Pak. J. Bot., 50(5): 2077-2084, 2018.

POTATO PRODUCTION IN PAKISTAN: CHALLENGES AND PROSPECTIVE MANAGEMENT STRATEGIES –A REVIEW

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Abstract

Potato is an important agricultural crop widely grown in different agro-climatic conditions of Pakistan and throughout the world. It is one of the four major staples which has a significant contribution to national domestic consumption and food needs. Despite the ease in cultivation and fewer labor requirements, potato productivity in Pakistan is not yet promising as compared to neighboring India and Bangladesh. Low productivity of the crop in Pakistan is due to several biotic, abiotic stresses and the relatively limited allocation of land. Different biotic constraints, including pathogenic diseases such as late blight, early blight, bacterial wilt, viral infections and nematodal parasites have a tremendous impact on potato production. Temperature extremes, nutrient deficit soil, drought, salinity, poor irrigation water, lack of availability of quality seed potatoes are among the abiotic stresses which pose challenges to potato productivity. Moreover, the allocation of the significantly lower area for the harvest to potato cultivation than other crops is also among the important underlying issues which result in substantial low yields of potato in Pakistan. The aim of this review is to highlight factors influencing potato production in Pakistan and to suggest prospective measures which can manage the challenges associated with yield and production and crop losses of potato in the country.

Key words: Biotic stress, Integrated disease management, *Phytophthora infestans*, Drought, Salinity, Potato export, Disease resistance.

Introduction

Potato (*Solanum tuberosum* L.) is one of the most widely produced and consumed tuberous crops in the world. The crop has a probable origin in Peru (South America), from where it is believed to be introduced to the rest of the world by war expeditions, shipment, and transportation (Spooner *et al*., 2005). Today, more than 5000 potato varieties are present in different parts of the world; the majority of them is mostly confined to South America (Zaheer & Akhtar, 2016). The crop is popular in Pakistan and elsewhere in the world based on its nutrient capacity, potentials for diverse uses (both in raw and processed) form and easy availability to low-income consumers. It is a rich source of water, carbohydrates, vitamins, minerals, proteins, and fats, which accounts for 390 KJ 100^{-1} g of baked potato (Zaheer & Akhtar, 2016).

Potato is ranked as the third most produced and consumed crop following rice and wheat and almost a billion people throughout the world consume it in different forms (Anwar *et al*., 2015). More recent data indicate that potato production in the world during 2014 was recorded as 381.7 million tonnes (MT) over an area of 19.1 million hectares (Mha) while in Pakistan, during the same period a total of 2.9 MT potatoes were produced from 0.15 Mha harvested area (FAOSTAT, 2017). In Pakistan, potatoes are used largely as a staple food in many parts and serve as a domestic vegetable available throughout the year. A significant portion of potato is also used in processed products such as finger chips, fry chips, and salad.

Generally, three crops of potato namely spring, summer and autumn are grown in different agro-ecological conditions of Pakistan ranging from plains to hilly areas (Khan & Akhtar, 2006). Potato cultivation requires less labor input and the time from sowing till harvest is relatively shorter than other major crops (less than 90 days) which makes it an ideal crop for farmers. Nevertheless, besides the availability of suitable environment, ease of cultivation and low labor requirement, potato productivity in Pakistan is not promising compared to other developing countries. There are several biotic and abiotic stresses which limit potato productivity in the country. Low-temperature stress, drought, salinity, soil problems, improper use of fertilizers and lack of availability of quality irrigation water are some of the prevailing abiotic problems in Pakistan which affect negatively potato productivity. Likewise, low yielding varieties, different fungal, nematodal, bacterial and viral diseases are biological constraints which have a drastic impact on the growth and production of potato (Majeed *et al*., 2017a). Levy *et al*., (2013) indicated that drought in tropical regions is the most limiting factor in potato productivity. Drought, indeed, is escalated by fluctuation in rainfall and high temperature, which result in further evaporation and reduced availability of water to potato and other crops (Obidiegwu *et al*., 2015). Rai *et al*., (2011) suggested that salinity caused physiological abnormalities in potato consequently resulting in reduced growth and yield. The productivity of the crop is severely affected by salinity in semi-arid regions (Katerji *et al*., 2003). Changing climate in various parts of the world and problems related to soils such as nutrient deficiency, particularly Nitrogen are also important abiotic factors which have a correlation with low yield and poor development of the potato crop (Hijmans, 2003; Khan *et al*., 2014). Among biotic constraints, viral diseases such as potato leaf roll virus (PLRV), potato virus X and Y (Solomon-Blackburn and Barker, 2001); fungal diseases like late blight and early blight, black scurf, dry rot, *Fusarium* wilt, powdery scab (Arora & Khurana, 2004; Sliwka *et al*., 2006) and bacterial disease such as common scab, soft rot, bacterial wilt, ring rot and brown rot (Czajkowski *et al*., 2011; Stead, 1999) have been widely reported for lower production of potato. These constraints are likely prevalent in Pakistan. Moreover, production losses of the crop elevate significantly due to poor management strategies during postharvest storage. This article focuses on the factors relevant to low productivity and potential management strategies necessary for the elevation of potato production in Pakistan.

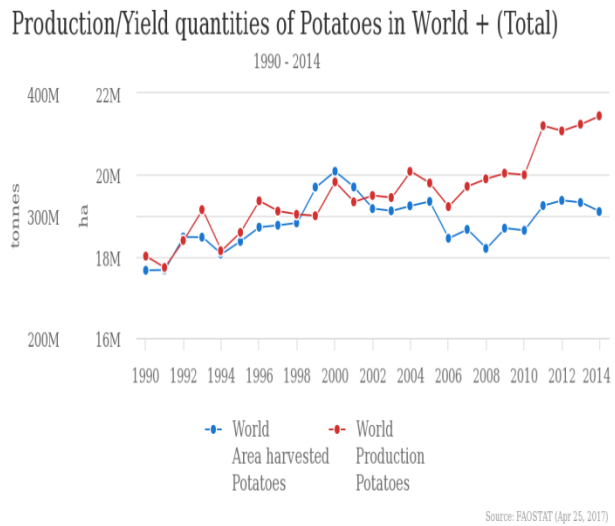

Fig. 1. Global potato production (MT) and area harvested (Mha) during the period 1990-2014 (FAOSTAT 2017).

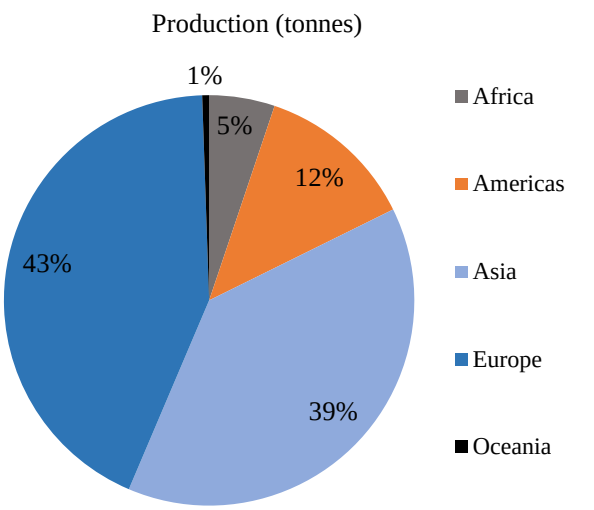

Fig. 2. Region wise production share (%) of potato during 1990-2014 (FAOSTAT 2017).

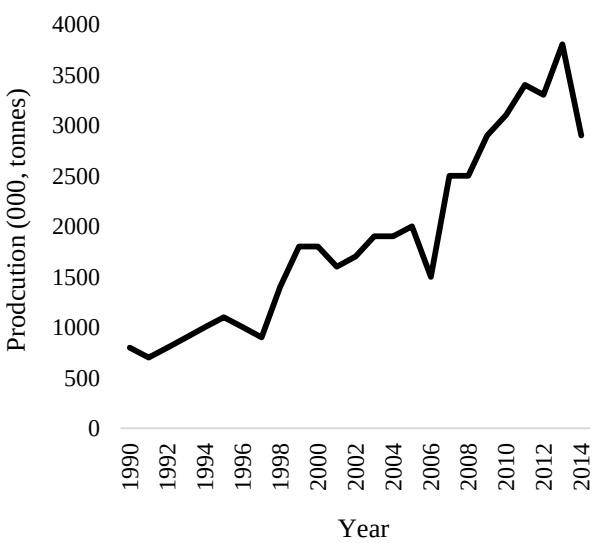

Fig. 3. Potato production (000, tonnes) in Pakistan during 1990-2014.

Potato production: World vs Pakistan: Potato production and consumption in the world has been substantially increased since the 1990s. Developed countries dominated the world in terms of potato production and consumption till the 1990s; however, since then, a significant increase in production and consumption has been observed in developing countries and currently, these are the leading potato producer of the world (FAOSTAT, 2017). Potato production in the world in 1990 was 266.8 million tonnes (MT) which did not show any substantial increase till 1999. Major growth in potato production occurred in the 2000s reaching to significant elevation during 2011-14 where production reached to the historic record level of 373-381 MT (Fig. 1). The area under harvest for potato crop was recorded 17.6 Mha in 1990 which has experienced a slight increase throughout the period reaching to 19 Mha in 2014. During 1990-2014, Europe produced 43% of the global potatoes followed by Asia, which shared 39% production while in Americas production share was 12% (Fig. 2). Latest statistics reveal that major potato producing countries of the world are China (95.5 MT), India (46.3 MT), Russia (31.5 MT), Ukraine (23.6 MT) and Unites States (20 MT) (Table 1). A shift in potato production from developed to developing countries is due to several factors. Developed nations tend to use potato for processed products while it is a staple food in many developing countries. A greater allocation of the cultivated area for potato production, use of fertilizers and high yielding varieties have major contributions in production elevation of potato in the developing countries.

In Pakistan, different crops are cultivated on approximately 24000-kilo hectare (kha) area while average area allocation for potato is roughly 1300 kilo-ha, which is significantly lower than area harvested for this valuable crop in other South Asian countries (FAOSTAT, 2017; Majeed *et al*., 2017). Overall annual production of potato in the country ranged between 0.7 and 3.8 MT during 1900-2014 (Fig. 3). Production was the lowest (0.7 MT) in 1991 while it reached to maximum (3.8 MT) in 2013 followed by a slight decline (2.9 MT) in 2014 (FAOSTAT 2017). Five-year data (2010-2014) presented in Table 2 indicates that India is the leading potato producer in South Asia followed by Bangladesh while Pakistan is ranked the third most potato producing country in the region followed by Nepal. During this five year period, the area under harvest and potato production in India and Bangladesh steadily increased; however, in Pakistan, both increasing and decreasing fluctuation were observed. The area under harvest for potato increased from 138 kha in 2010 to 175 kha during 2013 but sharply decreased to 159 during 2014. Likewise, potato production in the country reached to maximum 3802 kilo-tonnes during 2013 but fell to 2901 kilo-tonnes in 2014 (Table 2). Land brought under cultivation for potato in Punjab is significantly greater than other provinces; hence it is the major potato producer province of Pakistan. Recent data indicate that during 2011-12, area harvested for potato in Punjab was maximum (148 kha) followed by Khyber Pakhtunkhwa (9.9 kha) producing 3396 and 119-kilo tonnes of potato respectively. During the same period, Baluchistan produced 31 thousand tonnes over an area of 2 kha followed by Sindh, which produced the lowest potatoes 4 thousand tonnes against area harvested 0.4 kha (Anon, 2014).

Table 1. Top 10 countries of the world with substantial potato production during 2014 (FAOSTAT 2017).

Country	Area harvested (kha)	Production (MT)	Production share (%)
China	5647	95.5	25.02
India	2024	46.3	12.13
Russian Federation	2101	31.5	8.25
Ukraine	1342	23.6	6.18
United States	425	20	5.24
Germany	244	11.6	3.03
Bangladesh	461	8.9	2.33
France	168	8.0	2.09
Poland	276	7.6	1.99
Netherlands	155	7.1	1.86
World (total)	**19098**	**381.6**	-----

Table 2. Potato production and area under harvest in South Asian countries during 2010-2014 (FAOSTAT, 2017)

Country/Year	Area harvested (000, ha)					Production (000, tonnes)				
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014
India	1835	1863	1907	1992	2024	36577	42339	41483	45343	46395
Bangladesh	435	460	430	443	461	7930	8326	8205	8603	8950
Pakistan	138	159	185	174	159	3141	3491	3393	3802	2901
Nepal	185	182	190	197	205	2517	2508	2584	2690	2817
Sri Lanka	3	4	4	5	5	51	59	72	78	82
Bhutan	3	6	5	3	5	44	52	43	41	46
Maldives	----	----	----	----	----	----	----	----	----	----
Afghanistan	20	20	21	22	25	246	205	230	302	340

Production constraints

Biotic constraints: The diverse and suitable climatic conditions of Pakistan offer great opportunities for potato cultivation and its production can be elevated to a significant extent; however, several limiting factors prevail in the country which imparts a negative effect on potato productivity. Among biotic stresses, diseases caused by fungi, bacteria, viruses and nematodes and weed infestation in potato fields have a strong influence on the production of potato. The most common and potentially productive-limiting fungal diseases of potato prevailing in Pakistan are late blight (*Phytophthora infestans* Mont. de Bary), early blight (*Alternaria solani*), black Scurf and stem canker (*Rhizoctonia solani* Kuhn) and powdery scab (*Spongospora subterranean*) with major impact on yields, although the *Fusarium* dry rot and wilt (*Fusarium* sp.) have also been reported from different potato growing localities with varying degree of limitation on production and yields (Rauf *et al*., 2007; Majeed *et al*., 2014). Late blight of potato, black scurf, and powdery scab have a general occurrence in moist conditions and low temperature (11-25°C); thus, these diseases are common in hilly areas and regions of Pakistan, which are characterized by low temperature coupled with heavy rainfall such as Kaghan, Naran, Gilgit, Swat, Kohistan and most of the northern areas. In the plains, these diseases are most likely to occur in potato fields during the winter season if there is frequent humidity. On the other hand, early blight pathogen (*R. solani*) finds relatively warmer conditions (temperature range between 25 and 30°C) suitable for its growth and infection capacity and alternating period of dry and moisture help in accelerated disease progress (Kemmitt, 2002.). Unlike late blight and pathogens proffering low temperature, early blight disease may have an equal incidence in plains and hilly temperate regions of Pakistan. *Fusarium* wilt and dry rot of potato are less common in the plains, but prevails in northern Pakistan (Bhutta, 2008), although the fungus prefers warmer and moist soils.

Several bacterial diseases also correspond to production losses and poor growth of potato in the country of which common scab (*Streptomyces scabies*), bacterial wilt (*Ralstonia solanacearum*), blackleg and soft rot (*Erwinia carotovora*) are most commonly reported which have devastating effects on growth, production and post-harvest quality of potato (Ali *et al*., 2012; Anwar *et al*., 2013). Bacterial diseases of potato are prevalent in the hills as well as in the plains and their impact on crop productivity is variable in different potato growing zones. Sarwar *et al*., (2017) reported the wide prevalence of common scab of potato caused by *Streptomyces scabies* from different parts of Punjab province. Hussain *et al*., (2017) noted that black scurf of potato was a leading bacterial constraint in potato production in Gilgit Baltistan. Like other biotic constraints, different viral diseases caused potato leafroll virus (PLRV), potato virus S (PVS), potato virus M (PVM), potato virus X (PVX) and potato virus Y (PVY) are considered as potential threats to potato crop throughout the country (Ahmad *et*

al., 2011; Abbas *et al*., 2012). The incidence of one or many of these viral diseases in potato fields in Pakistan is not persistent relevant to geographic regions where potato is cultivated. Hameed *et al*., (2014) argued that most frequently reported viral diseases of potato from different potato zones of Pakistan are PLRV, PVX and PVY while PVS and PVM are less common in the country. Naveed *et al*., (2017) stated that there are several PVY strains which account for more than 70% yield loss of the crop in Pakistan and throughout the world. More recently, Hameed *et al*., (2017) reported 5-10% incidence of leaf curl virus from several potato growing regions of Punjab indicating a potential limiting factor in the crop productivity. Moreover, actual yield losses of potato associated with viral diseases in Pakistan have not been documented so far from authentic sources; nevertheless, different published reports estimate it in the range of 40-83 % (Ahmad *et al*., 2011; Hameed *et al*., 2014).

In addition to pathogenic diseases, different parasitic nematodes and occurrence of weeds in potato fields are of concerns and often results in lower yields of potato. Among parasitic nematodes in potato fields, root-knot nematode (*Meloidogyne* sp.) and potato cyst nematodes (*Globodera* sp.) have an adverse effect on growth and yield of potato. Since these parasites prefer warmer sandy soils, agricultural fields in plains and arid zones of Pakistan provide conducive environment for these nematodes and their incidence is maximum in plains as compared to temperate hilly regions of the country (Anwar & McKenry, 2010; Gondal *et al*., 2012; Kayani *et al*., 2013). Being soil-borne parasites, control measures of these nematodes offer challenges to potato growers. Weeds occurrence in potato fields and their influence on the crop is a problematic issue in many potato growing parts of the country. *Chenopodium album, Cynodon dactylon, Rumex crispus, Convolvulus arvensis, Medicago sativa* and *Fagopyrum tataricum* are among the most widely found weeds in potato fields which compete with the crop for resources and results in considerable yield losses if left unchecked (Jan *et al*., 2004; Muhammad & Cheema, 2009; Shedayi *et al*., 2011).

Although exact data about yield and production losses of potato in Pakistan are not available due to the lack of proper monitoring agency; however, it is estimated that yield losses in response to different fungal, bacterial, viral and nematode diseases and the prevalence of weeds range between 30 and 70 % (Ashraf *et al*., 2012) and may even be higher which greatly depends on the growing seasons, climatic conditions, potato growing areas and disease management practices. On the basis of agro-climatic conditions of different potato growing zones of Pakistan, greater production losses of potato as a result of late blight, black scurf, and powdery scab may be expected from temperate moist localities while early blight may have a profound effect on yields in relatively warmer regions. The incidence of bacterial, viral and nematode diseases and their impact on potato yields seems common throughout the country. Similarly, weed occurrences in potato fields are not specific to certain localities; hence, their uncontrolled prevalence may result in huge yield limitation both in the tropics and temperate zones of Pakistan where potato is cultivated.

Abiotic constraints: Abiotic constraints are considered to account for 50% losses of average yields of different crops globally (Wang *et al*., 2003). The significant abiotic constraints in potato productivity are poor soil, improper use of fertilizers, temperature extremes (heat and cold stress), soil salinity and drought and low allocation of the area for potato cultivation. A massive population of potato growers in Pakistan is uneducated and they are unaware of the properties of soil and its impact on crop growth. Due to lack of awareness, mono-crop and intensive crop cultivation are very common which results in deterioration of the physical quality of soil and its nutritional composition. Moreover, the timely application of appropriate fertilizers seems out of reach of most of the farmers because of financial constraints. Consequently, potato grown on soils with poor physical characteristics and nutrient deficiency could not produce the desired tubers. Hartman *et al*., (2011) argued that the availability of required nutrients and fertilizer applications in case the soils are deficient in the nutrients might strongly elevate yield and production of crops. Temperature effect on the growth of potato and other crops is another abiotic stress, which has severe influences on yields. Both extremes of temperature (very high and very low) are not ideal for desired tuber yield. Extremely low temperature (≤0°C) can cause direct injury to seedling, alteration in mobility of water in plant, mineral and water uptake and solubility of solutes in soil water consequently lowering tuber yield (Hijmans, 2003; Liao *et al*., 2016); extreme frosts (≥-3°C) can even lead to complete demolition of the whole field of the potato crop (Pino *et al*., 2007). High-temperature exposure often results in physiological wilting, high respiration rate, reduced photosynthetic activity, slow rate of tuber initiation, abnormalities in enzymatic and metabolic activities of the crop which are generally associated with low yields of potato in the tropics (Hijmans, 2003; Levy & Veilleux, 2007). Major abiotic constraints such as drought and fluctuation in temperatures incite disruption in physiological and biochemical processes in addition to physical injury which results in limited growth and production output of crops (Fahad *et al*., 2017). In Pakistan temperature falls below zero during December-January in northern areas while it exceeds 45C in southern parts of the country during June-July. Thus, the potato may experience challenging frost effects in North while hard heat stress in South of the country during different seasons.

Drought and salinity are one the worst environmental stresses negatively affecting the productivity of crops throughout the world (Hu & Schmidhalter, 2005; Tester & Langridge, 2010). The potato crop is sensitive to drought and salinity and substantial yield losses may occur under the influence of these problems (Obidiegwu *et al*., 2015). The problems of drought and salinity are prevalent in some parts of Pakistan, particularly in arid and semi-arid regions and overall about 6.3 Mha area of the country is affected by salinity and drought stress (Qureshi *et al*., 2008). Factors which contribute to drought and salinity are diverse; however, irrigation practices, poor water management

and reduced rainfall and high evaporation rate triggered by high temperature in the context of a changing climate are considered as some of the leading causes of salinity and drought (Athar & Ashraf, 2009). An increasing amount of growth, developmental and physiological abnormalities of potato and other crops which are challenged by drought and salinity have been widely reported (Heuer & Nadler, 1998; Teixeira and Pereira, 2007; Stiller *et al*., 2008; Lipiec *et al*., 2013). Levy and Veilleux (2007) stated that changes in temperature above and below the optimal range, drought and salinity stress affect photosynthesis, respiration, nutrient uptake capacity of potato which has profound effects on tuber formation, number of tubers and their size. Low productivity of potato in response to heat stress, poor water supply, drought, and salinity has been well established in earlier studies (Yuan *et al*., 2003; Tiele *et al*., 2010; Aksoy *et al*., 2015). Faried *et al*., (2017) argued that salinity had severe influences on potato and proposed that application of Salicylic acid could enhance the growth and yield of the crop under salt stress. Hirut *et al*., (2017) demonstrated that drought corresponds to lower yields and production of potato by affecting its leaves and the rate of photosynthesis and decreasing the growth period of the crop.

Prospective measures to improve potato production in Pakistan

Coping with biotic stresses: Since biological constraints - which range from a variety of phytopathogens to different nematodes - remain key determinants in losses of potato production, devising effective control measures for such constraints will likely increase production and yields. Local environmental and growth conditions play an important role in stimulating biotic stresses for the crop; thus, to avoid the maximum impact of the prevailing diseases of potato caused by pathogens and parasites, modification in the cultivation of potato in different climatic conditions of Pakistan is strongly required. It has been observed that late blight, early blight, and many bacterial diseases are greatly affected by temperature and moist, a suitable approach to minimize such constraints in the conducive environment seem crop rotation with potato. Potato growers need to understand the potential impact of diseases under conducive environment and thus need to opt for the cultivation of other crops than potato. In unavoidable circumstances, pesticide application at a proper timing and proper amounts can reduce the biotic constraints and associated yield losses of potato to a significant extent. However, reliance on pesticides for biotic stress management imparts negative environmental and ecological effects (Mahmood *et al*., 2016). In order to address biological constraints in potato production systems, integrated disease management - which uses the combined practices of disease resistant cultivars, monitoring of environmental conditions, pesticide application, growing disease-free seeds, cultural methods and decision support system- needs to be employed (Nyankanga *et al*., 2004; Khoury & Makkouk, 2010; Majeed *et al*., 2017a,b). Aliye *et al*., (2008) suggested that growth-promoting rhizobacterial strains were effective in controlling bacterial wilt and promoting growth characteristics of potato. Green manure of different *Brassica* species resulted in control of different pathogens of potato including *Sclerotinia sclerotiorum, Phytophthora erythroseptica, Fusarium sambucinam, Rhizoctonia solani* and *Pythium ultimum* through the bio-fumigation process (Larkin & Griffin, 2007).

Abiotic stress management: Like biological constraints, abiotic stresses are responsible for lowering potato production; hence effectively addressing these constraints can contribute to production increases. Winter frost in most of the Northern parts and scorching heat during summer in plains of Pakistan, salinity stress and drought in potato growing zones may have severe influences on growth and yield of potato. Moreover, contamination of irrigation water with industrial wastes and heavy metals deteriorate soil quality, nutrient uptake and physiological aspects (Sandalio *et al*., 2001) which will consequently result in low tuber formation and production suppressions. Necessary practices to lessen the abiotic impacts on potato growth are to deal with a single abiotic factor individually. For instance, temperature stress may be avoided by cultivating late and early maturing varieties in cooler and hot areas respectively. Irrigation water from tube wells and canals which are not polluted by industries can be costly but effective in abiotic stress management. Development of drought, salinity, and heat resistant cultivars through breeding and molecular approaches remains a long dreamt goal in agriculture, which need further stimulation and if successful, the underlying abiotic stresses can be handled with ease and production elevation can be attained many folds. Abreu *et al*., (2013) and Obidiegwu *et al*., (2015) have also argued that resistant cultivars in specific abiotic stressed condition are immensely required for minimizing potential negative impacts of abiotic stresses.

Low area for harvest: Potato is equally important for production and domestic consumption as other crops such as wheat, rice, sugarcane, maize, and cotton are; nevertheless, Pakistan Bureau of Statistics indicates that this crop has been overlooked in terms of area allocation than other crops. Latest figures show that during 2014-15, lowest area (159 kha) was allocated to potato which produced 3,997 kilo-tonnes potatoes while the highest area (9,204 kha) were used for cultivation of wheat producing 25,482 kilo-tonnes (Table 3). The data presented in Table 3 highlights that cotton; wheat, sugarcane, rice, and maize are cultivated in Pakistan on a priority basis while the potato is given less consideration as it is evident from area allocation. There are several reasons for low area allocation to the potato crop. Firstly, wheat and rice are major staple foods in the country; hence their production is required in substantial quantities for feeding more than 20 million people of the country. Secondly, allocation of a significant proportion of area to cotton and sugarcane is based on high economic returns of these crops.

Interestingly, maize is cultivated on 1142 kilo hectares land with production output as 4937-kilo tonnes in comparison to the extremely low area for potato 170-kilo ha which produces 3997 kilo-tonnes potato (Table 3) which demonstrates a huge gap between area allocations for the two crops but not much difference in production output. Thus, instead of allocating greater area allocation to maize, 50% of that area, if devoted to potato, will bring a substantial increase in potato production. Moreover, like cotton and sugarcane, potato is equally required to be considered as a cash crop and trade commodity so it could be grown on more area to elevate its production opening ways for its export besides national consumption.

Table 3. Area allocation (000, ha) and production (000, tonnes) of different crops cultivated in Pakistan during 2014-15 (Pakistan Bureau of Statistics)

Crops	Area (000, hectares)	Production (000, tonnes)
Cotton	2,961	*13960
Sugarcane	1,141	62826
Rice	2,891	7003
Maize	1,142	4937
Wheat	9,204	25,482
Potato	170	3997

*Bales

Conclusions and future prospects: In Pakistan, potato is grown on almost 170 000 ha with production output as 3997 0000 tonnes, which is significantly lower than other South Asian countries. Biotic and abiotic factors such as plant diseases, parasites, temperature extremes, drought, salinity and poor quality of soil and irrigation water have a prime influence on the production of this valuable crop. Key biotic constraints which serve as limiting factors in the production and quality parameters of the crop are the unavailability of high yielding varieties, the prevalence of early and late blight of potato, bacterial common scab, wilt and soft rot, diverse viral infections and nematodes. Among the abiotic challenges, water scarcity, salinity, heat stress and temperature fluctuations and nutrient deficiency in soils correspond to a greater reduction in the production of the crop. Allocation of the area for harvest of potato in the country is significantly lower than other crops which are also a leading cause of lower production. Being an important commodity form the consumption and trade perspectives, increase in potato productivity in future requires promising attention from the concerned stakeholders. Provision of high yielding varieties of the crop imported from other countries to farmers may significantly elevate its yield outputs and production. Besides importation of potato cultivars with good yield potentials, indigenous efforts are also needed to raise the production traits of locally available varieties through breeding programs. Biotic and abiotic challenges associated with low production of potato can be managed by employing a variety of integrated approaches such as proper disease management techniques, crop rotation and cultivation of resistant cultivars to avoid prevailing biotic or abiotic stress. The low land area used potato cultivation in Pakistan is also an important factor for lower productivity. Thus, maximum possible area allocation to potato crop is needed on a priority basis for attaining maximum yields, production and economic returns.

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(Received for publication 19 October 2017)