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Soil Borne Diseases of Vegetable Crops

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The total agricultural losses of economic crops which amount to about 50–75% are caused by soil- borne pathogenic fungi of *Rhizoctonia* spp., *Fusarium* spp., *Verticillium* spp., *Sclerotinia* spp., *Pythium* spp. and *Phytophthora* spp. The losses are due to seed rot, root rot, and wilt diseases in different crop fields and green houses. Since the last century, methyl bromide (MB) has been the most effective fumigation agent in broad spectrum pesticides. In France, it has been used since the 1930s in agriculture to fumigate soil in both plant nurseries and open fields, as well as greenhouses, for healthy transplants of economic vegetables, fruits, and flowers. They often survive for long periods in host plant debris, soil organic matter, free-living organisms or resistant structures like microsclerotia, sclerotia, chlamydospore or oospores. Accurate diagnosis of a particular disease is di cult due to the similarity in symptoms such as seedling damping-off, root blackening, root rot, stunting, wilting, yellowing, bark cracking and twig or branch dieback which in turn makes the disease harder to manage. In developing countries, MB is part of therapeutic applications to protect against soil-borne plant pests, weeds, and pathogens. The main disadvantage of MB application is the depletion of the ozone layer and its dangerous effects on human life. It causes failure of the nervous and respiratory systems, eyes, and skin (Barry *et al*. 2012). Physical solarization methods and hot water alternatives are more expensive and ineffective in a variety of soil conditions Researchers are constantly developing naturally safe organic materials that are effective alternatives for soil amendments against various plant pathogens that are biodegradable, non- ozone depleting, and enhance plant growth and yield. Classically, the main alternative measures for controlling soil-borne plant pests, pathogens, and weeds involve adding various inorganic and synthetic chemicals, which are hazardous to human health and suppress beneficial microorganis ms in the soil (Aktar *et al*., 2009). The use of fungicides against soilborne plant pathogens can help to manage some diseases, in contrast, frequent and indiscriminate use can increase environme ntal and health concerns and lead to development of fungicide resistance. Some environment- friend ly approaches such as the use of crop rotation, soil solarization, anaerobic soil disinfestation, soil steam sterilization, biofumigants, resistant cultivars/varieties or grafted plants and biocontrol products have been developed to control soilborne diseases while maintaining the environme nt. Studies on disease suppressive soils have led to the development and adoption of new approaches.

Major Pathogen Group

Some of the most important soil-borne diseases are caused by pathogens that are 'soil inhabitants', have broad host ranges that include weeds, and produce long-lived survival structures. Important soil-borne pathogens include fungi, fungi- like organisms, bacteria as

well as viruses and plant parasitic nematodes. Fewer diseases are caused by soil borne bacterial pathogens than by fungal pathogens. Examples of such bacteria are *Erwinia, Ralstonia* and Streptomyces. Pathogens in the Pseudomonas and Xanthomonas groups usually persist in the soil for only a short time. There are few soil borne viruses that affect vegetable crops. Soil borne viruses generally survive only in the living tissues of the host plant or in the nematode or fungal vectors that transmit them to the plant hosts. E.g. Beet soil borne furovirus, Lettuce big vein disease, Lettuce necrotic stunt disease. Nematodes are tiny, non-segmented roundworms. Soil borne plant-parasitic nematodes spend most of their lives in the soil, either as external feeders on plant roots or as residents inside roots. Root knot nematodes (*Meloidogyne* spp.) Cyst nematodes (*Heterodera* spp.) Needle nematodes (*Longidorus africanus*) Stubby root nematodes (*Paratrichodorus* spp.) are some important nematodes.

Fungi cause most of soil borne vegetable diseases and so are considered the most important pathogen group :

- Oomycetes: Aphanomyces, Bremia, Phytophthora, and Pythium
- Ascomycetes: Monosporascus and Sclerotinia
- Fungi Imperfecti: Fusarium, Rhizoctonia, and Verticillium.
- Plasmodiophoromycetes: Plasmodiophora brassicae (causal agent of clubroot disease of brassicas) and Spongospora subterranea (causal agent of powdery scab of potato)

Important Soil Borne Diseases in Vegetables

Crop	Diseases	Pathogen	Symptoms and Sign
Tomato	Bushy stunt	*Tomato bushy stunt virus*	Stunted and bushy plant, deformed fruits.
	White mould	*Sclerotinia sclerotiorum*	Soft, watery rot on the stems, profuse white mycelium and black sclerotia on bleached areas on affected stems.
	Damping off	*Phytophthora* spp.	Poor stands wilting and death of emerged seedlings, discolored rotted roots and crown
Potato	Charcoal rot	*Macrophomina phaseolina*	Stem lesions that result in aboveground wilting and yellowing.
	Fusarium dry rot	*Fusarium sambucinum*	Extensive dry, brown internal decay of tuber
	Powdery scab	*Spongospora subteranna*	Purple-brown color pustules that darken with masses of dark brown spore balls.
	Black scurf	*Rhizoctonia solani*	Red-brown stem lesions, yellowing of foliage if lesions griddle the stem. Leaf rolling in the aerial plant portion.
	Black leg	*Erwinia carotovora*	Inky black decay of stem, soft rot of tuber.
Chilli	Damping off	*Phytophthora* spp.	Poor stands wilting and death of emerged seedlings, discolored rotted roots and crown
	Phytophthora root rot	*Phytophthora capsici*	Aboveground stunting, wilting and death. Darkened rotted roots.
	Wilt	*Verticillium dahliae*	Aboveground stunting, wilting and death.
Potato	Charcoal rot	*Macrophomina phaseolina*	Stem lesions that result in aboveground wilting and yellowing.
	Fusarium dry rot	*Fusarium sambucinum*	Extensive dry, brown internal decay of tuber
	Powdery scab	*Spongospora subteranna*	Purple-brown color pustules that darken with masses of dark brown spore balls.
	Black leg	*Erwinia carotovora*	Inky black decay of stem, soft rot of tuber.

	Black scurf	*Rhizoctonia solani*	Red-brown stem lesions, yellowing of foliage if lesions griddle the stem. Leaf rolling in the aerial plant portion.
Leafy vegetables	Damping-off	*Fusarium oxysporum and Pythium spp.*	Poor stands, wilting and death of emerged seedlings. Discolored, rotted roots and crowns.
	Black rot	*Xanthomonas campestris p.v campestris*	Black veins, necrosis progress at edge of leaf in v- shape
Cole crops	Bottom rot	*Rhizoctonia solani*	Dark, discoloured leaves touchingthe soil. It occurs only on the brassicas which are forming the head.
	Club root	*Plasmodiophora brassicae*	Aboveground parts are stunting, roots are severely get swollen and blocks the transportation of water and minerals from roots to upper portion of the plants.
	Fusarium Yellows	*Fusarium oxysporum f.sp. conglutinans*	Above ground parts are stunting, wilting and death. Brown vascular discolorat ion. Primarily, occurs on cabbage.
	Wire stem	*Rhizoctonia solani*	Stunting, wilting and death of transplants. Hypocotyls are discolored, decayed and rotted. Brown mycelium present on decayed areas.

Management of Soilborne Disease

Sanitation : With the resting structures like chlamydospores, microsclerotia, oospores or sclerotia and basic reproductive systems, soilborne plant pathogens can survive in the soil for a very long time, even in the absence of a living host or plant debris and soil organic matter. Therefore, it becomes very important to remove the plant debris away from growing areas whenever possible or accelerate residue breakdown. Sanitation includes any sort of activities which are aimed to prevent the spread of pathogens by removing diseased and infected plant parts, decontamina t ion of tools and equipment and washing hands.

Legal Methods : Legal methods can be defined as any regulation, law or quarantine that prevents the movement of a disease-causing agent by country, region, state, or county. The long-dista nce transfer of soilborne plant pathogens may occur through packing materials, containers, plant material, seeds, plant products, soil, animals or even humans. Introduced pathogens can remain below the detection threshold for many years, only to emerge later with destructive intens ity (Crooks, 2005).

Resistant Cultivars/Varieties and Grafting : Using resistant cultivars or varieties is one effective way to reduce disease. Plant breeding is a laborious and time-consuming process that combines resistance with desired commercial features to create resistant cultivars or varieties. Using resistant rootstocks in grafted plants has been effective in controlling soilborne diseases in tomatoes, including *Pyrenochaeta lycopersici*, *F. oxysporum* f. sp. *lycopersici*, *F. oxysporum* f. sp. *radicis- lycopersici*, and *Meloidogyne* spp. Grafting is increasingly being used in high-value vegetable crops, while being more common in the production of fruits and nuts. One crucial tactic for controlling soilborne plant diseases is the grafting of sensitive scions onto suitable disease-resistant rootstocks. Grafting techniques are used to address certain soilborne diseases, such as Fusarium wilt of cucurbits and bacterial wilt and root-knot nematode of solanaceous crops.

Soil Solarization : An environmentally beneficial pre-planting technique called "soil solarizat ion" uses solar energy to manage weed seeds, fungi, bacteria, oomycetes, nematodes, insects, and other microorganisms in the soil. After enough irrigation, the production bed can be covered with sheets of translucent plastic. The top soil surface layers

are then heated by the trapped solar energy inside the plastic covering. Since soil solarization depends on the environment, it should be tailored to the appropriate areas and times of year.

Biofumigants : The crops in the family Brassicaceae, such as cabbage, broccoli, kale, turnip, radish, canola, cauliflower, rapeseed and various mustards contain substances which can be e ectively used to control soilborne pathogens and pests. A sulfur compound, glucosinolate, is produced by Brassica crops and releases biologically active products upon hydrolysis such as isothiocyanates (ITC), which are found to be toxic to many soil organisms such as P. nicotianae and R. solani. This method has been used effectively against soilborne pathogens and is widely known as biofumigation (Baysal-Gurel *et al*., 2018).

Chemical Control : One effective way to manage certain soilborne illnesses in agricultural crops is through chemical management. Growers are using a variety of well-known chemical alternatives to methyl bromide for soil fumigation as non-chemical alternatives can be laborious and less effective against soilborne plant diseases. In vast crop production areas, chemical management of soilborne plant diseases is typically preferred due to its easy operation and relatively quick effect. Certain soilborne fungal diseases are known to be successfully controlled by products belonging to the dicarboximide, benzimidazole, and triazole fungicide families. Generally speaking, the management techniques mentioned above should be used to treat minor illnesses, and fungic ides and fumigants should only be used as a last resort for soilborne diseases that negatively impact the crops' health and marketability.

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Damping off	**Black Rot**	**White Mould**
		
***Fusarium* Wilt**	***Phytophthora* Rot**	**Black Scurf**