The importance of the potato

Potato (Solanum tuberosum L.) is the most important world's leading vegetable crop by virtue of its inherent potential for tonnage production, remunerative income and good nutritional values. It is a starchy, tuberous crop from the perennial Solanum tuberosum of the Solanaceae family also known as the nightshades. The word potato may refer to the plant itself as well as the edible tuber. In the region of the Andes, there are some other closely related cultivated potato species. Despite being first introduced outside the Andes region four centuries ago, today potatoes have become an integral part of much of the world's cuisine and are the world's fourth-largest food crop, following rice, wheat, and maize (Hijmans and Spooner, 2001).

Wild potato species occur throughout the American continent, from the United States to Uruguay (Hijmans and Spooner, 2001). Today over 99% of all cultivated potatoes world wide are descendants of a subspecies indigenous to south-central Chile (Miller, 2008). Based on historical records, local agriculturalists, and DNA analyses, the most widely cultivated variety worldwide, Solanum tuberosum ssp. tuberosum, is believed to be indigenous to the Chiloé Archipelago where it was cultivated as long as 10, 000 years ago (Solis et al., 2007 and Francis, 2005). However, genetic testing of the wide variety of cultivars and wild species suggests that all potatoes have a single origin from a species in the Solanum brevicaule complex in the area of southern Peru, where potatoes were first domesticated between 3000 BC and 2000 BC Spooner et al., (2005).

In terms of nutrition, the potato is best known for its carbohydrate content (approximately 26 grams in a medium potato). The predominant form of this carbohydrate is starch. A small but significant portion of this starch is

resistant to digestion by enzymes in the stomach and small intestine, and so reaches the large intestine essentially intact. This resistant starch is considered to have similar physiological effects and health benefits as fiber: It provides bulk, offers protection against colon cancer, improves glucose tolerance and insulin sensitivity, lowers plasma cholesterol and triglyceride concentrations, increases satiety, and possibly even reduces fat storage (Cummings et al., 1996; Hylla et al, 1998; Raben et al., 1994). The amount of resistant starch in potatoes depends much on preparation methods. Cooking and then cooling potatoes significantly increased resistant starch. For example, cooked potato starch contains about 7% resistant starch, which increases to about 13% upon cooling (Englyst et al., 1992). Almost all the protein content of a potato is contained in a thin layer just under its skin (Brody, 1985).

Potato was introduced into Europe, first by the Spaniard to Spain in 1579, and secondly to the England around 1590 from the Andean region of South America (Malik 1995). Thousands of varieties persist in the Andes, where over 100 cultivars might be found in a single valley, and a dozen or more might be maintained by a single agricultural household (Theisen, 2007). From these two places the potato spread to rest of the world. Fifty years after its first introduction into Europe, Portuguese traders brought the potato to the Indo-Pak subcontinent when they landed north of Bombay. By 1675, the potato has already been established as garden plant in Karnataka. The potato was said to have entered China from Dutch East India (Indonesia). By the late seventeenth century potatoes were grown in parts of Africa, New Zealand and Japan (Malik, 1995).

Nature has gifted Pakistan with immense edaphic and climatic resources for ideal production of potatoes. It is the fourth major crop of Pakistan after Wheat, Rice and Maize. Around 3, 000 ha at the time of independence, the area under production increased to around 149, 000 ha during 2009-2010 with total production of 3411600 tons (Anon. 2010). During this period average yields rose from around 9 MT in 1947 to 22. 89 MT per ha in 2009-10 (Anon., 2010). Pakistan is self-sufficient in potatoes for household consumption and relies for more than 99% on locally produced seed potatoes. Presently, it is estimated that the total annual domestic production amounts to around 3. 4116 Million MT, of which 43116 MT is used as seed and 3. 38 Million MT is available for consumption. The recent large increase in acreage was reached by an intensification of the cultivation in existing potato growing areas, as well as by introduction of the crop in new areas and to inexperienced farmers.

Over the years, potato has become an important crop for both farmers and consumers in Pakistan. The main potato growing areas in Pakistan are present in the Punjab province. In Punjab is about 86 percent of the whole potato growing area in the country and the potato production is near about 88. 3 percent of the whole potato production in the country. The area used under cultivation in Sindh is about 0. 5 percent of the whole potato growing area in the country and the potato production is near about 0. 3 percent of the whole potato production in the country. The area used under cultivation in NWFP is about 9 percent of the whole potato growing area in the country and the potato production is near about 7. 2 percent of the whole potato production in the country. The area used under cultivation in Balochistan is

about 4. 5 percent of the whole potato growing area in the country and the potato production is near about 4. 2 percent of the whole potato production in the country (Ref Missing). The major potato growing districts of Punjab are Okara, Sahiwal, Kasur, Sialkot, Sheikhupura, Jhang, Lahore, Narowal, Pakpattan, Gujranwala, T. T. Singh and Khanewal. The major potato growing districts of NWFP are Nowshera, Dir, Swat, Balakot, Gilgit, Sakardu and Mansehra. The major potato growing districts of Balochistan are Pishin, Killa Saifulla and Kalat.

Average yield of potato tuber is only 22. 89 MT per ha in the country which is very low as compared to other potato growing countries of the world as Netherlands with 46. 27, USA 46. 27, UK 41. 43 and Australia 36. 18 t/ha respectively, (FAO Stats, 2009). There are several factors contributing to low potato production in Pakistan. In Pakistan potato is attacked by number of diseases like Scab, Black scurf, Early Blight, Late blight, Wilt, Black leg, Potato Leaf roll virus, Potato virus X and Y etc. Hence, many problems, like diseases and pests, became more hazardous as a large number of farmers lack the knowledge of the right cultivation technique. These include pests and disease control, land preparation and irrigation, fertilizer application, crop rotation and multi-cropping techniques. A significant part of produce is lost due pest and diseases (Kelman 1984). Among diseases late blight is the most important affecting potatoes (Dowley & O’Sullivan. 1994).

Phytophthora infestans (Mont.) de Bary, the causal organisms of the late blight disease of potato and tomato is the most important worldwide factor limiting the production of potatoes. It is heterothallic and can reproduce sexually and asexually (McLoad et al., 2001) with rapid asexual reproduction

under wet conditions. This pathogen infects all stages of plant growth which show symptoms of late blight; stem and tuber rot (Johnson et al. 1997). Late blight (Phytophthora infestans Mont. De Bary) was found major yield limiting factor in high hills and is also a serious problem in plains. Late blight is the most serious diseases of potato worldwide and can completely destroy the crop, resulting in 100% yield loss (Ghorbani et al., 2004). This disease is favored by temperature between 100 C and 250 C, accompanied by heavy dew or rain. When weather conditions are favorable, an uncontrolled epidemic can result in 100% losses in some fields (Tosun et al., 2007). Destructive nature of Phytophthora infestans can be realized by the fact that in 1845-46 about one million people died in Europe and 1. 5 million were forced to migrate due to this disease. In year 2006-07 late blight appeared as major disease in all potato growing areas.

The first sign of infected tissue is brown spots on the leaves often surrounded by a halo of chlorotic (yellowed) tissue. During moist weather, a white cottony growth will develop on the margins of the lesions on the underside of the leaves. Infected stems and petioles will turn dark brown or black. Stem blight lesions may appear before or after leaf lesions and are important sources of further infection. Spores from foliar lesions higher up the plant may be transported downwards. Tubers become infected by spores washing through the soil profile. These develop brown to purple lesions followed by a brown rot. When harvested and put into store, blight infected tubers may lead to serious losses of marketable yield. The pathogen survives in the soil for several years. This pathogen is the source of infection for healthy crops in the absence of blight infected tubers.

Phytophthora infestans reproduces both sexually and asexually. Sexual reproduction results in oospores-thick walled spores that can survive for several years in the soil. When oospores germinate, they produce asexual spores called sporangia. Sporangia only survive in the living host tissue, such as cull potatoes. These are often the original source of infection that initiates a major outbreak of the disease. Once released, sporangia can easily be carried for yards by rain splash and miles by wind. Wet conditions favor the disease with high humidity (greater than 90%) favors sporangia development. They also germinate readily on wet leaves. During moist weather, whole plants may be killed in a short time (George and Preston, 2004).

The late blight fungus attacks potato leaves, stem and tubers. Asexually produced spores (sporangia) spread through the crop by wind and rain splash and the disease progresses very rapidly when temperature exceed 10o C and relative humidity is over 75% for 2 days or more. At temperature above about 15oC, spores can infect leaves directly but at lower temperature, the spores germinate to produce 10-12 motile zoospores, each of which can swim in water films and infect the leaves. The fungus overwinter as mycelium in potato tubers infected during the previous season by spores that were washed through the soil. As the temperature increase in the spring and the infected tuber begins to grow, the mycelium within it grows to produce an infected plant on which spore-bearing lesions develop. These spores infect newly planted potato crops and the disease cycle begins again. (Ghorbani et al., 2004)

Late blight of potato can be successfully controlled by a combination of sanitary measures, resistant varieties, and well-timed fungicidal sprays. The ideal way to combat this disease is the use of resistant potato cultivars. Cultivation of resistant varieties is most economic and valid option in disease controlling strategies. None of the commercial varieties is found resistant to P. infestans. Many new varieties have been developed by breeders during the last few years but the response of these varieties is not known. If some varieties are resistant the information is not transferred to the farmers. However, the availability of the resistant cultivars is scanty and calls for extensive screening of potato germplasm against late blight of potato is necessary in order to identify the resistance sources because cultivation of resistant varieties is one of the most economical methods of disease management.

Minerals, apart from being a vital part of the plant nutrition, may manifest certain maladies in the plants either through disturbing normal metabolism and physiology of the plants or by favouring or discouraging the plant pathogens, if in excess or otherwise deficient

There are numerous reports on the role of phenolics (Kosuge, 1969) and Phytoalexins (Cruickshank, 1963; Kuc, 1972; Baily and Mansfield, 1982) in contributing resistance to the plants, by a number of host-parasite interactions. These substances act in the chemical defence of higher plants mainly in three ways. First, they are present in the healthy plants at concentrations sufficient to inhibit growth and sporulation of a pathogen (generally referred to as pre-formed resistance factors); Secondly, as a response to infection, their concentration is markedly increased imparting

resistance against the invading microorganisms; Finally, certain post-infection products (phytoalexins), which are not normally found in healthy plants, are synthesized or increase in amounts after infection (Manibushanrao et al., 1988). Phenolic compounds are essential for the growth as well as to confer resistance against plant pathogens as defense mechanism (Agrios, 2005). It has been established that phenolics and flavanoids are among the most frequent and widely distributed secondary metabolites in plants kingdom (Wahid and Ghazanfar, 2005). Limited work has been carried out on the role of phenolic compounds, which are produced as a result of pathogen attack.

At present, fungicide applications play a vital role in potato late blight control as resistant cultivars have not been widely available and adopted because resistant varieties are not well known and consumers often do not accept them. The mancozeb (as Dithane M-45) gave good control of late blight (Phytophthora infestans) of potato in field tests in the Kaghan valley, Pakistan. The fungicide was highly economical with a marginal rate of return of 484-534%. However, fungicides are not easily available in the area and the farmers are not aware of its use for late blight control. (Jan, 1999).

However, the realization of the harmful effects caused by the chemical pesticides has forced the scientists and farmers to search for the alternative materials to avoid the ecological hazards. Among the several materials available, plant product offered greater scope than the rest, as they are safe, easily biodegradable and eco-friendly. Neem (Azadirachta indica A. Juss) has been reported to have insecticidal, antifungal, antibacterial and antiviral properties (Rashid et al., 2004).

Thus, it seems imperative to undertake studies on the determination of biochemical characters of lentil which may possibly play a role in resistance against Phytophthora infestans). To eliminate the extensive and un-judicial use of fungicides studies were carried out to get best effective spray interval, combination and number of spray under field conditions before and after the disease appearance. As fungicides encourages the development of resistance in P. infestans and the pathogen requires higher doses for control which disturbs the cost benefit ratio. Management of Phytophthora infestans (Mont.) de Bary through bio-fungicides and plant extracts was undertaken.