

CURRENT PRODUCTION AND BREEDING STATUS OF POTATO IN PAKISTAN

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Potato is one of the most important crops serving a source of food for millions of people all over the world. It is cultivated on various agricultural conditions around the world. It is one of the four staple food crops which have major impact on domestic consumption and food needs among major population around the world. Despite of easy cultivation practices and low labour requirements, production of potato in Pakistan is not promising as compared to the world as well as to other South Asian countries like India and Bangladesh. Low crop productivity in Pakistan is the result of biotic and abiotic stresses and relatively less land to produce potatoes. Various biotic factors like fungal and viral diseases have a significant effect on potato production. Extreme temperatures, poor soil, drought, salts and less irrigation water, are some of the abiotic stresses that encounter potato production. The basic aim of this review is to pinpoint the influencing factors in potato production and to suggest the possible ways to address the issues that are related with potato production, yield and crop losses in Pakistan.

Keywords: Potato famine, staple food, germplasm, biotic stress, hybridization

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a very useful crop that provide high nutrition as well as energy, and also help in reducing the malnutrition and hunger among the world's population. In case of human consumption, potato graded as the third most significant crop all over the world, after rice and wheat (Grossi *et al.*, 2020). It is being used as food, feed as well as in raw material in industrial usage, and has also been endorsed as a crop having food security in scenario of present-day problems and all-time increasing world's population to supply food and nutrition (Devaux *et al.*, 2020). Potato is extremely significant crop and the first non-cereal crop in the world with an annual production of over 380 million tons (t) cultivated on a total area of 19.3 million hectares (ha) with an average yield of 22.2 t/ha in 2019 (FAOSTAT, 2020).

The domestication of potato being cultivated now-a-days started around 8000 to 10000 years ago. In the beginning, people presumed potato the relative of *S. nigrum* (nightshade family member). Progressively, this domestication practices started all over the world. First domestication resulted in *S. stenotomum* and was thought to be the inheritor of wild species. Hybridization of diploid landraces *Phureja* (2x) with *S. stenotomum* (2x) resulted in *S. tuberosum*, *Andigena* group (2x=2n=48).

The potatoes in Europe were first introduced from South America during the 16th century (Glendinning, 1983). At the

end of the 18th century, long-day photoperiod potato (*S. tuberosum* group *Chilotanum*, (2n = 4x = 48), was yielded from the modern-day commercial cultivars. Asexual (clone) propagation was extensively adopted by keeping tubers at harvest for next year's farming. A famine caused by disease "late blight (*Phytophthora infestans*)" caused famous Irish potato famine that ruined most potato varieties, thus caused drop in the gene pool of potatoes in Europe. In mid-19th century, after famine, serious efforts were made to collect wild potatoes from Chile and were hybridized those few European varieties that survived. True potato seeds (TPS) were collected from the berries attained after a self-pollination that occurred in an uncontrolled way (Kumari *et al.*, 2018). It enlarged the variations and hence new cultivars were released as "Rough Purple chili or Garnet Chili (open-pollinated)" and after the release of Garnet Chili, Albert Breese conducted selection trials on it and produced "Early Rose" cultivar in 1867. Luther Burbank, a botanist, worked on potato improvements and released "Burbank Seedling" in 1876, and further provided "Russet Burbank in mid-20th century". Cross-breeding hybridization received attention to improve potato germplasm in 20th century (Jansky and Spooner, 2018). Currently, around 4800 potato varieties have been dispersed around 125 countries worldwide, notably under tropical, sub-tropical, and temperate regions (Pieterse and Judd, 2014; Seo *et al.*, 2018; Hameed *et al.*, 2018). Shipping of Spanish sailors from South America to Canary Island helped potato to get introduced in other continents as

per the preliminary chronicles (Hawkes and Francisco-Ortega, 1993). Several studies suggested that first introduction to Europe was from landraces of Andean origin (Hawkes, 1990; Salaman, 1937; Hosaka and Hanneman, 1988; Salaman and Hawkes, 1949).

In Asia, China, India, and Bangladesh are sharing almost 45% of the overall potato production of the World in year 2019 (FAO, 2021) (Fig. 1). Potato in this continent was taken mainly by deckhands as well as traders from Europe. In this continent potato first arrived to Pakistan and India in the 16th century from the United Kingdom and Portugal (FAO, 2008; Singh and Rana, 2014). After their introduction, it was started growing in hilly areas during the 19th century; however, due to less adaptability to day length conditions the productivity was very less (Singh and Rana, 2014). From here, the potato was spread to the whole Asian countries (Tong and Zhao, 1991). Potato spread to Central Asian countries like Kazakhstan, Kyrgyzstan, and Turkey, Iran and South Korea in 19th century (FAO, 2008).

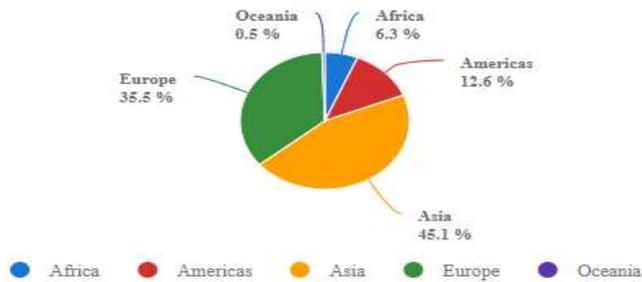


Figure 1. Production share of Potatoes by regions (source: FAOSTAT Accessed March 12, 2021).

POTATO STATUS IN PAKISTAN

Potatoes are currently grown on around 17 million hectares of farms worldwide, with a global production of 370 million tons. While in Pakistan, potato is cultivated on 0.19 million hectares with the production of 4.87 million tons (FAOSTAT, 2021) (Fig. 2). Five-year data (2015-2019) presented in Table 1 specifies that India is the leading potato producer among South Asian countries, Bangladesh is ranked second while Pakistan is on third position among most potato producing country in the region followed by Nepal (FAOSTAT, 2021). Potatoes in Pakistan are used as a staple food almost in every province and is taken as a domestic vegetable available throughout a year. A considerable portion of potato is also used in processed foods like finger chips, fry chips, and salad. In Pakistan, mainly three crop season exists namely spring, summer and autumn in different agro-ecological zones of Pakistan (Khan and Akhtar, 2006). Potato production requires less labor and input as compared to the other crops and has a comparatively shorter life span (almost 90 days) that makes it an ideal crop for the farmers.

AREA AND PRODUCTION IN PAKISTAN

In Pakistan, Potato is produced mainly in three provinces i.e., Punjab, Baluchistan and Khyber Pakhtunkhwa. Areas in these districts are,

Punjab: Okara, Sahiwal, Depalpur, Arifwala, Kasur, Daska, Shiekupura, Pakpattan

Baluchistan: Kalat, Ziarat, Kila Saifullah, Pishin, Loralai, Quetta

Khyber Pakhtunkhwa: Mardan, Nowshera, Swat, Abbottabad, Sawabi, Mansehra (Figure 3)

Table 1. Potato production and area harvested in South Asian countries during 2015-2019.

Country/ Year	Area Harvested (000, ha)					Production (000, tonnes)				
	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
India	2076	2117	2179	2142	2173	47009	43417	48605	51310	50190
Bangladesh	471	475	499	477	468	9254	9474	10215	9744	9655
Pakistan	170	177	179	193	195	3997	3977	3852	4591	4869
Nepal	197	199	194	195	193	2586	2805	2691	3088	3112
Sri Lanka	4	5	4	5	5	70	80	73	89	101
Bhutan	4	6	5	4	4	48	59	57	44	43
Afghanistan	25	35	32	32	57	327	427	513	615	921

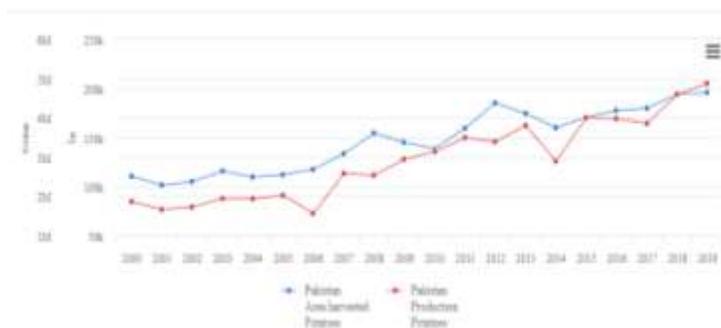


Figure 2. Area and production (2000 to 2019) of potato in Pakistan (Source: FAOSTAT Accessed March 12, 2021).

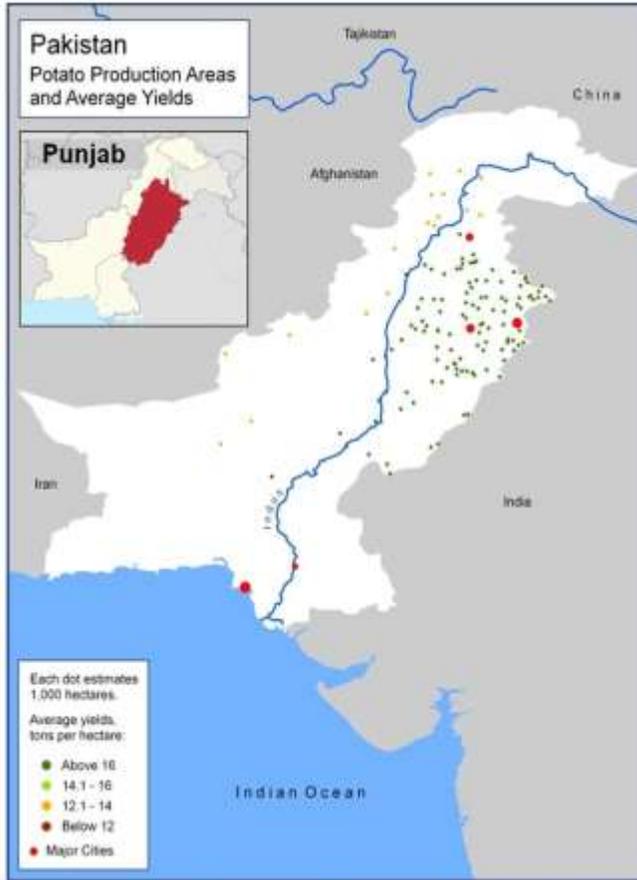


Figure 3. Impression of the geographical distribution of potato cultivation in Pakistan (Courtesy: International Potato Center (CIP)).

Different areas have different sowing time as per prevailing environmental conditions. Usually there are three main seasons of potato sowing (Table 2 and 3). Potato crop needs fertile soil with a good drainage system. Soil organic matter is also important in Pakistani fields that should not be less than 1.5. Proper ploughing and pulverization of the soil is very important for a good growth and development of this crop. Potato grows best on loamy soils having pH 6 to 7.5. Seed rate of potato in Pakistan varies with season. For autumn crop seed rate 1200-1500 kg per acre with a good tuber size is used. For spring and summer sowing seed rate is 500-600 kg per acre depending on the size of potato. 50–60 gram potato tubers are normally used. Typically, potato is grown in furrows apart 60-75 cm while the plants distance is maintained at 20 cm. Fertilizer and farm yard manure are of major importance as per the soil conditions in Pakistan. FYM (12-15 ton per acre) must be applied 45-60 days before sowing. Fertilizer requirement of this crop is as N = 100 kg, P = 50 kg, K = 50 kg and Zinc sulphate (21%) = 10 kg (Fayaz, 2019).

Table 2. Different sowing and harvesting time regarding to different areas.

Zone	Sowing time	Crop season	Harvest time
Upper Indus Plan	Mid to late January	Spring	April/May
	Half of September	Autumn	January
	August (Faisalabad)	Autumn	November
Baluchistan Northern Mountains	March to June	Summer	November
	April/ May	Hilly Crop	September /October
Lower Indus Plan	February	Spring	June
	August	Autumn	November
	September	Autumn	December
	Mid October	Autumn	January /February

Table 3. Share of seasonal potato crop production.

Crop	Planting	Harvesting	Production share
Spring	Jan.– Feb.	April– May	7-10 %
Summer	March– May	August– Oct.	15-20 %
Autumn	Sept.– Oct.	Jan.– Feb.	70-75 %

Following potato varieties are generally cultivated in Pakistan.

White	Red
Diamant	Desiree
Sante	Cardinal
Multa	Karuda
Ajax	Lal e Faisal
Vilja	Raja
Patrones	Faisalabad Red
Faisalabad White	Ruby
Sadaf	Sialkot Red

PROBLEMS OF POTATO PRODUCTION IN PAKISTAN

Besides suitable environment, shorter life span and other favorable conditions, the productivity of potato in Pakistan is not encouraging as compared to the developed countries. There are many abiotic as well as biotic factors which limit potato production in the country. Similarly, there are other factors that have a drastic effect on the production and yield of potato in Pakistan. These factors include different bacterial and viral diseases, low yielding varieties and poor farm practices (Majeed *et al.*, 2017). Levy *et al.* (2013) stated that the most limiting factor especially in tropical regions is the prevailing drought conditions in potato production areas. Drought conditions are escalated by the high temperature of the specific region. Fluctuations in rainfall ultimately make water less available for the potato crop, which is important for proper crop growth (Obidiegwu *et al.*, 2015). Salinity on the other hand causes physiological abnormalities in potato that results in the retarded growth and low yield as compared to the normal (Rai *et al.*, 2011). Changing environmental conditions in the several parts of the world and soil related problems have a direct correlation with the decreased yield and retarded growth and development specifically in potato

(Hijmans, 2003; Khan *et al.*, 2014). Due to such constraints as well as losses during post-harvest storage, the overall production in Pakistan is decreased. Besides some farmers in the northern areas, most of the farmers in Pakistan market their harvest in urban areas rather than their household uses; hence, potato has converted to an important foundation of rural income. Potato consumption in Pakistan has shown clear upward trend, where annual per capita consumption is more than 15 kg, which was around 10 kg a decade earlier. There are some other factors that cause reduced potato yield. These include viral infections to potato tubers which causes the replacement of seed every three years. Hence, the seed is imported and seed companies are importing poor quality seeds that are not certified virus free in return of huge income. Farmers have to pay more than half of the cost of production to buy seed. Moreover, production losses of the crop elevate significantly due to poor management strategies during postharvest storage. One of the other major factors is seed dormancy owing to low storage conditions. An average potato farmer can't afford a well-equipped storage conditions so they are relying on the available resources. Hence, storage conditions should be also improved to avoid seed dormancy.

Biotic stresses: Climatic conditions in Pakistan are very diverse and offer a significant opportunity to grow potato where its production can also be elevated to great extent. However, many factors prevail that affect negatively to the crop and hence the yield and productivity is low. Among biotic limitations, different diseases caused by bacteria, viruses, fungi, nematodes and weed infestations can cause a significant decrease in potato production. Among all these, the most common and most famous potato diseases occurring in the environment of Pakistan are late blight (*Phytophthora infestans*), early blight (*Alternaria solani*), stem canker (*Rhizoctonia solani* kuhan), black scurf and powdery scab (*Spongospora subterranean*) with great effect on production. *Fusarium* dry rot and *Fusarium* wilt have also been reported in different growing regions with different degree of attack and affect potato yield (Rauf *et al.*, 2007; Majeed *et al.*, 2014).

Many bacterial diseases also aid in low production and poor potato growth in Pakistan. Among bacterial diseases blackleg, common scab (*Streptomyces scabies*), soft rot (*Erwinia carotovora*), bacterial wilt (*Ralstonia solanacearum*) are the most common which have disastrous impact on potato growth, production and post-harvest quality (Ali *et al.*, 2012; Anwar *et al.*, 2013). Like other biotic factors, different viral diseases like potato leafroll virus (PLRV), potato virus S (PVS), potato virus M (PVM), potato virus X (PVX), and potato virus Y (PVY) are taken as serious threats to potato in Pakistan (Ahmad *et al.*, 2011; Abbas *et al.*, 2012). Hameed *et al.* (2014) claimed that commonly reported viral diseases of potato in different potato zones are PLRV, PVX and PVY while PVS and PVM are less common as compared to the others. Naveed *et al.* (2017) specified that there are many

PVY strains all over the world which accounts for more than 70% yield loss in potato crop. Furthermore, Hameed *et al.* (2017) stated that there are around 5-10% occurrence of leaf curl virus in many potato growing regions of Punjab, demonstrating a significant limiting factor in the crop productivity.

Abiotic Stresses: Abiotic stresses are considered to account almost 50% decrease in average yield among different crops all over the world (Wang *et al.*, 2003). The important abiotic constraints specifically in potato production are poor soil, extreme temperatures, drought, and improper use of fertilizers and soil salinity. A huge population among potato growers in Pakistan is uneducated and they don't exactly know the properties of the soil and its impact on crop growth, resultantly they get low production. Hartman *et al.* (2011) stated that the availability of the nutrients that are required and fertilizer applications in the soils having low nutrient content can elevate the potato production. Temperature effect on potato as well as on other crops has a potential influence on yield and development of the crops. Both the extremes in temperature are not good for crop production especially in potato. Extremely low temperature can cause the seedling injury, hindrance in water and nutrient movement, consequently lowering tuber yield (Hijmans, 2003; Liao *et al.*, 2016). Extremely high temperature can result in high respiration, wilting, reduced activity of photosynthesis, low tuber initiation rate, irregularities in enzymatic as well metabolic activities which ultimately decrease potato yield (Hijmans, 2003; Levy and Veilleux, 2007).

POTATO BREEDING IN PAKISTAN

Different public and private institutions are working on breeding seed potato production in Pakistan which include tissue culture as well as traditional breeding approaches.

Public Sector Private Sector:

- Tissue Culture, NARC. - Jaffar Brothers Ltd.
- Plant Virology, Faisalabad. Abdul Ghafoor Bhatti Corporation A.G.B.C.
- Potato Research Centre, Abbottabad. - Jabbar Combined International.
- Potato Seed Unit, Deptt. of Agric. Gilgit. - Gilgit Area Marketing Association.
- Vegetable Seed and Seed Potato Production VSSPP, Quetta. - Nangaparbat Potato Growers Association.
- Punjab Seed Corporation

Different kind of breeding practices are being carried out by different government and private institutions. Recently, a memorandum was signed between Pakistan Agricultural Research Council (PARC) and Green System Pakistan (Pvt.) Limited which states that PARC will produce two million tubers that will be disease free through tissue culture technology. Chairperson PARC, Dr Muhammad Azeem Khan stated that "Due to the attack of different kind of diseases on local varieties, Pakistan has to import tubers from Holland. With this agreement, virus free potato tubers will be produced

that will ultimately save our valuable foreign exchange". National Agricultural Research Council (NARC) is also working on virus free potato production using tissue culture technique and distribute to the cooperatives of potato seed growers and national potato programme. Till now, virus free nucleus seed of potato is being produced at NARC greenhouses. During the year 2009 and 2010, around 17,000 nucleus seed had been harvested from the greenhouses and are being tested and multiplied for further varietal development.

Conclusion and future prospects: In Pakistan, potato is grown on large scale; however, the potato production is significantly low as compared to other South Asian countries. Important biotic factors that affect production and quality of this crop include non-availability of high yielding varieties, viral, bacterial and fungal diseases. Among abiotic factors, drought, high temperature, prevailing soil salinity and nutrient deficiency causes a significant decrease in production. The area under potato cultivation in Pakistan is low as compared to other major crops which is also an important factor for low production. Potato crop is not an easy crop to be grown by everyone. However, to get high yield, it is necessary to sow the proper potato variety on a specific location and time. In addition to the introduction of potato cultivars with poor yield, serious efforts are required to increase the production of locally available varieties through systematic breeding programs. Biotic and abiotic factors that are associated with the low production can be managed by using different integrated techniques like disease management, crop rotation and production of certified seeds.

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