Mycopath (2013) 11(1): 45-50 **Review Article**

Important fungal diseases of potato and their management – a brief review

[*]**Muhammad Fahim Abbas, Farah Naz and Gulshan Irshad**

Department of Plant Pathology, PMAS Arid Agriculture University Rawalpindi
[*]*Corresponding author's email: fahimaaur@yahoo.co.uk*

Abstract

Edible potato (*Solanum tuberosum L.*) is ranked fourth among the staple food crop and fifth for human consumption. It is a vegetative propagated crop and a large number of pests and diseases can be carried from one generation to the next. Pathogens including fungi, bacteria, viruses and nematodes caused significant yield losses in field and storage conditions. Blights (*Phytophthora infestans, Alternaria solani* and *Phoma* spp.), powdery scab (*Spongospora subterranea*), wart (*Synchytrium endobioticum*), watery wound rot (*Pythium ultimum*), gangrene (*Phoma exigua* var. *foveta*), silver scurf (*Helminthosporium solani),* pink rot (*Phytophthora erythroseptica*), dry rot (*Fusarium* spp.), black scurf (*Rhizoctonia solani*), skin spot (*Polyscytalum pustulans*), wilt of potato (*Verticillium* sp.) and charcoal rot (*Macrophomina phaseolina*) are the most destructive fungal diseases and reduced the quality, quantity and market value of potato tubers. This brief review paper demonstrates the symptoms and management strategies against important fungal diseases of potato.

Key word: Blight, potato, rot gangrene, scab, scurf, skin spot, wart, wilt

Introduction

Potato cultivation was too old as 2000 years ago from South America Andes. Potato (*Solanum tuberosum* L.) is from genus *Solanum* and only 8 species are cultivated worldwide. The edible potato has achieved a significant important among non-cereals food crop as it can provide 15 times more yield as compare to cereals. Potato provides essential amino acid (lysine) along with more energy and protein as compared to other single food crop. Potato has a great adaptability of wide range of temperature (tropical, subtropical and temperate regions) and soil (light sands to heavy clay loam) but it is sensitive to drainage and aeration. Its tuber contains water (80%), carbohydrates (20%), low fat (0.1%), amino acids, mineral (2%) and high potassium. Potato has low sodium, fiber (0.6%) and vitamins (B, C, and B2) which play a pivotal role for its nutrition (Walt and Merill, 1963). Potato is used as food (72%), vegetable, French fries, chips, soups, boiled potato, wafers, mashed and fuel alcohol (Bajaj, 1987).

The crop of potato is small (30-100 cm) vegetative propagated and tuber's bud (eyes) sprout grows into mature plants. Tubers formation starts at flowering stage and cease at fruit stage while the size of tuber depends upon the cultivar and age of plants. High heterozygosity, male sterility, self-incompatibility and tetrasomic inheritance characters create hindrance in conventional breeding. Crossing for recombination, mutation and selection are the main parameters in the conventional methods of breeding. Selection is not a reliable criterion as 6-8 years are required to select a desirable variety among 100,000 seedlings (Wenzel, 1980).

Potato crop is susceptible to many biotic and abiotic diseases. Main abiotic constraints in potato production are zinc deficiency, salinity and high temperature and acidic pH. High application of nitrogen lowers the starch contents, delay maturity and make the tubers more susceptible to skinning and bruising during the harvesting (Hooker, 1983). Water stress or low fertility may enhance the susceptibility of potato crop to some diseases. High soil moisture is favourable for the growth and spread of fungus while wilting is more sever when soil moisture level is low.

Many plant viruses (Abbas *et al*., 2012; 2013: Gul *et al.*, 2013), nematodes (Parveen *et al*., 2013), bacteria (Ashraf *et al*., 2012), and fungi have been documented as serious pest of potato. The most destructive diseases of potato crop includes late blight, ring rot and leaf roll which can cause the total loss of a crop unless effective methods of control are practiced. Fungal disease plays a pivotal role for yield losses and categorized into foliar, soil and tuber diseases (Large, 1940). Late, early and Phoma blight are among the foliar diseases whereas common scab, black scuf, dry rot and wilting are important fungal diseases. This review provides the knowledge and management of important fungal disease of potato (Table 1).

Late blight

Late blight is caused by *Phytophthora infestans*, is placed at first among the destructive disease of potato crop that causes the rot (dry or wet) in tubers. It was first observed in Europe (1845 at Courtrcu in Belgium) and it has the tremendous ability to adapt itself to a wide range of environmental condition where potato cultivation occurs. It is one of the main reasons that it has achieved a significant importance among the potato diseases. It is it is famous for causing the worst ever Irish Potato Famine. British introduced the potato in subcontinent (1870) and it traces were observed first in Nilgiris Hill (Butler, 1961) and several outbreaks were reported from Assam, Bengal and Bihar. The first infection often occurs (despite its name late) soon after the plants emerge when favourable moisture and temperature prevail. The favourable temperature enhanced the growth of fungus. The growth of fungus is so fast that it can kill the entire plant within two weeks. It affects tubers, stems and leaves and water-soaked spots were observed on potato plants. Contaminated potato (one-fourth to one-half inch below the skin) provides the space for overwintering the pathogen and favourable environmental condition enhanced the production of sporangiophores bearing many lemon-shaped sporangia. High humidity (90%) is a key factor for the germination of sporangia and high temperature promote the mycelial development. During wet and cooler weather, 8-12 biflagellate motile zoospores are released which can penetrate directly into tissue and also infect the potato tubers near the soil surface (Tantine *et al*., 1986). Foliage infection caused the premature death of plant which reduced the yield and infected tubers starts rotting in field and stores (Robertson, 1991). The proper management of late blight depends upon the reduction of both foliar and tubers infection and cultural practices have significant value to reduce the primary inoculum (Bhattacharya *et al.*, 2002). The infected material should dispose of properly which will reduce the chance of introduction of blight in seed tubers. Allow the certified seed tubers to sprout and introduced them directly into field (Parry, 1990). Copper salts, Dithiocarbamates and 1,2-bisdithiocarbamates, cyanoacetamide-oxime and metalaxyl are effective chemicals for the control of late blight (Schwinn and Margot, 1991). After Irish faming, host resistance was introduced from the wild species (*S. demissum, S. phureja, S. andreanum* and *S. edinense*) and non-host resistance from related species (Gevens and Seidl, 2013).

Early blight

The pathogen (*Alternaria solani*) produces dark brown spots, which are surrounded by brown ring and looks like bull eye. Symptoms are more similar with late blight. This fungus remains viable more than 1 year in soil, infected dry leaves and infected potato debris (leaves and tubers) serve as a source for primary infection. Wind, water and insects are the key factor for the dispersal of conidia and they penetrate direct or through stomata. Frequent rains or abundant moisture followed by dry and warm weather enhanced the disease development and these conditions are not favourable for the potato crop. In India early blight causes 40% yield losses. Crop rotation is not effective in many regions and timely spray of fungicide is recommended for the better control. The fungicides (Brestan) should be applied after twenty one days of interval.

Wart disease

The wart disease of potato is caused by *Synchytrium endobioticum*. The disease was first reported in Hungry (1985) and has become a serious threat of potato production in temperate climates (Europe, North and South America, South Africa and Subcontinent) (O'Brien, 1976). In response of ward disease, potato plant exhibiting rough, warty outgrowths (spherical, spongy and soft) or protuberences on tubers, stolons on stem, leaves flower and not reported on roots. Resting spores overwinter on infected seed tubers or soil and motile zoospores are spread through potato tubers and soil moisture. Sporangia produced more zoospores which fuse in pairs and release in the soil and remain viable for thirty years. Prevention of entry of disease material is the key factor for the management of disease and it is not possible to manage this disease when infection was recorded. Periodic surveys, soil treatment, long crop rotations and removal of infected plant debris are important in reducing the build up of inoculum (Hodgron *et al*., 1974). Soil fungicide can eliminate the disease but it is costly and host resistance is the key factor for the proper management of wart disease (Jones, 1988).

Stem canker and black scurf

Rhizoctonia solani, is causal organism of this disease that reduces the market value of tubers and brown cankers appear on the underground stem and sever tubers cause aerial tubers along with rolling and wilting of foliage (Arora, 1999). During humid summer, stem canker is formed just above ground level and dark brown or black sclerotia can be observed on mature tubers. Infected tubers produced weakened stems and tubers will not grow during sever attack. Rolling of upper leave occur and infected tubers, plant debris and soil provide the place for over wintering (Tsror *et al.,* 2001). Planting of infected tubers is always a risk of disease development and healthy tubers will reduce the chance of heavy infection. Due to wide host range, management depends upon the proper treatment of soil, crop and seed. Clean tubers with margosa cake (23 quintala ha^{-1}) and fungicides such as carboxin, benomyl, thiabendazole and pencycuron are highly effective. *Trichoderma harzianum*, *T. viride*, *Rhizoctonia* and *Bacillus subtilis* have been identified as antagonistic fungi and bacteria for the management of disease (Mishra *et al*., 2000).

Powdery scab

Spongospora subterrannea is the causal organism of powdery scab (Hines, 1976) and this important pathogen was also observed in Asia, Australia, Africa, North and South America and Europe. During primary symptoms, spots are present under skin surface. Deformed and wart like growth in infected tubers and roots serves as a place for overwintering as spore balls. Motile primary zoospores invade epidermal cells, root hairs, lenticels or eyes and penetrate through wounds. During destructive phase of powdery scab, plasmodia produce secondary zoospores and spread the disease deeper into tissue. Spore balls remain viable for six year in contaminated soil (Parry, 1990). Highly resistance source is the most effective tools for the problem and *S. tuberosum* (CP-1742, 8-7) and *S. microdontum* (BRB/A-24) exhibiting no infection in artificial conditions and natural environment (Bhattacharya *et al*., 2002).

Pink rot

Pink rot is caused by *Phytophthora erythroseptica.* The disease appears on the surface of roots and tubers (O'Brien and Rich, 1976) and rubbery texture along with dark lenticels (Goss, 1949). Infected tubers have off white colour inside and watery fluid exuded on squeezing (Hodgson *et al*., 1974). The white tissue turns salmon-pink colour and finally into black. In the response of this pathogen, the smell of vinegar is produced in infected potato tubers (Hooker, 1981). Excessive irrigation in wet and warm summer enhances the disease development and oospores remain viable for many years in contaminated soil (O'Brien and Rich, 1976). Infected tubers release more oospore in soil and infect all underground parts. Healthy seed tubers, proper irrigation and water drainage, less damage during handling and harvesting and proper storage can reduce the losses of pink rot in potato (Rich, 1983).

Silver scurf

The pathogen (*Helminthosporium solani)* infects only tubers, with leathery, gray and smooth skin near the heel end (Conners, 1967). Potato tubers exhibiting a silver sheen (name 'silver scurf') and shrivel tubers were observed due to losses in moisture (Western, 1971). Infected tubers are the source of primary infection and it penetrates through skin periderm and lenticels. Optimal temperature range for growth of pathogen is 2-31 ^{o}C. Severity of disease may occur on soil born mature potato tubers and severe infection also recorded during storage. Tubers should be treated with chemicals and they should be storage below 3°C at 90% humidity. Soil treatment with pentachloronitrobenzene may be beneficial (Wright, 1968).

Watery wound rot

In the response of pathogens (*Pythium ultimum* and *P. debaryanum*) infection, watery soft rot is noticed on infected tubers and moisture leaks form the infected tubers. Yellow or black lines are present on the potato tubers. The pathogen is soil borne and only penetrates through wounds or abrasion during harvesting season and high temperature (22 °C) can increase the rotting of tubers. Rot can grow quickly in stored condition (21 °C) and less wound (during handling and harvesting) of potato, removal of soil and proper storage may reduce the infection (Blodgett and Rich, 1950).

Gangerene

The pathogen (*Phoma exigua*) appears one month after storage, with thumb marks and large cavity lines on the surface of infected potato tubers. The pathogen can overwinter in soil and field. High temperatures retards2-31 the growth of pathogen but low temperature (2-6 °C) during storage may enhance this disease. Certified seeds, resistance potato varieties, proper handling and storage (15 °C) and application of benomyl thiabendazole (TBZ), benomyl (1%) and captafol (1%) may provide significant control (Garibaldi *et al.,* 2006).

Dry rot

Dry rot is caused by *Fusarium* spp. (*F. coeruleum, F. eumartii, F. oxysporum* and *F.*

sulphureum) and in the response of these pathogens small brown areas appears on the surface of tubers (Leach and Nelson, 1975). The surface of infected tubers is wrinkled and the rolled tissues become brown, gray or black. During prolong and poor storage, blue, white, purple, black or pink spore masses are observed and this fungus can survive in the soil and tubers (Pinzon-Pera *et al.*, 1999). Less damage during harvesting, proper storage of harvested tubers, application of chemicals on seed tubers with 1200 ppm thiabendazole can manage the disease at large scale (Leach and Nelson, 1975). It has been documented that the pathogens of potato dry rot n has developed resistance against thiabendazole (Hanson, 1996), whereas biocontrol agents like *Trichoderma* spp. and *Pseudomonas aeruginosa* have been found to be effective management strategy (Gupta *et al*., 1999).

Skin Spot

It is caused by *Polyscytalum pustulans*, the pathogen can infect all ground parts and produces light brown lesion on roots, stolons and stems. During a prolong storage, spots appears on infected tubers and pathogen overwinters in soil and tubers and spread to the underground parts of the plant. Disease symptoms are absent on contaminated tubers during harvesting and spots are observed after storage. If the infected tubers are not stored properly, this disease-disperses to healthy potato tubers through air born conidia. Skin spots on the surface of potato tubers reduce its market value and this pathogen also decrease the sprouting of infected tubers. Cultural methods in the field and application of fungicides before storage are effective tools to manage this disease.

Wilt of disease

Verticillium albo-atrum causes of roots, tubes and stems. The pathogen was reported in North Central and North Western States, New England, America and Europe (Parry, 1990). Infected tubers contaminate the soil and wilted leaves become dull yellow and brown (Maurer *et al.*, 1968). At sowing time, application of captan and metiram, crop rotation and resistance cultivars are effective tools for disease management (Murphy *et al.*, 1982).

Charcoal Rot

Macrophomina phaseolina is pathogen of charcoal rot and is frequently reported in tropical and subtropical countries with a variable host range (Rao and Mukerji, 1972). It is more destructive in wet and warm condition and weak parasitic at normal condition (Chupp and Sherf, 1960). Dark colour rot was observed on lower side of stem and stem looks like black leg. At 30°C, the development of fungus is very high and at lower temperature (10°C) hinders fungus growth (Rao *et al.*, 1973). Poor plant nutrition favours the disease development and pathogen overwinters in plant debris, soil and perennial weeds. The incidence of this disease can be reduced through biological control using bacteria (*B. subtilis*), proper drainage and crop rotation.

Table 1: Important fungal disease of potato and their management.

Disease name	Causal organism	Management
Late blight	*Phytophthora infestans*	Certified seed and host resistance
Early blight	*Alternaria solani*	Crop rotation and chemical treatment
Wart disease	*Synchytrium endobioticum*	Soil treatment, crop rotation and removal of plant debris
Stem canker and black scurf	*Rhizoctonia solani*	Chemical and biological control
Powdery scab	*Spongospora subterrannea*	Resistance cultivars and cultural practices
Pink rot	*Phytophthora erythroseptica*	Proper drainage
Silver scurf	*Helminthosporium solani*	Chemical treatment and proper storage
Watery wound rot	*Pythium ultimum* and *P. debaryamum*	Proper storage
Gangerene	*Phoma exigua*	Chemical treatment
Dry rot	*F. coeruleum, F. eumartii, F. oxysporum* and *F. sulphureum*	Chemical and biological control
Skin spot	*Polysecytalum pustulans*	Cultural and chemical control
Wilting	*Verticillium alboatrum*	Crop rotation and resistance cultivars
Charcoal rot	*Macrophomina phaseolina*	Crop rotation, proper nutrition and drainage

References

Abbas MF, Hameed S, 2012. Identification of disease free potato germplasm against potato viruses and PCR amplification of potato virus X. *Int. J. Biol. Biotechnol.*, **9**: 335-339.

Abbas MF, Aziz-ud-Din, Ghani A, Qadir A, Ahmed R, 2013. Major potato viruses in potato crop of Pakistan: A brief review. *Int. J. Biol. Biotechnol*., **10**: 425-430.

Arora RK, 1999. Evaluation of bioagents for control of soil and tubor borne diseases of potato. *Indian Phytopathol*., **52**: 310

Ashraf A, Rauf CA, Abbas MF, Rehman R, 2012. Isolation and identification of *Verticillium dahliae* causes wilt on potato in Pakistan. *Pak. J. Phytopathol*., **24**: 112-116.

Bajaj YPS, 1987. Biotechnology in Agriculture and Forestry, Potato. Springer, Berlin, Heidelberg, New York, Tokyo, Vol. 3. pp. 509.

Bhattacharya RC, Vishwakarma N, Bhat SK, Kirti PB, Chopra VL, 2002. Development of insect transgenic cabbage plants expressing a synthetic Cry 1 A (b) gene from *Bacillus thuringiensis*. *Curr. Sci*., **25**: 146-150.

Blodgett EC, Rich AE, 1950. Potato tuber diseases, defects and insect injuries in the Pacific Northwest Washington Agricultural Experimental Station Popular Bulletin 195.

Butler EJ, Jones SG, 1961. Plant Pathology. Mac Milan and Co., Ltd., London and New York. pp. 979.

Chupp C, Sherf AT, 1960. Vegetable Diseases and Their Control. Ronald Press, New York.

Conners IL, 1967. An Annotated Index of Plant Diseases in Canada. Canada Department of Agricultural. Res. Bran. Pub., pp.1251.

Garibaldi A, Gilardi G, Minerdi D, Gullino M L, 2006. First report of leaf spot caused by *Phoma exigua* on hydrangea macrophylla in Italy. *Plant Dis*., **90**: 113.

Gevens AJ, Seidl AC, 2013. First report of late blight caused by *Phytophthora infestans* clonal lineage US-24 on potato (*Solanum tuberosum*) in Wisconsin. *Plant Dis*., **97**: 152

Goss RW, 1949. Pink rot of potatoes caused by *Phytophthora erythroseptica* Pethyb. *Amer. Potato J*., **18**: 209-212.

Gul Z, Khan AA, Khan AUR, Khan ZU, 2013. Incidence of potato viruses in different districts of Khyber Pakhtunkhawa, Pakistan. *Sci J. Plant Pathol*., **2**: 32-36

Gupta CP, Sharma A, Dubey RC, Maheshwari DK, 1999. *Pseudomonas aeruginosa* (GRCI) as a strong antagonist of *Macrophomina phaseolina* and *Fusarium oxysporum*. *Cytobios*. **99**: 183-189.

Hanson LE, Schwagor SJ, Loria R, 1996. Senstivity to thiabendazole in Fusarium species assoiated with dry rot of potato. *Phytopathol*., **86**: 378-384.

Hines M, 1976. The weather relationships of powdery scab disease of potatoes. *Ann. Appl. Biol*., **64**: 274-275.

Hodgson WA, Pond DD, Munro J, 1974. Diseases and pests of Potatoes. Publication of Canadian Department of. Agriculture. pp. 1492.

Hooker WJ, 1981. Compendium of Potato Diseases. American Phytopathological Society. St. Paul, Minnesota.

Hooker WJ, 1983. Research for the potato in the Year 2000. Int. Potato Center Lima Peru.

Jones JB, 1988. Soil testing and plant analysis. Procedure and Use Tech. Bull. 109: Food and Fertilizer Tech. Cen. Taipei City. Taiwan. pp. 14.

Large EC, 1940. The advances of fungi. The Hollen Street Press Ltd., London W.I. pp. 477.

Leach SS, Nelson LW, 1975. Elimination of fusarial contamination on seed potatoes. *Am. Potato J.*, **9**: 211-218.

Maurer AR, Van Aldrichem M, Youngand DA, Davis HT, 1968. Cariboo, a new late potato variety of distinctive appearance. *Am. Potato J*., **45**: 247- 249.

Mishra RC, Singh R, Singh HB, Dikshit A, 2000. In situ efficacy of *Trichoderma harzianum* as mycoparasite on *Sclerotium rolfsii* and *Rhizoctonia solani*. *Trop. Agric*., **77**: 205-206.

Murphy HJ, Morrow LS, Young DA, Ashley RA, Orzolek MD, Precheur RJ, Wells OS, Jensen R, Henninger MR, Sieczka JB, Pisarczyk JS, Cole RE, Wakefield RE, Young RJ, 1982. Performance evaluation of potato clones and varieties in the northeastern states 1981. *Mar. Life Sci., Agric. Exp. Stat. Bull*., 782.

O'Brien MJ, Rich AE, 1976. Potato diseases, US, Department of Agriculture Handbook. pp. 474.

Parry DW, 1990. Plant Pathology in Agriculture, Cambridge University Press, pp. 268- 306.

Parveen N, Mukhtar T, Abbas MF, Rauf CA, 2013. Management of root knot nematode with marigold (*Tagetes erecta* L.) and antagonistic fungus *Paecilomyces lilacinus* (Thom)

Samson in tomato crop. *Int. J. Biol. Biotechnol*., **10**: 61-66

Pinzon-Perea L, Salgado R, Martineg-Lopez G, 1999. Antagonism between different isolates of *Trichoderma* spp. and *Fusarium oxysporum* f. sp. *dianthi* (Prill and Del.) Synd. & Hans. *Fitopatol. Colomb*., **23**: 7-11.

Rao RV, Mukerji KG, 1972. Studies on charcoal rot disease of *Abelmoscus esculentus*. I. Soil-Host-Parasite relationship. *Trans. Mycol. Soc. Jap*., **13**: 265-274.

Rao RV, Ganapathy PS and Mukerji KG, 1973. Studies on charcoal rot disease of *Abelmoscus esculentus*. III. Pycnidial formation of the isolate as influenced by light, plant tissue and tissue extracts. *Phytopathol Z.*, **76**: 123-127.

Rich AE, 1983. Potato. Diseases, Acad. Press. pp. 238.

Robertson NF, 1991. The challenge of P*hytopnthora infestans* In: Advances in Plant Pathology. Vol. 7, *Phytophthara infestans*, the cause of late blight of potato (eds. Ingram D.S. and Williams P.H.), Acad. Press, N.Y. pp. 1-25.

Schwinn FJ, P Margot, 1991. Control with chemical. In: Advances in plant pathology (Eds. D.S. Ingram and P.H. Williams), Vol. 7. *Phytophthora infestans*, the cause of late blight of potato. Academic Press, N.Y. pp. 5-35.

Tantine PH, Fyte AM, Shaw DS, Spatlock RC, 1986. Occurrence of the A2 mating type and self-fertile isolates of *Phytophthora infestans* in England and Wales. *Plant Pathol*., **35**: 578-581.

Tsror L, Balak R, Sneh B, 2001. Biological control of black scurf on potato under organic amendment. *Crop Prot*., **20**: 145-150.

Walt BK, Merill AL, 1963. Composition of foods: Raw, processed, prepared Handbook No. 8, US Dep. Agri. Washington.

Wenzel G, 1980. The potentials and limits of classical genetics in plant breeding. In: Plant Cell Cultures: Results and perspectives (eds. Sala F, Parisi B, Cella R, Cefferri O) Elsevier/North Holland Bio. Pre. Ams. N.Y. pp. 33-47.

Western JH, 1971. Diseases of Crop Plants. John Wiley, New York.

Wright NS, 1968. Evaluation of Terraclor and Terraclor Super-X for the control of Rhizoctonia on potato in British Columbia. *Can. Plant Dis. Surv*., **48**: 77-81.