAGEMENT

Application of chemicals to seed before planting is one of the major practice of crop husbandary. About seed treatment, it is said "the seeds that have ripened in proper season should be extracted from the fruit, steeped in milk, and dried for five days. Then these should be fumigated with the fumes of gñee in which Vidanga (*Embelia ribis*) has been mixed"—Manusmriti. Appropriate treatment of seeds can get rid of a large number of fungi and can control to a larger extent diseases that would otherwise result. In fact the purpose of seed treatment by the use of fungicide / bactericide is to destroy the seedborne fungi and bacteria that cause seedling blight, seed decays or other diseases such as smuts and bunts. Such a treatment would protect the germinating seed from the attack of many soil-borne pathogens.

The use of chemicals for seed dressing is an age-old practice. Prevost (1807) carried out his classical work on the use of copper sulphate for the treatment of cereal seeds infested with spores of bunt. At a later stage mercurial fungicides opened a new chapter in case of fungal infections and formulations of organo-mercurials were widely used for seed disinfection. Mercuric chloride was first used in India by steeping potato tubers against *Rhizoctonia*. Ceresan (ethyl mercury chloride), new improved Ceresan (ethyl mercury phosphate), Aretan (methoxyethyl mercury chloride), Agrosan GN (ethyl mercury chloride + phenyl mercury acetate) have been successfully used mainly for dry or wet seed treatment to check several diseases like hill bunt of wheat, covered smut and net blotch of barley, *Helminthosporium* leaf spot of maize, brown spot of rice, grain smut of sorghum and loose smut of oats etc. However, the organo-mercurials are hazardous and environmentally unsafe and in most of the countries they have been banned for agricultural use. Alternative fungicides which are quite popular with the farmers and seed industries for seed dressing include chloranil, thiram (tetramethyl thiuram-disulphide) captan (cis-N-[trichloromethyl] thio)-4-cyclohexene-1,2 dicarboximide), maneb (manganese ethylene-1,2-bisdithiocarbamate) etc. (Chattopadhyay, 1980; Crosier 1946; Nene and Thapliyal, 1971). Captan as a seed dressing fungicide has found popularity all over the world and has shown effectiveness against various diseases such as damping-off of beans, chillies, pea, seedling blight of groundnut, seed rot and blights of maize etc.

The introduction of systemic fungicide has added further possibilities of effective control of pathogens located deep inside the seed. According to Aggarwal *et al* (1992,1993) and Srivastava *et al* (1981) some of the systemic fungicides like carboxin, oxycarboxin, carbendazim, bitertanol, propiconazole, acylalanine and raxil etc. are highly effective in controlling many seedborne diseases. Carboxin @ 0.25 per cent gave good control of leaf stripe of barley, loose smut of wheat, damping-off of chillies, seedling rot of sugarbeet, head smut of maize as seed treatment (Nene and Thapliyal, 1971). Aggarwal *et al* (1992), Gaur and Sharma (1992), Singh and Srivastava (1992) and Srivastava *et al* (1991) have shown that dichlofentazole and raxil are highly effective in controlling Karnal bunt and loose smut of wheat. Seed treatment of beans with oxycarboxin gave almost complete control of rust caused by *Uromyces phaseoli* on Pinto bean seedlings for two weeks. Igarashi and Oliviera (1992) demonstrated that seed treatment with diniconazole, iprodione+thiuram, prochloraz, tebuconazole+tolyfluanid have been effective against blast of paddy caused by *Pyricularia oryzae*. Bavistin, a benzimidazole fungicide has been found to be quite effective against sugarcane sett treatment as demonstrated by Singh *et al* (1984). Similarly efficacy of metalaxyl as seed treatment and spray for the management of downy mildew of bajra caused by *Sclerospora graminicola* has been demonstrated by Chopra and Grover (1977), Siddiqui *et al* (1987) and Williams and Singh (1981). Since the spray of propiconazole is effective in controlling Karnal bunt of wheat, Sharma *et al* (2009) conducted a multilocational trial at Ludhiana, Pantnagar, Faizabad and Durgapura to see if the spray could also control loose smut of wheat, but it was found to be ineffective against loose smut.

Chemicals for the eradication of internally seedborne viruses are yet not known. However, in Taiwan, in order to prevent the introduction of new strains of externally seedborne Tomato Mosaic Virus, Asian Vegetable Research and Development Centre has recommended that all sweet and hot pepper seeds be given a trisodium phosphate treatment before planting in the field and greenhouses. Seed treatment with Benomyl was effective in inactivating or killing the feeding *Xiphinema americanum* larvae and thus preventing the spread of this nematode, consequently the spread of the virus too in the cucurbits.

8.2 ANTIBIOTICS IN DISEASE MANAGEMENT

Antibiotics like streptomycin and tetracyclines are most successful against phyto-bacteria. The convention is to use antibiotic mixtures to reduce the selection of antibiotic resistant mutant. For example, seed infection in case of

bacterial blight of rice can be eradicated by soaking the seed in the mixture of streptomycin+tetracyclines @100ppm for 8 to 12hours. Jalali and Grover (1975) effectively controlled bacterial blight of cotton by a combination of oxycarboxin seed treatment followed by two foliar sprays of agrimycin-500. Koleva (1981) found that seed treatment with phyto-bacteriomycin is effective against bacterial blight of wheat.

Fungicides and bactericides are valued as most potential protective agents against number of plant pathogens. However, the adverse effects of fungicides on non-target species and other hazards underline the fact that they must be used judiciously and those that are narrowly selective against target pest must be sought. Seed treatment could be a part of integrated disease management system rather than using it as a single strategy.

8.3 BIOLOGICAL CONTROL AGENTS IN DISEASE MANAGEMENT

Although, control of the diseases through seed dressing with fungicides is quite effective, but this approach is not considered as an eco-friendly strategy. Therefore, biological control as an alternate strategy to combat diseases is becoming popular in the integrated disease management system. It aims at eradication and control of pathogens through antagonistic activity of microorganisms which is achieved by parasitism, competition, predation, commensalism etc.(Mukerji,1983;Upadhyay and Rai, 1983). Aggarwal and Mehrotra (1994) reported that several antagonists are capable of suppressing plant diseases including seedborne pathogens. Weller and Cook (1983) found that seed treatment with strains of fluorescent *Pseudomonas* spp. suppressed root damage caused by *Geaumannomyces graminis tritici* the causal organism of take-all disease in wheat. This disease is not known to occur in India. Brown (1974) reported that seed treatment of cereal seeds with bacteria has frequently increased plant growth. Broadbent *et al* (1971) reported that seeds of wheat, barley, oats and sweet corn when treated with the *Bacillus subtilis* strain A-B, originally isolated from the mycellum of the pathogenic *Sclerotium rolfsii*, increased tillering in soil infested with *Fusarium* spp. and *Pythium* spp. Mew and Kommedahl (1972) reported that maize seeds when treated with *Bacillus subtilis*, there was no incidence of seedling blight caused by *Fusarium moniliforme* and *F. roseum*. Prasad *et al* (1978) demonstrated the antagonistic effect of *Trichoderma* spp. and *Streptomyces* spp. on *Drechslera sorokiniana* causing the seedling blight. Wiley and Kommedahl (1981) found that if the seeds of wheat and sweet corn are treated with *Trichoderma harzianum*, it controls a number of diseases. According to Marshall (1982) the damping-off of snap bean

caused by *Rhizoctonia solani* is reduced if the seeds are treated with *Trichoderma harzianum*. Aggarwal *et al* (1992) reported that the incidence of loose smut of wheat caused by *Ustilago segetum* var. *tritici* was substantially reduced when the seed were treated with *Trichoderma viride*, *Gliocladium deliquescens* and *Bacillus subtilis*. They also found that *Trichoderma viride* was as effective as Carboxin @ 2g/kg seed. Angus (1989) reported that *Trichoderma viride* and *T. koningii* inhibits the mycelial growth and chlamydospore germination of smut pathogen. Singh *et al* (1991) tested the antagonistic property of *T. viride* and *T. harzianum* against *Neovossia indica* the causal organism of Karnal bunt. A significant reduction in teliospore germination was also observed. Rao and Thakur (1988) found that the ergot of pearl millet caused by *Claviceps fusiformis* can be effectively controlled by *Fusarium semitectum* var. *majus*. Similarly, Tripathi *et al* (1981) also reported that *Fusarium sambucinum* is a mycoparasite of the pathogen *Claviceps fusiformis* causing the ergot of pearl millet, and thus can be used as a bio-control agent against the disease. Effective parasitism of *Claviceps fusiformis* by *Fusarium* reduced sclerotial formation, thus the initial inoculum is reduced for the next crop season. Tveit and Moore (1954) isolated *Chaetomium* spp. from the oat seeds, which was found to protect oat seedlings from the infection of *Drechslera victoriae* which is seedborne in nature.

The biological suppression of pathogenic organisms has been achieved partially, especially in case of seedborne pathogen. It has to be suitably integrated with other measures, the aim being to develop an overall approach in tackling diseases. An integrated system of a biocontrol agent and fungicide may be the most effective and economical method of control. Combined cultural practice and chemical controls have been widely used, and integrated use of chemicals and biological controls is increasingly reported. According to Baker (1987) application of chemical may metabolically weaken the pathogen and make it vulnerable to an antagonist. Under integrated pest management, an antagonist insensitive to fungicide or biocide may be combined with it, extending the duration of effectiveness of control. To expedite such integrated control procedures, efforts are being made to develop antagonists resistant to chemicals, so that they can be applied together at lower concentrations.

Baker (1987) and Baker and Cook (1994) reported that an isolate of *Trichoderma harzianum* was developed in 1982 that was resistant to chemicals, and could be combined with chlorothalonil, iprodione or benomyl. Ordentlich and Chet (1989) and Abd-el-Moity *et al* (1982) has shown the positive compatibility of *Trichoderma* spp. with thirum, metalaxyl, chloroneb, procimydone and vinclozolin. Harder *et al* (1979) demonstrated that PCNB in low concentration

was ineffective against damping-off of radish but when it was mixed with *Trichoderma harzianum* it improved the control of the disease. Kaur and Mukhopadhyay (1992) found that chickpea wilt complex was effectively controlled by *Trichoderma harzianum* alone or in combination with vitavax 200 or ziram. Fiddaman and Rossell (1993) used thirum and carboxin as seed dressing fungicide in combination with *Bacillus subtilis* and found that the combination improved plant growth also. Mukherjee and Mukhopadhyay (1993) developed a mutant of *Gliocladium virens* insensitive to carboxin but sensitive to carbendazim. Mondal (1994) have shown the compatible reaction of *Trichoderma koningii* and *Trichoderma harzianum* with widely used seed dressing fungicide vitavax. He emphasized that these isolates could be used for seed treatment on pre-activated seed at lower concentration of vitavax for the control of loose smut of wheat. These studies reveal that antagonists resistant to chemicals may serve as an additive component in integrated pest management system and there is ample scope of an integrated system of control combining both chemicals and bio-control agents.

8.4 HOST- RESISTANCE IN DISEASE MANAGEMENT

The development and use of resistant varieties which possess economic traits is an economically and environmentally sound approach of disease management. Considerable progress has been made in developing varieties with acceptable level of resistance in case of several fungal pathogens. Even moderate degree of resistance are expected to play an important role. Though development of resistant varieties is a time consuming affair but in the longer perspective, it is the most judicious approach in the integrated disease management programme. Genetic resistance is appealing from an environmental stand point but, when used as the sole management tactics, is subject to many of the pitfalls as reliance on chemical control. The host-resistance is often, short lived because new races of the pathogen that can circumvent the resistance, soon evolve. Seed treatment extend the effective life of resistant cultivars by delaying the evolution of new races. In developing countries where the average holdings are comparatively small and very often fragmented, such measures appear to be ideal.

The phenomenon of resistance of a variety to seed transmitted virus, which is otherwise susceptible in the field, has been little explored. Cho and Goodman (1979) for the first time demonstrated that some soybean lines and possible lines of other legume species, are low or non-transmitters of certain viruses. It was also reported that low transmitters were generally more tolerant to soybean

mosaic virus infection than were high transmitters. In case of cowpea, certain lines i.e. K-39, L-868, L-1552 and p-1476 were identified in India, which were susceptible to cowpea aphid borne mosaic virus but did not transmit the virus through seeds (Mali *et al.*, 1981, 1983). Identification and exploitation of a line or germplasm which has resistance to seed transmitted virus but is otherwise susceptible, can contribute to a great deal in terms of integrated pest management. This helps in eliminating the primary source of inoculums. However, in such cases under integrated pest management strategy attempt has to be made to ensure the elimination of secondary source of inoculums.