POTATO-THE PRODUCT REPORT

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ACKNOWLEDGEMENT

Thanks to Allah Almighty who created the flora and fauna for the benefit of mankind. All praises to His Last Prophet (Peace be upon him) who taught us living in such way that help in conserving the planet resources including plants.

I would like to express my sincere thanks to the Board of Directors who provided me the opportunity to prove my research skills in the shape of this humble effort. I am also thankful to my ex-CEO Mr. Nauman Aslam who provided me guidelines for developing this report. My sincere thanks to current CEO, Mr. Usman Qureshi who encouraged me to make my understanding clear about the current product by reading and researching a lot. Sir, I have read and researched a lot but still I feel short of making my understanding clear about this fascinating produce, plant and its role in food security of mankind. I, however, assure you that with each passing day, I am becoming fascinated by this wonderful produce that have changed the course of history in several ways.

I felt short of words for expressing my thanks to General Manager (Agri Products) Mr. Sarfraz Hussain Iqbal who at every step guided me with his wide knowledge and logical way of thinking. His encouragement, guidance and time to have extensive discussions on some topics proved a good source of developing my understanding about the product. His pedagogic and compassionate approach help in finishing this task which other way would have not possible.

I am thankful to my colleagues who helped me in creating an academic environment around myself for writing this report. I am also thankful to the staff members who helped me during these days by doing little chores for me. This is a humble effort from a non-agrarian background layman, but I hope the experts will find a lot in this report. With their guidance, and ever encouraging feedback, I hope this report will serve as a reference document on potato in PHDEC.

Lastly I am grateful to my ailing wife and son who showed their utmost patience while I was working on this report, especially my youngest son Muhammad Ali who likes potatoes so much that his day starts with eating a potato paratha and ends with eating potato gravy. His innocent questions about the product and my answers also contributed towards the completion of this work.

I admit from the core of my heart that I am still unable to answer his very innocent question, PA, do you know something about potatoes? I hope one day I would be able to answer his question in a **YES**, Insha Allah.

All errors and omissions in this report are unintentional and regretted.

ABSTRACT

Theoretically this product report covers potato as a produce for trading from Pakistan. But this report has covered almost all aspects related to the humble tuber as a commodity for trade taking its biological, physiological and sociological aspects into account. This report not only provides an insight into the way this product moves from farm to fork but also other dynamics associated with its trade. Several interesting facts and figures have been emerged and several myths about the product are busted.

SECTION 1: PRODUCT DESCRIPTION AND CHARACTERISTICS

INTRODUCTION

The potato, with its botanical name of *Solanum tuberosum* L., is the tuberous, starchy crop and one of the staple foods of several countries. It belongs to the Solanaceae (nightshade) family of plants with flowers from Solanum genus with two cultivar groups; Andigenum (for short day conditions such as in the Andes) and Chilotanum or European potato, now being cultivated throughout the world. As per its taxonomic classification, the potato has eight species, but only *S.tuberosum* ssp., subspecies of potato is cultivated all over the world.[1,2]The potato is used as a vegetable, processed food, starch and feed for cattle[3,4]. Potato is the largest food security contributor and with its ability to grow in an array of climatic conditions have contributed a lot in its consumption. The production of potatoes is showing increasing growth trends in comparison to other food crops[5]. The humble tuber reached across six continents from its birthplace Andean, starved off the hunger of millions, fueled economic activities and played its role in changing the course of the world history.[3]

Solanum tuberosum now has been widely naturalized from its native lands of South and Central America in several extra-tropical regions but it is considered a weed in Australia, India, Indonessia and Turky and a noxious weed in the United States, South Africa and Turkey listed as *the worst invasive species in the conterminous United States* lists. Greater viglence and caution is remcomended for its cultivation to avoid its escape in wild.

TAXONOMY

Taxonomic tree of species *Solanum tuberosum* is given below[6];

- Domain: Eukaryota
    - Kingdom: Plantae
        - Phylum: Spermatophyta
            - Subphylum: Angiospermae
                - Class: Dicotyledonae
                    - Order: Solanales
                        - Family: Solanaceae
                            - Genus: Solanum
                                - Species: Solanum tuberosum

The Nightshade or Solanaceae family has 90 genera and around 4000 species with varied distribution and habit on all cotinents but Antarctica, having majority of species in South and Central America

(PBI Project 2014). The genus has few of world's most important crops including tomatoes, potatoes and peppers. It also includes some of world's deadliest plant species including belladonna, satan's apple, jimson weed and black henbane. Without clear origin of etymology of the scientific name of genus SOLANUM, it is suggested that it might have been derived from Latin word 'Sol' for 'sun', or SOLARE meaning to soothe.[7] S. Tuberosum with its diploid, triploid and tetraploid representation is a complex species. The tetraploid plants are further classified into Angigena and Tuberosum (cribband hawkes, 1986).[8]

DESCRIPTION

It is an erect and juicy herb with angular branches. The stem can grow up to 1.2 m tall. The roots usually go 40 to 50 cm deep and in few cases in the absence of any obstruction, it goes up to 1 m deep. Tubers are developed on the tips of stolons in globose to ellipsoid style that are quite variable in size, colour and weight. The skin is with scars of scale leaves also known as eyebrows with variable number of axillary buds or eyes which goes from 10 to 15 on a tuber of around 50 grams.[6]

The hollow, winged stems are usually 1.5 cm in diameter. The dark green leaves are alternate, petiolate with several interstitial leaflets; outline 10- 30 cm x 5- 15 cm forming usually 3-4 pairs that are unequal in size. In some varieties the plant bears subglobose berry like fruits with around 2 cm diameter having numerous pale and yellow brownish poisonous seeds.[6]

PLANT TYPE

It is a perennial herbaceious plant that is propagated vegetatively and through seed.

DISTRIBUTION

The potato speies SOLANUM is considered to have its nativity in Central and South America especially the highland plains (puna) between 40^0 N and 45^0 S. Native to Peruvian-Bolivian Andes region, potato is now introduced to the most parts of the world. From West Indeas and Mesoamerica, much of the Asian region and throughout Europe.[9,10] The distribution table updated up to 2020 is attached as Annex-IX.

HABITAT

Potato being one of the most important food crop is grown in cool-temperate regions and highlands of tropics.[11] Native to mountaneous areas of Peru, Bolivia and Chile, it is now an important crop of mountaineous regions of China.[12] It is also grown in Lower Montaine Rain Forest and Lower Montane Wet Forests. In Bolivia, it is seen growing dry valleys, Yungas forest and humid plains of Andes region.[11] Below is given the habitat list for solunum tuberosum which indicates that though the species is largely naturalized, it is found in natural forests and grasslands as natural and non-natural plant.[13]

Category	Sub-Category	Habitat	Presence	Status
Terrestrial				
	Terrestrial – Managed	Cultivated / agricultural land	Principal habitat	Productive/non-natural
	Terrestrial - Natural / Semi-natural	Natural forests	Present, no further details	Natural
		Natural forests	Present, no further details	Productive/non-natural
		Natural grasslands	Present, no further details	Natural
		Natural grasslands	Present, no further details	Productive/non-natural

GENETICS

S. TUBEROSUM has several cultivars with sporophytic count reporting to 2n= 24, 36, 48, 72, and 96.[11]

BOTANICAL INFORMATION

As mentioned earlier, tetraploid S. TUBEROSUM is classified into two cultivar groups; Andigena (Subsp. ANDIGENA) and Tuberosum (Subsp. TUBEROSUM). The cultivar group Andigena mainly occurs in South America from Argentina to Venezuela. It is supposed that this cultivar was originated from doubling of the chromosomes in an unknown wild diploid species from Andean region. The members of Andigena are tall, straggling with intensively dissected leaves. The plant is adapted for short days and produces pigmented tubers with irregular shape and deep eyes that unacceptable in the sophisticated European and North America markets. The cultivar has small presence in Mexico and Guatemala.[13]

On the other hand, cultivar group Tuberosum mainly occurs in Europe and North America and supposedly it is originated from the selections made during past 300 years from cultivar group Andigena. The members of cultivar group Tuberosum are smaller in size, less traggling and have less dissected leaves. The group is adapted to long days. This cultivar group is now cosmopolitan in its distribution and has become a world crop. The cultivar was first introduced in the Europe where selection began and from Europe it spread to North America. The process of continuous selection has resulted in development of several different cultivars with varied characteristics of their tubers, foliage, sprouts, flowers, disease resistence and growth cycle. Much of the variation is occurred through environmental factors. It is however important to note that propagation by true seed results in variation from genetic recombination.[13]

GROWTH AND DEVELOPMENT

The growth and development of potato plants depends on its cultivars, environment and fertilizer treatment. The tuber enters into the phase of dormancy after harvesting. The duration of dormancy depends on its cultivar, maturity, climatic conditions, soil, and storage conditions. The duration of dormancy usually lasts for 2 to 6 months. In few cases, however, the bud growth starts even before the harvesting of the tuber. If needed the dormancy can be broken by treating the tubers with certain chemicals such as chlorohyrin, gibberellic acid and or thiourea. However, the potato sector prefers naturally sprouted tubers without using any chemicals because they give better growth with more uniform germination. At the end of natural dormancy, the seed tuber goes through different subsequent physiological stages of apical dormancy of sprouts, multiple sprouting and senility.[13]

Apical sprout dominates the other buds on the tuber and keep them dormant unless the apical or top sprout is removed to allow other buds to develop sprouts. Apical dormancy is dependent on its cultivar. The multiple sprouting is the planting stage not for the reason of multiple sprouts but also for the reason of vigour of individual sprouts. The number of sprouts or germinating eyes on a tuber depends on the extent of dormancy, variety and physiological age of tuber. Other factors affecting tuber sprouts are nutrition, tuber health and tuber size. If the tubers are stored for quite a long time they may reach the stage of senility and hence unfit for planting.[13]

After plantation, the sprouts develop into stems where main stem grows directly from the seed tuber and secondary stems from lower lateral branches. There is possibility that a stem develops branches at later stage at higher nodes several times during the process of its growth. Main stem along with secondary stem are considered independent plants that have the ability to develop roots, stolons and tubers. Due to this reason, the plant population is expressed by number of stems rather than number of plants.[13] The underground stems develop adventitious roots in plants growing from tubers including the taproot with lateral branches. The tubers thus develop are underground modified stems which develop from the swelling of the tips of the underground stem (stolon).[13] The duration of growing period is dependent of cultivar, fertilizer treatment, insects and pests attackes especially the nematode burden on the roots. It is observed that in South Asian region the cultivars are generally mature from 3 to 5 months.[13]

REPRODUCTIVE BIOLOGY

The potato tubers produce viable seeds. The tuber is also capable of regenerating from its underground tubers.[13]

ECOLOGY

In order to have their optimal yield potential, the potato crops need a rainfall of around 500 mm to 750 mm during 3 to 5 months. However, potatoes can also be grown in dried areas such as Northern China but with a limited yield. Potato plant is able to tolerate annual temperature of 3.6℃ to 27.8℃. It is however a cool weather crop giving best yields at 15℃ to 20℃ for a larger number of cultivars.[14]

The most of the commercial varieties tuberize at their best in cool climates where night temperatures are below 20℃. If the night temperature raises above 22℃, no tuberization occurs. For the maximum production of dry matters, the temperature range is between 20℃ and 25℃. The intensity of light affects the production of dry matter due to photosynthesis. Short daylengths bring ealier maturity of tubers and crops are tolerant to moderate frost and cool soils.[14] In short daylength of subtropics and tropics, the yield is maximum in cool highlands and during cooler seasons. For example, in Papua

New Guinea, the maximum growth of potato is observed between 1500 to 2200 meters above sea-level where night temperatures are around 20℃ and day temperatures are not above 25℃.[14]

Potato shows its tolerability for most of the soils except waterlogged clays and heavy soils. In rest of the soils, good drainage is important. If the soil layers do not permit rooting depths and water available is low, these factors would reduce the yield greatly. On the other hand, soils with good water retention and aeration results in best growth and yield. The potatoes grow in a variety of soils including loams, loams and peats, silt loams where pH is 4.2 to 8.2. pH range for potato production is more suitable than other crops. Commonly the suitable pH is considered between 4.8 to 7.0, however, higher yields are also observed in soils having above 8.0 pH as in Lincolnshire, UK.[14]

Potato is gorwn up to 4500 meter sea-level in Americas. Even in Nicaragua, it is observed at 800-1000 meter above sea-level.[15] In Panama, it is grown even at 1000 meter to 2000 meters above sea-level.[16] In Colombia, it is observed at 2000 to 2500 meter above sea-level in Lower Montane Rain Forest (bh-MB).[17] In Pakistan, the potato crop is doing well in hilly areas up to 3000 meters above sea-level.[18] In Bolivia the potato crop is observed between 2500 to 4000 meters above sea-level and in Ecuador it is reported between 0 and 4500 meters above sea-level.[19,20]

ORIGIN

[redacted]

With its origin somewhere current borders of Peru and Bolivia around 8000 years ago[3], it was introduced to the world by Spaniards through war expeditions, transportation and other shipments during 16th century.[21] The world now has more than 5000 different varieties of potato but most of them limited to South America only. The breeding of potato for generations turned it into an array of varieties different in shape, colour, taste, cooking and starch content grown in tropical, subtropical and temperate conditions. Before getting popularity as a vegetable, the potato was appreciated for its flowers. Since that time, the potato has become the major source of carbohydrates for humans and animals around the world. Potato has become the third-largest crop being consumed by around a billion people in the world in its different forms after rice and wheat. Potato is considered a fast-growing crop which led the poor families to break the poverty circle by cultivating it on small plots. It became the source of survival for millions of people around the world.[22]

NUTRITIONAL VALUE

The spud (potato) produces more food than any other major food crop and hence is an excellent alternative for other food crops. It is estimated that one Hectare of potato crop yield more food value than four hectares of any grain crop. It provides two times more protein per hectare than wheat[23].Nutritionally, it is the rich source of carbohydrates, fats, proteins, minerals and vitamins (vitamin C, riboflavin, niacin, thiamin), traces of phosphorus, potassium, magnesium, Sulphur accounting for 390 KJ of energy for 100 gram of baked potato. With 205 solid matters, the starch is the main component making up around 85% of the solid mass while rest consists of different proteins. However, the potato starch cannot be digested by humans in raw form.[24] If dry weight is considered, the quantity of protein content in potatoes is equal to cereals. Above all, *the potato is low in fat*, and *rich in vitamin C.*[25] One medium sized potato of around 150 grams contains around 100 g of vitamin C. In other words, a medium sized potato provides around half of the daily need of an adult body requirements of vitamin C. It is a versatile food and is prepared in a number of different ways. It also contains certain traces of dietary antioxidants which may play their role in prevention of diseases related to old age and

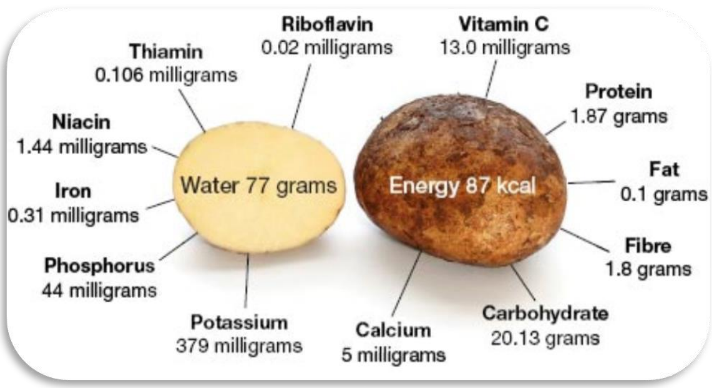


Figure 1 Nutrient content of potatoes;
Source; United States Department of Agriculture, National Nutrient Database

dietary fibers may help in maintaining health. The nutritive value of a dish prepared from potatoes depends on the method of preparation and other ingredients used in the dish. By default, potato is not a fattening vegetable as it brings in the feeling of satiety which may actually help in controlling weight. It is method of preparation and other high-fat ingredients which cause the raise in caloric value of the food. The methods of preparation of potato dishes affect its composition in several different ways reducing the proteins, fibers due to leaching in water or oil, and heat treatments. Boiling of peeled potatoes, the most commonly used method of preparing potatoes, brings in significant loss of vitamin C. Heated oil for French fries and chips results in absorption of high content of fat and reduction of ascorbic acid and minerals.[25] Potato can prove a source of bio fortification to overcome global iron and Sulphur deficiencies. It is estimated that globally around 1.6 billion people are suffering from iron and zinc deficiencies especially children and women. The bioavailability of potato has encouraged the scientists to believe that bio fortified varieties of potatoes can help in reducing malnutrition in populations at risk. Bio fortified varieties may help in providing around 50% of the daily intake of iron and zinc by consuming a 400 g tubers in a day. The bio fortification of the potato crops involve enhancing the density of vitamins, minerals through conventional or biotechnology methods.[26]

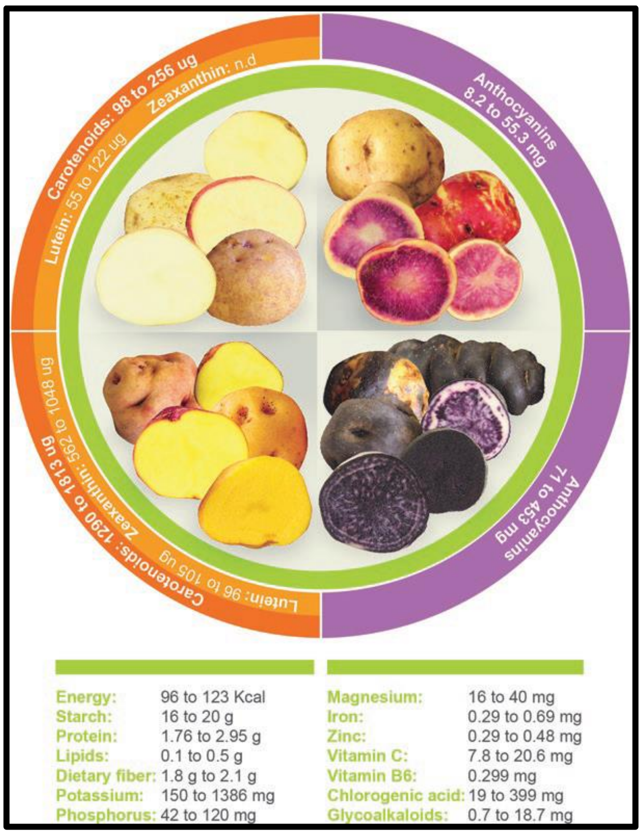


Figure 2 Nutritional Composition of Potato per 100 gm FW

Chemically, a fresh raw potato contains 70 to 75% water, 16 to 20% starch, 2 to 2.5% protein, and 1 to 1.2% fiber.

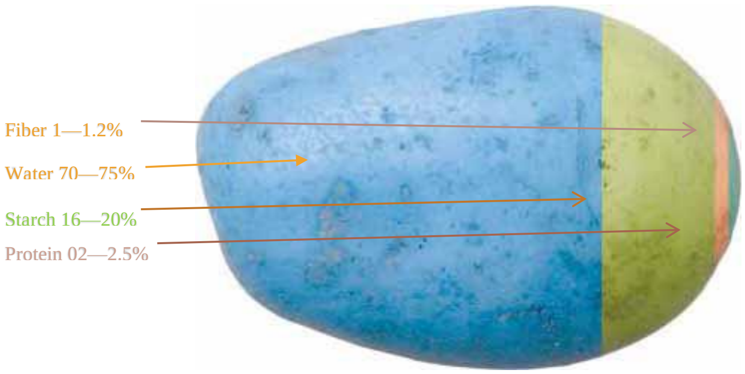


Figure 3 Chemical Composition of Potato

POTATO- HEALTH BENEFITS

Epidemiological studies have increasing highlighted the importance of nutrition in combating metabolic disorders associated with the emergence of diabetes, cardiovascular diseases, and cancer with diet. The higher intake of fruits and vegetables is recommended to cater these issues as fruits and vegetables provide effective protection against these chronic diseases.[27] The humble tuber in this regard has been underappreciated due to different controversies including labeling the spud with diabetes and obesity.[28] Ironically research has several times provided evidence that potato as food contains certain phytonutrients that help in counteracting these chronic diseases.[29] So far the humble potato has shown promising health promoting effects in human clinical studies, experiments on animals and human cell culture. These studies have evidence that potato consumption helps combating cancer, inflammation, cholesterol, obesity and diabetes. The nutritional compounds present in potatoes such as phenolic, fiber, anthocyanin and starch are considered beneficial for human health. Alongside this, other nutrients which are not considered nutritional such as glycoalkaloids, proteinase inhibitors and lectins also adds to the health benefits of potato.[29]

The studies have shown reduction in proliferation of cancerous cells when treated with potato extracts. The phenolic acids present in potato such as anthocyanin and glycoalkaloids have shown its in vitro and in vivo ability to fight cancer cell proliferation.[30] Phonlic acids in potato have shown their role in reduction of benzopyrene induced stomach cancer in mice and cytotoxic for prostate cancer cells.[31,32] The extracts of purple-fleshed potatoes have shown their effectiveness in suppressing colon tumorigenesis eliminating the colon cancer stem cells.[33] Chlorogenic acids are found effective against human liver colon and prostate cancer.[34] The potato fiber extract commonly known as protex has shown its effectiveness against tumor cell cultures.[35] The humble tuber has been associated with type 2 diabetes and obesity due to higher glycemic index in some of the potato varieties and processed potato products that contain higher amounts of saturated and trans fats.[36,37] Western dietary patterns of taking red meat along with potatoes have increased this confusion.[38] The potato chips and French fries have been becoming call of the day and dietary patterns of almost all nations. These products contribute towards the risk of obesity for containing higher amounts of fat and caloric content. Potatoes alone are not contributing towards obesity for being low-fat and high-water content food.[39]

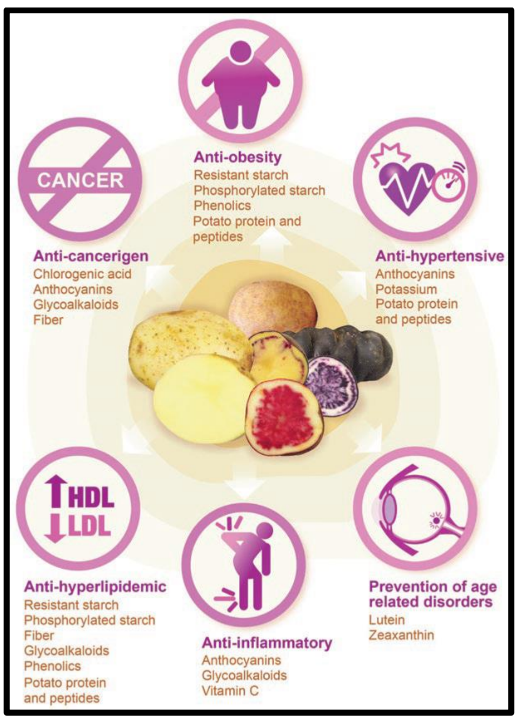


Figure 4 Health Benefits of Potato

<iframe width="480" height="360" src="https://www.youtube.com/embed/OESiymDsgqA" frameborder="0" allow="accelerometer; autoplay; clipboard-write; encrypted-media; gyroscope; picture-in-picture" allowfullscreen></iframe>

The story of potato reaching all continents of the world is not less than the story of an adventurer. It started from the Spanish conquest of Peru. The Spaniards destroyed the Inca civilization and killed around half of the population of Peru between 1532 to 1572. They came in search of gold as conquistadores but returned back home with another treasure *Solanum tuberosum*. The evidence suggests that potatoes were first grown in Europe on the Canary Islands of Spain around 1565 reaching Spanish mainland by 1573 and served as an exotic gift from Spaniards to the rest of the Europe. It changed hands from Spanish courts to the Pope in Rome and from Rome to Mons and from Mons to Vienna. It reached in London by 1597 and soon after to the Netherlands and France. After getting approach to the European botanical gardens, potato lost its popularity and only its flowers were seen as a source of admiration in the European backyards but its humble tuber was considered fit *only for poor and pigs*. '*The age of discovery*' in Europe added some value to the popularity of potato tubers as sailors took it as food on their occasional voyages. In this way potato reached China, India and Japan in the early days of the 17th century. During these days, however, Irish immigrants gave an extraordinary warm welcome to the humble tuber and got the name of Irish potato for being suitable to the cool and moist air of the Ireland. It took the humble tuber another 150 years to reach the northern hemisphere with long summer days. It was a crucial time in the human history as Europe was devastating with famine and hunger and soon the humble tuber was recognized as the food security crop. While Frederick the great of Prussia was ordering its subjects to grow potatoes as a security against cereal crops, French scientist Parentier declared the tuber as edible food. On the other side of the Atlantic, the President of the United States of America, Thomas Jefferson was serving *French fries* to its guests in the While House. For Russians, it was *devil's apple* and they hesitantly adopted it but the Napoleonic wars in 1815 proved that humble tuber is the only food reserve for armies. The industrial revolution caused displacement of agrarian society in Europe and the United

Kingdom to move to urban areas, where potato became the *convenience food* which was rich in energy, nutritious, easy to grow on small land plots, cheaper to purchase and ready to cook without much hassle. The humble tuber helped in overcoming the diseases of measles and scurvy, contributed towards higher birth rates and resultantly population explosion in the British Empire, the US and Europe. But this success of the potato was blighted by the late blight disease that hit the European continent as the varieties grown in these areas were genetically similar to the varieties grown in North America and thus quite vulnerable to diseases and pests. The late blight resulted in *potato famine*, the poor Irish who once welcomed the potato, now were facing the hardest of times as their 80% daily intake of calorie was coming from potato. This resulted in the deaths of around one million people as the late blight destroyed three consecutive crops in Ireland. In the other parts of the world, the European colonies and emigrants were taking the humble tuber in all parts of the world. The governors, viceroys and priests encouraged the world to grow potato in Bengal, Egypt, Morocco and Nigeria. On the other side of the world, the emigrants took the potato to the Australian continent and South America especially in Argentina and Brazil. The twentieth century dawned with potato's recognition as the global food. Soviet Union touched the 100 million tonnes mark. After the World War II, Germany and Britain dedicated huge areas for potato cultivation so much so that Belarus and Poland started producing more potatoes than cereals and are still doing that ardently.[40]

The current popularity of potato as a snack food has its own history and with the invention of mechanical peelers in 1920s, it became the top-selling snack of America. McDonalds and McCain spent millions of dollars in perfecting their respective French fries and frozen French fries. By the end of 1957, McCain had fifty-five production facilities across six continents of the world and today it supplies around one-third of the all French fry potatoes grown around the world. The popularity of potato started beginning in the developing world by 1960s. In southeast Asia countries like India, Pakistan and Bangladesh are trying to meet the exploding demand of potato from food industry. The humble tuber with its rich past and bright future has been shifting from its second home in Europe to developing world where its consumption is four times less than in Europe and hence has a wide room of expansion. Last but not least is the fact that Peruvian government took initiative of preserving the heritage and developing new varieties in its International Potato Center (CIP) where genetic diversity, for adoptable potato varieties to meet the needs of the world is being carried out and hopefully from here onwards, new chapters in the story of the humble tuber *Solanum tuberosum* will be written.[40] This crop has achieved not only a global agronomic and economic footprint, but also attained a significant social and artistic footprint, which is reflected in pre-Inca and Inca ceramics, "The Potato Eaters" painting of Vincent van Gogh[41], and the "Ode to Potato" composed by the Literature Nobel Prize winner Pablo Neruda.[42]

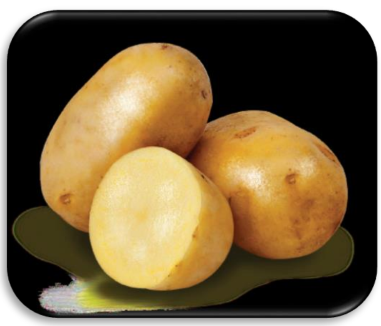
Figure 5 The Potato Easters by Vincent van Gogh Courtesy: CIP

The origin of English word potato is traced back to Spanish word patata (the name still under use in Spain). According to Spanish Royal Academy, the word patata is the combination of two words, Taino batata (sweet potato) and Quechua papa (potato). Originally, the word potato was used for sweet potato and not the other way around. The historical mistake has kept these two plants closer to each other which otherwise do not have a slightest of relationship with each other. English took both plants one of another and their chronicles on agriculture and plants do not differentiate between the two. The herbalist John Gerard from 16th century used the terms Virginia potato, and bastard potato for these species referring sweet potato as common potato. Irish potato and white potato are few other names which the English used for the humble tuber. The potato evolved its name from *papa* as it was called by Incas and still by Latin Americans. For Spaniards it was *patata*, confusing it with *batata* (the sweet potato). The Spaniard *papa* is; *patata* in Italian, *poteto* in Japanese, *patates* in Turkish languages. It is known as *aartapple* in Africa and *aardappel* in the Netherlands.[3]

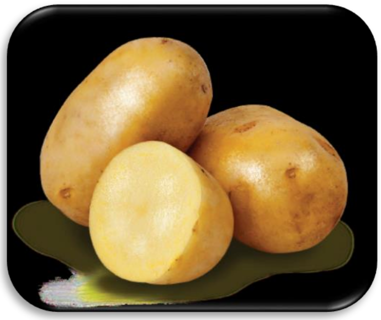
Geographically, he tuber is grown in more than 100 countries of the world from the southern extremitites in South America to the Arctic Circle. The product profile reveals that the humble tuber has witnessed a rich past, enjoying richer present and pointing to the richest future.[43] The scenario of potato production at world level is changing rapidly. During early 90s, the potato was considered the crop of the Europeans, Americans and the Russians. Since then, Asia, Africa and Latin America has shown a tremendous growth in potato production and demand where production has been increased manifolds. From 2005, for the first time in the history of potato production, the developing countries have grown more potatoes than the developed world. Today, China is the biggest potato producer in the world and around one-third of the world production is harvested in China.[43] China become the largest producer in 1993 due to a surge in production there [44], the potato output implosion in Europe and the melting down of the former Soviet Union and China became the world´s largest potato producer in 1993 due a surge in output there[44], the implosion of potato output in Europe, and the break-up of the former Soviet Union.[45] From only 7% of the world production in 60s, the developing countries are now contributing around 46% of the global potato production.[46] The potential of an increased growth in the future has gained attention of the world.[47] Adding the opportunities for the industrials developments in the developing world, increased incomes and urbanization and the population growth in Asian countries have made the potato a potential source of food security in the region in the coming decades.[46] The potato was introduced to the subcontinent through Portuguese and the British during their rule over India encouraged its cultivation in the 19th century. In India and Pakistan it was considered a curiosity plant grown in the botanical gardens to show off at the horticulture related shows in bigger towns and cities, and then as a vegetable to the king of vegetables and ultimately ending up as an essential ingredient of vegetable baskets of rich and poor alike.[48]Geographically, the tuber is grown in more than 100 countries of the world from the southern extremities in South America to the Arctic Circle. The product profile reveals that the humble tuber has witnessed a rich past, enjoying richer present and pointing to the richest future.[43] The scenario of potato production at world level is changing rapidly. During early 90s, the potato was considered the crop of the Europeans, Americans and the Russians. Since then, Asia, Africa and Latin America has shown a tremendous growth in potato production and demand where production has been increased manifolds. From 2005, for the first time in the history of potato production, the developing countries have grown more potatoes than the developed world. Today, China is the biggest potato producer in the world and around one-third of the world production is harvested in China.[43] China became the largest producer in 1993 due to a surge in production there [44], the potato output implosion in Europe and the break-up of the former Soviet Union.[45] From only 7% of the world production in 60s, the developing countries are now contributing around 46% of the global potato production.[46] The potential of an increased growth in the future has gained attention of the world.[47] Adding the opportunities for the industrial developments in the developing world, increased incomes and urbanization and the population growth in Asian countries, have made the potato a potential source of food security in the region in the coming decades.[46] The potato was introduced to the subcontinent through Portuguese and the British during their rule over India encouraged its cultivation in the 19th century. In India and Pakistan it was considered a curiosity plant grown in the botanical gardens to show off at the horticulture related shows in bigger towns and cities, and then as a vegetable to the king of vegetables and ultimately ending up as an essential ingredient of vegetable baskets of rich and poor alike.[48]

SOCIO-ECONOMIC IMPORTANCE

The incorporation of potato as a diet in the lives of people provided immense benefits to the world. Its diverse nature of braving all kinds of environmental conditions and pest attacks make it the household name throughout the world. Not only this, but potatoes were found nutritionally superior to several other staple crops. The cultivation of potato improved the food security of economically dis-advantaged people throughout the world including peasants without land and factory workers who flocked to urban areas fueling the process of industrialization during Industrial Revolution.[49]



FAO estimates that the average per capita consumption of global citizens during the first two decades of 21st century was around 33 Kg.[50] Today, the world is under unprecedented pressure to provide the world with sufficient nutritious foods in a sustainable and environmentally friendly way.[51] More than 830 million people in the world are under nourished and more than a billion are obese or overweight.[52] On the other hand, the activities of food production and processing are causing unsustainable pressure on natural resources. It is estimated that by 2050, the global population will be around 10 billion which will need 70% more food than today. Providing the nutritional and sustainable food will require enhancing the global food system is such way that can meet the needs of farmers as well as consumers with minimum environmental foot print.[53] Critical of all the challenges for food security is to produce food for such a huge population with lesser of same resources and current system will not be able to provide food for eradicating hunger even by 2050 and food security will remain a threat. Food and Agriculture Organization (FAO) has defined food security as *"Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life."*[54] Food security comprises of four key elements; availability, access, quality and use, and stability. Hence, potato will remain a food security crop in the process of *nutrition transition* in several developing countries. In several countries, potato is playing its role in diet diversification as small farmers and landholders supply the fresh agriculture produces to the local markets at affordable rates[41]. However, in developed countries the urbanization has lowered the dependency on traditional staple foods.[55] Another importance of potato as a food security crop is its ability to be dealt as '*local for local*' crop in several countries and have very little scope of trade as compared to other staples and its demand for processed products and hence will not be as active on global scale price volatility and hence the world can rely on potato for smoothing up the disruptions in global food supply and demand.[56] Another factor that adds to the ability of potato to serve as the food security crop is that it provides the income and employment opportunities which are directly related to household food nutrition and access and thus securing the vulnerable livelihoods.[57] There is a need to take potato as a multipurpose and healthy ingredient of a nutritious and balanced diet as it also play its role in combating the deficiency of micronutrients which are also seen as a global health problem (*hidden hunger*) affecting around two billion people globally.[58] To add to its socio-economic importance, the humble tuber is the prime candidate to be cultivated on space stations to provide nutritious food and oxygen to the astronauts and removing carbon dioxide from the air.[59] FAO estimates that the average per capita consumption of global citizens during the first two decades of 21st century was around 33 Kg.[50] Today, the world is under unprecedented pressure to provide the world with sufficient nutritious foods in a sustainable and environmentally friendly way.[51] More than 830 million people in the world are under nourished and more than a billion are obese or overweight.[52] On the other hand, the activities



of food production and processing are causing unsustainable pressure on natural resources. It is estimated that by 2050, the global population will be around 10 billion which will need 70% more food than today. Providing the nutritional and sustainable food will require enhancing the global food system in such way that can meet the needs of farmers as well as consumers with minimum environmental foot print.[53] Critical of all the challenges for food security is to produce food for such a huge population with lesser of same resources and current system will not be able to provide food for eradicating hunger even by 2050 and food security will remain a threat. Food and Agriculture Organization (FAO) has defined food security as *"Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life."*[54] Food security comprises of four key elements; availability, access, quality and use, and stability. Hence, potato will remain a food security crop in the process of *nutrition transition* in several developing countries. In several countries, potato is playing its role in diet diversification as small farmers and landholders supply the fresh agriculture produce to the local markets at affordable rates[41]. However, in developed countries, the urbanization has lowered the dependency on traditional staple foods.[55] Another importance of potato as a food security crop is its ability to be dealt as '*local for local*' crop in several countries and have very little scope of trade as compared to other staples and its demand for processed products and hence will not be as active on global scale price volatility and hence the world can rely on potato for smoothing up the disruptions in global food supply and demand.[56] Another factor that adds to the ability of potato to serve as the food security crop is that it provides the income and employment opportunities which are directly related to household food nutrition and access and thus securing the vulnerable livelihoods.[57] There is a need to take potato as a multipurpose and healthy ingredient of a nutritious and balanced diet as it also plays its role in combating the deficiency of micronutrients which are also seen as a global health problem (*hidden hunger*) affecting around two billion people globally.[58] To add to its socio-economic importance, the humble tuber is the prime candidate to be cultivated on space stations to provide nutritious food and oxygen to the astronauts and removing carbon dioxide from the air.[59]

BY PRODUCTS & OTHER USES

Potato's use as food is increasing shifting from consumption as fresh potatoes to value-added processed food products. One of the main value-added product of potatoes is generally known as frozen potatoes (having a very unappetizing name). Potato crisp is another value-added product of the crop (commonly known as chips in the US). It is considered the king of snacks in different developed and developing countries. Thin slices of potatoes are

baked or deep fried with a variety of flavors of simple salt to roast beef and Thai chili. Some of these products are produced using dough made from dehydrated potato flakes. It is estimated that global frozen potato market will reach to $ 74,403 million by 2025 with a CAGR of 3.8% during next five years. Frozen potatoes are considered a very convenient form of processed potatoes with its different nutrients and vitamins preserved with a longer shelf life. Advanced machinery and low temperature are used for frozen potatoes products such as French fries, shapes, battered potatoes, hash brown, topped potatoes and many more. Customers get these products from quick service restaurants (QSRs) and retail stores. Product-wise French fries contributes around 40% in the global frozen potato market. The French fries market has the huge potential for growth due to new product lines meeting the consumer preferences.

The dehydrated potato flakes and granules are prepared from drying the mash of cooked potatoes. These flakes are used in retail potato products such as snacks, and food aid. Potato flour is made from grounding cooked whole potatoes. Potato flour, rich in starch and Gluten-free carries the distinct taste of potatoes. It is used by the food industry to thicken the soups and gravies and binding meat mixtures. The starch processing can retrieve around 96% of the starch from potatoes. It can provide higher level of viscosity than maize and wheat flours and adds to the preparation of a tastier product. Potato flour and granules are

also used for thickening sauces and stews. It is an excellent binding agent in cakes, doughs, ice-cream and biscuits. In Scandinavia and Eastern Europe, the crushed potatoes are used for fermentable sugars by heating them and converting their starch into sugar and using it for distillation of alcoholic drinks, namely; akvavit and vodka.[60]

The potato starch is also used in non-food sector such as textile, pharmaceutical, paper, and wood industries as a binder and adhesive, filler, texture. Oil drilling companies use potato starch for washing boreholes. As a 100% biodegradable substitute, potato starch is used as a substitute for polystyrene and other plastics such as disposable plates, knives and dishes. The potato peels and other wastes known as zero value wastes are rich in starch and can be used for producing fuel-grade ethanol. A research study in Canada estimated that 440,000 tonnes of processing wastes of potato can produce at least four to five million tonnes of fuel-graded ethanol. It has been widely used as farm animal feed in Europe. Even today, half of the potatoes harvested in Eastern Europe and Russian Federation are used as animal feed. Some average weight cattle consume around 20 Kg of raw potatoes daily in these areas. It is also considered that if pigs are given around 6 kg of boiled potatoes daily, they fatten quite quickly. Chopped potatoes are added to silage and are cooked in the heat of fermentation for this purpose.[60]

Potatoes are mainly processed into four major types of products apart from being consumed, imported and exported directly as a raw commodity; frozen potatoes, potato starch, dried potatoes and prepared or preserved potatoes. Potato in its raw form falls in Chapter 7 of Harmonized Tariff System with 4-digit code of 0701. The 6-digit prefix for frozen, preserved and prepared including French fries fall in Chapter 20- 200410. Unfrozen potato prepared or preserved with vinegar or acetic acid also falls in Chapter 20 with 6-digit code of 200520. During 2018, the global export of fresh or raw potatoes amounted to $4.33 billion. On the other hand, the export of processed/preserved including the French fries amounted to $10.1 billion.[61] Overall, the value of fresh/raw potatoes declined in value by average -0.1% for all exporting countries since 2014. The processed, prepared and frozen potato exports including French fries increased by 15.5% over the same period.[61]

The highest export sales in 2019 were for frozen prepared or preserved potatoes (including French fries) amounting to $12.8 billion equal to around 81% of the overall export of prepared or preserved potatoes. On the other hand, the export of unfrozen prepared or preserved potatoes was touching $2.5 billion figure in 2019 representing around 20% of the overall potato export. The list of major exporting countries of prepared, and or processed, unfrozen prepared and or processed potatoes is given in the table below;

Table 1 Rank of Countries in Processed Potato Exports 2019

Rank	Country	Value of Export (US$)	% Share in Global Exports
1	Belgium	2.57 billion	24.8%
2	Netherlands	2.27 billion	21.9%
3	United States	1.5 billion	14.7%
4	Canada	1.2 billion	11.3%
5	France	495.4 million	4.8%
6	Germany	470 million	4.5%
7	Poland	312.2 million	3%
8	United Kingdom	266.5 million	2.6%
9	Argentina	218.9 million	2.1%
10	New Zealand	69.7 million	0.7%
	Source:[61]		

ISSUES AND PROPOSED SOLUTIONS

For mythical reasons, the potatoes are being related to the risks of obesity, Type II diabetes (T2D), and cardiovascular diseases (CVD).[37] Even in the developing countries like Pakistan, potato is being considered a meal component without any specific attributes and a fit-for-all vegetable. The negative image thus created without weighing in the factor of consumption of convenience food in shape of fried potatoes has marred the importance of such a nutritious food. Another negative impression created about potato along with its fattening effect is that it requires a whole array of pesticides to cultivate and potato crops add to soil erosion. There is a need to mitigate these negative images with better information about the nutritional value of potatoes and its importance in human diet along with its role as the food security crop.[41]

The second measure could be introduction and adoption of seed laws and regulations. Seeds play their vital role in per hectare yield and diseased seed prove a vehicle for importing potato diseases into the field. As a large quantity of potato is cultivated through vegetative propogation, the seed system introduced in some developing countries have not proved effective with less than 10% use of certified seeds. Following FAO guidelines, there is a need to develop the Quality Declared Seed (QDS), where some of the quality standards are relaxed and farmers are provided with the enough quality seed through informal seed system.[62] There are however concerns about the spread of seed-borne diseases such as *Ralstonia solanacearum*. The adoption of quality declared seed or *common seed* is proving helpful in developing countries like Peru, Ecuador, and Kenya.[41]

SECTION 2: PRODUCTION TECHNOLOGY

INTRODUCTION

Potato is produced in over 100 countries worldwide. Potato has vegetative propagation which means the new plant is grown from a piece of potato. The pieces used for sowing potato also are known as seed. New plants bear 5 to 20 new tubers which are considered the genetic clones of the mother seed. Interestingly, potato plants produce flowers and berries. The berries contain around 100 to 400 botanical seeds that can also be used for producing new tubers but these tubers would be genetically different from its mother plant. One hectare of potato can yield two to four times the food quantity of grain crops. Potatoes produce more food per unit of water than any other major crop and are up to seven times more efficient in using water than cereals.[3]

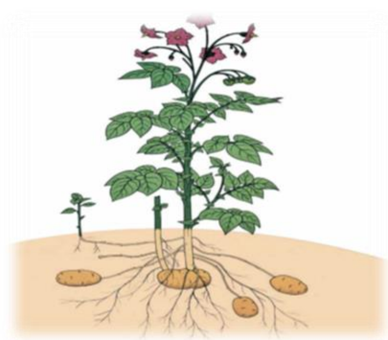


Figure 6 Potato Plant. Courtesy: CIP 2008

CLIMATE

Potato is essentially *a cool weather crop* and temperature is the major limiting factor in its production. The potato tuber starts losing its vigour below 10℃ and above 30℃. For maximum yields, the ideal daily temperature is between 18℃ to 20℃. For these reasons, in temperate regions, potato is cultivated in early spring season and in late winter in tropical and subtropical regions. However, in some sub-tropical regions, the product is grown throughout the year, here potato crop is cultivated within 90 days whereas in temperate regions, it takes around 150 days.[60] The summary of climatic status for potato plant is given in the table below;

Table 2 Summary of Climatic Status Description for Potato

Climate	Status	Description	Remark
Af - Tropical rainforest climate	Preferred	> 60mm precipitation per month	
Am - Tropical monsoon climate	Preferred	Tropical monsoon climate (< 60mm precipitation driest month but > (100 - [total annual precipitation(mm}/25]))	
As - Tropical savanna climate with dry summer	Preferred	< 60mm precipitation driest month (in summer) and < (100 - [total annual precipitation{mm}/25])	
Aw - Tropical wet and dry savanna climate	Preferred	< 60mm precipitation driest month (in winter) and < (100 - [total annual precipitation{mm}/25])	
Cf - Warm temperate climate, wet all year	Preferred	Warm average temp. > 10°C, Cold average temp. > 0°C, wet all year	
Cs - Warm temperate climate with dry summer	Preferred	Warm average temp. > 10°C, Cold average temp. > 0°C, dry summers	
Cw - Warm temperate climate with dry winter	Preferred	Warm temperate climate with dry winter (Warm average temp. > 10°C, Cold average temp. > 0°C, dry winters)	
Reference: CABI[13]			

AIR TEMPERATURE

Table 3 Summary of Air Temperature Required for Potato

Parameter	Lower limit	Upper limit
Mean annual temperature (ºC)	3.6	27.8

RAINFALL

Table 4 Summary of Rainfall for Potato

Parameter	Lower limit	Upper limit	Description
Mean annual rainfall	90	4100	mm; lower/upper limits

SOIL

Potato, rightly called humble tuber is very accommodating plant and can manage to grow without ideal soil and climatic conditions. Its susceptibility to diseases and pests is the highest in all tuber crops. For this reason, the farmers avoid its cultivation in the same fields year after year rotating it with alfalfa, beans and maize. Exercising good agriculture practices and irrigating the crop at suitable times, potato can give the yield of up to 40 tonnes per hectare whereas in developing countries like Pakistan, the average yield is little more than 20 tonnes per hectare. This huge difference in yield is due to lack of exercising good agriculture practices, using low quality seed and cultivars, lower quality fertilizers and lack of suitable irrigation along with lack of integrated pest management practices to deal with pests and diseases.[60]

As far as soil is concerned, potatoes can be grown in any kind of soil leaving alkaline and saline lands aside. The preferred soils for potato cultivation are loose soils that have least resistance against tuber enlargement. The loamy and sandy loam soils are hence considered the best for cultivating potatoes if they are rich in organic matters and have good aeration and drainage. The required pH range is from 5.2 to 6.4. Preparation of land for potato cultivation requires extensive labour including harrowing to making the soil free of all kinds of weeds and roots. Farmers prefer three ploughing, frequent harrowing and rolling to make the soil suitable for potato cultivation. The farmers also need to ensure that fields are well-aerated and well-drained.[60]

SOIL TOLERANCES[13]

SOIL REACTION

- Acid
- Alkaline
- Neutral

SOIL TEXTURE

- Light
- Medium

PLANTING

Propagated usually from seed potatoes which are small tubers or cuttings of tubers. These seeds are sown in the ground in the depth of around 10 centimeters. For having a successful crop, the purity of cultivar and health of the seed are the most important factors. It is imperative to sow disease-free seeds which are well sprouted (have developed well shown eyes) and are around 40 grams in weight. Use of commercial variety seed can increase yield up to 50%.[60]

The density of potato rows depends on the size of the potato seed selected for sowing. The row to row distance must be enough to allow ridging. Around two tonnes of seed potatoes are sown per hectare for better yields. In dry areas where production is dependent on rainfall, potatoes are sown in flat soils. For irrigated crops, potatoes should be sown on ridges.[60]

WATERING

Around seventy percent of the fresh water is used in agriculture, which is considered unsustainable, and a factor jeopardizing the ecosystem of the earth. Hence agriculture needs to improve its volume of production per unit of water use. The humble tuber stands out from other crops for its productivity against water used. Potato yields more food per unit of water than any other crop on earth. Its nutritional productivity ranks higher with carrots, groundnuts and onions. Potato produce more calories against the water applied. If we compare potato with other staple foods, potato produce around 5600 calories of dietary energy against one cubic meter of fresh water used for its cultivation, standing far above than maize with more than 3800 calories, wheat 2300 calories and rice 2000 calories. For the same amount

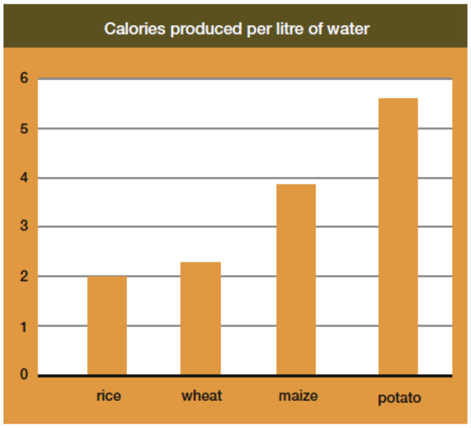


Figure 7 Calories Produced Per Litre of Water; Courtesy: FAO 2008

of water consumed, potato produces double the quantity of proteins than wheat and maize and four times than rice.[63]

Potato requires a high soil moisture content and for a 120 to 150-day crop, potato need around 500 to 700 millimeter of water (around 20 to 27 inches). Lack of water during middle and later part of the growth of tubers affects the yield considerably. With its shallow root system, potato needs a frequent irrigation which may produce high yields than flooding the crop with water. The use of mechanized sprinklers is the best suitable option. In temperate and subtropical regions, the potato crop of 120 days gives yield up to 25 tonnes per hectare which reduces to 15 to 20 tonnes per hectare if the crop is under-irrigated.[60,63]

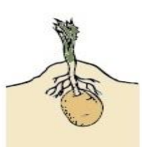
MATURATION STAGES

Potato goes through four to five distinctive growth stages from seed to mature tuber. The timing of these growth stages is dependent of several management and environmental factors. These factors vary from region to region and from cultivars to cultivars.[59,60,63,64]

THE SPROUTING STAGE

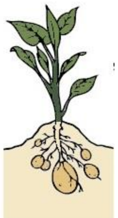
The sown seed sprouts from its *eyes* and grows upwards to come up from the soil, at the same time the roots developed from seed started going downwards from the sprouting points. At this stage the plant depends 100% on seed potato for its nutritional requirements.[59,60,63,64]

THE VEGETATIVE GROWTH



At the vegetative growth stage, the plant begins to develop leaves and brunch stems from the nodes above the ground. Under the ground the roots and stolons start developing from underground nodes. Above the ground with the emergence of leaves, the process of photosynthesis begins. At this stage, the plant takes 25% of its nutrients from the seed plant whereas rest of the nutritional requirements are met by small roots, though these requirements are still very small.[59,60,63,64]

THE TUBER INITIATION STAGE

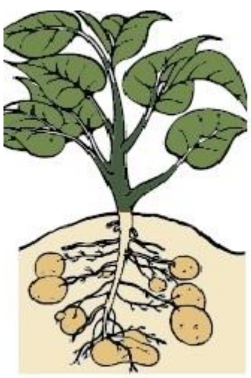


Small tubers at the end of stolon tips start forming underground which are not yet in the process of enlargement. At this stage depending on the cultivars sown, the early flowering at the plant begins. At this stage, the plant shifts its nutrient requirements to roots and stolon taking as much as nutrition from the soil as possible. The plant starts partitioning of the carbohydrates which means the carbohydrates start going to the tubers from leaves. [59,60,63,64]

THE TUBER BULKING STAGE

With the accumulation of carbohydrates, nutrients and water, the tuber cells start expanding in size. The tubers at this stage are the main hub of carbohydrates and inorganic nutrients. [59,60,63,64]

THE MATURATION STAGE



At the maturation stage, the leaves of the plant turn yellow and plant starts loosing leaves. The process of photosynthesis decreases with the loss of leaves and the growth of tubers slows down. The vines eventually die down on the ground during this stage. Under the ground the tuber reaches its mature stage containing the highest possible dry matter contents and the tuber skin thickens. At this stage the tubers start feeling the lack of supply of nutrition and their nutrient level begins to fall except the magnesium and calcium, which keep increasing in the tuber with each passing day.[59,60,63,64]

The compound leaves of potato plant manufacture starch which is transferred to its underground stems or stolon which thickens to form up to around 20 tubers of different sizes and shape up to 300 grams closer to the surface of the soil. The maturity of these tubers depends on the moisture and nutrients available in the soil. The leaves of the plant die down at the end of season and the tuber beneath the soil surface detach themselves from the stolon. These detached tubers then serve as the nutrition source for the plant to survive cold and other factors. These tubers then are ready to regrow and reproduce with at least two to ten buds (eyes) grown in a spiral pattern around the surface. The buds generate shoots which grow into new plants at the availability of favorable conditions. A fresh or raw potato tuber has several micronutrients, vitamins and minerals that are essential for health including potassium and vitamin B, C and phosphorus, magnesium.

As already mentioned being a cool weather crop potato production has temperature as the main limiting factor, tuber growth is inhibited above 30℃ and below 10℃ whereas daily temperature of 18℃ to 20℃ is considered favorable for potato growth. For this reason, in temperate zones, potato is grown in early spring and in late winter in warm regions. In tropical regions, potatoes are grown in the coolest moths of the year whereas in sub-tropical highlands, famers grow potatoes throughout the year. Another characteristic of potato is that it is very adaptable and accommodating plant and can grow even if the soil and other growing conditions are not favorable. Good agriculture practices together with irrigation are necessary to get the maximum yield from a hectare of land. Farmers in northern Europe and North America get more than 40 tonnes of fresh potatoes from a hectare whereas yield in developing countries ranges from 5 to 25 tonnes. Lack of high quality seed, improved cultivars, quality fertilizers and proper irrigation are the main reasons for low yield in developing countries. As developing countries lack a formal system of seed supply, farmers use their ad hoc methods for selecting potato seeds. As a practice, farmers in developing countries sell the largest potatoes in the market, eat the medium sized potatoes at home and keep the smallest tubers for seeds.[22]

HARVEST CALENDAR (DOMESTIC VERSUS INTERNATIONAL) – CURRENT POSITION VERSUS COMPETITORS

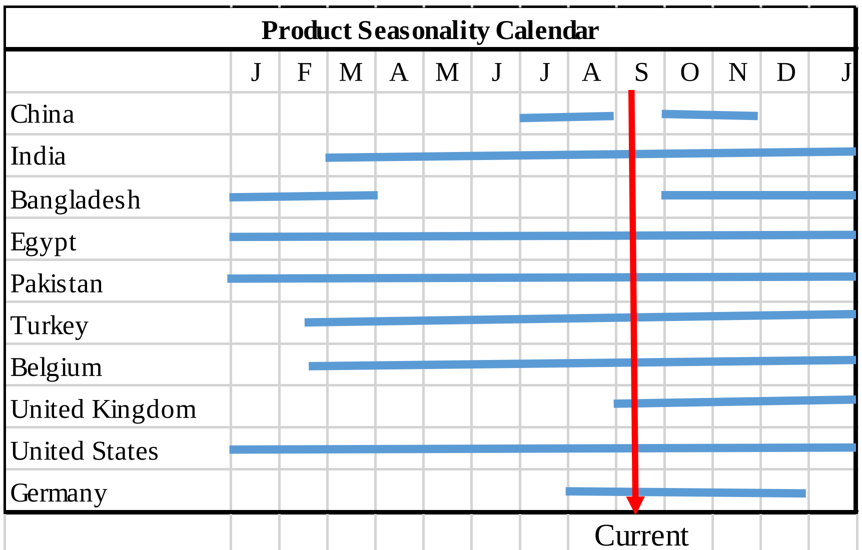


Figure 8 Product Seasonality Calendar

TISSUE CULTURE APPROACHES OF POTATO PROPAGATION

Potato is propagated asexually (vegetatively) and sexually (by botanical seed or true potato seed). Tubers of potato are basically shortened and thickened stems that have auxiliary buds. The research has established that physiological status and health of seed are the main factors influencing the potato yield. Potato needs around 15% of its area to produce required seed tubers whereas other cereals need just one thirtieth of their area to produce seeds (Struik and Wiersema, 1999).

Conventionally, seed potato tubers are used for multiplication and production.(Struik and Wiersema, 1999). But conventional production of tubers has its disadvantages including low rate of multiplication, inefficiency of seed tuber, risk of carrying different fungal, viral and bacterial diseases and a number of pests. Conventional multiplication requires extensive control and higher multiplications. These seed tubers are prone to degeneration due to transferred pests and diseases. Furthermore, specific storing conditions are required to store seed tubers for planting which results in higher costs for seed potato tubers. Using seed tubers for multiplications provide ease of planting, uniformity of tubers and healthy plant growth (Gopal, 2003). Generally, the farmers need 2.5 to 3.0 tons of potato tubers for production and multiplication (Khurana, Minhas and Pandey, 2003), whereas for true potato seed the farmers would need only 50 to 250 grams of TPS per hectare.

In comparison to the grain seeds, the potato seeds are less storable and have the possibility of carrying soil-borne diseases with the seed tuber. Secondly, potato seed is prone to degeneration for the reason of its vegetative propagation where continuous propagation decreases the quality of the seed mainly due to increased virus frequency and concentration. The potato tubers are naturally prone to transmit accumulated pathogens to the next generation of tubers increasing the risk of different diseases (Struik and Wiersema, 1999).

In this context, tissue culture techniques have gained immense popularity recently. Tissue culture as new technology has revolutionized the agriculture and industry by paving the way of meeting ever increasing demand of plants in the world (Khurana, Minhas and Pandey, 2003). The technology has contributed significantly in the advancement of agriculture sciences and is used for propagation of several kinds of woody and herbaceous plants (García-Gonzáles *et al.*, 2010).

Micro propagation is in vitro clonal propagation through the use of tissue culture in which the plant material is multiplied rapidly for producing a large number of progeny plants. Morel (MOREL and M., 1964) firstly used this technology for propagating orchids and today it is used for propagating several plants. The technique is helpful in speeding up the production of high quality plantlets which are free from pathogens and have physiological uniformity (SahayaSathish, Janakiraman and Johnson, 2011).

Tissue culture as a technique covers range of sub techniques which include in vitro culture of organs such as stems, flowers, shoot tips, runner tips, and root tips etc. In potato, different tissues are used for generating roots directly using them as explants (Anjum and Hakoomat, 2004).

INSECT/PEST, DISEASES AND ITS CONTROL MEASURES

INTRODUCTION

Getting sustainable production of potato remains a challenging issue for potato growers globally. Biotic constraints include insects and pests that affect the potato yield and quality. Potato's geographical spread makes it vulnerable for a large number of insect pests and the impact of climate change is exacerbating this phenomenon.[68] The global loss of product due to potato insect pests is estimated averagely 16%[69] and at local level if these pests are not controlled the yield and quality may deteriorated by 30 to 70% due to different pests.[70] There are around 49 species of insect pests affecting potato crops in tropical, subtropical and temperate regions.[68] Of these insect pests, herbivorous insects like all other arthropods being exothermic are unable to regulate their temperature internally and hence are dependent on the temperature they are exposed to. Hence, the climate change may have a positive as well as negative impact on insect pest population and resultantly on the yield and quality of tuber. It is estimated that potato insect pests will take advantage of the climate change and increase their geographical spread and population density and resultantly a greater pre and post-harvest loss of potato crops.[68] Potato foliage itself provide some control due to glycoalkaloids against herbivory. According to few researchers, potato is the most chemically dependent crop in the world.[49]

S. tuberosum is prone to several widespread diseases that affect its yield and quality wherever the plant is grown as crop. Some of the most prevalent diseases are; bacterial diseases including bacterial wilt caused by Ralstonia solanacearum, soft rot by Erwinia cartivora, and common scab by Streptomyces scabies, fungal diseases including late blight caused by Phytophthora infestans, early blight by Alternaria solani, black scurf by Rhizoctonia solani and pink rot by Phytophthora erythroseptica. Other viral diseases include potato leafroll luteovirus (PLRV) and mosaic viruses including potato X potexvirus (PVX) and potato Y potyvirus (PVY).[13]

It is interesting to note that in the USA, the potato crop is affected by more than 100 species of insects including Colorado potato beetle (Leptinotarsa decemlineata), flea beetle (Epitrix spp), potato aphids, leaf hoppers, and wireworms.[14]

PESTS IN TROPICAL AND SUBTROPICAL REGION

The middle of the earth is commonly known as the tropics falling between the latitude lines of the Tropic of Capricorn and the Tropic of Cancer. The areas in tropics include the equator, different parts of North and South America, Asia, Africa and Australia. The tropics accounts for around thirty-six percent of the landmass. One-third of the world population lives in the tropics. The tropics are considered warm around the year averaging from 25°C to 28°C. The tropics get more direct sunlight than other regions and just have two seasons; the wet and the dry. The amount of rain varies across the tropics; the Amazon Basin getting around 3 meters of rain per year and Sahara Desert getting only 2 to 10 centimeters. This difference of rain has its direct impact on the plant and animal life in the region.[71]

MAIN PEST INSECTS OF TROPICAL AND SUBTROPICAL REGION

POTATO TUBER MOTHS

PHTHORIMAEA OPERCULELLA

Figure 9 Potato Tuber Moth, Courtesy: Insect Images

ORIGIN & SPREAD

With its origin in the mountainous regions of South America, the Potato Tuber Moth (PTM), is now has worldwide distribution and is known as the most damaging of potato pests in the developing countries. Its presence is witnessed in almost all tropical and subtropical regions of the world including North and South America, Australia, Africa, Europe and Asia.[68]

HOSTING

It is an oligophages pest of vegetables and is related to mainly crops of Solanaceae family; potato, tobacco and tomato.

INFESTATION

P. operculella mines the potato leaves and stems to reach and feed on the tuber. The symptoms include damage of leaf due to eaten mesophyll by the insect without damaging the lower and upper epidermis of the leaves. At the end of attack when foliage is died completely or partially, the larvae of the pest enter into the soil finding tubers and feeding on them. Larvae enters the tuber through their eyes and start tunneling under the skin excreting larval excreta from the holes. It also enters the stem by making small holes in the axils.

PRODUCTION LOSS

P.operculella can cause yield loss up to 70% when the potato foliage is destroyed. If the infestation occurs earlier in the season, the tuber yield is affected drastically. The research finds a strong correlation between leaf and tuber infestation which suggests that minimizing the insect density and population at the time of harvest is quite important. Delayed harvest can be another cause of insect density and population as it may egg on the developing tubers.

The effect of *P.operculella* is also seen during storage. In case of storage of potatoes without any treatment, the damage could be devastating in rustic stores. The potato moth infestations are not only unsuitable for human consumption but also for seed. Infested seed give way to lower yield and a faster development of new population of P. operculella.[70,72]

SYMMETRISCHEMA TANGOLIAS

Figure 10 Symmetrischema tangolias; Courtesy: James Hayden, Microlepidoptera on Solanaceae, USDA APHIS PPQ, Bugwood.org

SPREAD

Native to Peru and Bolivia, The Andean potato tuber moth (APTM), *Symmetrischema tangolias* has been spread throughout the world including most recently in Indonesia.[68]

HOSTING

The host range of *S.tangolias* consists of potato, sweet cucumber, tomato, black nightshade, bell peppers and kangroo apple.[73]

INFESTATION

The larvae of APTM (*Symmetrischema tangolias)* use tubers and stems of potato plant as their food and hence potato is the primary host plant for *S.tangolias*. The new born larvae enter into the stem through axils and leaving excreta at the mouth of the tunnel and discoloration of the stem. The larvae may go upward as well as downward in the tunnels. In severe infestation cases the plant wilts and the stem bends off.[73]

PRODUCTION LOSS

It has emerged as the most economically important pest in potato cultivation areas of Peru, Bolivia and Ecuador, however, its presence in Colombia is not yet confirmed. Around 30% of crop losses are attributed to *S.tangolias* in these areas. The most devastating effect occurs during storage when infestation of stored potatoes take place. At home storage facilities farmers may lose all of their crop within three to four months. In Australia and New Zealand, it is known as tomato stem borer and minor pest of Solanaceae family crops.[70]

TECIA SOLANIVORA

Figure 11 Guatemala Potato Tuber Moth (GPTM); Courtesy: James Hayden, Microlepidoptera on Solanaceae, USDA APHIS PPQ, Bugwood.org

SPREAD

Tecia solanivora, commonly known as the Guatemalan Tuber Moth (GPTM) possibly has its origin but it is now endemic in Central America. Its unintentional shift to Venezuela and further invasion of Ecuador and Colombia in 1983, ended at Canary Islands. Now it is considered one of the dangerous pests of southern Europe.[70]

HOSTING

It is a monophagous pest and attacks only potatoes. GPTM exclusively feed on potato tubers during cultivation and storage. Larvae bore galleries in the tuber and when larvae leave one can witness a clear whole in the tuber. The attack occurs from tuberization to harvest.

INFESTATION

The infested crop develops a bitter taste and hence unsuitable for human and animal consumption.[70]

Figure 12 Potato Tuber Loss; Coutesy: Henry Juarez, International Potato Center, Bugwood.org

PRODUCTION LOSS

A complete loss of harvested potatoes is observed in areas where the farmers were not aware of the pest and without any treatment the storage may have complete loss of the stock depending on the temperature and storage period.[70]

PREVENTION AND CONTROL

The potato tuber moth control should be taken into fields as well as at the storage facilities. IPM is recommended both in the field and the stores. The control of *T. solanivora* is one of the most difficult as its larvae remains inside the tuber and hard to reach for any kind of treatment.[70,72]

MONITORING WITH PHEROMONE TRAPS

For the above-mentioned potato tuber moths, sexual pheromones have been synthesized to be used for monitoring the flight activity of the adult male population in the field and stores. For all three potato tuber moth species sexual pheromones have been identified and synthesized. The pheromone traps are used to detect the flight activity of the male population of these moths both in the field and the store to take earlier suitable control measures.[70]

CULTURAL PRACTICES

Common cultural practices for these potato tuber moths are using infestation and pest-free seeds, deep planting, irrigation at regular intervals to avoid soil cracks, high hilling, timely harvesting and not leaving the tubers exposed in the field for longer periods after harvesting, not leaving the harvested potatoes for night in the field. Removal of leftover potato tubers from the field is also important along with cultivating varieties that mature earlier to reduce the risk of infestation.[70]

BIOLOGICAL CONTROL

Traditional biological control has proved an effective strategy in areas where the pests are introduced unintentionally to keep the pest population below the economic threshold. Biological control include the use of species Copidosoma, Apanteles subandinus and Orgilus lepidus.[70,74]

BIOPESTICIDES

Two bio pesticides are tested for field control of P. operculella ; *Bacillus thuringiensis* subsp. *kurstaki* (*Btk*) and *Phop*GV (granulovirus specific for P. operculella). Btk is found effective with repeated applications, however, it is degraded due to ultraviolet light. *Phop*GV have shown mixed results. Use of *Phop*GV to gain more than 95% mortality rate is not economical and hence lower doses are recommended for mitigating field population which are relatively inexpensive.[75]

ATTRACT-AND-KILL

Attract-and-kill approach is useful in controlling both *P.operculella* and *S. tangolias* in fields and storage facilities. It is a co-formulation of pest-specific sexual pheromone and insecticide for attracting the male moths and killing them as they get contacted with the product. The special applicator for this purpose is a handheld devise using 100 µL droplet size. The application is 2500 droplets per hectare. The application of this approach reduces the number of male population and their offspring. Resultantly, the damage from larvae is minimized. This specific pest control approach is harmless for humans, environment and the natural enemies of the moth.[76,77]

CHEMICAL CONTROL

In order to reduce potato tuber moths and minimizing economic damage, broad spectrum insecticides are used but these have their negative effects including resistance of the pests to different active ingredients of the insecticides and causing human and environmental damages.[68]

INTEGRATED PEST MANAGEMENT

A wide range of integrated pest management (IPM) approaches have been developed and used successfully in areas where the pest is economically important for the agroecosystem of the area. However, potato being a vulnerable crop needs to adopt a system approach to deal with all economically important pests, which means there should be effective IPMs to reduce or eliminate the pests with the minimum use of insecticides.[72]

STORAGE MANAGEMENT

The infestation of potato tuber moth is observed frequently in rustic store managed by potato farmers in developing countries. The situation becomes more challenging when the temperature rises making it suitable for rapid population growth of potato moths and when these facilities are used for a longer time. It is recommended that storage facilities should be properly cleaned before storing the potatoes. Netting at storage facility windows would provide protection against invasion of adult moths entering the facility. Secondly, only healthy potatoes should be chosen for storage. Thirdly, the infested potatoes should be destroyed, however, the initial detection is difficult. Fourthly, sex-pheromone and funnel traps should be used to monitor the moth activity. In areas where presence of potato moth is confirmed, the potatoes should be stored after treatments.[68]

BIOPESTICIDES

Btk and PhopGV based bio pesticides are used in stores for moth controlling. The microbial are used through inert materials such as talcum and are dusted over potatoes for storage. Areas where all three moths are present, the use of Btk is recommended as PhopGV is effective only for *P. operculella.* Secondly, Btk is available on commercial basis and is easy to use with inert materials such as talcum, calcium carbonate and kaolin without requiring any active biologicals.[78]

ATTRACT-AND-KILL

As mentioned above, the attract-and-kill approach can be effectively used in the storage facilities applying one drop per quarter meter discharge of the storage area to reduce the male population of the moth in the stores.[76]

CHEMICAL CONTROL

WHO recommended class II Malathion dust is being used in stores in developing countries where precautions are needed in the use as potatoes are stored in the living areas. Btk however has proved more effective than any other approach.[68]

PEA LEAFMINER FLY

LIRIOMYZA HUIDOBRENSIS

Figure 13 Liriomyza huidobrensis: Courtesy: Central Science Laboratory

SPREAD

Pea leafminer , endemic to South America has been found in several other countries of the world since early 80s presumably due to trade of ornamental plants in the world.[79]

HOSTING

It is a polyphagous pest and is found on 14 families of plants including potato, tomato, peas, beans, lettuce, pepper, spinach and alfalfa along with several other weeds and ornamental plants.[80]

INFESTATION

L. huidobrensis damages the foliage of the plant by puncturing the surface. It feeds on leaf tissue and lays eggs. Newly born larvae enters the leaf to feed on mesophyll, the chloroplast-rich element. As the larvae grow the serpentine mine increases in diameter. It remains closer to the midrib and hence infested leaf tissues become brownish and give the sight of a burned crop.[81]

FIGURE 14 LEAFMINER INFESTATION; COURTSEY: MERLE SHEPARD, GERALD R.CARNER, AND P.A.C OOI, INSECTS AND THEIR NATURAL ENEMIES ASSOCIATED WITH VEGETABLES AND SOYBEAN IN SOUTHEAST ASIA, BUGWOOD.ORG

PRODUCTION LOSS

It is a serious pest throughout the world of arable crops, ornamental plants and vegetables in field as well as glasshouse conditions. The infestation reduces the photosynthesis and leaf starts wilting damaging up to 100% of the crop. The crop losses are reported in countries like Argentina, Chile and Indonesia. However, the reported loss is different for different potato varieties.[81]

PREVENTION & CONTROL

Integrated Pest Management Approaches (IPMs) for sound ecological and economical control of the fly gives best results. IPM approaches conserve natural enemies, use cultural practices, low-toxic insecticides to provide the desired results.[72,79,82]

PEST POPULATIONS MONITORING

Having a count of leafminer flies captured in sticky traps help in monitoring the fly activity and counting of larvae from plant's top, middle and bottom parts help in monitoring larvae infestation. An action threshold (AT) needs to be developed to avoid excessive use of insecticides. Action threshold can be defined as the point from where the control measures should be started before the population of the moth reaches the economic injury level (EIL). The use of insecticides as a preemptive measure is not justifiable unless the foliage injury reaches or surpasses the AT point.[81]

CROP MANAGEMENT

Healthy and vigorous potato plants tolerate the leafminer fly damages better in the vegetative growth phase. The excess of use of nitrogen based fertilizers help in growth of leafminer flies, hence, the use balanced N-fertilizers is recommended. Secondly, the continuous plantation of host crops help in developing leafminer population, the rotation with non-host crops is recommended to avoid abundance of leafminer flies.[68]

CONSERVATION OF BENEFICIAL INSECTS

Predators and parasitoids help in controlling leafminer flies. The strategies for conserving the beneficial insects through diversified cropping, floristic diversity, weed management and lesser use of broad spectrum insecticides is recommended.[79]

TRADITIONAL BIOLOGICAL CONTROL

In areas where leafminer fly has reached accidently introducing natural enemies of the fly can be a useful strategy to keep the population below the economic threshold. Introduction of endoparasitoids such as *Pteromalidae, Eulophidae, and Braconidae* is proved successful in high, low and middle altitudes in Kenya.[79] However, biocontrol should be accompanied by additional measures integrating them into a single holistic integrated pest management strategy for all vegetables to control the main pests of the ecological system.[79]

ENTOMOPATHOGENIC NEMATODES

The entomopathogenic nematode Heterorhabditis indica has proved beneficial by causing around 58% leafminer larvae mortality at potato leaves and hence is seen as a biocontrol-compatible control measure to be included in the IPM strategies for potatoes and other vegetables.[81,83]

PHYSICAL CONTROL

Leafminer flies are attracted toward yellow colour. Using mobile stick traps of one by four meters fixed at tractors or hand-held can be moved across the field to attract the adult leafminer flies. Second approach could be use of stationary fifty by fifty centimeter yellow sticky traps installing around 60 to 80 traps per hectare. Research has found that physical control is cost effective than chemical control.[79]

CHEMICAL CONTROL

The use of insecticides should follow the results of monitoring activity of physical control if the pest population reaches the economic injury threshold. Use of systematic insecticide can effectively reduce the leafminer larvae. The use of abamectin and cyromazine is recommended in insecticides.[79]

INTEGRATED PEST MANAGEMENT

An integrated pest management strategy including the treatment of potato seeds, action threshold, traps, and insecticides has shown greater efficacy than use of insecticides. It is observed that use of IPM approach may be 56% more effective than using conventional crop management methods. IPM is also observed decreasing environmental effect by around 70% and fetch 35% more marketable potato yield than by use of conventional methods.[84]

It is relevant to mention here that leafminer fly is a polyphagous pest and asks for adopting such an IPM approach which may target leafminer flies as well as other economic pests of potato.[49]

ANDEAN POTATO WEEVILS

There are at least 14 species of Andean potato weevil complex. Twelve of these species fall in genus Premnotrypes and two fall in the genus Rhigopsidiu, Phyrdenus. The important of these weevils attacking potato crops are *Premnotrypes vorax*, *P. latithorax* and *P.suturicallus*.Premnotrypes species show the characteristic of sexual dimorphism which means the females in the specie are larger than males. Females are 6.8 cm to 8.0 cm whereas males are 5.6 cm to 7.5 cm.[85–87]

FIGURE 15 PREMNOTRYPES VORAX; COURTESY: NATASHA WRIGHT, COOK'S PEST CONTROL, BUGWOOD.ORG

Figure 16 P. latithorax: Courtesy: Plantwise

Figure 17 P.suturicallus; Courtesy: K.V. Raman, CIP, Lima (PE), Bugwood.org

SPREAD

The origin of Andean potato weevils is suggested in Andean region 2800 meter above sea level from Argentina to Venezuela spreading a territory of around 5000 km long.[85–87]

HOSTING

Native and wild potato species in Andean region are host to Andean potato weevil.[85–87]

INFESTATION

The beetle causes damages to potato crop in larval as well as adult stages. Adult weevils feed on leaves starting from the corners of the leaves and making semicircles. In case of higher population density of beetles, the leaves are eaten up to central leaf vein. Not only this, Andean potato weevil can also damage the tubers and stolon during their development period. The larvae make characteristic tunnels in tubers filling them with excreta.[85–87]

PRODUCTION LOSS

The pest causes serious product losses to the Andean farmers even to the extent of threatening their food security. With the use of insecticides, the losses range from 16 to 45%. If the beetle is left uncontrolled, the losses may reach up to 80 to 100%.[72]

FIGURE 18 DAMAGE TO POTATO TUBERS BY LARVAE OF PREMNOTRYPES SP.; COURTESY: K.V. RAMAN, CIP, LIMA (PE), BUGWOOD.ORG

PREVENTION & CONTROL[72,85,88]

CULTURAL CONTROL

The fields of potato crops previously infested are the main source of infestation. In this case community rotation system at a distance of around 1 kilometer is recommended. No plantation should be carried out for consecutive two seasons and it is better if the field rests for three to five years. The best alternatives for cultivation are barley and beans. Eliminating the infested plants should be practices. Harvesting crops earlier is also helpful along with leaving pigs and sheep in the harvested fields.[86]

MECHANICAL CONTROL

The method of shaking the plants at night and collect the adult beetles in buckets is also recommended for infested fields.[86]

PHYSICAL BARRIERS

In this method, plastic barriers are placed around field to preventing the adult weevils entering the potato fields. It is suggested that such barriers should be placed before the plantation to save the crop from adult beetles. The use of plastic barriers have proved more effective than applying insecticides.[86]

PLANT BARRIERS

Plant barriers are also recommended method for preventing the weevils entering into potato field. The recommended plants are *Lupinus mutabilis(Local name: Tarwi or tarhui), and Tropaeolum tuberosum (Local name: Masha/Anu/ Mascho).*[68]

CHEMICAL COTROL

Use of insecticides against potato weevil has not shown promising results and despite 2 to 3 applications, the farmers experience product losses.

NATURAL ENEMIES

Being native to Andeas, the potato weevil does not have specific parasitoids to deal with, however, predators such as carabids are widely used in Andeans areas to combat potato weevil. Other natural enemies of the weevil are entomopathogenic fungi, and nematodes.[72,88,89]

INTEGRATED PEST MANAGEMENT

Integrated pest management strategy consisting of using plast barriers, cultural practices and insecticides is recommended. In case of using plastic barriers, the farmers may need to apply insecticides one time. Lastly, potato crop rotation is recommended strategy.[72]

POTATO PSYLLID [redacted]

Figure 19 Bactericera cockerelli (tomato, potato psyllid); Courtesy: Whitney Cranshaw, Colorado State University, Bugwood.org

SPREAD

Bactericera cockerelli, the potato psyllid has its origin in North America, especially in Great Plains from Colorado to Utah. Its presence is also witnessed in Mexico, Nicaragua, Honduras and Guatemala. It is presence is also observed in New Zealand after an accidental introduction in the country.[90,91] *Bactericera cockerelli*, the potato psyllid has its origin in North America, especially in Great Plains from Colorado to Utah. Its presence is also witnessed in Mexico, Nicaragua, Honduras and Guatemala. Its presence is also observed in New Zealand after an accidental introduction in the country.[90,91]

HOSTING

The presence of *B. cockerelli* is primarily witnessed on the plants of Solanaceae family. It develops on a range of weedy plants including potato, eggplant, tomato, and tobacco and also on non-crop species of Solanaceae including ground cherry and matrimony vine.[90,91]

INFESTATION

Figure 20 Damage to the foliage of a potato plant, caused by the potato psyllid (Bactericera cockerelli); Courtesy: Eugene E. Nelson, Bugwood.org

The adults and nymphs suck the sap from the plants and inject injurious substances to the plant cell. Consequently, the production of Chlorophyll is interrupted and leaves become yellowish and develop stuntedness. The condition of the crop is known as psyllid yellows. Other infestations include transmission of bacterium Candidatus liberibacter solanacearum (psyllaurous) which is found causing infectious diseases such as permanent tomato (PT), zebra chip and potato purple top (PM). Potato zebra chip causes yellowing of foliage, leaf scorching, shortened internodes, small size of tuber and early death of plant. In the ground, zebra chip cause stolons collapse and browing of vascular tissues. The tubers when fried show a dark brown streak from where the disease got its name zebra chip.[91,92] The adults and nymphs suck the sap from the plants and inject injurious substances to the plant cell. Consequently, the production of Chlorophyll is interrupted and leaves become yellowish and develop stuntedness. The condition of the crop is known as psyllid yellows. Other infestations include transmission of bacterium Candidatus liberibacter solanacearum (psyllaurous) which is found causing infectious diseases such as permanent tomato (PT), zebra chip and potato purple top (PM). Potato zebra chip causes yellowing of foliage, leaf scorching, shortened internodes, small size of tuber and early death of plant. In the ground, zebra chip cause stolons collapse and browning of vascular tissues. The tubers when fried show a dark brown streak from where the disease got its name zebra chip.[91,92]

PRODUCTION LOSS

Potato zebra chip causes millions of dollars of product loss in potato sector. The major symptom is the presence of dark strips in French fries and potato chips which makes them unmarketable for processed foods. The research has determined that *C.liberibacter* spreads quite rapidly and a singly psyllid in a plant can spread up to potato tuber within six hours. Hence, its control becomes challenging for controlling and preventing potato zebra chip transmission. The presence of few psyllids in few plants can result in spreading the diseases in the field or region in a very short time.[91]

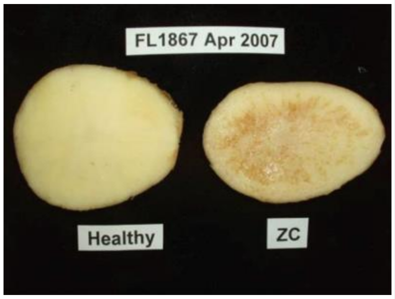


Figure 22 Freshly cut potato chips infestation

Figure 23 Zebra Chips infestation in fried potatoes

PREVENTION & CONTROL

PEST POPULATION MONITORING

To minimize the production losses, it is imperative to manage this insect early in the season to avoid reproduction of the psyllid in the field. For eggs and nymphs, the visual examination of the foliage is important. For adults, yellow traps are helpful if installed in the beginning of the season to monitor the immigrant population of the insect. Even the low population density in the beginning of the season can cause substantial production losses.[93–95]

PLANT RESISTANCE

While the most effective strategy for managing zebra chip disease would be using plants that are poses resistance to psyllid and discourage vector feeding, however, until now, no such potato variety has been developed which could tolerate or show significant tolerance to zebra chip.[68]

BIOLOGICAL CONTROL

There are several predators and parasites for *B. cockerelli* such as *Lecanicillium muscarium* , *Isaria fumosorosea* and *Beauveria bassiana* though a very little documentation is present on the effectiveness of the use of this biological control measure.[96]

CHEMICAL CONTROL

Use of insecticides or translaminar activities are found effective as the insect is mainly found on the underside of the potato leaf. However, the selection of insecticides is important as several generation of same ingredients overlap. Secondly, the insecticides should be selected according to the life stage of the insect.[68]

INTEGRATED PEST MANAGEMENT

B. cockerelli has been associated with Candidatus liberibacter solanacearum which makes it challenging for devising an effective IPM strategy. There are however several components suggested for IPM including cultural, chemical and biological controls. In New Zealand, the farmers have adopted strategies like careful monitoring of the pest invasion, application of insecticides with alternative chemicals, vector monitoring and sampling and developing action thresholds for treatment throughout the season.[97]

BUD MIDGE

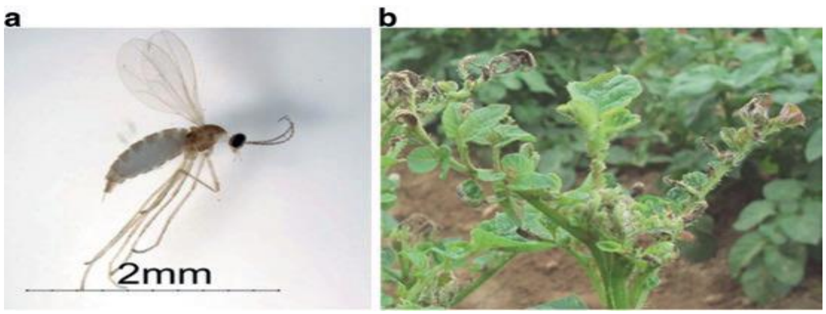


Figure 24 Prodiplosis longifila adult (a), larvae (b) and damage on potato sprouts (b). (Photo credits:CIP

SPREAD

Prodiplosis longifila, is a polyphagous specie found in Americas only. Its origin is still unknown. It was first reported in 1934 in Florida and then in Virginia in 1990 and rest of the South America in the countries of Peru, Colombia and Ecuador. Research has also mentioned its presence in West Indies which is later on declared as a misidentification.[98]

HOSTING

The polyphagous specie P.longifila has been found in several plant species. The economic damage is reported in potato, pepper, tomato, asparagus, onion, watermelon, melon, cucumber, artichoke, soybean, alfalfa, and grapes. The presence of P.longifila has not yet been resolved suggesting that it may belong to another species.[98]

INFESTATION

Though small in size, *P.longifila* is extremely dangerous pest under warm climatic conditions. The larvae pass through three stages which cause damage to buds and flowers of several above mentioned crops. The larvae pierce the epidermal tissues of the plant by mouth distorting growth points. Resultantly, the stem is becomes wounded and blackish in appearance, causing a low quality fruit.[98,99]

PRODUCTION LOSS

P. longifila has its economic importance for Solanaceae crops including potatoes and other vegetables as mentioned above and can cause production loss up to 50%. If the pest is not controlled it affects flowers, fruits, and buds in open field as well as crops in greenhouses. Its control during first 50 days of the crop is important as it eats up the terminal and lateral buds. If left untreated, the pest however does not affect the flowers of potato. In areas of higher temperatures, the population of the pest increases rapidly causing substantial damage to the crop.[98,99]

PREVENTION & CONTROL

CROP MANAGEMENT

The larvae and eggs of *P.longifila* are not visible with the naked eyes as they are protected under the calyx. The best way of getting rid of these larvae and eggs is to develop strategies that help in early and healthy potato plant growth with the use of suitable fertilizers, healthy seeds, proper irrigation. These factors would help in exposing eggs and larvae to dehydration and natural enemies of the pest. Other factors of crop management include maximum planting density, making of furrows from east to west to maximize isolation, and management of broadleaf weeds.[84]

SEED TREATMENT

The use of systemic insecticide is recommended to protect newly formed buds from being affected by initial bud midge infestation before the formation of first leaves and stems. It is a critical practice as it ensures the protection of the plant form 35 critical days. It also does not affect the natural enemies of the pest.[84]

CHEMICAL CONTROL

The chemical control approach recommended for *P.longifila* consist of;

- Spreading Sulphur on the initial plants to reduce the chances of early infestation.
- Using translaminar
- Spraying dry powder based insecticides in the soil
- Use of different active ingredients like dimethoate, chlorpyrifos, imidacloprid etc.[68]

BIOLOGICAL CONTROL

The most suitable biological control for this pest is introducing Synopeas parasitoids. Other important predators for larvae and pupa are *Chrysoperla asoralis, Nabis capsiformis , Methacantus tenellus.*[99]

PESTS OF TEMPERATE REGIONS [redacted]

COLORADO POTATO BEETLE

Figure 25 Colorado Potato Beetle

Colorado potato beetle, Leptinotarsa decemlineata has its origin in Mexico. The beetle has spread to Central America, a larger part of the United States, Europe and even few regions of Asia.[100,101]

HOSTING

Being an oligophagous specie, Colorado potato beetle feeds on several plants of Solanaceae family. These plants include eggplants and tomato along with potato.[102]

INFESTATION

Colorado potato beetle adults and larvae are insatiable potato foliage eaters and are able to eat the complete foliage. In some cases, potato tubers which are exposed to earth are also eaten by them. What is left of stem and leaves is a sticky black exreta.[68]

Figure 26 Colorado Potato Beetle feeding on potato foliage

PRODUCTION LOSS

L. decemlineata has its economic importance in potato sector. As the beetle eats up the foliage, the potato tuber yield is reduced even up to 100% in some cases. The losses are more devastating if the beetle is in the instar larvae stage, which is the most voracious stage for eating up the foliage. This has become a challenge for farmers in the regions of their presence and they spent millions of dollars on insecticides for controlling them.[100,101]

PREVENTION & CONTROL

IPM

Integrated Pest Management (IPM) strategies against this beetle includes adopting control measures to reduce the insect pest population through crop rotation, changing the time of plantation to avoid the crop during its vulnerable stages. Application of *B.thuringiensis* and other relevant insecticides are found useful when the crop reaches the economic injury level. The IPM also includes developing biological control measures to minimize the pest population.[100,101,103]

SAMPLING

To find the beetle the entire plant of potato should be examined for sampling as beetle has characteristically different life stages. The adult beetles are attracted to yellow color and hence use of yellow-colored traps can help in capturing the beetles.[68]

CULTRUAL CONTROL

Cultural controls include crop rotation. A distance of around half kilometer among potato fields is recommended for having protection against beetles. Initially the beetle reaches other fields through walking and hence use of trenches and crop rotation can help in controlling the beetle population.[102]

BIOLOGICAL CONTROL

Colorado potato beetle has several natural enemies but they are unable to reduce the beetle population before the economic injury level. However, tachinid fly (Myiopharus doryphorae) gives higher parasitism rates when applied early in the season to prevent the beetle from becoming a serious economic threat. The entomopathogenic nematode Steinernema feltia and Beauveria bassiana provide some control at different stages of the pest development.[102]

BIOPESTICIDES

Different bio pesticides including abamectins, tenebrionis and spinosins has shown excellent results against this pest at its different stages of life.[68]

CHEMICAL CONTROL

The most common control measure against Colorado potato beetle is chemical control. However, this pest has shown a rapidly increased resistance against pesticides to the extent that there were 51 compounds failings in 10 chemical groups using 8 modes of action.[102]

EUROPEAN CORN BORER

Figure 27 European Corn Borer; Courtesy: insectimages.org

ORIGIN & SPREAD

European corn borer (Ostrinia nubilalis) has its origin in Europe. The pest was introduced to America in 1917 and gradually spread to the United States and Canada and then to Asia including China and India, Middle East including Syria and Israel, North Africa including Algeria and Egypt.[104]

HOSTING

It is primarily a pest of maize but being a polyphagous, it feeds on at least 17 families which include potato, pepper, celery, tomato, hop, oat, beans, millet, apple, and peach and other ornamental plants and weeds such as mugwort, pigweed, and hollyhock and several others.[68,104]

INFESTATION

The obvious signs of infestation in potato is stem wilt. The stem shows the entrance hole from where the larvae enter the stem and expel excreta as they feed deep into the stem. Larval presence can be observed by cutting the stem. The tunnels in the leaf petioles by young larvae and main tunnel in the stem by the bigger and older larvae. The larval damage by European corn borer is often confused with other borers.[105]

PRODUCTION LOSS

The potato plants have higher degree of tolerance against this insect and even the large density of pest population does not affect the tuber yield significantly.[106] However, the varieties with weak stems may fall prey to this pest and show reduced yield. The weak stems after boring may break during rains, storms and heavy winds. Secondly, larvae presence may give way to other fungal and bacterial diseases such as Erwinia carotovora.[106]

PREVENTION & CONTROL

SAMPLING

Flight monitoring of adult moths is necessary to determine the timing when the field is at the economic injury point. Using sticky traps accompanied with strain-specific sex pheromone is useful for this purpose. Infestation at the beginning of crop has shown more drastic damages than later attacks. It is suggested that farmers should remain vigilant of the presence of this pest by scouting for eggs and instar larvae on leaves.[49,106]

CULTURAL CONTROL

The cultural control measure includes early planting, intercropping with non-host plants, field sanitation after the cropping season.[34]

CHEMICAL CONTROL

Killing European corn borer larvae is not difficult but the application of pesticides should be done before the larvae enter the stems. It is recommended that pesticide application should be carried out when 10% of the stems show tunnel activity.[107]

BIOLOGICAL CONTROL

Use of Btk (as mentioned above somewhere) is recommended for the first instar larvae alternatively, the commercially available parasitic wasps are used for biological control.[105]

GLOBAL PESTS

APHIDS [redacted]

The insects in superfamily Aphidoidea and order Hemiptera are commonly known as Aphids. Eventually nothing above or underground is safe from aphid attacks not even barks. The reasons for this spread is their fascinating biological features that make these small insects a great performer as phytophagous insects. The feeding and reproductive habits of aphids make them economically important insect of the agriculture sector throughout the world, especially in the temperate regions having the ability to transmit phytopathogenic viruses. They are polyphagous as well as monophagous.[108]

MYZUS PERSICAE

Figure 28 Myzus Persicae; Courtesy: [Jim Baker, North Carolina State University, Bugwood.org]()

ORIGIN & SPREAD

Myzus persicae, the green peach aphid presumably has its origin in China due to being associated overwintering host peach plant. It is now considered a cosmopolitan pest.*Myzu euphorbiae* (the potato aphid) has its origin in North America, but has spread to the temperate zones of Europe and Asia and now is found globally in all potato growing areas.[109]

HOSTING

Myzus persicae (green peach aphid) and *Myzu euphorbiae* (the potato aphid), both species are polyphagous and live and feed on hundreds of plants.[110]

INFESTATION

Figure 29 Green peach aphid infestation; Courtesy: Jim Baker, North Carolina State University, Bugwood.org

Aphids feed on potato leaf sap directly and indirectly they transmit several viral diseases. Directly, the aphids suck on sap and slow down the plant growth. Removal of sap from leaves and injection of toxic saliva makes potato leaves deform. Consequently, the tubers produced are low in quality. Excreta from aphids leaves a sooty black mold on potato leaves and stems which reduces the process of photosynthesis. Indirect damage include virus transmission to tubers such as potato leaf roll virus (PLRV).[109]

PRODUCT LOSS

Large population of aphids may cause heavy death of potato plants. As the attack of aphids in the field is clumped usually causing areas of dead plants called aphid holes in the field. This is however a quite uncommon phenomenon. In most of the cases, the aphids do not affect the yield directly. It is transmission of Potato leaf roll virus (PLRV) and potato virus Y (PVY) that reduce the potato yield in almost all of the potato growing areas.[109]

PREVENTION & CONTROL

BIOLOGICAL CONTROL [redacted]

Several natural enemies of aphids including predatory insects (lady beetle) and parasitic wasps have been proved an effective biological control agent against aphids. Orius spp., Nabis spp. And Geocoris spp., are other general predators that can be used against aphids. It is recommended that in areas with aphid attacks, growing flowering vegetation plants increases the population of aphid's natural enemies.[111]

Different fungi (Lecanicillium spp, Beauveria bassiana) also act as aphid's natural enemy and help in controlling its population if applied at the proper time. The use of fungi should be carried out at proper time keeping in view the fact that they are sensitive to different environmental conditions including humidity and temperature.[112]

BIOLOGICAL INSECTICIDES

The single or compound use of extracts of red chili (Capsicum annum L.), neem (Azadirachta indica A. Juss.) and garlic (Allium sativa L.) have been proved useful at the early stage of infestation.[102]

CULTURAL PRACTICES

Some cultural measures such as removal of weeds from the fields, using white plastic mulch and intercropping with coriander, garlic and onion has shown sufficient results against aphids. It is also recommended that even in the presence of a vast majority of aphids in the field, removal of infected plants also help in reducing aphid population.[102]

CHEMICAL CONTROL

The use of insecticides that have low effect on aphid's natural enemies and are particularly for homopterous, such as pymetrozine, flonicamid and spirotetramat have been suggested to be included in the IPM strategies. The use of broad spectrum pesticides is not recommended as it may harm natural enemies more than aphids and it may actually give way to rapid regrowth of aphids than their natural enemies. Green peach aphids have shown a high propensity of insecticide resistance. There are 69 active ingredient failures are reported so far that include several of commonly used chemicals.[102]

WHITEFLIES [redacted]

Throughout the world, whiteflies are considered an important economic pest that hosts on an array of agriculture commodities. There are confirmed 1556 species names of whiteflies exist in 161 genera in the world.[113] The most damaging of whiteflies are *Bemisia tabaci* (sweet potato fly) and Trialeurodes vaporariorum (the greenhouse whitefly). Their attacks are witnessed equally in open fields and greenhouses. Whiteflies have characteristic mouthparts that help them sucking the sap from leaves and excreting honeydew transmitting viruses and damaging the plant leaves and stems.[114]

BEMISIA TABACI & TRIALEURODES VAPORARIORUM

Figure 30 Whitefly Bemisia tabaci; Courtesy: W. Billen, Pflanzenbeschaustelle, Weil am Rhein, Bugwood.org

FIGURE 31 GREENHOUSE WHITEFLY TRIALEURODES VAPORARIORUM; COURTESY: W. BILLEN, PFLANZENBESCHAUSTELLE, WEIL AM RHEIN,

ORIGIN & SPREAD

Bemisia tabaci is more the pest of tropical and subtropical regions. Its presence in temperate habitats is not much prominent. *Trialeurodes vaporariorum* in the most probability has its origin in tropical and subtropical America presumably Mexico or Brazil. However, today, it has been considered a cosmopolitan pest that can be found in almost all zoogeographic regions of the world.[115]

HOSTING

B. tabaci originally known as tobacco whitefly, being a vigorous polyphagous insect, hosts not only on Solanaceae crops (tomato, potato, eggplant) but also wide range of other crops and vegetables. Other host crops and plants for *B.tabaci* include cotton, cucumber, cassava, sweet potato, melon and several other vegetables. *T.vaporariorum* is considered a pest of greenhouse plants since long to the extent that it has also named glasshouse whitefly. Both whiteflies are considered to have the heaviest interaction with tomato crops in open field as well as greenhouses. Though both whiteflies have almost same characteristics and host range, their association with tomato plants in the field and greenhouses has much observed. Both are considered as a virus vector and research has found that their polyphagous nature make them a dangerous not only for tomatoes but also potatoes and other vegetables.[116]

INFESTATION

FIGURE 32 WHITEFLY BEMISIA TABACI; COURTESY: DAVID RILEY, UNIVERSITY OF GEORGIA, BUGWOOD.ORG

The infestation of adult whiteflies is observable with naked eyes and one can find a host of whiteflies underside of the leaves. The whiteflies suck the sap from leaves which damages the leaves physiologically such as chlorosis of the newly born leaves. Whiteflies leave whitish spots on leaves which turned black with the passage of time. The blackish spots turn into black sooty mold that accumulates and necrosis develops at the corners of the leaves, resultantly some leaves curl upwards. The next stage of infestation is turning of necrotic into coalesce when the whole leaf becomes black and dried out. The honeydews excreted by whiteflies are sugar-rich which help in developing a sooty mold fungus on leaves and consequently hindering the process of photosynthesis. Whiteflies transmit a whole range of viruses into the plants and each virus has its own signs and symptoms. One of such examples is transmission of potato apical leaf curl virus (PALCV) which curls the potato leaves upward or downward. On the other hand, potato yellow vein virus (PYVV), makes the potato plant's veins yellowish and as the diseases grows, the veins get their normal colour green whereas leaves become yellow. The yield from such viruses may produce deformed potato tubers with quite large protruding eyes.[115]

PRODUCT LOSS

The direct and indirect damage from whiteflies is reported reducing the yield by 40% and more.[115,117]

PREVENTION AND CONTROL

MONITORING PEST POPULATIONS

Monitoring of whitefly pests are possible with naked eyes as well as using yellow sticky traps. It also helps in keeping record of the whitefly population increase or decrease over a period of time.[115]

BIOLOGICAL CONTROL

Though a lot of research has been done on the interaction of these whiteflies with potato and tomato crops, a very small number of natural enemies for these whiteflies are identified to date. Other biological controls include the use of different entromopathogenic fungi as biopesticides.[115]

CROP MANAGEMENT

Maize plants are identified as the crop or trap crop for controlling the population of whiteflies and enhancing the development of biological control agents.[115]

PHYSICAL CONTROL

Whiteflies are attracted towards yellow. It is recommended that sticky yellow traps should be installed around the field to capture the migrant adult whiteflies. The use of yellow sticky traps has shown effective results in potato field.[81,88]

CHEMICAL CONTROL

The use of broad spectrum insecticide is not recommended as it affects the natural enemies of whiteflies. Buprofezin has shown high efficacy of more than 90% in controlling the whitefly population when in immature stage. Use of potassium soaps is also recommended. It is recommend that action threshold (AT) should be developed such as three nymphs per leaf of the plant.[88]

LADYBIRD BEETLES

Ladybird beetles are from Coccinellidae family of insect order Coleoptera, which has six subfamilies; Epilachninae, Coccinellinae, Scymninae, Sticholotidinae, Chilocorinae and Coccidulinae.The holomatabolous insects go through five stages for their lifecycle; eggs, larvae, prepupa, pupa and adult. Todate around 6000 species of family Coccinellidae have been recorded. The children are more interested in ladybirds for their colour. They are natural enemies of several acarine pests and insects. Of this family, Epilachninae is the most phytophagous.[118]

HENOSEPILACHNA VIGINTIOCTOMACULATA & HENOSEPILACHNA VIGINTIOCTOPUNCTATA [redacted]

Ladybird beetles, *H. vigintioctomaculata* and *H. vigintioctopunctata* are morphologically similar phytophagous beetles that a[illegible] beelte, even 28-spotted ladybird beetle. Of these two species, *H. vigintioctomaculata* is commonly found in temperate zones of Russia, Korea, Japan, China and Asia. The range of their interaction with potatoes overlaps especially in China. *H. vigintioctomaculata* is fond of warmer climates hand hence its spread in countries in Southeast Asia such as Pakistan and India is more visible. The beetle is even introduced to New Zealand, Australia and several other Pacific Ocean islands.[119–121] Ladybird beetles, *H. vigintioctomaculata* and *H. vigintioctopunctata* are morphologically similar phytophagous beetles that are commonly known as potato ladybird or hadda beelte, even 28-spotted ladybird beetle. Of these two species, *H. vigintioctomaculata* are commonly found in temperate zones of Russia, Korea, Japan, China and Asia. The range of their interaction with potatoes overlaps especially in China. *H. vigintioctomaculata* is fond of warmer climates hence its spread in countries in Southeast Asia such as Pakistan and India is more visible. The beetle is even introduced to New Zealand, Australia and several other Pacific Ocean islands.[119–121]

FIGURE 33 28-SPOTTED LADYBIRD (HENOSEPILACHNA VIGINTIOCTOPUNCTATA); COURTESY: MERLE SHEPARD, GERALD R.CARNER, AND P.A.C OOI,

HOSTING

Potato ladybirds are polyphagous species that have been found on an array of plant species but they cause the most damage to the crops in Solanaceae family such as potato.[121]

INFESTATION

Potato ladybird larvae and adults feed on potato foliage to the extent of complete defoliation and resultantly death of the plant in case of severe infestation. Larvae start feeding on lower side of the potato leaf eating up lower epidermis and mesophyll leaving behind the higher epidermis and thicker veins uaffected.[121,122] The leaves in the absence of mesophyll dry and died. The infestation may also facilitate the infection by Botrytis cinerea.[49]

PRODUCT LOSS

Potato ladybirds are serious potato pests which can cause yield losses up to 10 to 15% during normal years. Higher yield losses of around 20 to 30% are reported in case of heavy infestation and even complete destruction in case of severe infestation.[122]

MOTHODS OF PREVENTION

PEST POPULATION MONITORING

Ladybirds have conspicuous life stages. The aposematic coloration of ladybirds makes these life stages easily detectable through naked eye. Ladybirds usually lay eggs on lower surface of leaf in a cluster of 20 to 30. In this case, turning the scouted leaves upside down.[123]

BIOLGOICAL CONTROL

Crawford (Pediobius feveolatus) is the best option for parasitizing. It kills around 50 to 60% ladybird population. Reducing the economic loss lower than the economic injury level. These rates should not be taken as granted and a continuous pest monitoring is necessary.[123]

CROP MANAGEMENT

Removal and destruction of postharvest residue leaves ladybirds without food and thus increasing their mortality rate dramatically.[121,122]

PHYSICAL CONTROL

It is recommended that ladybirds in small potato farms should be destroyed manually. This approach is also recommended for the reason that it prefers overwintering sites away from potato fields. The phototactic nature of ladybirds make them attract towards light and hence use of light traps is useful (zhou). However, this approach should be used carefully as some other species of enemy pests also are attracted towards light and get killed by this strategy.[121]

BIOLOGICAL INSECTICIDES

In biological control strategy, botanical products such as azadirachtin has shown strong efficacy against ladybirds.[124] Other entomopathogenic fugi include Beauveria bassiana, Metarrhizium anisopliae and Bacillus thuringiensis.[125]

CHEMICAL CONTROL

Common broad spectrum insecticides are effective against ladybirds and to date it is the most common approach for controlling ladybird infestation.[121]

GLOBAL PRESENCE OF MINOR PESTS

CUTWORMS

[redacted]

Figure 35 black cutworm (Agrotis ipsilon) arva; Courtesy: [James Kalisch, University of Nebraska,](#)

Figure 34 black cutworm (Agrotis ipsilon) adult; Courtesy: [James Kalisch, University of Nebraska, Bugwood.org](#)

Cutworms are the larvae of a host of noctuid moths. The origin of cutworms is uncertain but it was first detected in Austria back in 1766. Of these cutworms, black cutworms (*Agrotis ipsilon*), turnip moth (*Agrotis segetum*) and variegated cutworm (*Peridroma saucia*) are the most widely spread.[98]

Being polyphagous, cutworms attack almost all vegetable crops and few cereals. The common vegetables affected by cutworms are alfalfa, cotton, sugarr beet, strawberry, rice, maize, tomato and potato.

During daytime, the cutworm larvae remains in the soil and emerge in the night to feed on potato stem and leaves and sometimes tunneling through the potato stem causing stem damage. Ferocity of these cutworms is evident from the fact that a single larva can damage a host of potato plant in a single night. Failure in early detection may cause a damage of up to 100%. Use of white and yellow traps is useful in detecting the movement of moth and prediction of attack. The use of baited traps is also helpful in monitoring the larvae population.[126]

Deep tillage is suggested to expose larvae and pupae to the natural enemies. Weed control is another control measure. Proper hilling of the potato tubers also impedes access of larvae to the tubers. In small landholdings, hand picking of the larvae from the field early in the morning is also useful. Crop rotation and fallowing is also helpful especially with non-host crops such as onion, peppermint, coriander and bluegrass. Use of trap cropping such as cosmos and sunflower and killing the larvae on trap plants daily may also prove helpful. Use of neem plants and seeds is an effective bio-pesticide control as these plants and seeds are toxic to the larvae.[49,126]

Figure 36 southern armyworm (Spodoptera eridania) larva; Courtesy: Eddie McGriff, University of Georgia, Bugwood.org

Figure 37 southern armyworm (Spodoptera eridania); Courtesy: Central Science Laboratory, Harpenden , British Crown, Bugwood.org

Armyworms *(Spodoptera eridania)* have their spread in North, South and Central America, India and Africa. It is present on the EPPO A1 list of quarantine pests and occasionally is intercepted in Europe from the plant materials imported in Europe. *S. eridania*'s spread is found in central and south America, southern USA and the Caribbean, however, it has failed to establish in Europe. *Mamestra configurata* has its restriction to North America.[126]

Armyworms host on a wide variety of crops and are considered important economic pest of cereals but it is reportedly feed on potatoes in the absence of any primary host crops.[127] Armyworms are forage feeders. They feed on potato crop during the day and do not make burrows and have the capacity to migrate from other crops to potato fields. They reach to the exposed potato from soil cracks.[98]

The loss of up to 100% of defoliation of potato crop is reported in case of severe attacks. Suitable soil preparation is recommended to expose pupas to natural enemies. Spotted field infestation should be detected and destroyed. Use of toxic baits is also recommended.[49]

WIREWORMS

Figure 39 click beetles (Agriotes sp.); Courtesy: Metin GULESCI, Bugwood.org

FIGURE 38 CLICK BEETLE AGRIOTES LINEATUS; COURTESY: ERIC LAGASA, WASHINGTON STATE DEPARTMENT OF AGRICULTURE, BUGWOOD.ORG

The larvae of click beetles are wireworms and there are more than 39 species of wireworms in 21 genera. They reportedly attack potato crops. The spread of wireworm is cosmopolitan but with different specie presence in different regions. *Agriotes lineatus, A.sputator*, and *A.vobscurus* are mostly found in the UK, whereas the US has *A.lineatus*, *A.obscurus*. Though grass is the main host of wireworms, they also attack asparagus, sugar beet, carrots and potatos.[128]

Wireworms are the pests of temperate zones like Pakistan, there presence in warmer tropical areas is less recorded. The lustrous pest with thoracic legs lives underground. The larvae borrow deep in potato tubers making uncharacterized tunnels in potato tubers.[128]

Wireworms may feed on potato seeds but they also damage the tubers by tunneling into them and thus reducing yield quality. Pathogens enter these tunnels causing tuber rot. In the US, the damage is recorded up to 45% and hence a substantial economic loss.[49]

Avoiding potato growing in infested field is the first and foremost control. Use pheromone and bait traps to monitor the presence of insects. Plough based cultivation may also help in reducing wireworm population. Though no biological control against wireworms is identified so far, the use of *Metarhizium ansopliae*, an insect pathogenic fungus has shown effective results in experimental conditions.[129] The chemical control needs use of insecticides in soil at plating stage is effective.[130]

FLEA BEETLES

Figure 40 potato flea beetle (Epitrix cucumeris); Coutesy: Whitney Cranshaw, Colorado State University, Bugwood.org

Figure 41 tuber flea beetle (Epitrix tuberis) (different life stages);Coutesy: Art Cushman, USDA Systematics Entomology Laboratory, Bugwood.org

Epitrix spp. (Cloeoptera) genus has several beetles that feed on Solanaceae family plants. Two of these beetles; *Epitrix tuberis* and *Epitrix cucumeris* are common in North America, another pest Epitrix papa is damaging potato crops in Portugal and Spain.[72,131] The host range of these beetles consists of potato, tobacco, eggplant and tomato and other weeds of Solanaceae family. Being small in size, flea beetles easily jump into the foliage making characteristics circular holes. Larvae also cause damage to tubers, stolon and roots.[128] The flea beetles are considered serious pest endangering the whole EPPO region affecting foliage and photosynthesis and ultimately plant yield.[132] Cultural control includes crop rotation, removing of weeds and appropriate soil management. Several insecticides used for potato crops are also effective for flea beetles.[128]

WHITE GRUBS

Figure 43 white grubs, scarabs, scarab beetles;
Coutesy: Jim Baker, North Carolina State University, Bugwood.org

Figure 42 white grub; Courtesy: Alton N. Sparks, Jr., University of Georgia, Bugwood.org

White grubs, the worldwide phenomenon in family Scarabaeidae are found in several genera. White grubs being polyphagous feed on more than one thousand plant species including potato, maize, asparagus, soybean, and fruits such as apple, grapes, and peach. The host range also include ornamentals and trees. White grubs include *phyllophaga spp*, *popillia japonica*, *anomala spp*., *anomala orientalis, holotrichia oblita, temnorhynchus cronatus, brahmina coracea,* and *melolontha melolontha Linnaeus*.[133]

White grubs are the larvae of large beetles and damage the soil and then roots, underground stems, stolon and ultimately tubers. An earlier infestation may cause the plants drying up. The developed tubers come under attack and the larvae make large holes in them.[128]

The yield losses of white grubs are reported from 40 to 80% in India. The main reason for this huge damage is planting potatoes in areas of pastures and grazing fields which are preferred habitats of white grubs.[128,133] Cultural controls include deep tilling which exposes white grubs to environmental conditions and predatory vertebrates. As white grubs are fond of moist soils, draining potato fields properly helps in reducing the white grub population. Crop rotation is another effective control measure including planting of legumes, and Allium crops such as garlic and onions. Parasitic wasps of *Tiphia* genera including Myzinum, Pelecinus, and Pyrgota undata are seen as effective biological control measure. This pest is not easily controlable with insecticides. The developed larvae go deep into tubers after application of insecticides.[134]

MITES

[redacted]

FIGURE 45 TWOSPOTTED SPIDER MITE (TETRANYCHUS URTICAE); COURTESY: FRANK PEAIRS, COLORADO STATE UNIVERSITY, BUGWOOD.ORG

Figure 44 Two spotted spider mite (tetranychus evansi)

Tomato and tobacco red-spider mite *Tetranychus evansi* has its origin in Brazil. During it was introduced to South Africa in 1980. Other two spotted or red-spider mite *Tetranychus urticase* and *Polyphagotarsonemus latus* are found in tropical and subtropical regions of the world.[128,135] Mites are polyphagous in nature and host on range of plants including potato, eggplant, pepper, tobacco and tomato. Other fruits, vegetables and crops include watermelon, strawberry, citrus, cucumber, papaya, celery, cotton, maize and beans.[136] Tomato and tobacco red-spider mite *Tetranychus evansi* has its origin in Brazil. During in 1980, it was introduced to South Africa. Other two spotted or red-spider mite *Tetranychus urticase* and *Polyphagotarsonemus latus* are found in tropical and subtropical regions of the world.[128,135] Mites are polyphagous in nature and host on range of plants including potato, eggplant, pepper, tobacco and tomato. Other fruits, vegetables and crops include watermelon, strawberry, citrus, cucumber, papaya, celery, cotton, maize and beans.[136]

T. urticae and other mites are commonly known as red-spiders despite the fact that red in not their characteristic colour. These mites are very small and hardly visible by naked eyes. They feed on cellular material of leaves giving them tan coloring and ultimately wilting the plants. Leaves under attack of *P.latus* become tender and deformed. Whole colonies of white mites are found underside the young leaves. The mite infested plants become moderately green in colour and show leathery appearance, causing death of the plant. The infected plants remain small in size and do not produce tubers. Severe infestation destroys the whole field reducing the photosynthesis activity of the plant.

The attack of mites begins at the boundaries of potato fields from the adjacent host plants such as alfalfa, maize and mint. Mites are able to multiply rapidly in hot weather above 30°C during hot seasons.[135] Sprinkle irrigation is one of the cultural control methods increasing humidity on the plant leaves forcing mites to migrate. Secondly, proper sanitation and removal of infected plant is helpful along with cultivating volunteer crops.[135]

The natural enemies of mites including thrips, gall midges, ladybird beetles and lacewings keep the mite population under control.[136] When the use of pesticides kill natural enemies, mites become the primary pests in the field. The plants extracts of garlic, clover cotton and neem seeds are used as biopesticides.[135] In low population use of a single application of an acaridae is sufficient. Other treatments include soap, Sulphur and spirotetramat.[136]

THRIPS

Figure 46 onion thrips (Thrips tabaci); Courtesy: Alton N. Sparks, Jr., University of Georgia, Bugwood.org

Figure 47 western flower thrips (Frankliniella occidentalis); Courtesy: P.M.J. Ramakers, Applied Plant Research , Bugwood.org

Originated in western North America, *Frankliniella occidentalis*, the western flower thrips is now a cosmopolitan pest. *Thrips tabaci*, presumably has its origin in Mediterranean region but now is found on all continents of the world except Antarctica.

F. occidentalis has a wide range of host plants of more than 200 in around 50 genera including fruits, vegetables and ornaments. The attack of *F.occidentalis* causes damage to the potato leaves. The infested leaves develop chlorotic dots and ultimately become deformed. The chlorotic colour is due to emptying of the leave cells.[128,137]

Thrips are minor potato pests. Few of the thrips species are tomato spotted wilt virus (TSWV) vectors and F.occidentalis is the most important virus vector as it reduces the yield and tuber quality substantially.[138]

Thrips host on a wide variety of plants and weeds and from there it invades potato crops. Hence, weed control is considered a good crop management strategy and cultural control measure. To avoid thrips attack on potato crops, plantation of susceptible crops such as onion, corn, artichoke, pumpkin and tomato next to potato crops should be avoided. The removal of potato plants showing signs of TSWV should be removed immediately.[128,137,138]

Use of yellow and blue sticky traps is suggested to monitor the thrips population. Species of genus Orius are an effective biological control against thrips.[138]

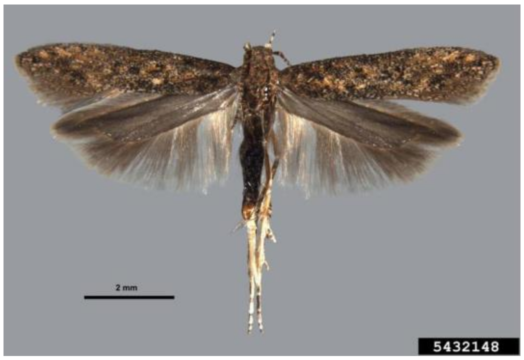


Figure 48 tomato leafminer (Tuta absoluta); Courtesy: Sangmi Lee, Hasbrouck Insect Collection, Arizona State University, Bugwood.org

Tuta absoluta, the tomato leaf miner was first found in Peru in 1917 around 3200 meter above sea level. Its presence is recorded in all South America Countries. In 2006, it was seen in Spain and from Spain to other European countries and recently in Asia and Africa.[139,140]

Tuta absoluta has a wide range of host plants in Solanaceae family including potato, tomato, eggplant, tobacco and cucumber. Its attack on potato is on aerial part and it seldom attacks tubers. Larvae feed on foliage eating mesophyll building tunnels in the leaf. As the larvae grow so grow the mines. After the plant foliage dries or withers, the larvae moves to other parts of the plant.[128]

Tuta absoluta is basically fond of tomato and is considered a major pest of tomato plants but it also attacks potato. The damage by larval activity on leaves and shoots results in low tuber production. The larval damage is accentuated in young plants during tuberization phase. Though the changes of tuber infestation from *Tuta absoluta* are slim, the heavy infestation may cause considerable loss at the last stage of the potato crop.[128]

Early detection and monitoring of *Tuta absoluta* is possible through pheromone traps. Pheromone traps can also be used for reducing moth population by deploying higher number of traps. One trap per hectare is generally recommended.[141]

The cultural practices against *T. absoluta* are crop rotation, especially with non-solanaceous crops, proper irrigation and fertilizing, removal of plants from previous season and regular ploughing. Trichogrammatidae, and Nesidiocoris tenuis are natural enemies of eggs and larvae of T.absoluta. Biological and chemical controls can reduce the damage by 49%. Neem oil is a systematic insecticide for *T.absoluta* and its first and second stage larvae. The use of broad spectrum chemical is not recommended as *T.absoluta* is well known for developing resistance against insecticides.[141]

POTATO LEAFHOPPERS [redacted]

Figure 49 potato leafhopper (Empoasca fabae); Courtesy: Steve L. Brown, University of Georgia, Bugwood.org

The member of leafhopper family Cicadellidae, potato leafhopper (*Empoasca fabae*) has its origin in North America. The pest now has its distribution throughout the world. Bright limy green adult is around 1/8 inches' long with a wedge-like broad head with antennae and big white eyes. It is presence is often noted in the fields late June or July.[142,143]

Being a polyphagous pest, *E.fabae* has a wide hosting range including alfalfa, eggplants, cucumbers, beans, melons, tomato and potato. A sucking insect that extracts sap from leaflets, petioles and occasionally from stems. The attack of potato leafhopper is sporadic and is encouraged by humid conditions. Mostly, the leafhopper lives on the lower part of the leaflets, injecting toxic saliva and deteriorating the plant growth. If the attack is severe, the plants die in quite young age. It can also rarely transmit viruses.[128,144]

The complex symptoms from the attack of *E. fabae* results in reduced plant growth and sometime regrowth of the plants. A heavily infested field can show up to 75% yield loss.[144] The use of synthetic insecticides have made potato leafhopper a major economic pest. In Ontario, Canada the yield losses are reported up to 85%. It has been considered a serious pest in our neighbouring country India causing substantial hopperburn to the potato crops in some areas.[145]

The control measures for potato leafhopper include monitoring, cultural controls and application of insecticides. Placing sticky yellow traps at the edges of potato field is helpful in monitoring the potato leafhopper population. Nymphs are observable underside the leaves. Monitoring middle part of the plant is more successful than other parts. The economic threshold for management is set at 10% of the leaves infestation by nymphs.[144] Other measures include avoiding cultivating host crops such as beans near potato fields along with elimination of crop residuals and proper irrigation. Though potato leafhopper has several natural enemies in the shape of predators and parasites, they are not of much help in case of heavy infestation.[128,144] Though use of resistant or tolerant varieties in infected areas is helpful, in case of heavy infestation the use of systemic insecticides is imperative.[146] Application of chemical controls is only recommended if the population reaches the economic injury loss threshold.[146]

LEAF BEETLES

Figure 51 diabrotica beetle (Diabrotica speciosa speciosa); Courtesy: Alexander Derunkov, Diabrotica ID, USDA APHIS PPQ, Bugwood.org

Figure 50 rootworm beetle (Diabrotica viridula); Courtesy: Alexander Derunkov, Diabrotica ID, USDA APHIS PPQ, Bugwood.org

Leaf beetles has their origin in Central and South America. *Diabrotica viridula* and *Diabrotica speciosa* are found in 116 species of 24 families. The host range include peanuts, maize, soybean, beans and potato roots. The beetle likes maize the most for larval food and oviposition.[147] Leaf beetles have their origin in Central and South America. *Diabrotica viridula* and *Diabrotica speciosa* are found in 116 species of 24 families. The host range include peanuts, maize, soybean, beans and potato roots. The beetle likes maize the most for larval food and oviposition.[147]

Like other beetles, *D. viridula* feed on leaflets interfering with the photosynthesis process of the plant and thus reducing the tuber production. Larvae from leaf beetle feed on stolon and make galleries in tubers.[147,148] The economic loss due to infestation include gnawed surface of the tuber that makes it vulnerable for soil pathogens reducing tuber quality.[128] Eggs and larvae develop in wet season.

Recommended controls include deep tillage to expose larvae to natural enemies. Elimination of host weeds is also helpful. In case of heavy infestation, the use of insecticides is recommended against adult pests.[128]

Potato is a major crop for humankind and may prove a source of food sustainability in future in the wake of heavy populations. Its growth is global but a myriad of pests' attack potato reducing its productivity and quality substantially. There is need for creating more awareness of its agro economic, nutritional value and cash advantages in developing countries like Pakistan. The adaptation of integrated pest management may prove an important area of research that may pave way for more resilient and profitable potato crops throughout the world. Biological approaches are recommended for pest management discouraging the prevalence of insecticides that may pose the risk that pest populations develop resistance against these insecticides. It is evident from the above that several of these pests and insects will respond to climatic changes across the world thus expanding their geographical spread and increasing their population densities. This phenomenon will result in more crop and post-harvest losses, especially in tropical and subtropical regions. Modeling of the response of potato pests and insects in the wake of global warming may be helpful in predicting the potential changes in these pests and insects. This may help the potato growers in adopting the most suitable pest management strategies for controlling these pests and insects.

FUNGAL, OOMYCETE AND PLASMODIUM DISEASES OF POTATO

The major plasmodiophorid, oomycete, and fungal disease of potato worldwide are early blight, late blight, powdery scab and wart.[149] These diseases are main biotic constraints of potato crops throughout the world causing a loss of around €6.1 billion and posing a major threat to food security especially in developing countries like Pakistan.[149]

OOMYCETE

Fungus-like microorganisms, oomycetes are a diverse group which is now recognized as different from true fungi, closer to algae, or to say more closely related to brown algae. Oomycetes has been known for causing devastating diseases to plants impacting the agriculture and environment drastically. To emphasize its effect one should remember the Irish potato famine causing millions of deaths due to pathogen *Phytophthora infestans* which is known for causing significant effect on potato crops worldwide.[150] Oomycetes cause late blight disease in potato.

LATE BLIGHT [redacted]

Late blight is caused by oomycete *Phytophthora infestans* Mont de Bary. It is considered one of the major biotic constraints of potato production.[149] Under optimal conditions of higher humidity and moderate temperature, the disease can destroy a potato field in few days. The most challenging part of the pathogen is its continuous evolvement through migration from other areas.[150] The symptoms include water-soaked light brown spots on leaves, and stems and slightly reddish brown depressed areas in tubers. Monitoring of the pathogen population is important for developing any effective management strategy against P. infestans. Until now fungicides are the most effective control measure against late blight management. However, the use of fungicides is also considered an environmental concern.[149]

SPREAD & INFESTATION

The disease is spread through asexual sporangia like an epidemic on potato crops. The sporangia is able to germinate itself directly or from zoospores which first encyst, then germinate and penetrate into the host tissue.[151] Unfortunately, this stage of infection cannot be noticed by naked eye and inside the plant cell a whole range of molecular interactions begins secreting effector proteins.[152] Under higher moist conditions, the diseases spreads rapidly destroying the crop within days.[153] The infection of *P.infestans* is shown in the figure below;

ECONOMIC & SOCIAL IMPACT

Late blight has had its economic and social impact which is best publicized in the shape of Irish potato famine during the nineteenth century that caused death of millions of Irish people.[154] It outbreak worldwide have caused food insecurity and hunger, destroying the domestic potato industry.[155] The research has estimated a 16% loss of the all global potato production in different countries during different times causing around €6.1 billion losses per annum in the world.[156] The attacks of late blight have been shown a rapid growth in developing countries like Pakistan lowering the per hectare yield.[149] Late blight has had its economic and social impact which is best publicized in the shape of Irish potato famine during the nineteenth century that caused death of millions of Irish people.[154] Its outbreak worldwide have caused food insecurity and hunger, destroying the domestic potato industry.[155] The research has estimated a 16% loss of the all global potato production in different countries during different times causing around €6.1 billion losses per annum in the world.[156] The attacks of late blight have been shown a rapid growth in developing countries like Pakistan lowering the per hectare yield.[149]

MANAGEMENT

Late blight being a polycyclic disease bursts out in favour conditions. A whole array of diseases management approaches is required to combat the disease; good sanitation, avoiding infected seeds, fields, and volunteer plants. The use prophylactic and curative fungicides, use of resistant and early maturing varieties and cultivating the potato crop in areas where chances of disease development are minimum.[149] Late blight being a polycyclic disease bursts out in favourable conditions. A whole array of diseases management approaches is required to combat the disease; good sanitation, avoiding infected seeds, fields, and volunteer plants. The use prophylactic and curative fungicides, use of resistant and early maturing varieties and cultivating the potato crop in areas where chances of disease development are minimum.[149]

The use of chemical fungicides has made the pesticide sector an essential driver for controlling late blight throughout the world. Every year, the demand for the use of chemical fungicides generates billion-dollar business in the pesticide industry.[156] However, even today, the most effective and efficient approach against late blight is the use of host resistance. Genetically resistant varieties are seen a better option due to less or shorter use of chemical fungicides.[157]

With proven evidence of the efficiency of resistant varieties against late blight, the developing countries are still far behind in managing late blight due to higher disease pressure, problems in accessing quality fungicides, and poor knowledge of the farmers' community in these countries about the dynamics of the disease. However, the use of resistant varieties is seen as an uncommon approach and people use susceptible varieties under influence of marketing companies in developing countries.[158] Genetic resistance coupled with chemical controls help in reducing human health and environmental risks.[153] Hence, understanding of disease dynamics by small landholders in developing countries is critical.[159]

Cultural control of the disease involves agronomic management practices including the monitoring of the climate, pathogen behavior, hosting conditions to mitigate the survival, reproduction and dispersal of the pathogen. Other cultural practices include use of certified seed, resistant varieties, substantial distance between plants and rows, crop rotation, suitable hilling, and harvesting of the potato during dry season.[153] In temperate regions like Pakistan, the use of chemical desiccants or plant extracts two to three weeks before the harvest is a common practice.

Biological controls involve the use of *Trichoderma*, *chaetromium globosum* and *Pennicillium viridicatum* is reported in research. The use of garlic as intercrop is also recommended.[149]

TAKE AWAY

The research has proved that *P.infestans* are capable of developing resistance against resistant varieties and fungicides for decades now. It is the reason that late blight still is a major biotic constraint worldwide despite the fact that millions of dollars have been invested in its management. Intercontinental trade of potato is another factor of spread of *P.infestans* strains in different countries. Use of efficient inoculum tools is being seen as an effective measure for monitoring the presence of disease in the area.[160] Use of spore traps mounted on tractors and use of drones for real time monitoring is the way forward for combating late blight align with web-based agriculture extension service networks.[151,160] Other steps include building capacity of farmers in disease management skills, use of innovative and novel diagnostic tools, and use of low-toxicity fungicides are the potential measures to be adopted by developing countries like Pakistan.

FUNGUS

A fungus, plural fungi is a eukaryote. It has the ability to absorb food externally through its cell walls taking in nutrients. Fungi are known to be reproducing by spores and have a thallus (body) composing of microscopic hyphae. Being heterotrophs, fungi obtain their carbon and energy from other organisms. However, some fungi are biotrophs and they obtain their nutrition from living hosts; animals and plants. Fungi obtaining nutrition from dead animals and plants are called saprotrophs. Another kind of fungi known as necrotrophs kill the cells in host to obtain their nutrition.

Initially fungi were placed in plant kingdom as primitive member just above bacteria. Today we know that fungi are not our next of kin but they absolutely are next of kin of animals and are placed in the group Opsthokonta. Today we also know that fungi are related to three unrelated groups; eumycota, the oomycetes and slime molds. Fungi and plants have a long and traditional association causing most of the diseases in plants.[161] Fungi cause early blight and wart diseases in potato.

EARLY BLIGHT

Alternaria solani fungus causes early blight on potato and other solanaceous crops.[162] The research, however, has also evidence that *Alternaria* spp., *A.grandis*, *Alternaria protenta* cuase EB in some countries.[162]

SPREAD & INFESTATION

Early blight is found in almost all potato growing countries around the world. The symptoms of early blight (EB) include dark brown to black necrosis on foliage. The first signs are visible on older leaves few weeks after the attack leaving blotches of a few millimeters in diameter taking up the whole leaf and destroying the green leaf tissues. The infestation sometimes remains restricted to leaf veins in angular shape having different widths typical to EB attack. Fungal mycotoxins turn the leaves to yellow leaving chlorosis that engulfs the whole leaf gradually. The infestation is observed in increased density during the month of July in Europe on older plants. EB gradually moves from lower leaves to middle and then upper leaves.[149]

ECONOMIC & SOCIAL IMPACT

After late blight, EB is the second most important fungal disease in potato in the most of countries growing potato worldwide especially in warmer temperatures. *A. solani* causes considerable yield loss in susceptible cultivars, higher temperatures and earlier infested fields.[163] In Australia it is recorded more than 20%, Brazil up to 60%, Germany up to 40%, United States up to 40%, and South Africa up to 50%.[149]

MANAGEMENT

IPM for EB requires adopting serval approaches including cultural practices, cultivating less susceptible varieties, and using recommended pesticides.

In case of EB, taking care of phyto-sanitary aspect of crop cultivation is necessary. Crop rotation is the recommended method as *A. solani* is able to persist in shape of mycelium and spores in the debris and filed from one season to next. Sometimes farmers prefer short crop rotation such as tomato with potato and vice-versa which results in severe EB epidemic.[164] Bio fumigation is another measure to suppress the soil borne pathogens. Use of bio fumigant plants such as leaf radish and white mustard is recommend against EB.[165]

A.solani also affects potato tubers and hence to reduce the infection, it is recommended to harvest tubers at their full maturity without wounding the tubers. Next is the use of disease free potato varieties as infected seeds are more vulnerable to EB. Controlling biotic and abiotic stresses such as drought, overhead irrigation, and higher temperatures along with the attacks of aphids which are known to infect the plants with viruses by being virus vectors.[165]

TAKE AWAY

EB is going to be the next big challenge for potato growing world. A number of factors are seen as encouraging the spread of the disease including climatic change. The global warming is providing favorable conditions for pathogens. The shortage of irrigation water will also increase the susceptibility of the potato plant. The IPM strategies based on the use of pesticides and fungicides will become ineffective with the passage of time as the pathogens will develop resistance and mutation against these chemical treatments.

The successful approach against EB would remain the use of cultural practices along with focused pesticides and fungicides and cultivation of healthy and non-susceptible varieties.

WART

The fungus causing potato wart disease, *Synchytrium endobioticum*, is a soil-borne bio trophic fungus having its origin in Andean zones. *S. endobioticum* has the ability to produce summer sporangia having mobile zoospores which move in the soil.

SPREAD & INFESTATION

The current geographical distribution of pathogen includes European and Mediterranean, Asian, North and South American, and Oceanic countries. The typical symptoms of potato wart are cauliflower-like galls developing all around potato plant except roots. The pathogen was first discovered in Hungary by Schilberszky and hence is named Synchytrium endobioticum (Schilb.) Perc., The disease however was well known in Europe by 1876.[166] The disease has around a dozen names including potato cancer, black scab, potato tumor, black wart, warty disease, and cauliflower disease.[167] Under normal conditions, the wart is not visible despite the fact that plant may start showing a reduction in its growth. In case of quite suitable conditions, small greenish warts are visible on plant stem and foliage.[167] The symptoms are more visible on underground parts of the plant; roots, bulbs, stolon, primary stems and eyes of mature tubers eventually covering all eyes of potato tubers.[168] The warts on tubers are irregular in shape but most spherical and whitish or green in colour that darkened with the passage of time. As the warts are similar to cauliflowers, they have the same colour but sometime are seen as walnut kernel colour.[168]

ECONOMIC & SOCIAL IMPACT

The economic and social importance of pathogen is evident from the fact that for around six decades, the governments throughout the world are enforcing legislations to prevent the cultivation of susceptible varieties to prevent the spread of the disease. The economic loss is not limited to product loss but also loss of international trade markets, and regulatory restrictions by importing countries (Przetak).[168] The world has increasingly felt the need for regulatory actions as the only measure to prevent the spread of pathogen. The pathogen in itself does not have the ability to spread naturally so regulatory measures are the most suitable way of its prevention.

The damage from *S.endobioticum* is so serious that introduction of the disease in a field makes the whole crop unmarketable due to persistent nature of the diseases and hence makes it almost impossible to cultivate potato in the infected fields for several years especially with crops that are intended for export.[168]

MANAGEMENT

In the management of *S.endobioticum*, the biggest discovery was the finding of resistant varieties from Snowdrop and Flourball cultivars helping in developing the resistance breeding.[167] Due to its persistent nature, the pathogen is included in A2 quarantine list of NPPOs. USDA has enlisted it in the list of toxins and agents. EU issued a special directive in 2000 against the pathogen to save EU from organisms harmful to plant and human health and to prevent its spread in the EU.[167]

TAKE AWAY

It is assumed that *S.endobioticum* will reappear in Europe as new foci are observed in warmer climates in countries like Turkey, Bulgaria, Greece and Georgia.[169] This fact coupled with inadequate control measures by some of the EU countries are providing conducive conditions for the growth of new pathotypes.[170] It seems as *S.endobioticum* will emerge again in warmer climates where even slightly susceptible varieties are under cultivation.[170]

PLASMODIOPHORID

Multinucleate plasmodia plant parasites, the plasmodiophorales or plasmodiophorida are distinguishable from other parasites for having unique characteristics like cruciform nucliare division and its mode of penetration in the plants during infection.[171] Plasmodiophorid cause powdery scab disease in potato.

POWDERY SCAB

Tuber powdery scab and root galling is caused by *spongospora subterranean* infecting the tuber with Potato mop-top virus (PMTV) as a natural vector.[172]

SPREAD & INFESTATION

Powdery scab is an economically important disease of potato in different regions of the world. The disease spreads in favorable conditions of cool and damp weather. Powdery scab is an intractable disease.[173] Once considered a fungi, spongospora are now placed in the family Plasmodiophoridae which is known for causing hypertrophy in the cells of its host.[174] The parasite infects the underground parts of the plant; roots, stolon and tubers. It encourages the enlargement and division of host cells which resultantly turned into primary symptoms within four to eight weeks. The brownish lesions turn into raised mature lesions that burst to expose the sporosori making the infestation visible to naked eye. In few cases, the tubers are known to swell forming infected outgrowths and galls (hyperplasia).[175]

ECONOMIC & SOCIAL IMPACT

Powdery scab destroys the cosmetic look of the produce reducing its quality for fresh or processed use. The disease has its reach up to seed tuber certification and different countries have introduced certification tolerance for powdery scab. The production loss is reported around 50% in Australia and up to 100% in Venezuela.[176,177] The infection is also seen as reducing water absorption and nutrition intakes by tubers. Other effects include loss of weight of tuber.[178]

Being the vector of PMTV, *S.subterranea*, it causes tuber blemish disease. The PMTV infection can remain viruliferous for several years.[179] Until today very little is known about the interactions of virus vector due to the possibility of different other symptoms which have not been studied yet.

MANAGEMENT

Worldwide, few varieties have resistance against powdery scab.[177] However, it is proven that not all the potato plant parts have the resistance against powdery scab and there is little evidence of any correlation between susceptibility of variety and tuber infection.[177] The use of highly resistant varieties is recommended that may also help in keeping the *S.subterranea* into soil not infecting the tubers or roots.

The research has provided that no single controlling approach is sufficient for controlling powdery scab and hence an integrated pest management strategy is needed. Using un contaminated seed in an uncontaminated soil is seen as the best method for disease prevention.[175] Resting spores of the pathogen are able to survive weathering the environmental stress and able to attack for more than ten years.[180] It is recommended that crop rotation for more than seven years excluding potato crop is recommended.[180] The research has provided that no single controlling approach is sufficient for controlling powdery scab and hence an integrated pest management strategy is needed. Using un-contaminated seed in an uncontaminated soil is seen as the best method for disease prevention.[175] Resting spores of the pathogen are able to survive weathering the environmental stress and able to attack for more than ten years.[180] It is recommended that crop rotation for more than seven years excluding potato crop is recommended.[180]

TAKE AWAY

The research has now established that high water content in soil encourages the release of zoospore facilitating its movement to the host and subsequent infection of the host. Higher the water content in infected soil, higher would be the chances of powdery scab disease. The chemical management of powdery scab is difficult and perhaps economically unviable for farmers in developing countries like Pakistan. The only way forward could be abandoning the infected fields for other crops and choosing the best resistible seeds after a decade for potato plantation.

BACTERIAL DISEASES OF POTATO

Other than viral diseases, bacterial diseases are important biotic constraints of potato cultivation, especially in warm and temperate regions around the world. The research has established that around seven bacterial diseases affect potato crops throughout the world damaging potato tubers, economically the most important part of the plant. In these diseases, bacterial wilt and blackleg are seen as the major diseases whereas common scab, pink eye and potato ring rot are considered minor diseases. Until today a very little knowledge is available on the occurrence and management of potato zebra chips disease occurring in the USA, Mexico, Europe and New Zealand.[181]

Bacterial diseases can cause direct and indirect loss to potato crops such as yield loss, unmarketability, other environmental, social and economic issues at national and international level. They also considered a hindrance in clean seed potato production affecting the international trade.[181] Bacterial diseases can cause direct and indirect loss to potato crops such as yield loss, unmarketability, other environmental, social and economic issues at national and international level. They are also considered a hindrance in clean seed potato production affecting the international trade.[181]

BACTERIAL WILT & BROWN ROT (*RALSTONIA SOLANACEARUM)*

The species complex and genus *Ralsonia solanacearum* (pathogenic races and biovars) recently classified as *R. Solanacearum, R. syzgii, and R. pseudosolanacearum*.[182] The host range of these species other than potato include banana, tomato, eggplant, tobacco and several other ornamental plants. The above-mentioned three races has been known for attacking more than 250 plants in fifty-four botanical families at a temperature range of 27°C to 35°C (Williamson).[183]

SPREAD & INFESTATION

The attack of bacterial wilt beings from the youngest leaves in potato plants during the warmest days. The infestation could be visible only in any one stem of the plant, a leaf or even a sector of a leaf depending on place of vascular infection. Infected leaves become chlorotic and bronzed and wilting of the whole plant may occur rapidly under the favorable conditions causing epinasty. With the progression of the disease, the xylem becomes brownish in colour near the soil line. A cutting of the stem may show a slimy, creamy mass of bacterial exudes. The wilting results in collapse and death of plant. The infection on potato tuber may be visible depending on the severity and progress of the disease according to the prevailing temperature. Hence low temperature is not suitable for pathogen killing it in very short period of time. However, the bacteria have shown viability of survival in a viable but non-cultural able (VBNC) environment.[184] Severity of disease is well established at 24 to 35°C.[184]

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plant may occur rapidly under the favorable conditions causing epinasty. With the progression of the disease, the xylem becomes brownish in colour near the soil line. A cutting of the stem may show a slimy, creamy mass of bacterial exudes. The wilting results in collapse and death of plant. The infection on potato tuber may be visible depending on the severity and progress of the disease according to the prevailing temperature. Hence low temperature is not suitable for pathogen killing it in very short period of time. However, the bacteria have shown viability of survival in a viable but non-cultural able (VBNC) environment.[184] Severity of disease is well established at 24 to 35°C.[184]

ECONOMIC & SOCIAL IMPACT

After *Pseudomonas syringae*, *Ralsonia solanacearum* recently has been considered the second most important bacteria (Mansfield) with an extremely wide spread and host range. It is estimated that only in potato the loss of product touches US$1 billion affecting around three million farmer families over an area of around 1.5 million hectares in around 80 countries of the world. The affected usually include small landholders which are restricted not to cultivate potato in contaminated lands.[181]

MANAGEMENT

The disease management of bacteria is quite difficult as the pathogen has the ability to survive in wet environment on asymptomatic hosts and plant debris. The debris act as inoculum reservoir. In the absence of any effective chemical control, the best option is to use the bacteria free plant material and monitor the areas for any signs of bacteria in the field. Other suitable option include using stock of zero tolerance against disease seed from certified sources.[181]

BACTERIAL BLACKLEG & TUBER SOFT ROT (***PECTOBACTERIUM)***

Pectobacterium is from family *Pectobacteriaceae*, which also consists of genera *Brenneria*, *Lansdaleam Sodalis* and *Dickeya*.[185,186]

SPREAD & INFESTATION

Pectobacterium hosts on a wide range of plants, and share around one-third of these plants with *Dickeya*. It means some plants are equally attacked by *Pectobacterium* as well as *Dickeya*.[187] The spread is recorded rice, mango, cabbage and cotton.[187]*Pectobacterium* hosts on a wide range of plants, and share around one-third of these plants with *Dickeya*. It means some plants are equally attacked by *Pectobacterium* as well as *Dickeya*.[187] The spread is recorded in rice, mango, cabbage and cotton.[187]

The bacteria are present in all potato growing continents in the shape of saprophytes living in water, soil and in few cases in plant roots. The continents may have different species of *Pectobacterium* with few showing ubiquitous characteristics.[188] In Europe, one of the *Pectobacterium* specie, *P. atrosepticum* is responsible for blackleg disease, and *P. carotovorum* for soft rot.[189]

The disease is a stem necrosis originating from infected seed tuber.[190] Necrosis is visible few centimeters above the infected area decaying pith. After the infection, the leaves become yellow, plant wilts and die. Hence, producing no or very few tubers. The next step is bacteria’s entrance into daughter tubers through insect or mechanical damages decaying the inside of the tuber and causing soft rot. In almost all cases both *Pectobacterium* and *Dickeya* are witnessed in the plants.[191]

ECONOMIC & SOCIAL IMPACT

Pectobacterium remains the economically important disease throughout the world. Farmers suffer loss of millions of dollars due to blackleg, stem rot (aerial) and soft rot. Of these diseases soft rot is the most devastating as by the appearance of disease the farmers has had invested a lot in the shape of inputs.[181] *Pectobacterium* remains the economically important disease throughout the world. Farmers suffer loss of millions of dollars due to blackleg, stem rot (aerial) and soft rot. Of these diseases, soft rot is the most devastating as by the appearance of disease the farmers has had invested a lot in the shape of inputs.[181]

MANAGEMENT

The management of Pectobacterium is dependent of cultural practices.[192] The farmers are recommended to use micro-propagated Pectobacterium free plantlets. As the tubers are quickly contaminated by bacteria the process of suberize is recommended. The cut seeds should not be planted in wet grounds. Irrigation is recommended from ground water with less use of nitrogen fertilizers. At the time of harvest, killing potato vines is strongly recommended. At the storage facilities like warehouse good airflow and high humidity is recommended. The farmers should be aware of the fact that higher levels of carbon dioxide will increase the chances of soft rot in stores.[181] The management of Pectobacterium is dependent of cultural practices.[192] The farmers are recommended to use micro-propagated Pectobacterium free plantlets. As the tubers are quickly contaminated by bacteria the process of suberize is recommended. The cut seeds should not be planted in wet grounds. Irrigation is recommended from ground water with less use of nitrogen fertilizers. At the time of harvest, killing potato vines is strongly recommended. At the storage facilities like warehouse, good airflow and high humidity is recommended. The farmers should be aware of the fact that higher levels of carbon dioxide will increase the chances of soft rot in stores.[181]

POTATO RING ROT (CLAVIBACTER MICHIGANESIS SUBSP. *SEPEDONICUS*

Microbacteriaceae family of Actinobacteria contains *Clavibacter michiganensis* subsp. *Sepedonicus.* It is coryneform, non-spordic aerobic bacterium.

SPREAD & INFESTATION

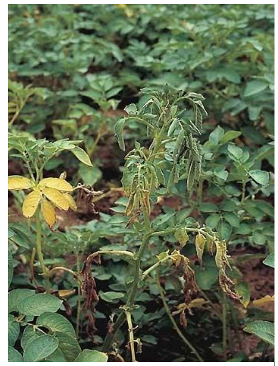

Figure 52 Courtesy: EPHATIA France

Economically important host for the bacterium is potato. However, recently the infection is also report in tomato.[193] Other solanaceae family members are also susceptible for the infection if growing in infected fields of ring rot.[194] The spread is now reported in all potato growing regions from Andeans to Asia including China, Kazakhstan, Nepal, Uzbekistan and Pakistan. Its presence is not reported in Australia, Africa and South America.[181] Economically important host for the bacterium is potato. However, recently the infection is also reported in tomato.[193] Other solanaceae family members are also susceptible for the infection if growing in infected fields of ring rot.[194] The spread is now reported in all potato growing regions from Andeans to Asia including China, Kazakhstan, Nepal, Uzbekistan and Pakistan. Its presence is not reported in Australia, Africa and South America.[181]

The foliar symptoms are not visible early and emerge mostly at the end of season. The wilt caused by ring rot bacteria is slow. It emerges at the margins of leaves which expands slowly to other parts of the leaves and ultimately growing to the xylem of the stem blocking it and developing yellow, chlorotic interveinal areas. Resultantly, the leaf, stem and eventually the plant may die. At times stunted growth of leaves, stems and the whole plant is witnessed. The spread of disease from plant to plant is uncommon and without much scientific evidence.[181]

ECONOMIC & SOCIAL IMPACT

Figure 54 Coutesy: EPHATIA France

The tuber rot and wilting are moderate losses at field and store level in the presence of modern seed certification systems. Apart from this ring rot constitutes the constraints on potato seed production as an indirect loss in shape of trade losses from statutory measures taken by different countries against ring rot spread. Other losses include costs of disinfections, purchasing of new seed stock in place of infected seed stock, disposal of infected produce and lastly the loss of reputation in the export avenues.[181]

MANAGEMENT

The management of ring rot has no effective chemical and biological control measures, hence the management depends on production and safe distribution of seeds. The import of seed should be preferred from countries which can show evidence of regular tests and surveys to support that their seed system is free of ring rot infection. The control agents against Cms are chlorine, iodine and ammonia compounds ensuring at least 10 minutes' constant contact. Other management measures include controlling solanaceasous weeds and use of whole tuber instead of cut seeds to further reduce the chances of spread of Cms.[181]

COMMON SCAB (STREPTOMYCES)

Belonging to Actinobacteria family of Streptomycetaceae, *Streptomyces* is an aerobic, spore-forming, filamentous bacterium causing common scab in potatoes. Most of the *Streptomyces* are saprophytes living in soil. Around 12 Streptomyces are known for causing common, netted and or pitted scab in potato. Of these, *S.scabies* is known for causing common scab[195], pitted scab by *S. caviscabiei*.[196]

SPREAD & INFESTATION


Figure 55 Courtesy: AHDB

Streptomyces has potato as the most economically important host, though it also affects other root crops such as radish, turnip, sweet potato, and carrots.[197] Living in potato growing soils and causing the most important potato diseases common scab, Streptomyces are yet not explored completely because no global survey has been conducted to determine its presence in different regions.[198,199] All underground parts of potato plant are affected by necrosis caused by Streptomyces.[200] It can also spread necrosis to young seedlings from true potato seeds. Its impact on foliar is not witnessed though it reduces the vigor of the plant due to necrosis in roots. Interestingly, the scabs caused by Streptomyces include common, erumpent, pitted, and mild netted scab depending on the toxin produced by the bacterium and genotype of the potato plant. To add more, the disease is not witnessed in storage facilities.[181]

ECONOMIC & SOCIAL IMPACT

The disease can cause complete loss of production. Though the loss cannot be contributed only to bacterium. There are other factors such as mismanagement of crop, insufficient irrigation, cultivation of susceptible varieties. Direct losses of destruction of crop are occurring annually and the disease is listed as the most dangerous disease around the world, up to 82% in Canada.[201]

MANAGEMENT

The best management practice is developing tolerance or resistance in potato crop. Unfortunately, there is a very limited number of varieties so far that show high tolerance against common scab. Managing other factors contributing towards disease development including soil moisture, chemical composition, and crop rotation is also challenging.[202]

Further recommendations include suitable quantity of irrigation during development of tubers. Next step is keeping the soil pH less than 5.2 by using sulfur fertilizers as this practice can reduce the severity of disease.[203] These management practices however are not void of other challenges such as the possibility of over irrigation leading to development of powdery scab and other potato diseases.[204] Crop rotation with brassica crops is another management tool to reduce the severity of the disease that serve as bio fumigant and allelopathic.[205] Use of rice bran and peat is also recommended.[206]

ZEBRA CHIP (LIBERIBECTOR)

From Rhizobeaceae family, there exist seven *Candidatus Liberibacter* and out of these species *Candidatus Liberibacter solanacearum* (Lso) is known for infecting potato crops. It is a phloem-limited pathogen having five haplotypes. From these haplotypes A and B are known for causing disease on potato and rest of the three haplotypes infect celery and carrots.[207,208]

SPREAD & INFESTATION

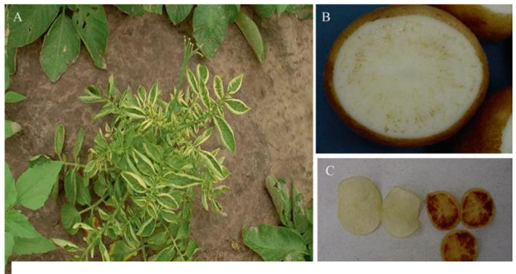

Figure 56 Courtesy: CIP

Lso haplotypes A and B not only has potato as their the most economically important host but they also attack other solanaceous crops. In potato the disease is spread by B.cockerelli causing zebra chip.[209,210] Coming from potato psyllids which are native to Central and North America, the pathogen has known for recently invading New Zealand spreading its vector and can be found in regions where potato psyllid exist.[211] Zebra chips disease affects the foliage and tubers of potato causing leaf curling, shortening of internodes, aerial tubers, chlorosis, necrosis and eventually death of the plant.[212] The tuber give a glossy streaks look. These streaks get brown when the tuber is fried and hence getting the name of zebra chip. The plant loses its vigor and develop slowly causing a dropped yield and infected tubers have shown less protein.[213] The infected tubers show only hairy sprouts and if these tubers are cultivated as seed, the emerging plants die shortly.[213] The temperature has its effect in storage facilities. It is observed that the crop show more infection symptoms at cooler temperatures (3℃) and less symptoms when stored at rather warmer temperature of 6℃ to 9℃.[214] Zebra chips disease affects the foliage and tubers of potato causing leaf curling, shortening of internodes, aerial tubers, chlorosis, necrosis and eventually death of the plant.[212] The tuber give a glossy streaks look. These streaks get brown when the tuber is fried and hence getting the name of zebra chip. The plant loses its vigor and develops slowly causing a dropped yield and infected tubers have shown less protein.[213] The infected tubers show only hairy sprouts and if these tubers are cultivated as seed, the emerging plants die shortly.[213] The temperature has its effect in storage facilities. It is observed that the crop show more infection symptoms at cooler temperatures (3℃) and less symptoms when stored at rather warmer temperature of 6℃ to 9℃.[214]

ECONOMIC & SOCIAL IMPACT

North American farmers have lost millions of dollars due to zebra chip disease despite the fact that the disease is not spreadable from seed tubers. The major losses occur in losing export markets. New Zealand has suffered substantially losses after emergence of this disease. Other indirect losses include higher costs of vector management.[181]

MANAGEMENT

Zebra Chip is mostly controlled by using insecticides. The farmers monitor the psyllid population to determine the use of insecticides, especially during the growing season to protect the potato crop.[215] As the insects are found underside of the leaves, the spray should cover the underside well. In the long run use of insecticides prove costly due to the reason that insects may develop resistance and frequent sprays may kill natural enemies of the insects.[181]

Concluding the above, bacterial diseases are economically significant diseases worldwide causing loss of millions of dollars. Bacterial soft rot, wilt and ring rot have gained the attention of the world being a huge constraint for seed production. This factor is causing huge indirect economic loss due to restrictions on trade. Though developed countries have minimized the risks of zebra chip with rigorous seed certification programs, the developing countries like Pakistan lack disease free planting material and hence causing latent infection from tubers that result in next generation tubers affecting yield and quality. Unfortunately, the farmers in developing countries continue to replicate diseased seeds year after year. These countries like Pakistan lack the systemic approach to deal with bacterial diseases. There is a need for focusing disease management efforts to disease specific operation practices to reduce the occurrence of such pathogens in potato fields. The systemic approaches include on and off farm training of farmers, sanitation, crop rotation and cultural practices. Last but not least is the introduction of quality seed certification in these countries including Pakistan.

VIRAL DISEASES OF POTATO

Potato production has viruses as the most significant biotic constraint. The high-throughput in plant virology since the beginning of nineteenth century has made it possible for us to learn about viruses attacking potato crop. This biotic constraint has increased with the increase in global warming.[216] The occurrence of virus epidemics is increasing with increase in temperature. It results in increase in insect vectors. This fact coupled with a weak seed system in developing countries has made potato virus disease an important topic.[217] The virus attacks in developing countries are causing an estimated more than 50% loss of potato yield.[218]

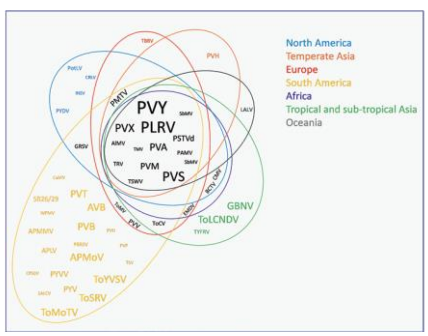

Figure 57 VENN diagram of geographic occurrence of commoner potato viruses worldwide.

The shortage of cool upland areas for potato production in developing countries with lower insect vector presence and year round cultivation in rather warmer plains is also contributing towards the spread of viral diseases in these countries.[219,220]

More than 50 different viruses have been detected worldwide so far but only few of them are causing major losses of potato production globally. Among these, Potato virus Y (PVY) and Potato leaf roll virus (PLRV) are considered the most damaging viruses throughout the world. Both viruses are causing more than 80% losses in potato crops along with other viruses. Losses by Potato Virus C are estimated from 10% to 40% during a single infection due to its ability to synergize with PVY and or PVA.[217] Another important virus is PVS which is less severe but can cause damage up to 40% if mixed with PVX. The losses are not limited to yield reductions only but also other indirect economic losses affecting the crop quality by causing necrosis.[221,222] For past three decades these viruses are causing heavy economic losses in Europe and America. The spread of these viruses are also reported in Asian countries including Pakistan.[223] The list of reported viruses worldwide is given in Annex-VII. More than 50 different viruses have been detected worldwide so far but only few of them are causing major losses of potato production globally. Among these, Potato virus Y (PVY) and Potato leaf roll virus (PLRV) are considered the most damaging viruses throughout the world. Both viruses are causing more than 80% losses in potato crops along with other viruses. Losses by Potato Virus C are estimated from 10% to 40% during a single infection due to its ability to synergize with PVY and or PVA.[217] Another important virus is PVS which is less severe but can cause damage up to 40% if mixed with PVX. The losses are not limited to yield reductions only but also other indirect economic losses affecting the crop quality by causing necrosis.[221,222] For past three decades these viruses are causing heavy economic losses in Europe and America. The spread of these viruses is also reported in Asian countries including Pakistan.[223] The list of reported viruses worldwide is given in Table (1).

CONTROL MEASURES

Clonal propagation of potato tubers increases the risk of virus transmission to next crop and hence application of insecticides on seed tubers and foliar sprays are the most effective control measures.[224] Three principal methods are used for controlling viruses; clean seed systems, host plant resistance and cultural practices. However, despite heavy investments in insecticide industries, and other sectors, the control of virus diseases in developing countries is very limited. This factor along with low quality planting material, higher costs of seed production and lack of economic resources by farmers has added to this problem. With the development of Loop Mediated Isothermal Amplification instead of ELISA method it is hoped that the new technology will provide more sensitive results for detecting potato viruses.[225,226] Clonal propagation of potato tubers increases the risk of virus transmission to next crop and hence application of insecticides on seed tubers and foliar sprays are the most effective control measures.[224] Three principal methods are used for controlling viruses; clean seed systems, host plant resistance and cultural practices. However, despite heavy investments in insecticide industries, and other sectors, the control of virus diseases in developing countries is very limited. This factor along with low quality planting material, higher costs of seed production and lack of economic resources by farmers adds to the speard of viral diseases. With the development of Loop Mediated Isothermal Amplification instead of ELISA method it is hoped that the new technology will provide more sensitive results for detecting potato viruses.[225,226]

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INSECTS, PESTS & DISEASES OF POTATO IN PAKISTAN

Much of the insects, pests and diseases prevailing throughout the world including Pakistan are discussed above. While the loss due to these biotic constraints are of different degrees, the practices especially cultural practices are different in each country based on the experiences of the farming community. In this section, a brief discussion is carried out on insects, pests and diseases present in Pakistan along with a brief overview of the management practices.

Pakistan Agriculture Research Center (PARC) has identified 14 diseases in potato that commonly occur in Pakistan. These diseases are mostly soil and seed borne and they are likely to become a major threat for potato industry in Pakistan. The most frequent of these diseases are powdery scab (*Spongospora subterranean*), black scurf (*Rhizoctonia solani*), common scab (*Streptomyces scabies*), and wilts (*Verticillium, Fusarium*).

The foliar diseases present include late blight (*Phytophthora infestans* Mont de Bary), early blight (*Alternaria solani*), bacterial wilt (*Pseudomonas solanacearum*), potato cyst nematodes (*Globadera rostochiensis*). Viral diseases include potato leaf roll, potato S Carla virus, potato A potyvirus, and Potato mop-top furovirus. Unfortunately, there are evidences of emergence of a new disease with phytoplasma symptoms spreading in Punjab, the hub of potato production.[227] These biological constraints have a drastic impact on the production and growth of potatoes.[228]

INSECTS & PESTS

As mentioned earlier the insects and pests attacking potato include beetles, hoppers and nematodes. Of these insects and pests, leaf hoppers are of considerable economic importance. There are about seventy-nine leaf hopper species attacking potato.[229] As mentioned earlier the insects and pests attacking potato include beetles, hoppers and nematodes. Of these insects and pests, leaf hoppers are of considerable economic importance. There are about seventy-nine leaf hopper species attacking potato.[229]

JASSIDS

The leaf hopper specie attacking potato crops in Pakistan is *Amrasca devastans* Dist.[228,230]

INFESTATION

Both adult insect and nymphs suck sap from cell leaves causing stunted growth of the plants and browning, curling of the leaves.[229] The green color nymphs develop two wings when turning into adults and hop from one leaf to another damaging the foliar.[228,230]

DAMAGE

The beginning of damage is visible with yellowing of the leaves. With the severity of infestation, the leaves crinkle and curl upwards from the margins and ultimately start to fall of the plant. These symptoms are commonly known as *hopperburn*. Heavy infestation causes stunted growth of the plant. The pest is also known for transmitting diseases.[230,231]

MANAGEMENT

Generally adopted control practices in Pakistan include the uprooting of the weeds and use of chemical insecticide sprays.[230]

WHITEFLY

Just like jassids, whitefly is also a sap feeding insect having white powdery wings. The female whitefly lays eggs on underside of the leaves. These eggs develop into small nymphs that develop into pupae and then winged adults.[230,232]

DAMAGE

The attack of whiteflies reduces the vigor of potato plant and in case of severe infestation, the plant loses all of its leaves prematurely. Honeydew secreted by whiteflies attracts other insects and facilitate fungal assembly.[230]

MANAGEMENT

The management of white fly include removing the host plants and use chemical insecticide sprays.

CUTWORMS

Noctuid moths generate larvae which are known as cutworms. The female moth lays eggs in soil which are capable of overwintering for next season.[98,230]

DAMAGE

Cutworms start chewing the plant stem from the base attacking young potato plants and eventually cutting the stem off underneath and ultimately attacking shoots. Resultantly, the plant dies causing a huge yield loss.[230]

MANAGEMENT

As mentioned above, the use of yellow colored traps is the best management option for capturing the moths. Other management options include use of light traps, flood irrigation but at suitable times. Scouting the worms manually at night is also in practice in Pakistan. The use of chemical sprays is seen as the last resort for the management of cutworms.[98,230]

FUNGAL DISEASES

A detailed description of major potato diseases has already been described above. This section will encapsulate the potato fungal diseases reported in Pakistan. Fungi has been considered a serious pest of potato throughout the world. In Pakistan, the fungal diseases of potato include early blight, late blight, leaf roll , and ring rot.[233,234] The fungi and its related diseases prevailing in Pakistan are given in the table below;

Table 5 Fungal Diseases of Potato In Pakistan

Fungi (Pathogen)	**Diseases**
Rhizoctonia solani	Black Scurf
Alternaria solani	Early Blight
Fusarium sp	Fusarium dry rot
Fusarium spp	Fusarium rot
Phytophthora infestans	Late blight
Spongospora subterranean	Powdery scab
V. albo-atrum & V. dahliae	Wilt/Verticillium wilt
Source: [234]	

MANAGEMENT

The management practices of fungal diseases in Pakistan are use of fungicides. However, the recommended practices include well irrigated and drained fields, use of disease free seeds and its treatment with benzoyl, planting seed in raised beds. Harvesting is recommended as soon as the tubers are mature. This practice may help in reducing the number of sclerotic on the tubers. At the storage facility, application of boric acid is recommended.[234]

BACTERIAL DISEASES

Table 6 Bacterial Diseases

Bacteria (Pathogen)	**Diseases**
Ralstonia (Pseudomonas) solanacearum	Bacterial wilt
Erwinia carotovora spp. carotovora and carotovora spp. atroseptica	Black leg and soft rot
Streptomyces scabies	Common scab
Source: [233,234]	

MANAGEMENT

The management practices include use of healthy seed tubers, cultivation in un-infested lands, destroying the debris of diseased plants completely, use of cultural practices to check the spread, exercising rotational crops for longer period of time, and lastly destruction of host plants and weeds. [228,233,234]

DISEASES CAUSED BY VIRUSES

Table 7 Diseases Caused by Viruses

Diseases Caused by Viruses
Potato leaf roll virus (PLRV)
Potato mop top virus (PMTV)
Potato Virus A
Potato Virus M
Potato Virus S
Potato Virus X
Potato Virus Y
Phytoplasma
Source:[233,234]

MANAGEMENT

The recommended management control of diseases caused by viruses is use of certified seed free of viruses, control of aphid vectors, preferring resistant varieties, rouging, heat treatment of seed tubers, modifying cultivation procedures, use of chemical insecticides and fungicides for better control of vectors including nematodes, insects and fungi. Recommended non-chemical control of vectors include; use of barriers and reflective mulches, biological controls such as use of enemy insects and predators, taking serological tests through ELISA method for assessing the plant resistant and health of the tubers.[228,233,234]

DISEASES CAUSED BY NEMATODES

Today, we are best accustomed with the name of nematodes. But in its origin *Caenorhabditis elegans* has been under use of experimental biologists who traced back its origin millions of years ago. The model organism for genetic and biomedical research has won the researchers 03 Nobel prizes; for programmed cell death, green fluorescent proteins (GFP). Today more than a thousand companies worldwide are working on nematodes. So the elegant worm has its own amazing importance in agriculture and human life.[235,236]

The importance of nematodes in human life is evident from the fact that around 50% of the human life on earth is affected by gastrointestinal nematodes, around 8 to 15% of crops are lost worldwide due to nematodes causing around $80 billion loss.[235]

NEMA is the Greek word for thread, nematodes have a narrow, long, threadlike body which is not segmented like earthworms. Nematodes are a tube within tube, within outer and inner tubes is pressurized fluid filled cavity which works as a hydrostatic Skelton.

Table 8 Diseases cuased by Nematodes

Diseases
Potato cyst nematode
Root knot nematode *(Meloidogyne* spp.)
Source:[233,234]

MANAGEMENT

The nematode cysts are observable at the roots during flowering stage. The analysis of extraction from soil is an excellent mean of diagnosing nematodes. The viable control is use of resistant varieties.[233,234]

ISSUES AND PROPOSED SOLUTIONS

The viral and bacterial diseases do not have chemical control. The basic precautions against these diseases are cultivating the tolerant varieties that have certified seed tubers. The control of these diseases is the regular monitoring and spraying the fields to destroy aphid vectors when the population reach economic injury threshold. The fungal diseases such as late blight can spread quickly depending on the time of first infection, the weather conditions as increase in temperatures expands the chances of many insect pests of potato.[3] Phonology models, process based climatic response are being introduced in the world in order to assess the effect of temperature on potato crops in the wake of global warming phenomenon.[84]

Further to above, in Pakistan the occurrence of late blight, powdery scab, and black scurf is reported in mainly in hilly areas of Pakistan including Naran, Kaghan, Swat, Kohistan and Gilgit where temperature is low (11-25°C). In plains such as Punjab and few areas in KPK, these diseases are most likely to occur during winter season whenever the humidity level is up. The occurrence of early blight is observed in Pakistan in warmer climatic conditions where temperature ranges from 25 to 30°C. Occurrence of common scab from Streptomyces scabies is well observed in Punjab province.[237]Black scurf in found in Gilgit, Baltistan and other northern parts of Pakistan.[238] Along with aforementioned biotic constraints the occurrence of potato leaf roll virus (PLRV), potato virus X(PVX), potato virus

M(PVM), potato virus Y (PVY) are found throughout the country in Pakistan which are causing around 70% yield losses in the world.[239]

For this quite a hefty range of pathogens to different nematodes, remained main determinants of potato production losses. The growth conditions and environmental conditions in the affected countries have an important role in stimulating the biotic stresses of potato crops. In Pakistan's context, cultivation of potato crops in different climatic conditions is the key measure to deal with biotic stresses. The research has established that temperature and moist conditions impact the spread of diseases like early and late blight and several other bacterial diseases. In such situation the most viable solution seems the crop rotation. There is a need to educate the farmers about the potential impact of such diseases and the benefits of opting for other crops according to the prevailing climatic conditions in the area. If there are unavoidable conditions then the use of pesticides at suitable time can reduce the yield losses through the use of such pesticides may have other ecological and environmental effects.[240]

Integrated disease management practice is the call of the day which includes a combination of practices; cultivating resistant varieties, scanning environmental conditions properly, using suitable pesticides at suitable times, developing disease free seeds, using cultural practices and decision support systems.[241,242]

It is established that use of green manure of different brassica species helps in controlling the burden of pathogens such as *Fusarium sambucinam*, *Sclerotinia sclerotiorum, Rhizoctonia solani, Pthium utimum* and *Phytophthora erythrosectica*.[205,241]

SECTION 4: GLOBAL PRODUCTION, YIELD AND CONSUMPTION

INTRODUCTION [redacted]

The new figures released by the Food and Agriculture Organization (FAO) has revealed that the world potato production has stalled at its 2018 position and did not recover significantly during 2019 recording a decrease of around 1.5% and halting at 368.247 million tonnes. This knockout was mainly due to adjustments made in the figures by FAO from 158 countries that were estimated at 19.099 million hectares in 2019 but then reduced to 17.580 million hectares of the figures of 2017 showing a reduction of around 7.9%. As per revised figures the average yield has also decreased by 1.2% in 2018 mainly due to European drought. On the other hand, Africa was the only region to show an increase in production and area registering 3.3% increase to 1.904 million hectares nearing the distance to take the third place in potato production overtaking North America. The figures show that more than 50% of the potatoes were produced in Asia in 2018 leaving Europe at 30% of the global production. FAO further estimates a decrease in planting area by around 10,000 hectares during 2019.[243] Below is shown the potato production map illustrating positions of different regions in potato production in 2016. The position of regions has not changed much even today;

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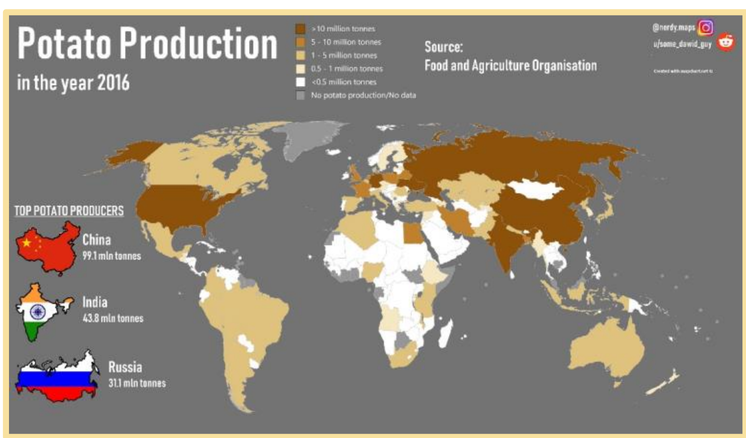


Figure 58 Potato Production Map (2016)

Asia is sustaining its dominance even after the revised figures where China and India are contributing 40% of planting area of the world. Other countries in Asia including Pakistan, Bangladesh, and

Kazakhstan showed increase in production. Pakistan demonstrated the largest increase potato production in 2018.[243]

Despite some encouraging figures above, as a crop potato continued lagging behind other crops in yield development. Though potato still is the highest yielding crop in comparison to rice, maize, wheat and soy, these products have shown a considerable increase in yield in past five decades. Potato yield increased from 14.3 tonnes per hectare in 1968 to 20.9 in 2018 – improvement of 46.2% only. On the other hand, the maize recorded 158.8%, wheat 135.5%, rice 109.6% increase in yield during the corresponding period.[243]

The figure below shows the market growth rate in different regions of potato from 2019 to 2024.

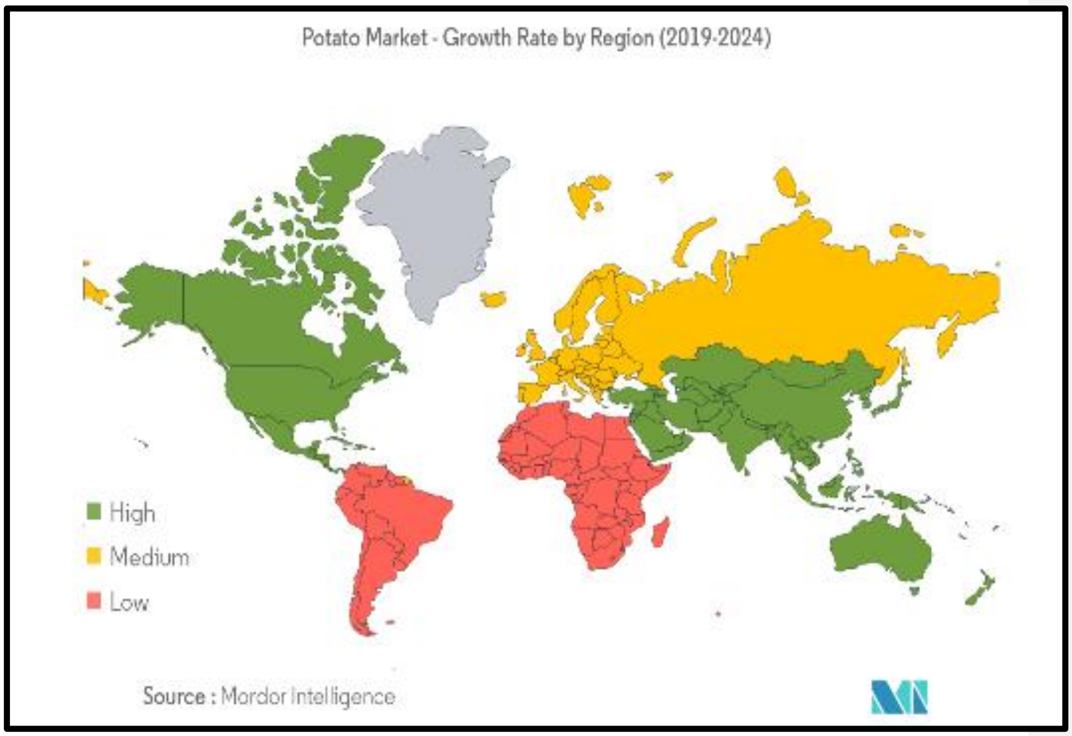
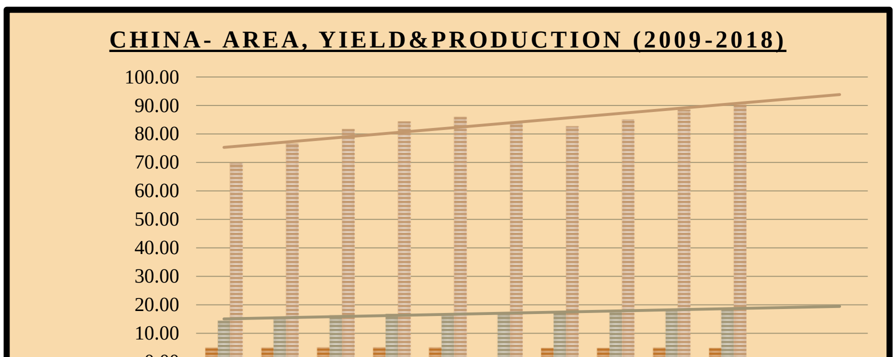


Figure 59 Growth Rate by Region (2019-2924)

China is the largest producer of potatoes in the world. China and India together produce one-third of the world potato production. According to FAO, the world production of potatoes reached more than 368 million tons in 2018 increasing from 333.6 million tons in 2010. Since 90s, the developing countries have shown substantial increase in potato production and currently developing countries are the leading exporters of potato. The world produced the historic record level of 373-381 million tons during 2011 to 2014.

CHINA

As is evident from the figure below, China has been engaging averagely an area of 5 million hectares for potato cultivation for past ten years. China has shown a consistent increase in its production volumes.



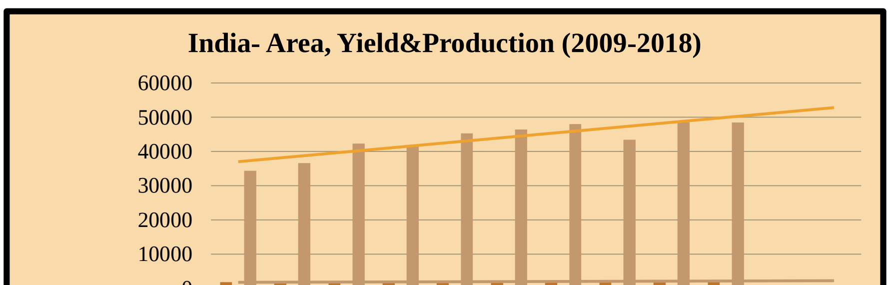
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
Area Harvested (Mil ha)	4.85	4.89	5.01	5.03	5.03	0.49	4.79	4.81	4.86	4.81		
Yield (Tonnes/ha)	14.42	15.67	16.28	16.77	16.77	17.14	17.27	17.69	18.21	18.76		
Production (Million tonnes)	69.89	76.59	81.64	84.40	85.93	84.21	82.68	84.99	88.54	90.32		

Figure 60 China- Area, Yield, Production (2009- 2018) Source: FAO

The remarkable growth in production to capture the first position in potato production China followed the recommendations of the Chinese Academy of Science to develop potato into a staple food. Traditionally, Chinese are not a potato eater nation. In line with the Chinese consumer preferences, around 200 potato products have been introduced in China recently. These products include potato noodles, steamed bread, frozen French-fries, potato chips, cakes, puffed snacks, and potato beverage and liquor.[244] China sees these figures more promising in the wake of the truth that its production was around 10 million tonnes in 1986. Though there is considerable increase in per unit area from around 15 tonnes per hectare in 2009 to around 19 tonnes per hectare in 2018. China is about to reach the world average of 20 tonnes per hectare but still lags behind from the developed countries that show around 40 tonnes per hectare.[244]

INDIA

The inclusion of potato along with rice in its food security policy resulted in India's major shift in food sovereignty. This shift coupled with establishment of Central Potato Research Institute (CPRI) for developing locally adaptable varieties paved way for India to become the second largest potato producer in the world. Efforts at CPRI resulted in establishing the '*Seed Plot Technique*' seed system that played its vital role in increasing the seed production in India. In 2018, India produced 48.53 million tonnes of potato from just 1.5 million tonnes in 1950. The world termed it as *Brown Revolution* that ranked India 2nd in the world in potato production.[245]



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Area Harvested (Mil ha)	1830	1840	1860	1910	1990	2020	2080	2120	2180	2150
Yield (Tonnes/ha)	18.81	19.93	22.72	21.75	22.76	22.92	23.13	20.51	22.31	22.56
Production (Million tonnes)	34390	36580	42340	41480	45340	46400	48010	43420	48610	48530

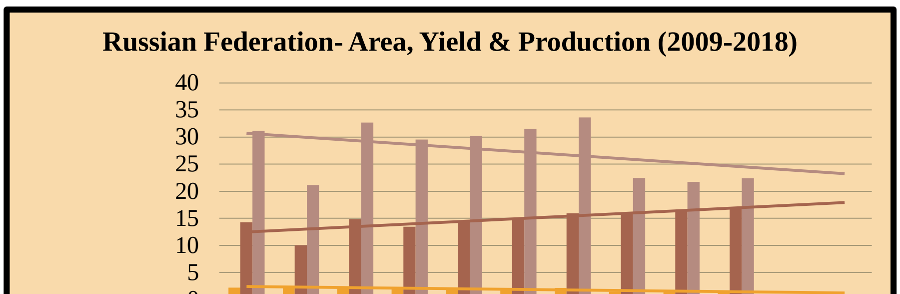
Figure 61 India- Area, Yield, Production (2009- 2018)

From the above figure it is evident that during past ten years, India increased its area of potato cultivation by 17%, yield by 20% and production by 40%. This reveals that working on adaptable varieties could be the main reason behind this astonishing increase in production.

RUSSIAN FEDERATION

The legends have it that Czar Peter the Great brought the *devil's apple* home coming back from his voyage from western Europe in 1697. It took Russians around hundred years to accept potato as a food crop rather than a poisonous shrub.[246] From mid 1800s, when Russians eventually got warmed with potato, they never look back and were producing the world's largest potato quantities (more than 100 million tonnes) along with Ukraine up to 1973. But then the area under cultivation of potato started shrinking at a steady pace resting at around 35 million tonnes for past two or so decades. Despite this, Russia remained a giant producer of potato after China up to 2007.

On an average a Russian consumes around 130 kilograms of potato per annum. Interestingly, more than 90% of Russian potato crop is grown on small household plots and private farms with an average yield far below the world average at 13 tonnes per hectare. As mentioned earlier that pest and diseases cause around 50% of potato loss, late blight, Colorado beetle and viruses remained the major threat destroying around 4 million tonnes of potatoes annually.[246]



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
Area Harvested (Mil ha)	2.18	2.11	2.2	2.2	2.09	2.1	2.11	1.43	1.34	1.31		
Yield (Tonnes/ha)	14.27	10.02	14.84	13.44	14.46	14.99	15.93	15.76	16.25	17.05		
Production (Mil Tonnes)	31.13	21.14	32.68	29.53	30.2	31.5	33.65	22.46	21.71	22.39		

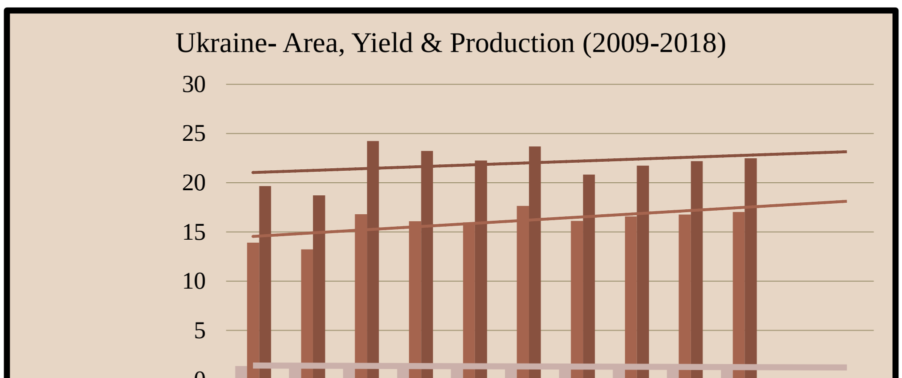
Figure 62 Russian Federation- Area, Yield, Production (2009- 2018)

The above figure illustrates that Russian Federation witnessed a steady loss of around 40% in area harvested for potatoes. Though it observed an increase of 19% in yield, it lost its production by around

28% from 2009 to 2018. The production that was staggering at 35 million tonnes annually during is settling down at around 20 million tonnes annually from 2015 onwards. While the linear forecast trend line shows a steady fall in production, it shows a gradual increase in yield per hectare.

UKRAINE

Despite being cultivated since 18th century, the potato reached Ukrainian tables quite slowly. Initially it was used only for producing alcohol and starch. In twentieth century, the potato reached the tables to the extent that now it is called and revered as *second bread* in the country. Perogie dumplings filled with potatoes are now the favourite national dish. Ukraine is now world's 4th largest producer after China, India and Russian Federation. Like Russians, Ukrainians are also hearty potato consumers with per capita consumption of around 136 kg per year. The black soils of central Ukraine are the hub of potato growing farms. The best product is however available from Polesye wetlands in the northern parts of the country.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
Area Harvested (Mil ha)	1.41	1.41	1.44	1.44	1.39	1.34	1.29	1.31	1.32	1.32		
Yield (Tonnes/ha)	13.93	13.25	16.8	16.1	15.97	17.64	16.14	16.58	16.78	17.05		
Production (Million tonnes)	19.67	18.71	24.25	23.25	22.26	23.69	20.84	21.75	22.21	22.5		

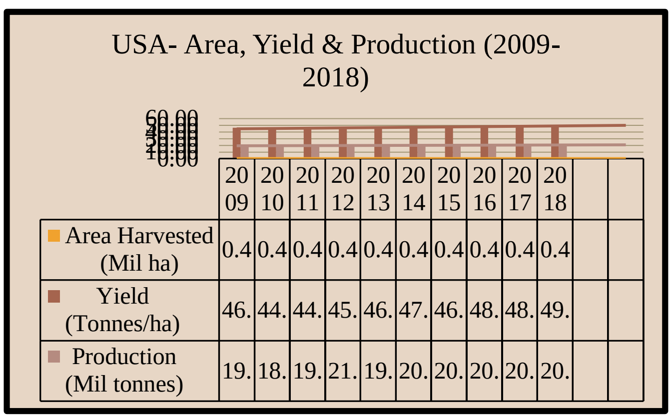
Figure 63 Ukraine- Area, Yield, Production (2009-2018)

With a production yield of more than 17 tonnes per hectare, the country is not a potato exporter despite growing more than 22 million tonnes of potatoes. A large quantity of the production is lost due to pests and diseases especially Colorado potato beetle. Other factors contributing to product loss are inadequate storage facilities in the country.[247]

As is evident from the above figure, with an area of 1.32 million hectares, the country has shown 22% increase in yield, and 14% increase in production despite losing 7% of area harvested for potatoes.

UNITED STATES

Though potato has been a household item in South America for millennia, it got hold in small patches in North America in[248] 1719 in New Hampshire. The processed French fries from potato were served at the white House in the era of President Thomas Jefferson in early 1800. With a production of more than 19 million tonnes, the US stood at fifth position in potato production in 2009. Thirty American states grow potatoes. However, around 50% of crop comes from the states of California, Colorado, Maine, Michigan, Minnesota, Oregon, North Dakota, Washington and Wisconsin with Idaho the largest producer.[249] The crop is mainly harvested in fall season from September to October. American consume only one-third of the produce freshly. Around 60% of the annual production goes to processed industry to be served as frozen fries and wedges, chips, dehydrated potatoes, and flakes. Around 6% goes back to be used as seed for next season. Per capita consumption of Americans is more than 55 kg per year with an increased trend of fresh consumption from 22 kg in early nineties to just around 15 kg per person in 2018.[248]



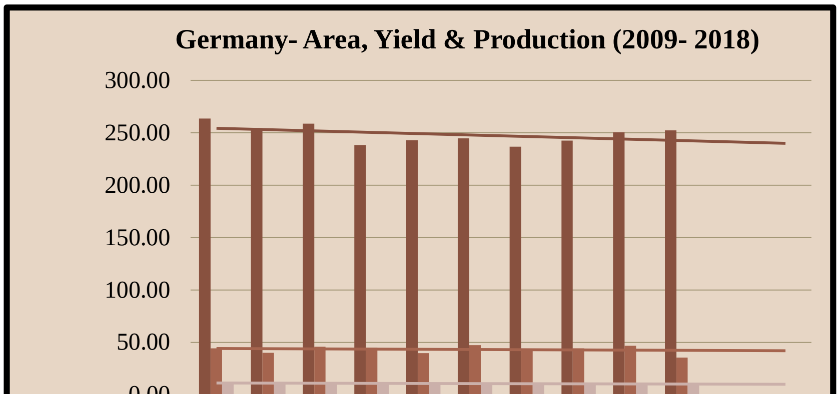
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
Area Harvested (Mil ha)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4		
Yield (Tonnes/ha)	46.	44.	44.	45.	46.	47.	46.	48.	48.	49.		
Production (Mil tonnes)	19.	18.	19.	21.	19.	20.	20.	20.	20.	20.		

Figure 64 USA- Area, Yield & Production (2009- 2018)

During the past decade, USA lost around 2% of area harvested for potatoes but increased its already huge per hectare yield from 46.44 tonnes per hectare to 49.76 tonnes per hectare registering an increase of 7% in yield which resulted in an increase of around 5% in production with an almost stagnant area for production.

GERMANY

Potato landed in Germany at the end of 1500s but for next two hundred years, the humble tuber was almost exclusively used as animal feed. It was the famine of 1770s that brought the humble tuber into the attention of Germans especially with the efforts of Frederick the Great of Prussia who prompted use of kartoffel as staple food crop. Today, Germany stands at sixth position and largest in Western Europe with around 9 million tonnes. Despite this fact, Germany has been continuously losing its production vigor since 1960 when it was producing around 33 million tonnes of potato from 10% of its all arable land which has now shrunken only to 1.3 million hectares.[250]



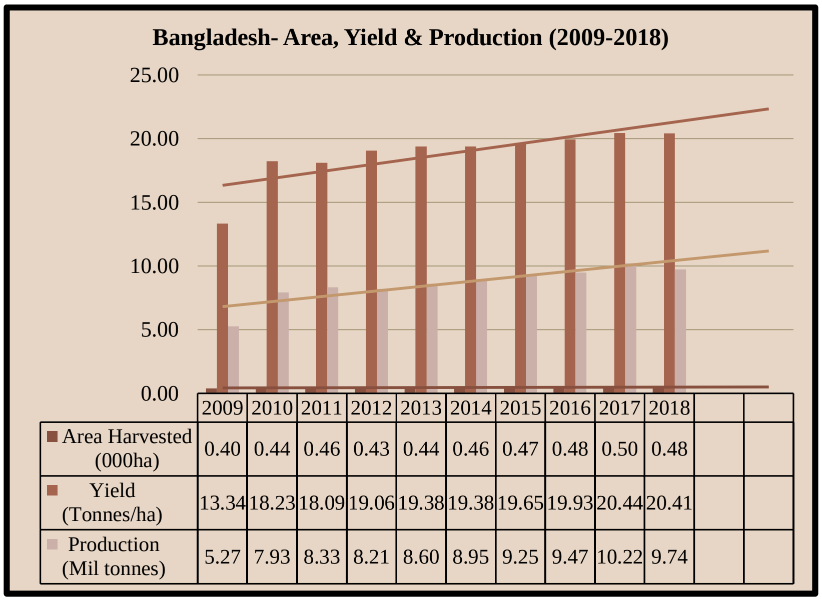
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
Area Harvested (000ha)	263.7	254.3	258.7	238.3	242.8	244.8	236.7	242.6	250.5	252.2		
Yield (Tonnes/ha)	44.30	39.88	45.76	44.76	39.83	47.42	43.81	44.40	46.79	35.37		
Production (Mil tonnes)	11.68	10.14	11.84	10.67	9.67	11.61	10.37	10.77	11.72	8.92		

Figure 65 Germany- Area, Yield & Production (2009-2018)

For past decade, Germany is showing a consistent decrease in area, yield and production. Its area has reduced by 4%, yield by 22% and production by 14% mainly due to losing cultivated area.

BANGLADESH

The British governors prompted cultivation of potatoes in Bangladesh like other commonwealth countries during 1770s. Within a century, potato became an established garden vegetable. It was lack of adaptable varieties that held Bangladesh back in large scale production of potato as the introduced European cultivars were not adaptable to hot Bengali plains. Bangladesh is now among top ten potato producing countries where it is grown from October to March in comparatively cooler months. Today, with production of around 10 million tonnes, Bangladesh is among the top potato producing countries in Asia, second only to India and China.[251]



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
Area Harvested (000ha)	0.40	0.44	0.46	0.43	0.44	0.46	0.47	0.48	0.50	0.48		
Yield (Tonnes/ha)	13.34	18.23	18.09	19.06	19.38	19.38	19.65	19.93	20.44	20.41		
Production (Mil tonnes)	5.27	7.93	8.33	8.21	8.60	8.95	9.25	9.47	10.22	9.74		

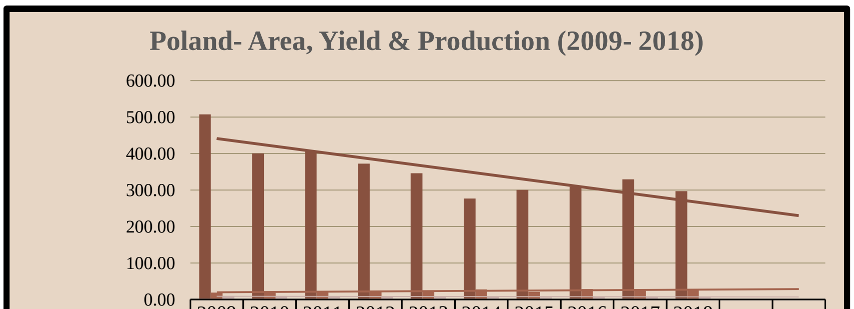
Figure 66 Bangladesh- Area, Yield & Production (2009- 2018)

The rise of Asia as leader in potato production is now an established fact. Bangladesh's progress in potato production may help in understanding this rise. The country was standing at 14th position among potato producing countries in the world just a decade ago and at number 4 in Asia. Today, with an increase of 17% in harvested area, 53% in yield has resulted in 85% increase in production, Bangladesh stands at number 7 in the world. It can be easily deduced from the above figure that Bangladesh showed that pattern that an increase of 1% in area resulted in an increase of 3% in yield and 5% in production.

POLAND

For several years, Poland has been a leader in Europe for producing the largest quantity of potatoes. The formal cultivation began in nineteenth century, though it was already present there since the reign of King John III Sobieski. The legend has it that he brought it from Vienna in the middle of 1600s. Initially it was named *amerykany* (literal meaning from America).[252,253]

The Polish romance with potato began when the King presented the humble tuber to his beloved Marysienka as a decoration for garden. This romance led Poland into a giant potato producer in the twentieth century. Since then, Polish dinner table is incomplete without potato. It is served as cooked vegetable, with butter and dill, roasted, mashed and in the shape of purees, not limiting it to chips and fries.[252,253] It is interesting to know that by 1970, Poland was producing more than 50 million tonnes of potato annually surpassed only by the Soviet Union. Even today, Poland stands into the list of top ten potato producers in the world. The gradual decrease in production has left country with producing around 10 million tonnes in 2009 to mere 7.5 million tonnes in 2018. Nevertheless, potato is still in the heart of Polish society and around 2.2 million farmers are associated with this crop cultivating around 10% of the total area for field crops.[253]



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
Area Harvested (000 ha)	507.95	400.70	406.44	373.00	346.13	276.93	300.36	309.90	329.32	297.48		
Yield (Tonnes/ha)	19.10	21.08	23.03	24.38	21.06	27.77	21.02	28.63	27.85	25.14		
Production (Mil tonnes)	9.70	8.45	9.36	9.09	7.29	7.69	6.31	8.87	9.17	7.48		

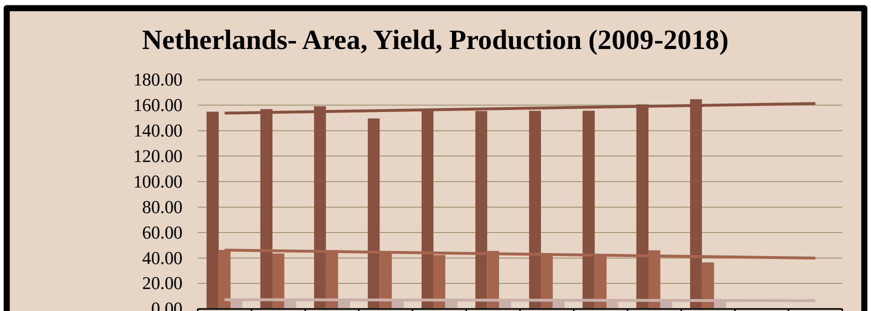
Figure 67 Poland- Area, Yield & Production (2009- 2018)

It is evident from the above figure that Poland is losing its romance with potato. From past one decade the production has decreased by 23%, despite an increase of 32% in yield, as the area under cultivation has decreased by more than 40%.

NETHERLANDS

Since its introduction to the Dutch society in 1600s, the potato has become one of the most important crop of the country. Today, Netherlands is among the top ten potato producing countries in the world with a production of more than six million tonnes.[254]

Though European as a whole are losing their romance with potato, the Dutch still are growing around 25% of their arable land with potatoes on an area of around 165 thousand hectares. The Dutch have



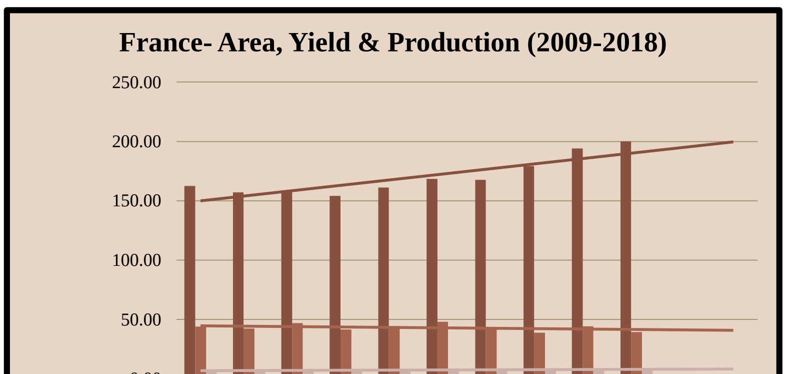
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
Area Harvested (000 ha)	154.97	156.97	159.23	149.77	155.82	155.50	155.66	155.59	160.79	164.69		
Yield (Tonnes/ha)	46.34	43.60	46.06	45.17	42.21	45.66	42.73	42.00	45.97	36.61		
Production (Mil tonnes)	7.18	6.84	7.33	6.77	6.58	7.10	6.65	6.53	7.39	6.03		

achieved the highest yield level in the world by crossing 46 tonnes per hectare figures during past decade. The Netherlands has a very mechanized potato sector with around 250 approved varieties to be cultivated. The Netherlands uses 50% of its potato crop for food, 20% is dedicated to seed production and rest of the 30% is used for processing into starch. Seventy percent of the Dutch ware potatoes goes in export in the form of fresh or processed products. The growth of potato industry in the Netherlands has developed it into one of the major certified seed supplier in the world.[254]

The decline discussed above is well illustrated in the figure above where the production of potato has decreased from 7 million tonnes to 6 million tonnes during the past decade with decrease in yield from record 46.34 tonnes per hectare to mere 36.61 tonnes per hectare despite the fact that harvested area has been increased by 6%. This drop is contributed to weather extremities of wet start and wet ending of the potato season.[255] The fall in area, yield and production from 2017 to 2018 is mainly contributed to the European drought which caused an 18% decrease in yield and 2% decrease in production.

FRANCE

Potato was introduced to France in early 1700s but like other European countries it took the humble tuber two centuries to get recognition as food. Thanks to A.A. Parmentier, the famous army chemist who recommended its use to deal with the endemic famines that were devastating the Europe in general. France took off with potato production producing around 1.5 million tonnes in early 1800s to 11.8 million in 1865. It took France another hundred years to reach at the zenith of its potato production with 16 million tonnes in 1955. After that the decline in potato production is witnessed to the extent that now it has decreased to 6 million tonnes. France's consumption of fresh potatoes is around 1 million tonnes whereas another 1 million tonnes is used for processing.[256,257]



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
Area Harvested (000 ha)	162.59	157.08	158.64	154.10	161.21	168.52	167.51	179.13	194.06	199.89		
Yield (Tonnes/ha)	43.79	42.16	46.90	41.38	43.16	47.98	42.51	38.83	44.05	39.38		
Production (Mil tonnes)	7.12	6.62	7.44	6.38	6.96	8.09	7.12	6.95	8.55	7.87		

Figure 68 Netherlands- Area, Yield & Production (2009-2018)

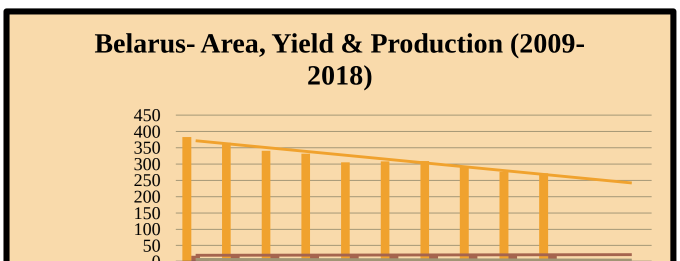
The above figures show that France has increased its harvested area for potato in the past decade from 162.59 thousand hectares to around 200 thousand hectares showing an increase of 23%. Its per hectare yield which was around 44 tonnes remained at same level in 2017 but it decreased to 39.38 tonnes per hectare in 2019. One interesting thing to note here is alternate bearing. However, overall France has shown an increase in production during the past decade.

BELARUS

The humble tuber was well adopted by the poor land of poor people Belarus to the extent that they are nicknamed *potato people* or *Bulbiachy.* As they are considered a nation of peasants, potato remained their food through the history and still is the most important food of their everyday life. No one else has shown so much love for humble tuber than Belarusians. They consume more potatoes than other nation in the world. The per capita consumption is more than 180 kg per year which makes it around half kilogram every day.[258]

It is believed that Belarusian got their potatoes from the Netherlands before 1800s and during these days it became the heart of cuisine in Belarus. Belarusian love for potato is evident from the fact that Belarus is still among the top potato producing countries with an annual output of around 6 million tonnes. At the time when Belarus was a part of Soviet Union, Belarus varieties were grown on one-third of Soviet lands and at that time, USSR was exporting more than half a million tonnes fresh potatoes to the world and around 300,000 tonnes in shape of potato seeds.[259]

But those days are gone and today Belarus has a shrunken area of around 271 thousand hectares producing around 6 million tonnes of potato thanks to gradual increase of 16% in yield during the past decade.



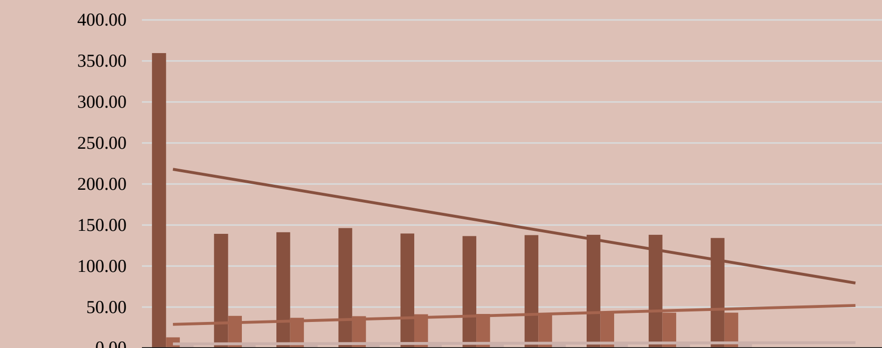
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
Area Harvested (000 ha)	383	366.8	341.1	332	305.4	307.9	309.6	292.4	276	271.8		
Yield (Tonnes/ha)	18.60	21.35	20.96	20.81	19.35	20.39	19.36	20.47	23.24	21.58		
Production (Mil tonnes)	7.12	7.83	7.15	6.91	5.91	6.28	6.00	5.98	6.41	5.87		

Figure 70 Belarus- Area, Yield & Production (2009- 2018)

CANADA

It was mid 1600s when settlers on the Atlantic coast of Canada cultivated potatoes. Today, Canada is among the top potato producers and exporters. With an output of around 570, 000 tonnes of potato, Canada cultivates one third of its all-vegetable farm area thus making potato as one of the most important horticultural crop. Canada has a consistent area under production to meet the ever increasing international demand for frozen potato products. Canada ranks second only to the Netherlands in export of French fries. The Canadian has developed the crop to the extent that today Canada is among the top five potato seed exporting countries not mentioning the export of ware potatoes.

Canada- Area, Yield & Production (2009- 2018)



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
Area Harvested (000 ha)	359.70	139.21	141.16	146.12	139.64	136.37	137.56	138.13	138.19	134.10		
Yield (Tonnes/ha)	12.75	39.08	36.65	38.61	41.06	41.38	42.71	42.86	43.20	43.18		
Production (Mil tonnes)	4.58	5.44	5.17	5.64	5.73	5.64	5.87	5.92	5.97	5.79		

BELGIUM

It is a legend now that one of the Belgian officials in Mons received potatoes as a gift from a friend of Vatican ambassador back in 1587. The official forwarded the gift to a botanist in Vienna. It took Belgians a century to reach at the zenith of potato development with their claimed invention of French fries. Belgium is one of countries producing highest yields in potato. Even today, potato is the main food crop of the country despite the fact that cultivated area for potato has decreased to 100,000 hectares which is less than 5% of the total Belgian farmland.[260]

The climate and soil of Belgium in special and northwestern Europe in general is considered the best land for potato cultivation. It is one of the major reasons that the region produces highest yields of potato in the world. More than 3500 farmers are involved in farming potatoes in Belgium at an area of around 100,000 hectares producing around 3.0 million tonnes of potato annually.[261]

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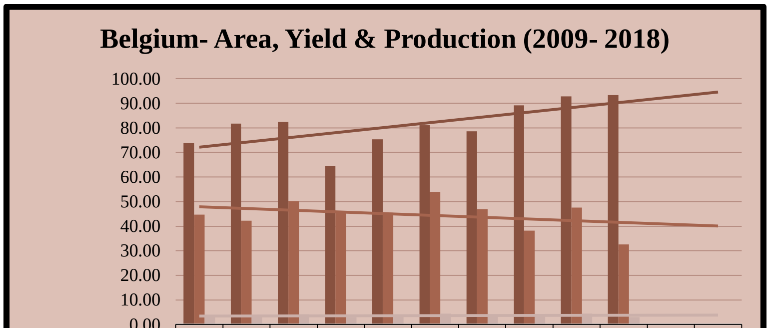

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
Area Harvested (000 ha)	73.72	81.76	82.34	64.50	75.40	81.12	78.64	89.16	92.86	93.33		
Yield (Tonnes/ha)	44.71	42.27	50.14	45.42	45.46	54.00	46.92	38.16	47.57	32.63		
Production (Mil tonnes)	3.30	3.46	4.13	2.93	3.43	4.38	3.69	3.40	4.42	3.05		

Figure 71 Belgium- Area, Yield & Production (2009- 2018)

The above figure shows that though Belgium has increased its cultivated area by 27%. Its per hectare yield is reduced by 27% from 44.71 to 32.63 tonnes per hectare. During the past decade, the production has also decreased by 8%. This trend shows that Belgian potato sector is declining consistently.

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GLOBAL VARIETIES (NAMES, FEATURES, ORIGIN, ETC.)

Though belonging to one botanical specie, Solanum tubersum, potato has thousands of varieties with difference in shape, colour, size, texture, taste and cooking characteristics.[60] Today, we have more than 5000 varieties of potato throughout the world though the most of these varieties are confined to South America.[262] A small sample of potato diversity is shown in the table below;

Table 9 Global Varieties of Potato Source: CIP

S.No	Variety	Origin/Place of Cultivation	Characteristics	Photo/Illustration
1	Atahualpa	Propagated in Peru	A high yielding variety good for both baking and frying	
2	Nicola	Propagated in the Netherlands	One of the best for boiling, also good in salads	
3	Russet Burbank	Classic American Variety	Excellent for baking and French fries	
4	Lapin puikula	Classic Finland Variety		
5	Yukon Gold	Classic Canadian Variety	Suitable for frying, boiling, mashing	
6	Tubira	CIP-bred variety grown in West Africa	White flesh, pink skin	

7	Vitelotte	gourmet French variety	Prized for its deep blue skin and violet flesh	
8	Royal Jersey	From the Isle of Jersey	the only British vegetable with an EU designation-of-origin	
9	Kipfler	Hails from Germany.	Elongated with cream flesh, popular in salads	
10	Papa colorada	Brought to the Canary Islands by passing Spanish ships in 1567		
11	Maris Bard	Bred in the United Kingdom	White variety with a soft waxy texture good for boiling	
12	Désirée		Red-skinned, with yellow flesh and a distinctive flavour	
13	Spunta		Another popular commercial tuber, good for boiling and roasting	

14	Mondial	A Dutch potato	With smooth good looks. Boils and mashes well	
15	Unknown		One of more than 5000 native varieties still grown in the Andes	

CONSUMPTION PATTERNS IN INTERNATIONAL MARKET INCLUDING CONSUMPTION PER CAPITA [redacted]

Per capita consumption of potatoes has reached more than 33 kg. It is nearing the all-time high per capita consumption of 35.7 kg in the year 1961. The consumption recorded an all-time low per capita figure of 26 kg in the year 1991. Yearly consumption of potatoes per capita is shown in the figure below;

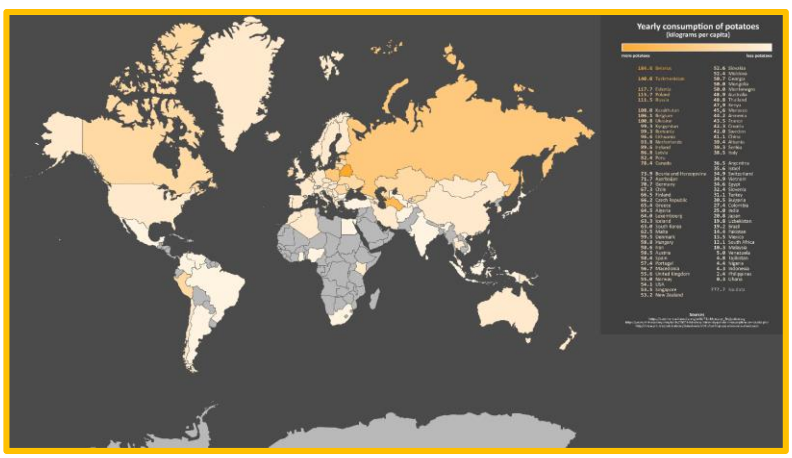


Figure 72 Yearly Per Capita Consumption of [Potatoes]

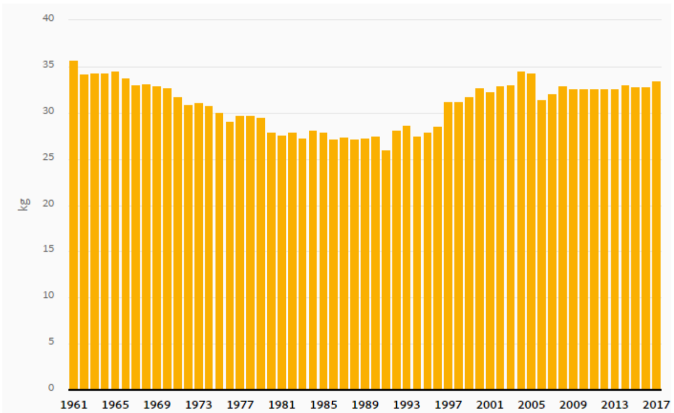


Figure 73 World Per Capita Consumption (1961- 2017) Source: HelgiLibrary

ISSUES AND PROPOSED SOLUTIONS

For hundreds of years, potato has been an affordable staple food. Recently, it has been associated with obesity and thus its consumption is on a decline. Several reports have erroneously linked it with unhealthy food. There is need to educate masses about the fact that potatoes are an important source of micronutrients including vitamin C, vitamin B6, iron and potassium. There reports stating that there is a strong link between potato intake and non-communicable diseases. The people are need to understand that it is the cooking method that destroys the nutrients from the food such as leaching of water soluble nutrients in water during boiling and accumulation of resistant starch by frying.[263]

On the production fronts, though world produced millions of tons of potatoes each year. The issue of lower yields and diseases resistant varieties has not been resolved for several countries including Pakistan and the world has yet to realize its real potential in potato production. There is need to develop diseases resistant varieties. If the world needs the planet has a food security, then all efforts should be focused on increasing potato yield and developing disease resistant varieties.

Pakistan should aim at improving its ranking in potato production in global context by improving its yield and area of cultivation to become a member of top ten potato producing countries.

SECTION 5: DOMESTIC PRODUCTION, YIELD AND CONSUMPTION

INTRODUCTION

The potato has been under cultivation in the Indian subcontinent since early 17th century. In 1947, when Pakistan gained independence from British Raj, we were producing a mere 30,000 tonnes of potatoes annually. Since then potato (aalu) has become one of the fastest growing staple crop of the country mainly due to increase in cultivated area and average yield per hectare. One of world's best irrigation systems made it possible for Pakistan to increase its output from one million tonnes in 1995 to around 3 million tonnes in 2009.[264] From 2009 onwards, Pakistan has shown an increase of 34% in cultivated area. The per hectare yield has increased by 17% whereas production has increased by 56% registering more than 4.5 million tonnes from an area of 194 thousand hectares. The production of potato is strongly concentrated in the province of Punjab with more than 95% of production.

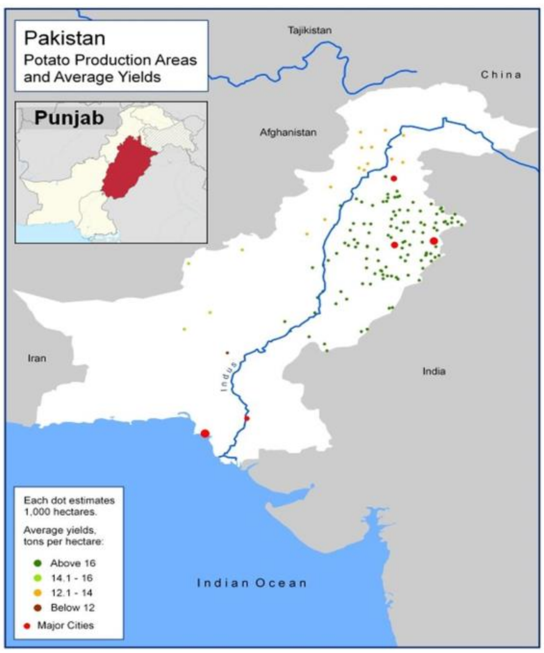
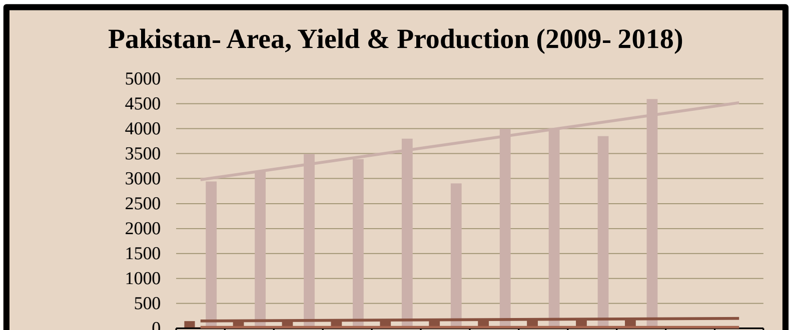


Figure 74 Pakistan- Area, Yield & Production (2009-2018) Source: PotatoPro

Other provinces include Khyber Pakhtunkhwa, Baluchistan and Sindh. There are however some subsistence growers in northern parts of the country otherwise most of the Pakistani farmers grow potatoes for urban markets near them rather than for household consumption. Thus today, potato has gained popularity as a significant source of rural income in Pakistan.[264]



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
Area Harvested (000 ha)	145	139	159	185	174	160	171	177	180	194		
Yield (Tonnes/ha)	20	23	22	18	22	18	23	22	21	24		
Production (000 tonnes)	2941	3142	3492	3393	3802	2901	3998	3978	3853	4592		

Though low from average world consumption, Pakistan's potato consumption is showing an upward trend with more than 15 kg per capita per year.
Over the years, potato has gained importance in Pakistan as the one of the largest cultivated vegetables both for farmers and consumers. It is the fourth crop by volume of production in Pakistan. In Pakistan, it is also known as the king of vegetables and Pakistani household vegetable basket is incomplete without potato.[48] With the most favorable agro-climatic conditions, Pakistan is cultivating four potato crops round the year at different zones in the country. For autumn crop, the plains of Punjab and KPK, for winter crop the plains of southern Punjab, Baluchistan and Sindh, for spring crop lower hills in Punjab and KPK. The summer crop is produced on high hills of KPK, Baluchistan, Punjab and AJK.[265]

National Agriculture Research Council of Pakistan has divided the country into the following agro-ecological zones for production of potato.

- Irrigated plains of Sindh, Southern Punjab and Baluchistan.

- Irrigated plains of Central Punjab and South East NWFP.
- Irrigated and rain-fed plains of NWFP and Northern Punjab.
- Irrigated lower valleys of NWFP.
- Rain-fed high valleys and hill sides of NWFP, Northern Punjab and Azad Kashmir.
- Irrigated high valleys of NWFP, Northern Areas around Chillas and Azad Kashmir.
- Irrigated high valleys of Northern Areas and NWFP around Mastuj.
- Irrigated high valleys of Baluchistan, South and North Waziristan.

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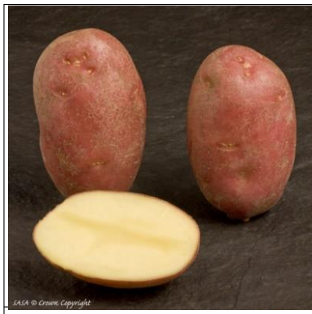
LOCAL VARIETIES AND THEIR CHARACTERISTICS VIS-À-VIS INTERNATIONAL VARIETIES

Pakistan mostly grows exotic varieties imported from the Netherlands, United Kingdom and Ireland. Only a few varieties are developed nationally including Raja, Lal-e-Faisal. Below is given the characteristics of the varieties cultivated in Pakistan on commercial basis.

ASTERIX

Developed in Netherlands, Asterix is a high yield multi-purpose potato variety which is specifically recommended for French fries. With a medium dormancy, early sprouting adds to the vigor of the plant. The variety is suitable for all types of soil with its good drought tolerance and strong foliage. The variety is suitable for long-term storage at a consistent 8°C, however, the use of sprout inhibitors is recommended after six to eight weeks of curing.[266]



ASTERIX

Parentage	Cardinal x SVP VE 70 9
Country of Origin	Netherlands
Plant Characteristics	
Maturity	Intermediate to late
Growth habit	Erect
Foliage cover	Moderate
Flower colour	Red violet
Flower frequency	Occasional to frequent
Berries	Rare
Light sprout colour	Pink
Tuber Characteristics	
Tuber skin colour	Red
Tuber eye colour	Red
Primary tuber flesh colour	Light yellow
Tuber shape	Oval to long
Tuber eye depth	Shallow to medium
Tuber skin texture	Smooth to Intermediate
Utilization Characteristics	
Cooking type / 411 Cooked texture	Fairly firm (Multipurpose)
Frying colour	Pale
After cooking blackening	None to trace
Taste	Good
Crisp suitability	Poor

French fries suitability	Good
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	Medium to high
Wart (Synchytrium endobioticum)	-
Resistance to gangrene (Phoma foveata)	-
Resistance to dry rot (Fusarium spp.)	-
Resistance to blackleg	-
Resistance to ring rot	-
Resistance to Virus Diseases	
Resistance to potato virus A	Low to medium
Resistance to potato virus X	Very high
Resistance to potato virus Y (strain not specified)	Medium to high
Resistance to potato leaf roll virus	Low to medium
Resistance to virus YN	-
Resistance to Fungal Diseases	
Resistance to late blight on tubers	High to very high
Resistance to late blight on foliage	Medium
Resistance to late blight on tuber (laboratory test)	Very high
Resistance to Dry rot	Medium
Resistance to stem canker	-
Resistance to powdery scab	-
Resistance to Wart	Field immune

BARNA

A strong and robust potato variety from Ireland is considered good for different culinary uses. It is also recommended for French fries. It has good storage capacity and capability and shows strong resistance against different potato diseases.[267]

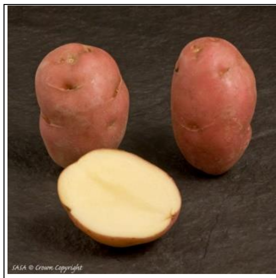
BARNA

Parentage	Desiree x Cara
Country of origin	IRELAND

Plant Characteristics	
Maturity	Intermediate to late
Growth habit	Semi erect
Foliage cover	Poor to moderate
Flower colour	Red violet
Flower frequency	Rare
Berries	Rare
Light sprout colour	Pink
Tuber Characteristics	
Tuber skin colour	Red
Tuber eye colour	Red
Primary tuber flesh colour	White
Tuber shape	Oval to long
Tuber eye depth	Very shallow
Tuber skin texture	Smooth
Utilization Characteristics	
Cooking type / 411 Cooked texture	Fairly firm (multi-purpose type)
Frying colour	Medium
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	Medium
Wart (Synchytrium endobioticum)	Field immune
Resistance to gangrene (Phoma foveata)	High
Resistance to dry rot (Fusarium spp.)	Low
Resistance to Virus Diseases	
Resistance to potato virus X	High
Resistance to potato virus Y (strain not specified)	Low to medium
Resistance to potato leaf roll virus	Low to medium
Resistance to Fungal Diseases	
Resistance to late blight on tubers (Laboratory test)	High
Resistance to late blight on foliage (Artificial inoculum in the field)	Low to medium
Resistance to late blight on foliage (Laboratory test)	Medium

DESIREE

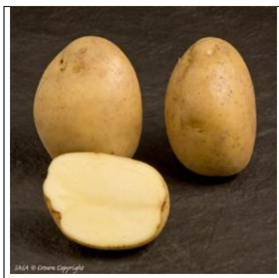
The variety is considered fairly good for cooking purposes with its firm mealy texture. Desiree has long-oval large tubers which are good for French fries. The variety is considered quite good for making French fries when it is cultivated in warm climates.[268]

 DESIREE	
Parentage	Urgenta x Depesche (tbr)
Country of Origin	Netherlands
Plant Characteristics	
Maturity	Late, Intermediate to late
Growth habit	Semi erect to erect
Foliage cover	Moderate, Good, Good to dense
Flower colour	Red Violet
Flower frequency	Occasional
Berries	Occasional to frequent
Light sprout colour	Pink
Tuber Characteristics	
Tuber skin colour	Red
Tuber eye colour	Red
Primary tuber flesh colour	Cream
Tuber shape	Oval to round
Tuber eye depth	Medium, Medium to shallow
Tuber skin texture	Rough, intermediate, smooth
Utilization Characteristics	
Cooking type / 411 Cooked texture	Fairly firm
Frying colour	-
After cooking blackening	Little
Taste	Moderate to good
Crisp suitability	Poor
French fries suitability	Moderate
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	Low to very low
Wart (Synchytrium endobioticum)	-
Resistance to gangrene (Phoma foveata)	-
Resistance to dry rot (Fusarium spp.)	Medium to high

Resistance to blackleg	High
Resistance to Virus Diseases	
Resistance to potato virus A	Medium to high
Resistance to potato virus X	Low
Resistance to potato virus Y (strain not specified)	Medium to low
Resistance to potato leaf roll virus	Very low to low
Resistance to virus YN	High
Resistance to Fungal Diseases	
Resistance to late blight on tubers	Low to medium
Resistance to late blight on foliage	Medium
Resistance to late blight on tuber (laboratory test)	Low to medium
Resistance to Dry rot	Medium to high
Resistance to stem canker	Low to medium
Resistance to powdery scab	Very low
Resistance to Wart	Susceptible

HERMES

It is a late variety to some extent which is considered quite suitable for making crisps. The bulk of Hermes is cultivated in warmer climates around the Mediterranean Sea and is heavily used by processing industry.[269]

 HERMES	
Parentage	DDR 5158 x SW 163 55
Country of origin	Austria
Plant Characteristics	
Maturity	Intermediate
Growth habit	Semi erect
Foliage cover	-
Flower colour	-
Flower frequency	No flowers
Berries	No berries
Light sprout colour	Pink

Tuber Characteristics	
Tuber skin colour	White to Yellow
Tuber eye colour	Yellow
Primary tuber flesh colour	Yellow
Tuber shape	Oval to round
Tuber eye depth	Shallow, Medium
Tuber skin texture	Smooth to intermediate
Utilization Characteristics	
Cooking type / 411 Cooked texture	Mealy (Floury type)
Frying colour	Mealy to firm
After cooking blackening	Little to some
Taste	Moderate
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	Medium to high
Wart (Synchytrium endobioticum)	
Resistance to gangrene (Phoma foveata)	
Resistance to dry rot (Fusarium spp.)	
Resistance to Virus Diseases	
Resistence to potato virus A	High
Resistance to potato virus X	Low
Resistance to potato virus Y (strain not specified)	High to very high
Resistance to potato leaf roll virus	
Resistance to Fungal Diseases	
Resistance to late blight on tubers	High
Resistance to late blight on foliage	Medium
Resistance to late blight on tuber	High to very high

LADY ROSETTA

It is moderately early variety considered best for crisping industry. Early in the cultivation period, the variety possesses higher dry matter levels and low sugar content. With its very uniform round tubers, the variety has a liking for it in North America, Europe and ME, mainly due to its suitability for crisping.[270]

LADY ROSETTA	
Parentage	Cardinal x SVP VTn2 62 33 3
Country of Origin	Netherlands
Plant Characteristics	
Maturity	Early to Intermediate
Growth habit	Semi erect to erect
Foliage cover	Moderate to good
Flower colour	Red violet
Flower frequency	Rare
Berries	No berries
Light sprout colour	Pink
Tuber Characteristics	
Tuber skin colour	Red
Tuber eye colour	Red
Primary tuber flesh colour	Light yellow
Tuber shape	Round
Tuber eye depth	Shallow to medium
Tuber skin texture	Rough to smooth
Utilization Characteristics	
Cooking type / 411 Cooked texture	Mealy and Multipurpose
Frying colour	-
After cooking blackening	Trace
Taste	Good
Crisp suitability	Moderate to good
French fries suitability	Poor
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	Medium to high
Wart (Synchytrium endobioticum)	-
Resistance to gangrene (Phoma foveata)	-
Resistance to dry rot (Fusarium spp.)	-
Resistance to blackleg	-

Resistance to ring rot	High
Resistance to Virus Diseases	
Resistance to potato virus A	Low
Resistance to potato virus X	High to very high
Resistance to potato virus Y (strain not specified)	Medium to high
Resistance to potato leaf roll virus	-
Resistance to virus YN	High
Resistance to Fungal Diseases	
Resistance to late blight on tubers	Medium
Resistance to late blight on foliage	Low
Resistance to late blight on tuber (laboratory test)	High to very high
Resistance to Dry rot	-
Resistance to stem canker	-
Resistance to powdery scab	-
Resistance to Wart	Susceptible

SANTE

Sante is the most commonly grown organic variety. It is considered suitable for processing, general ware and pre-pack.[271]

SANTE

Parentage	SVP Y 66 13 636 x SVP AM 66 42 WY 66-13-636 x AM 66-42
Country of Origin	Netherlands
Plant Characteristics	
Maturity	Intermediate to late
Growth habit	Spreading to semi erect
Foliage cover	Good
Flower colour	White
Flower frequency	Rare

Berries	No berries
Tuber Characteristics	
Tuber skin colour	White to yellow
Tuber eye colour	Yellow
Primary tuber flesh colour	Light yellow
Tuber shape	Oval to round
Tuber eye depth	Shallow to medium
Tuber skin texture	Smooth
Utilization Characteristics	
Cooking type / 411 Cooked texture	Mealy
Frying colour	Pale to medium
After cooking blackening	Little
Taste	Good
Crisp suitability	Poor
French fries suitability	Poor
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	Low to medium
Wart (Synchytrium endobioticum)	-
Resistance to gangrene (Phoma foveata)	-
Resistance to dry rot (Fusarium spp.)	-
Resistance to blackleg	Low to medium
Resistance to ring rot	-
Resistance to Virus Diseases	
Resistance to potato virus A	High to very high
Resistance to potato virus B	High
Resistance to potato virus C	Medium to high
Resistance to potato virus X	High
Resistance to potato virus Y (strain not specified)	Very high
Resistance to potato leaf roll virus	Medium
Resistance to virus YN	Very high
Resistance to Fungal Diseases	
Resistance to late blight on tubers	Medium
Resistance to late blight on foliage	Medium
Resistance to late blight on tuber (laboratory test)	Medium to high
Resistance to dry rot	Medium to high
Resistance to stem canker	-
Resistance to powdery scab	High
Resistance to Wart	Field immune

SENTANA

Sentana has higher dry matter which is considered suitable for crisping. It has a good quality for storage and gives pleasing fry colour even throughout storage. Sentana is a high yielding variety which is preferred by farmers for growing and storage. Not only crisping but it is also liked for fresh use. It is considered highly suitable for organic protection.[267]

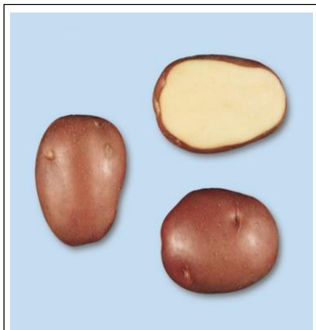
SETANTA

Parentage	Brodick x Rooster
Country of Origin	Ireland
Plant Characteristics	
Maturity	Very late
Growth habit	Semi erect to erect
Foliage cover	Medium
Flower colour	White
Flower frequency	Absent or low
Berries	Absent or low
Tuber Characteristics	
Tuber skin colour	Red
Tuber eye colour	Red
Primary tuber flesh colour	Creamy to yellow
Tuber shape	Oval
Tuber eye depth	Shallow to medium
Tuber skin texture	Smooth
Utilization Characteristics	
Cooking type / 411 Cooked texture	-
Frying colour	-
After cooking blackening	-
Taste	-
Crisp suitability	-
French fries suitability	-

Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	-
Wart (Synchytrium endobioticum)	-
Resistance to gangrene (Phoma foveata)	-
Resistance to dry rot (Fusarium spp.)	-
Resistance to blackleg	-
Resistance to ring rot	-
Resistance to Virus Diseases	
Resistance to potato virus A	-
Resistance to potato virus B	-
Resistance to potato virus C	-
Resistance to potato virus X	-
Resistance to potato virus Y (strain not specified)	-
Resistance to potato leaf roll virus	-
Resistance to virus YN	-
Resistance to Fungal Diseases	
Resistance to late blight on tubers	Low to medium
Resistance to late blight on foliage	Low to medium
Resistance to late blight on tuber (laboratory test)	-
Resistance to dry rot	-
Resistance to stem canker	-
Resistance to powdery scab	-
Resistance to Wart	-

KURODA

Kuroda is a multi-purpose potato variety which is mainly used for fresh consumption. It has higher yields and is considered an early maturing variety with good initial development.[272]



KURODA

Parentage	AR 76-199-3 x KO 80-1407
Country of Origin	Netherlands
Plant Characteristics	
Maturity	Medium early to medium late
Growth habit	Good to fairly good
Foliage cover	Good to fairly good
Flower colour	medium, conical,
Flower frequency	Frequent
Berries	-
Tuber Characteristics	
Tuber skin colour	Red
Tuber eye colour	Yellowish
Primary tuber flesh colour	Fairly yellowish
Tuber shape	Oval
Tuber eye depth	Rather shallow
Tuber skin texture	Medium rough
Utilization Characteristics	
Cooking type / 411 Cooked texture	Fairly firm
Frying colour	-
After cooking blackening	-
Taste	Good
Crisp suitability	Poor
French fries suitability	Poor
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	Moderate
Wart (Synchytrium endobioticum)	Good
Resistance to gangrene (Phoma foveata)	-
Resistance to dry rot (Fusarium spp.)	-
Resistance to blackleg	-
Resistance to ring rot	-
Resistance to Virus Diseases	
Resistance to potato virus A	Very good
Resistance to potato virus B	
Resistance to potato virus C	
Resistance to potato virus X	Fairly susceptible
Resistance to potato virus Y (strain not specified)	-
Resistance to potato leaf roll virus	-
Resistance to virus YN	Fairly good
Resistance to Fungal Diseases	
Resistance to late blight on tubers	Moderately good
Resistance to late blight on foliage	Fairly susceptible

Resistance to late blight on tuber (laboratory test)	-
Resistance to dry rot	-
Resistance to stem canker	-
Resistance to powdery scab	-
Resistance to Wart	Fairly resistant

DIAMANT

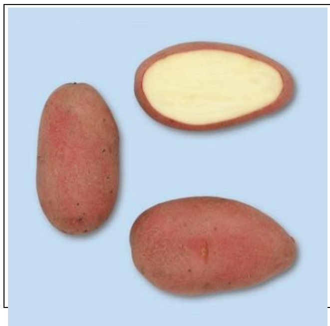
The yellow skin variety is considered good for higher yield. In warmer areas its growth is excellent which enhances its production. Diamant is considered quite suitable for processing industry.[273]

DIAMANT

Parentage	Mutant Cardinal
Country of Origin	Netherlands
Plant Characteristics	
Maturity	Medium
Growth habit	
Foliage cover	Good
Flower colour	Medium
Flower frequency	High
Berries	-
Tuber Characteristics	
Tuber skin colour	Yellow
Tuber eye colour	Yellow
Primary tuber flesh colour	Pale yellow
Tuber shape	Oval
Tuber eye depth	Shallow
Tuber skin texture	Medium rough
Utilization Characteristics	
Cooking type / 411 Cooked texture	Fairly firm
Frying colour	Medium pale

After cooking blackening	Little
Taste	Good
Crisp suitability	Poor
French fries suitability	Good
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	Susceptible
Wart (Synchytrium endobioticum)	Immune
Resistance to gangrene (Phoma foveata)	-
Resistance to dry rot (Fusarium spp.)	-
Resistance to blackleg	-
Resistance to ring rot	-
Resistance to cyst nematode	Fairly good
Resistance to Virus Diseases	
Resistance to potato virus A	Very good
Resistance to potato virus B	-
Resistance to potato virus C	-
Resistance to potato virus X	Fairly good
Resistance to potato virus Y (strain not specified)	Fairly good
Resistance to potato leaf roll virus	Moderate
Resistance to virus YN	Fairly good
Resistance to Fungal Diseases	
Resistance to late blight on tubers	Good
Resistance to late blight on foliage	Moderate
Resistance to late blight on tuber (laboratory test)	-
Resistance to dry rot	-
Resistance to stem canker	-
Resistance to powdery scab	-
Resistance to Wart	Good

RODEO



RODEO	
Parentage	Mondial x Bimonda
Country of Origin	Netherlands
Plant Characteristics	
Maturity	Medium early to medium late
Growth habit	-
Foliage cover	Good
Flower colour	-
Flower frequency	Frequent
Berries	-
Tuber Characteristics	
Tuber skin colour	Red
Tuber eye colour	Red
Primary tuber flesh colour	Pale yellow
Tuber shape	Large, Long-oval
Tuber eye depth	Very shallow
Tuber skin texture	Medium smooth
Utilization Characteristics	
Cooking type / 411 Cooked texture	Mealy
Frying colour	Pale yellow
After cooking blackening	Little
Taste	Good
Crisp suitability	Poor
French fries suitability	Fair
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	Fairly susceptible
Wart (Synchytrium endobioticum)	Good
Resistance to gangrene (Phoma foveata)	-
Resistance to dry rot (Fusarium spp.)	-
Resistance to blackleg	-
Resistance to ring rot	-
Resistance to cyst nematode	
Resistance to Virus Diseases	
Resistance to potato virus A	-

Resistance to potato virus B	-
Resistance to potato virus C	-
Resistance to potato virus X	-
Resistance to potato virus Y (strain not specified)	Moderate
Resistance to potato leaf roll virus	Good
Resistance to virus YN	Moderate
Resistance to Fungal Diseases	
Resistance to late blight on tubers	Fairly good
Resistance to late blight on foliage	Good
Resistance to late blight on tuber (laboratory test)	-
Resistance to dry rot	-
Resistance to stem canker	-
Resistance to powdery scab	-
Resistance to Wart	Resistant

AJAX

AJAX

Parentage	Froma x MPI 19268 (adg,dms)
Country of Origin	Netherlands
Plant Characteristics	
Maturity	Moderate
Growth habit	Semi erect
Foliage cover	Good
Flower colour	White
Flower frequency	Occasional to frequent
Berries	No
Tuber Characteristics	
Tuber skin colour	White to yellow
Tuber eye colour	Yellow
Primary tuber flesh colour	Yellow
Tuber shape	Oval

Tuber eye depth	Shallow to medium
Tuber skin texture	
Utilization Characteristics	
Cooking type / 411 Cooked texture	Mealy (Multipurpose)
Frying colour	Pale
After cooking blackening	Trace
Taste	Moderate to good
Crisp suitability	-
French fries suitability	-
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	Medium
Wart (Synchytrium endobioticum)	Resistant
Resistance to gangrene (Phoma foveata)	-
Resistance to dry rot (Fusarium spp.)	-
Resistance to blackleg	-
Resistance to ring rot	-
Resistance to cyst nematode	-
Resistance to Virus Diseases	
Resistance to potato virus A	Low
Resistance to potato virus B	-
Resistance to potato virus C	-
Resistance to potato virus X	Low to medium
Resistance to potato virus Y (strain not specified)	High
Resistance to potato leaf roll virus	High
Resistance to virus YN	-
Resistance to Fungal Diseases	
Resistance to late blight on tubers	Medium to high
Resistance to late blight on foliage	Medium to high
Resistance to late blight on tuber (laboratory test)	-
Resistance to dry rot	-
Resistance to stem canker	-
Resistance to powdery scab	-
Resistance to Wart	Field immune

PATRONES

PATRONES

Parentage	(Bintje x Record) x (Black 581 x Alpha)
Country of Origin	Netherlands
Plant Characteristics	
Maturity	Intermediate to late
Growth habit	Erect
Foliage cover	Good to dense
Flower colour	Red violet
Flower frequency	Occasional to frequent
Berries	Very rare
Tuber Characteristics	
Tuber skin colour	White to yellow
Tuber eye colour	Yellow
Primary tuber flesh colour	Light yellow
Tuber shape	Oval
Tuber eye depth	Shallow to medium
Tuber skin texture	Very smooth
Utilization Characteristics	
Cooking type / 411 Cooked texture	Fairly firm (Mutlipurpose)
Frying colour	-
After cooking blackening	Trace
Taste	Moderate to good
Crisp suitability	Poor
French fries suitability	Poor
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	Medium to high
Wart (Synchytrium endobioticum)	Field immune
Resistance to gangrene (Phoma foveata)	-
Resistance to dry rot (Fusarium spp.)	-
Resistance to blackleg	Medium to high

Resistance to ring rot	-
Resistance to cyst nematode	-
Resistance to Virus Diseases	
Resistance to potato virus A	Medium to high
Resistance to potato virus B	-
Resistance to potato virus C	-
Resistance to potato virus X	High
Resistance to potato virus Y (strain not specified)	High
Resistance to potato leaf roll virus	Medium to high
Resistance to virus YN	Medium to high
Resistance to Fungal Diseases	
Resistance to late blight on tubers	Medium
Resistance to late blight on foliage	Low to medium
Resistance to late blight on tuber (laboratory test)	High
Resistance to dry rot	Medium to high
Resistance to stem canker	-
Resistance to powdery scab	-
Resistance to Wart races	Race 1

CARDINAL

CARDINAL

Parentage	
Country of Origin	United Kingdom
Plant Characteristics	
Maturity	Intermediate
Growth habit	Erect to very erect
Foliage cover	Moderate to good
Flower colour	Red violet
Flower frequency	Frequent
Berries	-
Tuber Characteristics	

Tuber skin colour	Red
Tuber eye colour	
Primary tuber flesh colour	Cream
Tuber shape	Long to oval
Tuber eye depth	Shallow
Tuber skin texture	Rough
Utilization Characteristics	
Cooking type / 411 Cooked texture	Mealy
Frying colour	Dark
After cooking blackening	None
Taste	Moderate to good
Crisp suitability	-
French fries suitability	-
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	High to very high
Wart (Synchytrium endobioticum)	-
Resistance to gangrene (Phoma foveata)	-
Resistance to dry rot (Fusarium spp.)	-
Resistance to blackleg	-
Resistance to ring rot	-
Resistance to cyst nematode	-
Resistance to Virus Diseases	
Resistance to potato virus A	-
Resistance to potato virus B	-
Resistance to potato virus C	-
Resistance to potato virus X	-
Resistance to potato virus Y (strain not specified)	-
Resistance to potato leaf roll virus	-
Resistance to virus YN	-
Resistance to Fungal Diseases	
Resistance to late blight on tubers	Medium
Resistance to late blight on foliage	Medium
Resistance to late blight on tuber (laboratory test)	-
Resistance to dry rot	-
Resistance to stem canker	-
Resistance to powdery scab	-
Resistance to Wart races	-

OSCAR

OSCAR

Parentage	Desiree x VK 64 491
Country of Origin	Netherlands
Plant Characteristics	
Maturity	Intermediate to late
Growth habit	-
Foliage cover	-
Flower colour	-
Flower frequency	-
Berries	-
Tuber Characteristics	
Tuber skin colour	Red
Tuber eye colour	Red
Primary tuber flesh colour	Yellow
Tuber shape	Oval
Tuber eye depth	Shallow
Tuber skin texture	-
Utilization Characteristics	
Cooking type / 411 Cooked texture	Very mealy
Frying colour	Dark
After cooking blackening	None
Taste	-
Crisp suitability	-
French fries suitability	-
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	Medium
Wart (Synchytrium endobioticum)	Field immune
Resistance to gangrene (Phoma foveata)	-
Resistance to dry rot (Fusarium spp.)	-
Resistance to blackleg	-
Resistance to ring rot	-

Resistance to cyst nematode	-
Resistance to Virus Diseases	
Resistance to potato virus A	Very high
Resistance to potato virus B	-
Resistance to potato virus C	-
Resistance to potato virus X	Medium
Resistance to potato virus Y (strain not specified)	High
Resistance to potato leaf roll virus	Medium
Resistance to virus YN	-
Resistance to Fungal Diseases	
Resistance to late blight on tubers	High to very high
Resistance to late blight on foliage	Medium to high
Resistance to late blight on tuber (laboratory test)	-
Resistance to dry rot	-
Resistance to stem canker	-
Resistance to powdery scab	-
Resistance to Wart races	Race 1

RAJA

RAJA	
Parentage	Elvira x CB 70 162 23
Country of Origin	Netherlands
Plant Characteristics	
Maturity	Intermediate
Growth habit	Semi erect to erect
Foliage cover	Moderate
Flower colour	Red violet
Flower frequency	Occasional
Berries	Rare
Tuber Characteristics	
Tuber skin colour	Red

Tuber eye colour	Red
Primary tuber flesh colour	Cream
Tuber shape	Oval to long
Tuber eye depth	Shallow to medium
Tuber skin texture	Intermediate
Utilization Characteristics	
Cooking type / 411 Cooked texture	Mealy (Multipurpose type)
Frying colour	-
After cooking blackening	Trace
Taste	Good
Crisp suitability	Good
French fries suitability	Good
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	Medium to high
Wart (Synchytrium endobioticum)	Field immune
Resistance to gangrene (Phoma foveata)	-
Resistance to dry rot (Fusarium spp.)	-
Resistance to blackleg	-
Resistance to ring rot	-
Resistance to cyst nematode	-
Resistance to Virus Diseases	
Resistance to potato virus A	Very high
Resistance to potato virus B	-
Resistance to potato virus C	-
Resistance to potato virus X	Very high
Resistance to potato virus Y (strain not specified)	High to very high
Resistance to potato leaf roll virus	Medium to high
Resistance to virus YN	-
Resistance to Fungal Diseases	
Resistance to late blight on tubers	High to very high
Resistance to late blight on foliage	Low to medium
Resistance to late blight on tuber (laboratory test)	Very high
Resistance to dry rot	-
Resistance to stem canker	-
Resistance to powdery scab	-
Resistance to Wart races	-

MULTA	
Parentage	Oberarnbacher Fruhe x (Record x CPC 1673 1)
Country of Origin	Netherlands
Plant Characteristics	
Maturity	Late
Growth habit	-
Foliage cover	Good to dense
Flower colour	Red violet
Flower frequency	Occasional
Berries	No
Tuber Characteristics	
Tuber skin colour	White to yellow
Tuber eye colour	-
Primary tuber flesh colour	Light yellow
Tuber shape	Oval
Tuber eye depth	Medium
Tuber skin texture	-
Utilization Characteristics	
Cooking type / 411 Cooked texture	Mealy (flour type)
Frying colour	-
After cooking blackening	Trace to little
Taste	Poor to moderate
Crisp suitability	Poor
French fries suitability	Poor
Resistance to Bacterial Diseases	
Resistance to common scab (Streptomyces scabies)	High
Wart (Synchytrium endobioticum)	
Resistance to gangrene (Phoma foveata)	
Resistance to dry rot (Fusarium spp.)	
Resistance to blackleg	High to very high

Resistance to ring rot	
Resistance to cyst nematode	
Resistance to Virus Diseases	
Resistance to potato virus A	Medium
Resistance to potato virus B	-
Resistance to potato virus M	Medium to high
Resistance to potato virus X	Medium to high
Resistance to potato virus Y (strain not specified)	High
Resistance to potato leaf roll virus	Low to medium
Resistance to virus YN	Medium to high
Resistance to Fungal Diseases	
Resistance to late blight on tubers	High
Resistance to late blight on foliage	Medium
Resistance to late blight on tuber (laboratory test)	High to very high
Resistance to dry rot	Medium to high
Resistance to stem canker	-
Resistance to powdery scab	-
Resistance to Wart races	Race 1

PROVINCE/DISTRICT WISE (SEPARATELY) - AREA UNDER CULTIVATION (HECTARES), PRODUCTION (MT) AND YIELD FOR THE LAST 10 YEARS AND ITS ANALYSIS

Province-wise, Punjab is the leading potato producer contributing more than 93% of area followed by Khyber Pakhtunkhwa with slightly more than 5% of area. Baluchistan contributes more than 1% whereas Sindh has negligible share of 0.29%. Ninety-six percent of production comes from Punjab followed by 3% from KPK and 1% from Baluchistan. Average yield of potato in Punjab exceeds average yield of Pakistan registering more than 21 tonnes per hectare. KPK and Baluchistan have far less yield with 14 tonnes and 15 tonnes per hectare respectively. The potato area, production and yield of four provinces is given in the tables below;

PUNJAB

Table 10 Punjab- Area, Production & Yield (2008/9- 2017/18)

PUNJAB			
Year	Area (000 ha)	Production (000 Tonnes)	Yield (Tonnes/ha)
2008-9	133.20	2782.70	20.89
2009-10	127.20	2990.90	23.51
2010-11	148.10	3339.90	19.05
2011-12	173.70	3235.30	22.55
2012-13	162.60	3639.10	18.63
2013-14	148.60	2743.30	22.38
2014-15	159.40	4019.90	18.46
2015-16	165.50	3811.10	25.22
2016-17	166.40	3660.30	21.43
2017-18	180.50	4402.60	23.03
Average	**156.52**	**3462.51**	**21.51**
Source: MNFS&R DATA			

KHYBER PAKHUNKHAWA

Table 11 KPK- Area, Production & Yield (2008/9- 2017/18)

Khyber Pakhtunkhwa			
Year	Area (000 ha)	Production (000 Tonnes)	Yield (Tonnes/ha)
2008-9	9.10	121.00	13.30
2009-10	8.70	113.70	13.07
2010-11	8.90	118.20	13.36
2011-12	8.60	120.60	13.28
2012-13	7.50	109.40	14.02
2013-14	7.20	105.60	14.59
2014-15	7.20	105.60	14.67
2015-16	7.80	116.40	14.67
2016-17	9.20	143.40	14.20
2017-18	10.80	152.60	14.92
Average	**8.5**	**120.7**	**14.0**
Source: MNFS&R DATA			

BALUCHISTAN

Table 12 Baluchistan- Area, Production & Yield (2008/9- 2017/18

BALUCHISTAN			
Year	Area (000 ha)	Production (000 Tonnes)	Yield (Tonnes/ha)
2008-9	2.30	34.60	15.04
2009-10	2.20	33.50	15.23
2010-11	2.00	29.70	13.87
2011-12	2.20	32.70	14.85
2012-13	2.20	33.10	14.86
2013-14	2.00	30.50	15.05
2014-15	2.00	29.90	15.25
2015-16	1.90	30.00	14.95
2016-17	1.50	22.40	14.99
2017-18	1.50	23.40	15.79
Average	**2.0**	**30.0**	**15.0**
Source: MNFRS DATA			

SINDH

Table 13 Sindh- Area, Production & Yield (2008/9- 2017/18

SINDH			
Year	Area (000 ha)	Production (000 Tonnes)	Yield (Tonnes/ha)
2008-9	0.40	3.00	7.50
2009-10	0.40	3.30	8.25
2010-11	0.40	3.90	8.35
2011-12	0.40	3.90	9.75
2012-13	0.50	4.30	9.75
2013-14	0.50	4.40	8.60
2014-15	0.50	4.70	8.80
2015-16	0.60	4.90	9.40
2016-17	0.60	5.60	9.22
2017-18	0.60	5.70	8.17
Average	**0.5**	**4.4**	**8.8**
Source: MNFRS DATA			

Despite having seasonal diversity, Pakistan's potato production during Autumn, Spring and Summer is drastically different. The share of Autumn crop is 75%, Spring 10% and Summer 15%. In Punjab, districts of Okara, Sahiwal, Kasur, Sheikhupura, Sialkot, Jhang, Lahore, Pakpattan, Narowal, Gujranwala, Khanewal and Toba Tek Singh are prominent in potato production. In KPK, the districts of Swat, Nowshera, Dir, Balakot, Mansehra, and Sakardu are prominent for potato production. In Baluchistan, potatoes are mostly cultivated in the districts of Kalat, Killa Saifullah, and Pashin.[274274] During the reported period in MNFS&R Data from 2008-09 to 2017-18, the provinces have shown different developments regarding cultivated area, production and yield. The analysis shows that during the reported period, Punjab registered an increase of 36% in area, 58% in production and 10% in yield. Khyber Pakhtunkhwa showed an increase of 19% in area, 26% in production and 12% in yield. Sindh showed an outstanding performance by increasing area of cultivation by 50%, production by 90%. However, the progress in yield by 9% is not corresponding with progress made in area and production. On the other hand, Baluchistan showed negative progress with respect to area and production registering 35% decrease in area and 32% decrease in production whereas a meagre increase of 5% is registered in yield during the corresponding period. Pakistan as a whole registered a growth of 33% in area, 56% in production and 11% in yield during this period.

PAKISTAN

PAKISTAN- Punjab, KPK, Baluchistan & Sindh (Area, Production & Yield 2008/9- 2017-18)			
	Area (000 ha)	**Production (000 Tonnes)**	**Yield (Tonnes/ha)**
Punjab	156.52	3462.51	21.51
Sindh	0.49	4.37	8.78
KPK	8.50	120.65	14.01
Baluchistan	1.98	29.98	14.99
Pakistan	**167.49**	**3617.51**	**21.00**
Source: MNFRS DATA			

Different districts in these provinces are popular for potato production but dominance of Punjab province is without any doubt is stamped whether we talk about area under cultivation or production. Unfortunately, no latest authentic data from the relevant agriculture departments or provincial governments websites is available. The available data is analyzed in the table below from districts of

Punjab and Khyber Pakhtunkhwa. Though data provides some insight into potato area under cultivation and production in these provinces, there are drastic discrepancies are found in the reported data which makes it impossible to do the detailed analysis.

	2016-17						2015-16					
Districts	Autumn		Spring		Total		Autumn		Spring		Total	
	A	P	A	P	A	P	A	P	A	P	A	P
Okara	52891	20928	1186	6434	54077	27362	54186	22077	1194	6005	55380	28082
Sahiwal	24766	37444	263	4465	25029	41909	25009	30581	283	4180	25292	34761
Kasur	19304	21811	37	62	19341	21873	20214	21674	37	52	20251	21726
Pakpattan	18211	104378	429	1535	18640	105913	16997	95469	405	1633	17402	97102
Chiniot	9429	32920	20	122	9449	33042	9227	30014	35	83	9262	30097
Khanewal	6879	196265	6	247	6885	196512	6273	210878	16	428	6289	211306
T.T.Singh	4816	92754	95	377	4911	93131	4528	91703	101	359	4629	92062
Sialkot	4762	68403	62	2454	4824	70857	4795	84404	60	2736	4855	87140
Sheikhupura	3359	59619	202	0	3561	59619	3555	58669	221	330	3776	58999
Lahore	2549	428841	0	338	2549	429179	2468	465848	26	857	2494	466705
Vehari	2497	1254753	0	14982	2497	1269735	2064	1369087	--	15349	2064	1384436
Khushab	1942	519327	293	3372	2235	522699	1821	563078	283	3658	2104	566736
Multan	1619	412007	18	5539	1637	417546	1295	407036	19	5412	1314	412448
Jhelum	1275	47029	369	185	1644	47214	1315	38656	334	207	1649	38863
Faisalabad	1254	156726	5	50	1259	156776	1204	127722	4	137	1208	127859
Jhang	1137	51639	9	0	1146	51639	1028	45423	6	0	1034	45423

A= Area (Hectares), P= Production (Tonnes)
Source: AMIS.PK

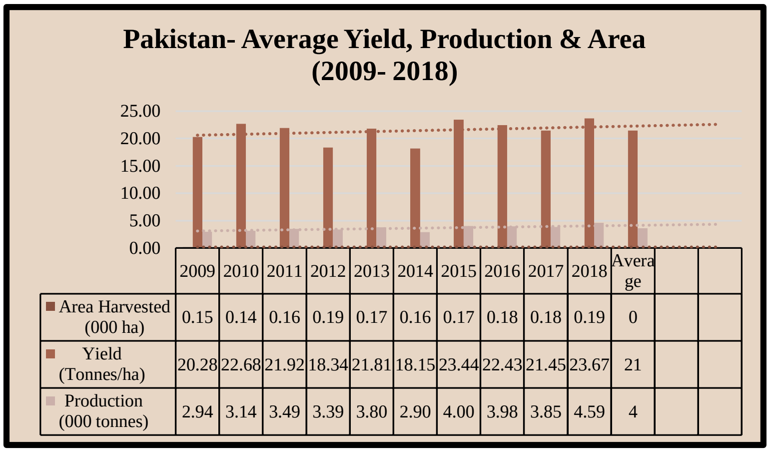
Commented [SI7]: Data needs to be rechecked.

Figure 75 Area, Production of Different Districts in Punjab (2015-2017)

Khyber Pakhtunkhwa province has the most conducive conditions for growing three crops of potatoes during the year. On the other hand, Baluchistan produces only one crop where the area and production is on a consistent contraction.

The above analysis shows that KPK and Sindh has the potential to increase area, production and yield as they have shown double digit yield in the past. Punjab on the other hand needs to focus on yield enhancement by introducing new higher yield varieties.

AVERAGE YIELD OVER THE LAST 10 YEARS, COMPARISON OF AVERAGE YIELD WITH WORLD AVERAGE YIELD AND AVERAGE YIELD OF TOP 10 PRODUCING COUNTRIES



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average		
Area Harvested (000 ha)	0.15	0.14	0.16	0.19	0.17	0.16	0.17	0.18	0.18	0.19	0		
Yield (Tonnes/ha)	20.28	22.68	21.92	18.34	21.81	18.15	23.44	22.43	21.45	23.67	21		
Production (000 tonnes)	2.94	3.14	3.49	3.39	3.80	2.90	4.00	3.98	3.85	4.59	4		

From 2009 to 2018, Pakistan has registered an average yield of 21 tonnes per hectare which is quite better against the world average below 20 tonnes per hectare.

The average yield of top potato producing countries in comparison to Pakistan is given in the figure below which shows that in the cluster of thirteen top producers, Pakistan is ahead of China, Belarus and Bangladesh.

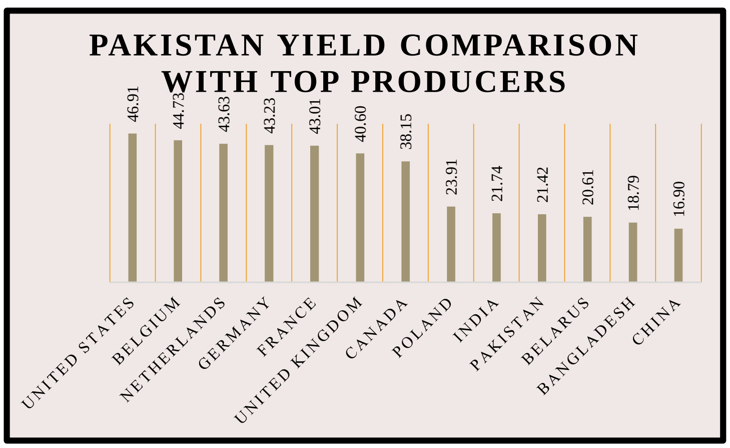
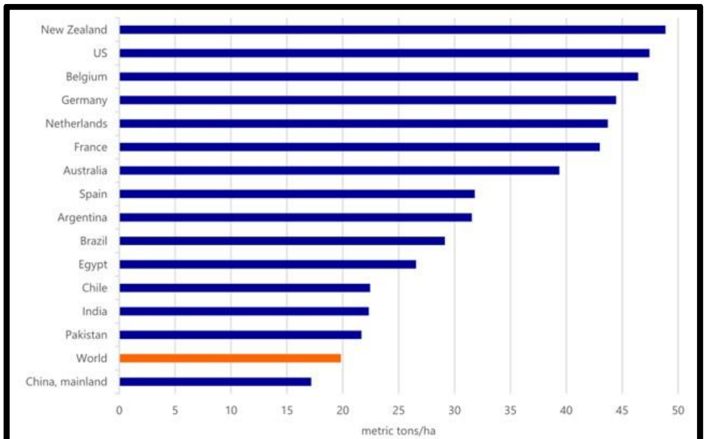


Figure 76 Yield Comparison Pakistan vs Top Producers

The above figure shows that United States is far ahead of other potato producing countries followed by Belgium, Netherlands and Germany. Belarus, Bangladesh and China are behind Pakistan in per hectare yield. Interestingly, the largest producer of potato; China has the lowest per hectare yield. Imagine a world with China having per hectare yield equal to USA. This again proves the potential of potato as the best candidate for food security of the world.

Comparing Pakistan's average per hectare yield with the potato growing world provides a promising scenario where Pakistan is quite ahead of the world in per hectare average yield as shown in the figure below;



Source: Food and Agriculture Organization of the United Nations, Rabobank 2019

COMPARISON OF AVERAGE YIELD BY PROVINCES, AVERAGE YIELD BY PROGRESSIVE LOCAL GROWERS ALONG WITH REASONS FOR ABOVE AVERAGE YIELD AND LESSONS LEARNT ETC.

If we compare the average yield from four provinces of Pakistan, it is revealed that Punjab leads with more than 21 tonnes per hectare yield that in itself is more than average yield of the country when seen in conjunction with other provinces. It can cautiously be said that per hectare yield from Punjab is almost equal to the combined yield from Sindh and Khyber Pakhtunkhwa. The major reasons for this increased yield are the crop season. While 75% of potato crop comes from Autumn season, the most of the cultivation for Autumn season is carried out in Punjab. Secondly, the potato industry in Punjab is more developed than other provinces. Thirdly, the selection of varieties by farmers is being made according to the soil available. Fourthly, the processing industry in Punjab has played its role in development of potato sector through contract farming and seed development not mentioning the training program initiated by these players including Pepsi Co and Fauji Fresh & Freeze.

Province-wise Area, Production & Yield 2008/9- 2017-18)			
	Area (000 ha)	**Production (000 Tons)**	**Yield (Tons/ha)**
Punjab	156.52	3462.51	21.51
Sindh	0.49	4.37	8.78
KPK	8.50	120.65	14.01
Baluchistan	1.98	29.98	14.99
Pakistan	**167.49**	**3617.51**	**21.00**
Source: MNFS&R DATA			

The leading position of Punjab is also evident from historical perspective. Since 1947, after independence of Pakistan the provinces took off from almost same point in area under production but with the passage of time, Punjab distinguished itself from other provinces as is shown in the figure below;

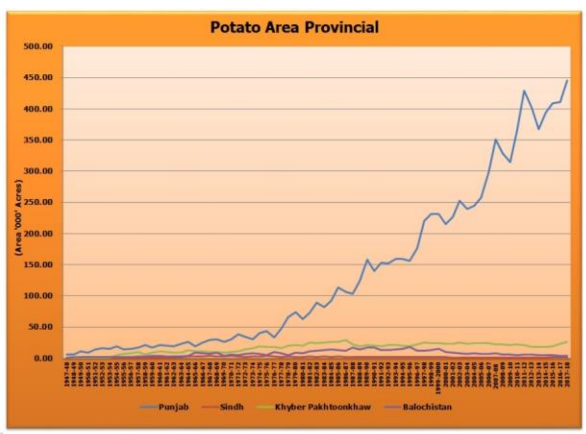


Figure 77 Pakistan- Area Under Potato Cultivation in Historical Perspective (1947- 2018)

The situation becomes clearer when have a look at the per hectare yield from these provinces in historical perspective. It is evident from the figure below that all provinces tried to compete in average yield but ultimately Punjab registered its dominance with more than 20 tonnes per hectare yield in recent years.

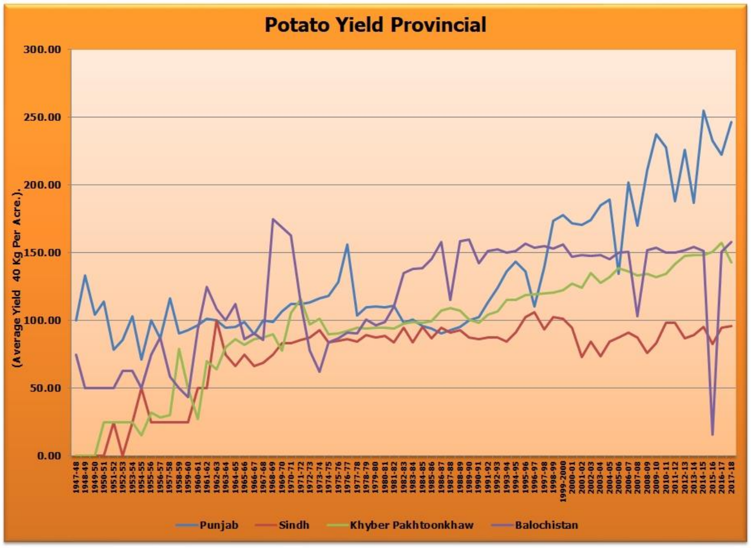


Figure 78 Pakistan- Yield per Acre in Historical Perspective (1947- 2018)

The above figure reveals some more interesting facts. One of these facts is that during late 60s, the province of Baluchistan took off in registering more per acre yield than any other province. Apparently the lack of ground water disturbed the yield in Baluchistan. Keeping its dominance in yield production up to early 20s but then dipped low but still competing with KPK.

LIST OF DOMESTIC GROWERS/FARMERS WITH DETAILS ON THEIR FARMLAND E) AND CONTACT

The number of small farmers in the world exceeds 500 million, especially in the developing countries.[275275] The number of potato producers in Pakistan is more than 125 thousand and each year farmers are increasing the area of cultivation for more production.[5050] Certain factors including lack of scientific agriculture practices, difficulty in acquiring physical inputs, poor access to credit facilities and poor infrastructure keeps the farmers at the most disadvantageous position. To add their miseries, the powerful players in the supply chain such as middlemen exploit the situation to the maximum.It all happens in supply chain of potato in Pakistan despite the farmers bear the greatest of risks and is at the lowest position for reaping benefits. This asymmetry in power goes in favor of Aarthi creating opportunistic behavior by middlemen. This coupled with information asymmetry cause the farmers to have low yield due to non-availability of scientific knowledge to deal with pests and ultimately remain the most disadvantaged player of the value chain.[275275] As mentioned earlier 96% of the potato product is routed from Punjab, a list of prominent growers in Punjab is annexed with this report as Annexure-1.

CONSUMPTION PATTERNS IN LOCAL MARKET INCLUDING CONSUMPTION PER CAPITA

Not like other major producers of potato in the world, Pakistan is self-sufficient in potato for household consumption. As per estimates from different data sources, Pakistan currently produces more than 4.5 million tonnes of potato. Out of which around 0.3 million tonnes is used as a seed for the next crop, leaving Pakistan with around 4.2 million tonnes of potato for domestic consumption and exports. As per latest figures Pakistan, exported more than 0.66million tonnes of potato leaving us with around 3.5 million tonnes for domestic consumption. Leaving aside 0.5million tonnes for post-harvest losses, Pakistan is left with around 3.0 million tonnes of potato for domestic consumption. The latest population census of Pakistan shows that Pakistan has a population of more than 207 million people. With the current population, the per capita consumption of fresh and processed potato comes out to be 14.5 per annum which is far less than world per capita consumption of more than 33 kg per annum.[276276]

PRICE TRENDS IN DOMESTIC MARKET DURING LAST 05 YEARS

Potato is one of the important cash crops of Pakistan farmers. It is also one of the main exportable horticulture commodity that helps in improving the income of potato farmers as well as a source of earning valuable foreign exchange. It is observed throughout the world that several natural and environmental conditions affect the cultivation and production of agriculture products. These factors may include heavy rains, hailing, floods, storms, earthquakes and pests and diseases of different kinds. These higher levels of risks, unpredictability, and irregularity are the hallmark of agriculture sector. On the other hand, the price of agriculture commodities depends heavily on demand and supply of the agriculture products after braving the above mentioned natural and environmental factors. Hence the rise and fall of the prices of agriculture products determine the distribution of area for production and at the same time influence the profitability of production of vegetables.[277277]

In this regard, potato fall in the category of one of the leading crops for farmers and consumers as an important kitchen item. The price of potato has been increasing consistently but asymmetrically for past five years. For the purpose of current report, the market of Lahore is selected for looking into the price trends for past 5 years. The selection of market is based on the assumption that it is the nearest market to the hub of Punjab's potato production area including Okara, Sahiwal, Depalpur and Kasur. The price trend for 100 kilogram of fresh and stored potatoes is given in the figures below;

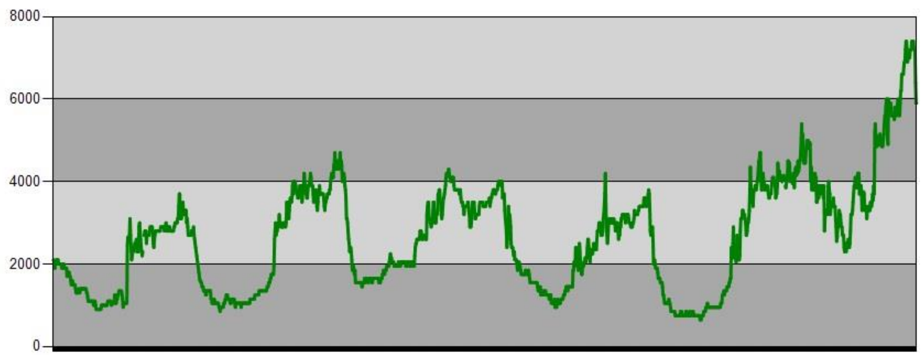


Figure 79 Price Trend Fresh Potatoes (January 2015 to July 2020) Source: AMIS

Indication on months on graph would explain it more explicitly

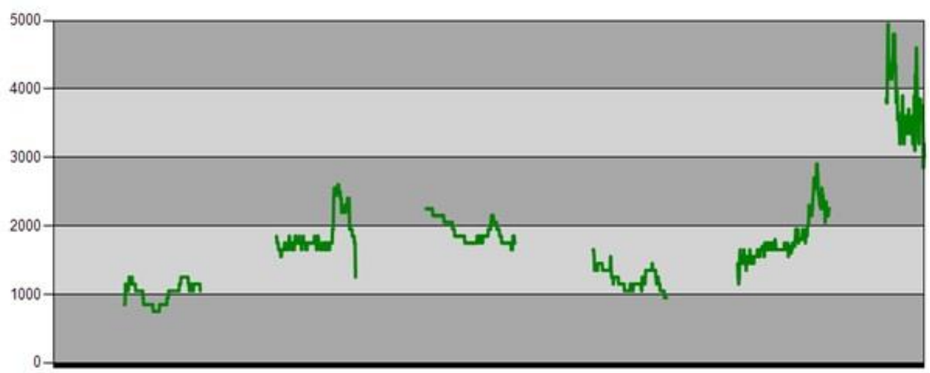


Figure 80 Price Trend stored Potatoes (January 2015 to July 2020) Source: AMIS

The above figures illustrate and strengthen the viewpoint adopted in earlier researches that potato as agriculture commodity has highly volatile price trend depending on natural, environmental and supply, demand factors. This point is further strengthened by the fact that prices of potato in the market during current summer season are higher than usual which indicate supply from stored potatoes than fresh product.

ISSUES AND PROPOSED SOLUTIONS

Potato is the fourth most produced food crop in Pakistan after rice, wheat and maize. Though production of potato has been increased manifolds since independence, the per hectare yield is still low in comparison to some other potato producing countries. The use of fast food is on the increase and it will increase the utilization of potato as a product. There are several processing industries mushrooming in recent years. The non-availability of quality product as raw material for processing industry is one of the major impediments in the way of potato processing industry. There is need to develop more desirable varieties for processing than depending on two to three such varieties as is the case currently. This will help in meeting the demands of the processing industry. Currently, Pakistan has almost no local variety to be produced commercially to meet the demands of the processing industry. The development of such varieties that can have good storability and processing potential will also help in utilizing the product during glut seasons. It will also help in reducing post-harvest losses at large and ultimately enhancing the stakeholders' income. National Agriculture Research Centre Islamabad has recently carried out work on the selection of new varieties with desirable characters for the processing industry. In this context 32 genotypes are being evaluated including the standard varieties grown in Pakistan of Desiree, Cardinal and Diamont.

SECTION 5: SUPPLY CHAIN

DOMESTIC MARKETING SYSTEMS

INTRODUCTION

The marketing system is considered a prerequisite for producers to have stable and compensatory price for their product such as potato. It is the return to producer from marketing system that provides the vital incentive to grow more. A live and working marketing system provides assurance to the producers for their produce. There are however several players in this marketing system which play their role at different levels of the movement of produce from farmer to end consumer. At times, the nature of these intermediaries is exploitive resulting in low share of profit to the producers. Despite this fact the role of all marketing system players is undeniable throughout the supply chain or value chain.[278278]

POTATO VALUE CHAIN

By marketing system in this report we mean the marketing channel through which the produce moves from the farmers to the ultimate consumers-you and me. In this section we will discuss the role of different players in the marketing system illustrating the movement of potato from producer to end consumer at the domestic level and then compare it with a simple marketing or value chain system at international level. This comparison will help us in finding gaps in our marketing system and ways to improve this system to some extent.

Value chain of potato in Pakistan is evolving day by day but till today, the chain has two only two significant end products- fresh potatoes to be used as main course meal in Pakistan's daily household and the processing industry for making potato chips and related items. The main drivers of the potato value chain are growers who begin the production of potatoes from seeds. Pakistani growers mostly import seeds from Netherlands and then multiply it for future use keeping it in cold storages for the next season with few exceptions of importing seed potato directly for next season.[279279]

Harvested potatoes are sold in the different fruits and vegetable markets. The markets have different modes of sales of potatoes; Beopari (local contractor) pay around 10 to 15% of the payment in advance before the harvesting of the crop to the grower. This practice is mostly carried out with small landholders and landless growers (cultivating lands on rental contract). This is also a prevailing practice in northern areas of Pakistan such as Chitral and Swat where landholdings are very small. These local contractors (beopari) have their contacts in bigger markets of Lahore, Karachi and

Islamabad along with big local markets in nearer cities; Okara, Depalpur, Sialkot and Gujranwala. These contractors have long lasting and sustainable linkages with Aarthis in bigger markets which make it possible for them to get credit in cash, kind and sometimes seeds for distributing to the small farmers so that they can meet their needs. On the other hand, medium and large farmers deal directly with Aarthis by taking their product to these markets to be sold through open auction through aarthi. [279279] Aarthis charge commission both from the seller and the buyer. In this case the buyer could be a local wholesaler (Pharya), wholesaler for other markets (Ladhanya), exporters (commercial exporters) for exporting the produce to other countries and in some rare cases the importer from another country contacts Aarthi for the produce.[279279]

Potato value chain has the basic functions of production of potatoes for stock and seed multiplication, storage of produce in cold stores, processing of product for finished goods, and marketing of fresh produce for local markets, export and for processing industry. These functions are regulated under government's regulatory regime. Though most of the regulatory regime deals with the processing functions, the import of seed needs compliance of certain documentation and acquiring phyto-sanitary certification for importing the seed which is subject to inspection by DPP and approval from Federal Seed Certification and Registration Department (FSCRD). At the provincial level, there are specific marketing Acts that regulate the marketing functions of fresh produce with the help of local governments. Processors have their own industry standards to meet such as Improved Product Specifications (IPS) by Pepsico.[279279]

SUPPLY CHAIN DIAGRAM

While the Potato Value Chain (PVC) has a range of players, the most important are the growers as the main drivers of the chain followed by cold store operators as 30% of the fresh table potatoes are stored in cold stores. This helps in avoiding the glut in fresh produce market that may result in decrease in prices to unbearable extents making the whole cycle of production just a futile exercise. Secondly, the processing industry in the country uses around 500 tonnes of potato per day utilizing their maximum throughput. This asks for storing potatoes to meet the daily throughput on a time series base.[279279]

Next the role of input suppliers is also important. These input suppliers include the importers of chemicals and seeds. These input suppliers need to maintain their stocks before commencement of the season including fertilizers and fungicides. The role of major players in potato value chain is illustrated in the figure below;

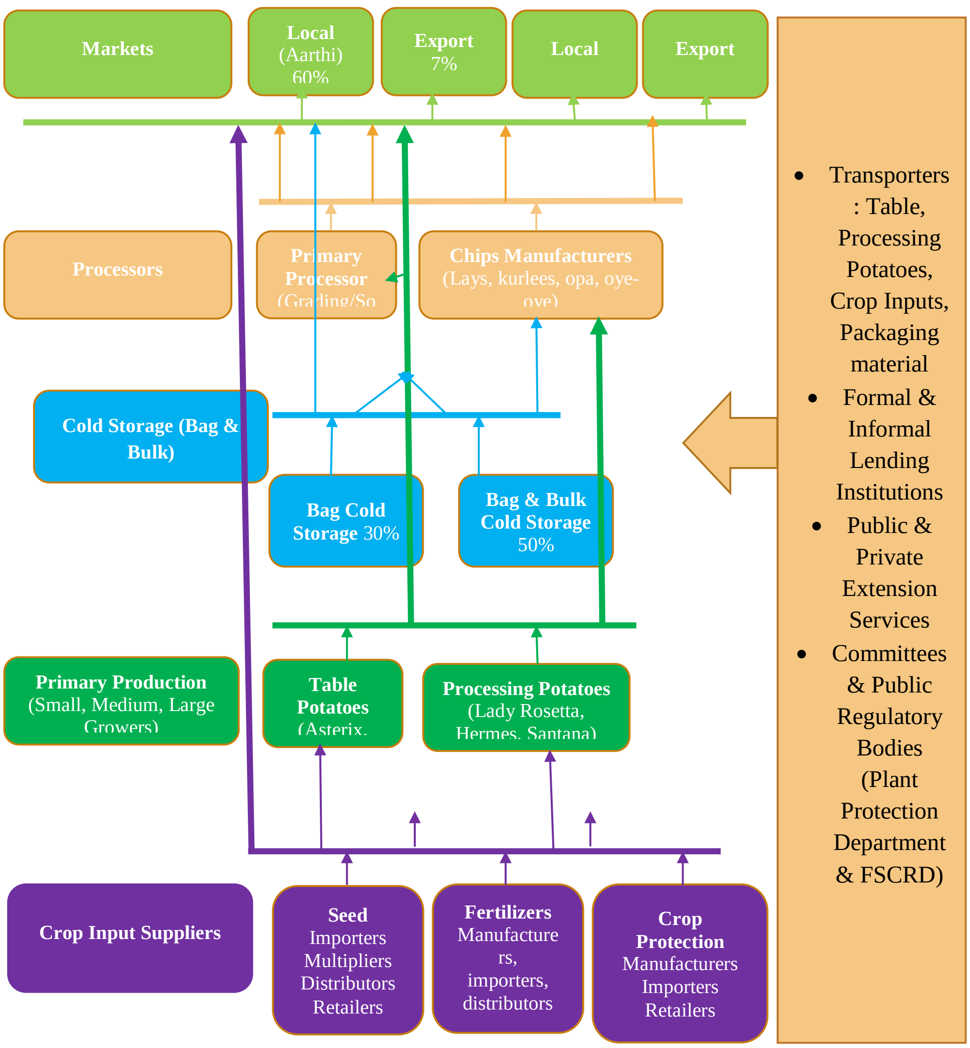


Figure 81 POTATO SUPPLY CHAIN MAP (Adapted from Agriculture Credit & Microfinance Department SBP -2014)

The potato value chain (PVC) broadly consists of four components; crop input suppliers, producers, processors and end-consumer (buyer).

The input suppliers include seed, fertilizers, farm machinery, irrigation system and fuel providers from their respective distribution points in the area of cultivation. Seed is primarily imported from other countries mainly from Netherlands and UK and then multiplied locally to reduce production costs. Syngenta, Ali Akbar Group, FMC, Jaffar Brothers, Fauji Fertilizers, Daud Hercules and Engro Fertilizers Limited are main agriculture input suppliers with their well spread distribution networks across the country.[279279] In contract farming cases such as contract farming of Pepsico, the processor itself acts as seed importer and extends this seed to growers as loan without any margin or interest.[279279]

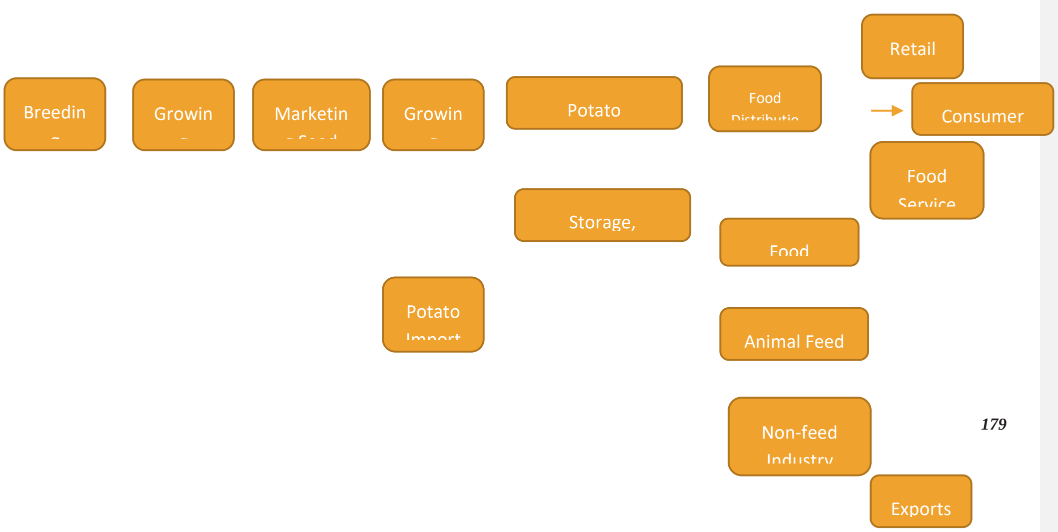
Next on the supply chain map are producers. A significant number of producers are from the category of landholdings between twenty-five to two hundred and fifty acres further distinguished as small growers with 100 acres or less and large growers with more than hundred up to 250 acres. The land holdings could be owned by farmers themselves or have been rented partially or totally. Central Punjab is considered the hub of potato production. The Autumn crop from this region comes into market when product from other growing pockets such as Soan Sakesar, Malakand, Chitral and Gilgit Baltistan starts dwindling. The growers in these areas are completely dependent on buyers from downstream markets including arhtis, processors and traders. The growers in these areas use beoparis as conduit to gain access to bigger markets in major cities such as Islamabad, Rawalpindi, Gujranwala, Lahore, Sialkot, Karachi, Hyderabad and Quetta.[279279] Another character in the range of these aggregators comes local beoparis who deal in small villages and growing areas for gathering product by paying a suitable advance to the grower called baiyana and contact the arhtis in bigger markets to sell product from these areas. These beoparis in the system enjoy the most exploitive status as they get commission from seed suppliers and from arhtis too for providing product from these areas. For these aggregators, more production means more commission.[279279]

Another breed of aggregators emerging in Pakistan. These aggregators are exporters who are developing direct links with farmers to get graded product at source and saving at their margins by bypassing the middlemen. This situation is helping farmers in getting increased margins from these exporters. It is assumed in the years to come, the role of middlemen in the fresh produce marketing system will diminish slowly.[279279]

The role of processors is as important as other players in the value chain. As mentioned earlier, Pepsico and Fauji Fresh are producing their own brands and other end products from potatoes. There are also other small manufacturers such as super crisp that are having their share in the chips market. Another cottage like industry of homemade chips providers exists who provide chips and other potato products at bakeries and convenience stores.[279279]

The processing industry takes it a rule of thumb that for processing one kilogram of chips, the processor needs to process four kilograms of fresh potatoes. By adopting new technologies and using varieties that are rich in solid matters help in increasing productivity and profitability of these processors. Hence they prefer to buy fresh produce rather than stored product which has less solid matters.[279279] Lahore, Okara, Depalpur and Kasur are considered bigger potato markets due to higher volumes of trade. The volumes traded in these markets include local demand and demand for storing product in cold stores. From these markets, the product is routed to other markets including Karachi, Islamabad, Quetta and Peshawar. Another phenomenon of Ladhan exist in these markets. It includes rerouting the product to nearby small markets in other words, from where the product was routed to these markets.[279279]

The international potato value chain is somehow different from potato value chain in Pakistan. The main difference in the value chain is that international value chain does not mention the presence of middlemen like beoparis in international value chain. An overview of the international potato value chain is illustrated in the figure below;



GRADES & QUALITY STANDARDS

Grades and quality standards for fresh potatoes are not provided under Codex Alimentarius Standards. However, different countries have developed their grades and quality standards for fresh and processed potatoes such as India, USA , Canada and EU (The latest version of FFV-52 is attached as Annex-II). The handling of potatoes throughout the value chain is quite important as it has strong effect on the ultimate quality of the products derived from potatoes. Potato tubers have the tendency to differ from each other in shape, size, and uniformity. Naturally a product with good appearance, uniform shape and size attracts the consumers with its better sales appeal. Hence, the need for grading and sorting parameters becomes of paramount importance. Throughout the world the grading and sorting is done by trained hands with some using prototype automation potato inspection stations. Another reason for having grades and quality standards is that there is a need for quality evaluation for the acceptance and or rejection of potato lots based on certain quality parameters.[280280] Pakistan Horticulture Development and Export Board (PHDEB), currently PHDEC developed draft standards taking cognizance from the standards above in its Potato Marketing Strategy document. The same is reproduced here;

DEFINITION OF THE PRODUCE

These standards are meant for early and ware potato (fresh potatoes) of cultivars grown from *Solanum tubersum* L. and its hybrids for fresh consumption and for export purposes. These standard exclude ware potatoes meant for industrial use or processing. For this report, early potato means potatoes which are harvested before their full maturity and its skins can be removed easily by rubbing the surface without the need for properly peeling off the skin. Its export is subject to the demand from importers.

PROVISIONS CONCERNING QUALITY

The standards are meant to be used for early and ware potatoes defining the quality requirements at the export control stage after completing the preparation and packaging stages.

MINIMUM REQUIREMENTS

In all cases, subject to the special provision for each class and tolerances allowed the tubers must be;

- of normal appearance for the variety according to the producing area

- intact, i.e. they should not have had any part removed nor have suffered any damage
- sound; produce affected by rotting or deterioration such as to make it unfit for consumption is excluded
- practically clean
- covered with well-formed skin
- In the case of early potatoes, a partial absence of the skin shall not be considered as a defect;
- Firm
- Free of external or internal defects detrimental to the general appearance, the quality, the keeping quality and presentation in the package, such as:
    - Brown stains due to heat;
    - Cracks (including growth cracks), cuts, bites, bruises or roughness of skin (only for varieties of which the skin is not normally rough);
    - Green coloration;
    - Deformities (not exceeding 5% in a lot);
    - Grey, blue or black sub-epidermal stains;
    - Rust stains, hollow or black hearts and other internal defects;
    - Deep common potato scab and powdery potato scab;
    - Superficial common potato scab i.e. scab spots in all must not extend over more than a quarter of the surface of the tuber;
    - Free of frost damage;
    - Free of abnormal external moisture; i.e. adequately \"dried\" if they have been washed;
    - Free of any foreign smell and/or taste.

In early and Ware potatoes no sprouting is allowed.

The development and condition of the early and ware potatoes must be such as to enable them;

- to withstand transport and handling, and
- to arrive in satisfactory condition at the place of destination.

Each package must be free from waste, i.e. attached or loose earth, detached growth shoots, extraneous matter.

CLASSIFICATION

The potatoes are classified into two classes defined below:

- Class I

Potatoes in this class must be of good quality. They must be characteristic of the variety. The tubers must be:

- whole, clean and sound,
- free from sprouts,
- free from foreign smell,
- free from external and internal defects,
- free from soil and other material,
- free from soft rots and dry rots, and
- free from admixture of varieties.

The following defects (not exceeding 2% in a lot), however, may be allowed provided these do not affect the general appearance of the produce, the quality, the keeping quality and presentation in the package:

- slight defect in shape,
- slight defect in coloring,
- slight rubbing,
- slight bruising.

- Class II

This class includes potatoes which do not qualify for inclusion in Class I, but satisfy the minimum requirements specified above. They must be reasonably firm.

The following defects (not exceeding 5% in a lot) may be allowed provided the potatoes retain their essential characteristics as regards the quality, the keeping quality and presentation:

- defects in shape,
- defects in coloring,
- traces of rubbing,
- small healed cracks,
- slight bruising, healed, unlikely to impair keeping qualities.

PROVISIONS CONCERNING SIZING

Size of the tuber is determined by square mesh. Tubers must have a minimum size such that they do not pass through a square mesh as given below unless otherwise demanded by the importer:

I. 35 x 35 mm for early potatoes;
II. 45 x 45 mm for ware potatoes.

There is no maximum size. However, uniformity in size (tuber diameter in mm in each pack) is desirable as follows:

- Extra-large Above 70mm
- Large 55-70mm
- Medium 40-55mm
- Small 28-40mm

PROVISIONS CONCERNING TOLERANCES

Tolerances in respect of quality and size shall be allowed in each package for produce not satisfying the minimum requirements.

- Quality Tolerances

For all classes tubers by weight not satisfying the minimum requirements shall be allowed:

- 5 per cent by weight of tubers of early potatoes; and
- 5 per cent by weight of tubers of ware potatoes.

- Size Tolerances

Five per cent (5%) by weight of tubers not satisfying the requirements as regards sizing and if sized, above and/or below the size range indicated.

PROVISIONS CONCERNING PRESENTATION

- Uniformity

The contents of each package must be uniform and contain only early or ware potatoes of the same origin, variety, quality, colour of the skin, colour of the flesh and size (if sized).

- Packaging

Early and ware potatoes must be packed separately in such a way as to protect the produce properly and to ensure adequate ventilation.

The materials used inside the package must be new, clean and of a quality such as to avoid causing any external or internal damage to the produce. The use of materials, particularly of paper or stamps bearing trade specifications is allowed provided the printing and labeling has been done with non-toxic ink or glue.

In the case of early potatoes, special packaging materials may be used in order to better protect the produce during long distance transportation.

- Presentation

Early and ware potatoes must be packed in appropriate packages. These may include corrugated boxes, polypropylene net bag, jute sacks or other such packaging as specified in the sale contract and allowed in the country of import.

Early and ware potatoes are marketed by lot. A ***lot*** is a quantity of early or ware potatoes which are uniform as concerns the following characteristics:

- packer and/or dispatcher;
- country of origin; - variety;
- size (if sized)/class;
- type and net weight of package (if packed)
- date of packaging

A consignment may consist of several lots.

PROVISIONS CONCERNING LABELING

Each package must bear the following particulars, in letters grouped on the same side, legibly and indelibly marked, and visible from the outside either printed on the package itself or on a label secured to the fastening. If the labels are placed inside the package (string woven bags), it should be done in such a way that the indications concerning marking are readable from the outside.

- Identification

Packer and or) Name and address or officially issued or
Dispatcher) accepted code mark

- Nature of Produce

  - Early potatoes or ware potatoes, if the contents are not visible from the outside
  - Name of the variety

- Origin of Produce

  Country of origin and, optionally district where the product is grown or national, regional or local place name

- Commercial Specifications

  - Size expressed (subject to the uniformity rules, as minimum and maximum size)
  - Gross/Net weight
  - Optional Indications: colour of flesh (for example cream or yellow/white), colour of skin, shape of tuber (round or long/oval) and cooking type (for example mealy/floury/firm)

- Official control mark (optional)

PHYTO SANITARY CERTIFICATE

The phyto-sanitary certificate is a pre-requisite. It is issued by the National Plant Quarantine Department to the effect that produce is fit for human consumption. It will neither pose any health risk to human beings nor will transmit any insect/pest or disease to the importing country.

PHDEC may use these draft standards to develop new grade and quality standards for fresh early and ware potatoes.

GRADING (INCLUDING PARAMETERS OF GRADING)

The grading of horticulture products is mostly done through individual parameters such as shape, size, colour and weight. Potatoes are mostly graded through mechanical grading system on the basis of square mesh size. Grading has its own importance as it is used for preparing potatoes for commercial as well as seed use.

Grading potatoes by size is the common practice in developing countries like Pakistan where farmers grade potatoes by hand according to size. The process is cumbersome and costly. In the manual grading process, an expert is deployed to grade the produce keeping in mind all major characteristics. Grading and sorting ensures that produce is qualifying for the minimum quality requirements both for seller and buyer. Quality sorting is done by humans according to specific quality attributes. Quality sorting through manual process gives inconsistent results and takes more time.[280,281] Grading potatoes by size is the common practice in developing countries like Pakistan where farmers grade potatoes by hand according to size. The process is cumbersome and costly. In the manual grading process, an expert is deployed to grade the produce keeping in mind all major characteristics. Grading and sorting ensures that produce is qualifying for the minimum quality requirements both for seller and buyer. Quality sorting is done by humans according to specific quality attributes. Quality sorting through manual process gives inconsistent results and takes more time.[280,281]

To overcome these grading and sorting issues, the industry is now gradually equipping itself with power graders, and most recently with computer vision graders.

In Pakistan, the potatoes are graded on mesh size. The flow diagram of a potato grading line is illustrated below.

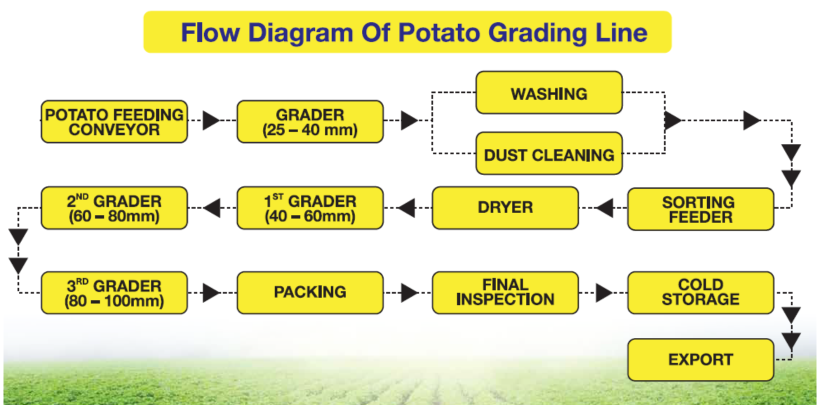


Figure 82 Potato Grading Line Courtesy: IAC

PROCESSING (PROCESSING PROCEDURES, LIST OF PROCESSING FACILITIES/UNITS - HWT PLANTS, VHT PLANTS, COLD TREATMENT PLANTS, IRRADIATION FACILITIES, AVAILABLE AND REGISTERED FOR EXPORTS TO DIFFERENT COUNTRIES)

As per data provided byThis section need extensive traveling throughout the country to develop the list of processing units/facilities… Department of Plant Protection (DPP), there are more than 40 processing units and pack housesis contacted for potatoes in Pakistan. the list of plants…The list is attachedsame will be annexed to this report as Annex-III. .

The data reveals that most of these processing units and pack houses are situated in potato growing area of Punjab including Okara, Depalpur, and Kasur. There are few processing units in Karachi (Sindh). As already mentioned in this report, KPK and Balochistan do not have any processing unit or pack house. This fact strengthens the findings of this report that there is need to work on potato production sector in these provinces.

PACKING (LOCAL PRACTICES, INTERNATIONAL REQUISITES)

As per FFV Standard -52, early and ware potatoes need to be packed for properly protecting the produce ensuring the suitable ventilation. The material used for packaging should be clean and do not cause any internal or external damage to the product. The use of materials such as paper and stamps of trade specifications are allowed to the extent that they have been done with a non-toxic ink or glue. In case of early potatoes, the use of peat is allowed for protecting the produce from any damage during long-distance transport. The packages should be free of all foreign materials.[282282]

The most commonly used packaging materials for potatoes are used to maintain their post-harvest quality parameters. These materials include;

- Polypropylene (PP)
- Perforated Polypropylene (PP(P))
- Low-density polyethylene (LDPE)
- Perforated low-density polyethylene (LDPE(P))
- Brown gunny sacks (BGS)
- Nylon gunny sacks (NGS)[283]Nylon gunny sacks (NGS)[283]

STORAGE FACILITIES (ANALYSIS OF THE CURRENT SITUATION IN PAKISTAN VIS-À-VIS INTERNATIONAL BEST PRACTICES)

It is estimated that the country has more than 550 cold storage units. These units have the capacity of storing around 900 thousand metric tons of fruits and vegetables. Against the annual production of around 15 million metric tons, the available facilities can store only 0.006% of the fruits and vegetables.[284284]

Unfortunately, these cold storages are established away from the producing areas and hence farmers of small landholdings are unable to benefit from these storage facilities at large. Secondly, these storage facilities are mainly used by processors and traders to store and release the product for better profit margins.[284284]

According to Agriculture and Horticulture Development Board (AHDB) of the United Kingdom, the best practices for potato storage facilities are as under;

- The most important step in preparation of storage facility for potatoes is its annual inspection. The best way is to carry out the inspection at the time of store cleaning few weeks prior to the loading of the product without failing and not to leave it to the last moment. During the inspection specially look for any damaged fabric/material and if found gaps in the fabric or sheet get it properly repaired. Also look for any damaged equipment and get it repaired.
- The loading activity should be planned well before the harvest. Another step is matching of crops with potatoes in terms of their quality and their likely storage period keeping in view the market expectations to the stored crops.
- The crop for storing should be as free as possible from soil, haulm, stones and physical damage. It is important that the potato crop should be ventilated within two to three hours after entering the storage facility to remove the surface moisture from the product and any remaining soil left on crop.
- The crop should be stored within a week to two and not more than that in any case. This will help in optimal control of the crop and reduce the need for store management.
- Before storage, it is recommended to do field as well as warm storage sampling. The field sampling will help in identifying blemish disease, rots and slug damage whereas warm storage sampling will help in identifying the behavior of the crop above 20°C for potential rotting.
- The mechanical damage during the loading should be kept to its minimum. The wounds give way to rots and blemish diseases. Same is the case with bruising that does not give premium price when sent to the market.
- The stacking arrangement is also important. A well management stacking arrangement help in having uniform air distribution and crop temperature in box stores.[285285]

To have a good idea of the working of potato store management. The potato store manager's guide is a complete guide for people who are running storage facilities and or working as managers of such facilities annexed to this report.

POST-HARVEST LOSSES AT DIFFERENT STAGES (WITH DEFINITE ESTIMATES) WITH REASONS AND PROPOSED SOLUTIONS

Like other horticulture produces, potato too is a living entity. As a living entity it respires, transpires and reproduce. Respiration is one of the most important metabolic process as it releases energy by breaking down the carbon compounds which in case of potato are starch. During the respiration the tuber generates heat. This heat is an important factor to be considered while storing potatoes. The respiration process is slowed down by refrigeration and cool temperatures. This process helps in enhancing the post-harvest life of the tuber and maintain its quality. As mentioned earlier, potato is 75% water and 25% starch. Hence, the tuber has the greater tendency of losing internal water. The major reasons for post-harvest losses of potato are loss of internal water, physiological damage, mechanical damage and pest/insect damage. These losses occur during harvesting, hauling, cleaning, sorting, packaging, storage, transportation, marketing, distribution and processing. According to research the post-harvest losses in developing countries range from 20 to 50%. In Pakistan post-harvest losses range from 15 to 40% and in India it is recorded up to 17%.[283,286283,286]

In a recent research, the post-harvest losses of potato are calculated according to their disposal pattern from farm level. According to the findings of the research, around 2.92% potatoes are used by the farmers for family consumption, 0.52% are gifted to friends and relatives, 62.04% are sold at the time harvesting, 12.73% are stored in cold storage for seed and 23.04% for selling later to fetch prime prices. During all these stages when potato leaves the farm, the post-harvest losses start occurring. The pre-harvest losses of potato are found to be around 5.65% of the total production; 1.21% from insect damage, 1.40% from rotting, 1.14% from cuts and bruises, 0.89% for potatoes left underground during harvesting, 1.02% for greening and off sizing of the tubers. In areas where farmers store produce in traditional way, the post-harvest losses during this period of 3 to 4 months are reported as 7.35%. The total post-harvest loss before storage is calculated as 8.15% making including losses during harvest, sorting, curing and cleaning making it 15.50%. Post-harvest losses in the household and restaurant level are reported 3.24% and 4.52% respectively. The total loss of potato from harvesting to end consumer is calculated 27.65% for traditional storage methods and 23.11% for cold storage potatoes in India.[283,286–288283,286–288]

A synopsis of reported damage and loss occurring within different market channels is illustrated in the below figure;

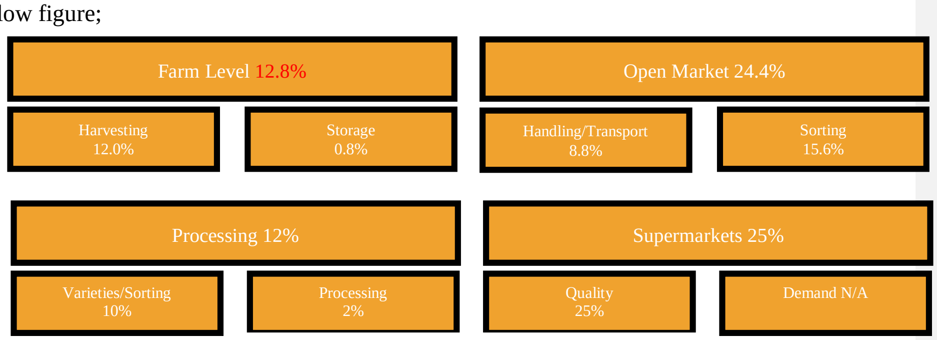


Figure 83 Synopsis of losses within different marketing channels

PROPOSED SOLUTIONS

BREAKING THE VICIOUS CIRCLE

The vicious circle around potato farmers of exploiters like beoparis, contractors, and other aggregators needs to be broken to untangle farmers from insecure market conditions and exploitation through extended bags by beoparis. In this case, capacity building of farmers with the help of extension services is needed.

SEED IMPROVEMENTS

There is need to improve seed varieties, during the current research it is revealed that Pakistan is using Dutch and Ireland varieties developed more than two decades ago. The characteristics and yield results of newly developed varieties by Pakistan are un-recorded. Though research on new varieties is underway at public and private level, the farmers are not showing willingness to shift their focus from tested varieties.

IMPROVING PRODUCTION & HARVESTING TECHNOLOGIES

There is need for improving the production and harvesting technologies through soil analysis to analyze the fertility of soil for growing potatoes. The farmers are growing potatoes without having any sort of soil analysis. This factor attributes towards reduced yields. Crop rotation in areas around major cities for potato production is the least. Crop rotation is the best option to get higher yields in the next season and avoid soil borne diseases and pathogens.

QUALITY OF FERTILIZERS

The quality of fertilizers used in Pakistan is low as compared to fertilizers used by other potato producing countries. Ever increasing prices of fertilizers are another factor that adds to the input costs along with prices of insecticides, and fungicides.

ADEQUACY OF HARVESTING TOOLS

Mechanization of potato sector on small, medium and large potato farms is rudimentary and old to some extent. Most of the harvesting process is carried out manually engaging women and children which results in significant damage to the tubers. There is further need to develop machinery that can be used at small, medium and large farms at the same time. Moreover, capacity building of harvesting labor may be beneficial in this regard.

IMPROVING POST-HARVEST HANDLING

The traditional practice of on and off farm handling and storage needs to be revisited. There is need to introduce low cost storage alternatives to farmers especially for seed storage. The cold storage facilities should be in the areas of production. In case of distant facilities, the small farmers should be provided transport by the cold storage management to send their product to the cold storage. The farmers should develop small clusters and aggregate their produce to send to the cold storage. It will help in reducing costs. Government may introduce incentive schemes for establishing such facilities in potato growing areas.

IMPROVING PACKAGING MATERIAL

Farmers have no incentives for earnestly packaging potatoes in new and good quality materials. The potato sacks get the same price in market and there is no incentive for packaging and grading good quality potatoes.

IMPROVING MARKET INFRASTRUCTURE

The plight of market infrastructure in Pakistan is not a secret anymore. An ordinary buyer sometime gets potatoes covered with a large amount of soil. The handling of potato sacks in the market is in the way that sacks are thrown from the vehicle on ground without seeing whether they are landing in water or dust. The same sacks are traded to retailer and other aggregators. There is a need to improve market infrastructure for fruits and vegetables. The people working in the market should be educated to realize the fact that they are dealing with a living thing.

IMPROVING CONTRACT FARMING CONDITIONS

It is now established fact that contract farming arrangements are a win-win situation both for the farmers and contractors or processors. In Pakistan, farmers associated with Pepsico have more opportunities of gaining knowledge about the best production technologies than other farmers. The contract farming also help farmers to negotiate their terms than other farmers. It is recommended that farmers should develop clusters under associations according their geographical locations.

VALUE-ADDITION/BY-PRODUCTS

INTRODUCTION

The potatoes consist of mostly water (78%) and starch (21%) which is indigestible in its raw form. The main reason behind potato starch's being indigestible is its β- crystalline structure that is resistant to its digestion. The processing such as boiling, microwaving, baking and frying breaks down the starch with the help of heat to make it consumable. In processed form, potatoes are eaten as boiled, baked, mashed, potato chips, French fries, cakes and pancakes.[24]

The burgeoning population growth, industrialization and urbanization has increased the importance of potato for food security due to its ability to produce the highest quantity of dry matter and nutrition per unit area. Potatoes are not only used as vegetable but also for other purposes as mentioned above such as chips, fries, granules and dehydrated potatoes. Another factor that makes potato a candidate for processing industry is its perishability due to high water content and short period of storability which is not more than three to four months under normal conditions. Hence, either it should be stored in cold storages or processed to prolong its shelf life and add value.[289289]

DEMAND OF PROCESSED POTATO PRODUCTS

The demand for processed potato products is increasing continuously due to a number of factors including but not limited to increased purchasing power, increasing preferences for fast food, expanding globalization and increased number of working women who prefer ready to cook foods. These value-added products have opened up new avenues for agriculture sector to become more remunerative.[289289] According to recent reports, the global potato processing market reached at the value of USD 24.83 billion in 2018. It is expected to cross USD 37 billion by 2026 at a CAGR of 5.2%.[290290] A synopsis of increase in demand of fresh and processed potatoes during last ten years is given below;

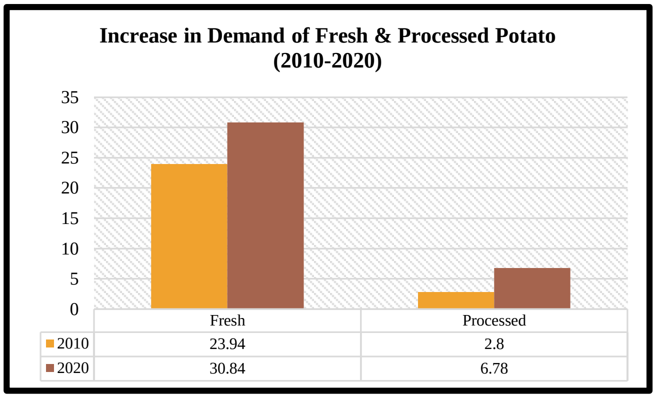


Figure 84 Increase in Demand of Fresh & Processed Potatoes (2010-2020)[289] Increase in Demand of Fresh & Processed Potatoes (2010-2020)[289]

The above figure shows that the demand for fresh and processed potato products is increasing with each passing year. The demand for fresh potatoes has increased by 22% whereas demand for processed potato products has increased by 59%. Product-wise the demand during last ten years is illustrated in the figure below to further ascertain the point of value-added potato products.

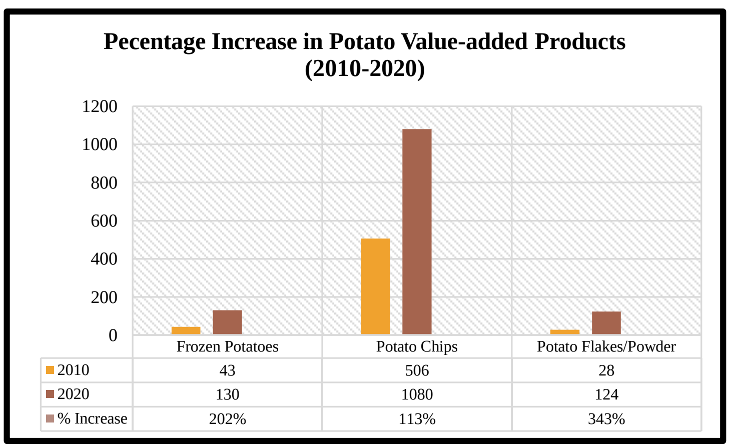


Figure 85 Increase in Demand of Fresh & Processed Potatoes (2010-2020)[289] Increase in Demand of Fresh & Processed Potatoes (2010-2020)[289]

PRODUCT ATTRIBUTES FOR PROCESSING

The potatoes should have certain morphological and biochemical quality characteristics to make superior quality processed potato products. It is not only the water and starch content that make potato the best candidate for value-added products. A summary of the product attributes for processing purposes is given below;

Attributes	French Fries	Chips	Canned	Dehydrated
Tuber Shape	Oblong	Round to Oval	Round to Oval	Round to Oval
Tuber Size (mm)	> 75	45-80	25-30	> 30
Eyes	Shallow	Shallow	Shallow	Shallow
Specific Gravity	1.080	>1.080	<1.070	1.080
Dry Matter (%)	>20	>20	<18	>20
Reducing Sugar (%)	0.15	<0.1	0.5	0.25
After Cooking Discoloration	Slight	-	Nil	Slight
Texture	Firm to mealy	Firm to mealy	Waxy	Firm to mealy
Source: Adapted from Marwah et al. 2010[291]				

Figure 86 Attributes of Potato for Processing

FROZEN POTATOES

It is estimated that global frozen potato market will reach to $ 74,403 million by 2025 with a CAGR of 3.8% during next five years up to 2025.[292] Frozen potatoes are considered a very convenient form of processed potatoes with its different nutrients and vitamins preserved with a longer shelf life. Advanced machinery and low temperature are used for frozen potatoes products such as French fries, shapes, battered potatoes, hash brown, topped potatoes and many more. Customers gain these products from quick service restaurants (QSRs) and retail stores.

The frozen processed potato market has shown a tremendous growth during last decade. Interestingly, the countries outside Europe and North America were the leading consumers of frozen processed potato products including countries in Asia, Latin America and the Middle East. The below figure shows the consumption of frozen potatoes against GDP per capita. The results may seem interesting and revealing the potential of growth in sector by developing countries like Pakistan.

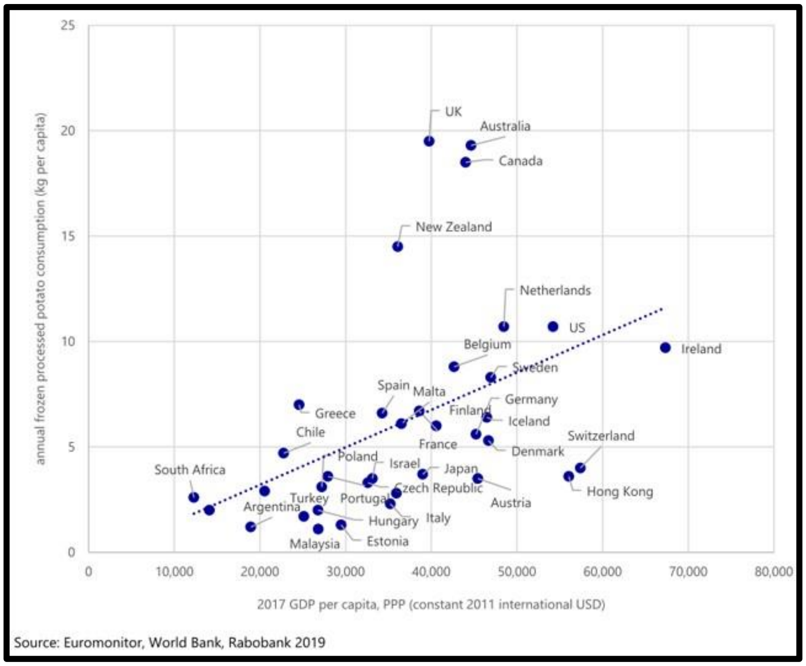


Figure 87 Annual Frozen Potato Consumption against GDP per Capita

The market is segmented on the basis of products, regions and end-users. Product-wise it is divided into French fries, shapes, battered potatoes, hash brown, topped potatoes, cooked and twice baked potatoes. The end-user segment can be bifurcated into residential and commercial. Region-wise, the frozen potato products are segmented into North America, Asia-Pacific, North-America and LAMEA.[292]

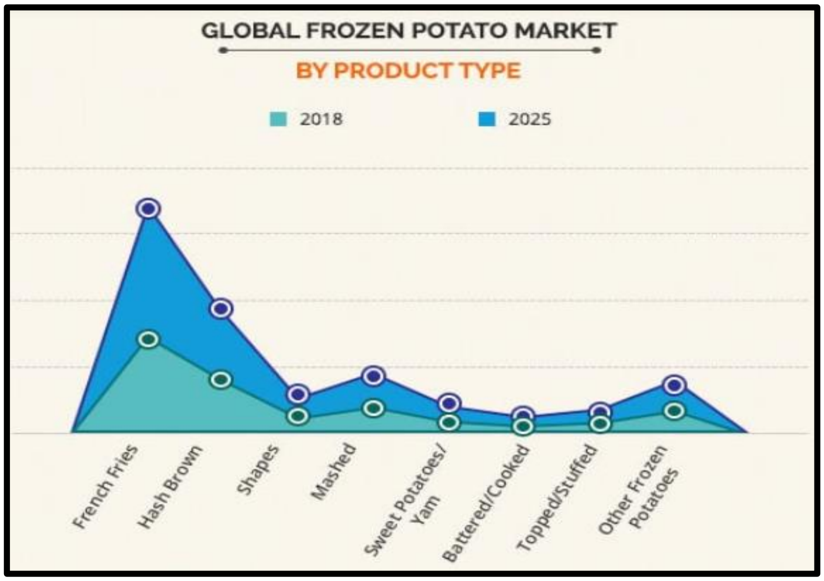


Figure 88 Global Frozen Potato Market by Product Type; Courtesy: Allied Marketing Research

The current change in lifestyle is smoothly paving way for huge opportunities in the sector. Increase in women workforce, restaurants time-constraints, nuclear families, acceptance of western culture and socializing at home are the major driving forces in the frozen food sector, indirectly supporting the market of frozen potatoes.

Product-wise French fries contributes around 40% in the global frozen potato market. The French fries market has the huge potential for growth due to new product lines meeting the consumer preferences.

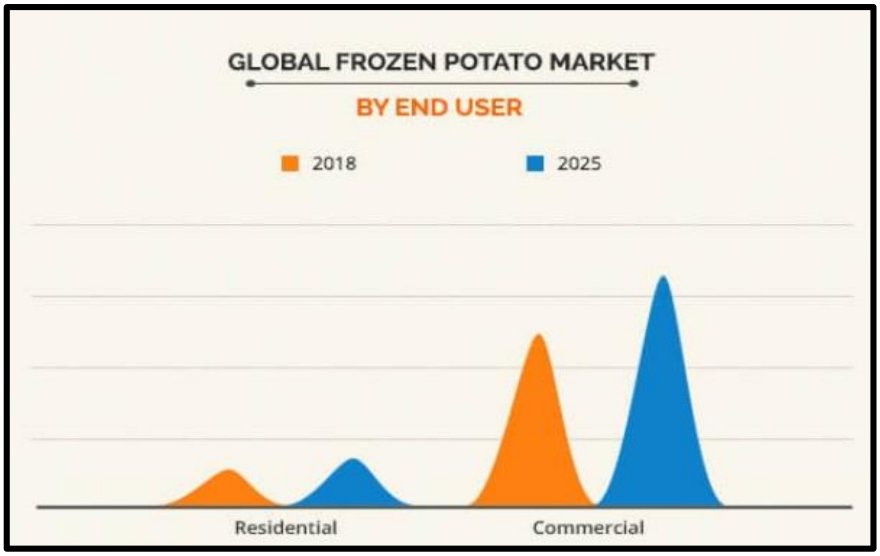


Figure 89 Global Frozen Potato Market by End User Courtesy: Allied Marketing Research

The key end-user of frozen potatoes is commercial sector and has a huge market potential for investment due to rise in number of QSRs in different countries. The large scale acceptance of frozen food products goes to the convenience of using these products including reduced time span for preparation and ease of use. Climatic changes and convenience offered by these products is also fueling up the growth of frozen potato market. The demand for frozen potato is rapidly increasing due to rise in the number of fast food restaurants, increase in the food processing capacity of different countries, increased urbanization, rise in income and above all the lower tariffs from WTO on the export and import of frozen potatoes. By far Asia-Pacific is considered the next best potential market for frozen potatoes after Europe. The region is observing an increase in female working force, convenience food and expansion of QSRs in this region which is resulting in an increased consumption of convenience products such as French fries and dehydrated potato products. Major players of frozen potato market are Agrarfrost GmbH, Bart's Potato Industry, Greenyard, Farm Frites, Himalaya International, J.R. Simplot Company, McCain Foods, Al-Salam Cooling Co, Lexia Foods, Meade Potato Company, Bem Brasil Alimentos and The Kraft Heinz Company.[292]

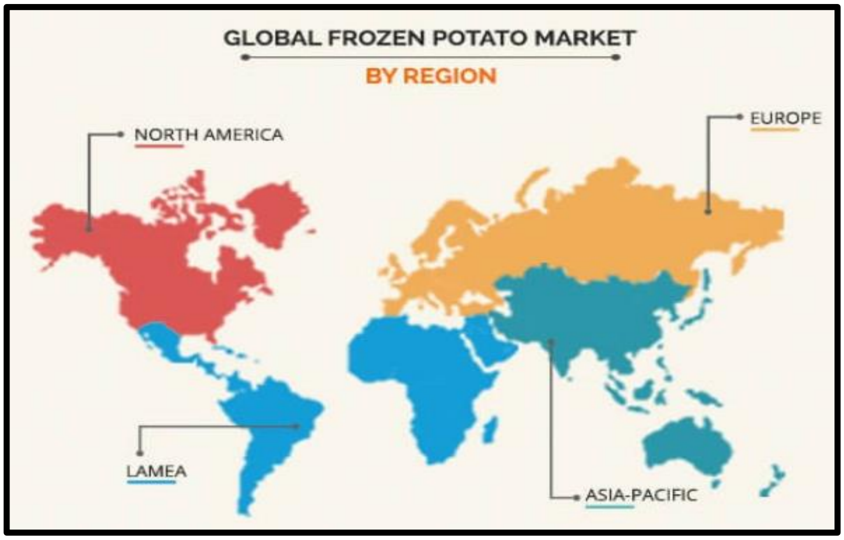


Figure 90 Global Frozen Potato Market by Region Courtesy: Allied Marketing Research

POTATO CHIPS

The global potato chips market touched the figures of USD 30 billion in 2019 and is expected to show a stable growth up to 2025. Potato chips are one of the most cherished snack foods across the globe which is sold in plain and flavored potato chips product types. Chips are thin slices of potato which are fried until crisp. The process of frying breaks down the sugar to combine with amino acids resultantly the slices become brownish that further result in yellowish-brown color of the chips. The packaging of potato chips is done in a way that they are safe from chemical, enzymatic and microbiological spoilage along with moisture. Potato chips maintain their color, taste and texture for longer period of time as they are packed in air-tight plastic bags which also adds to their longevity. Potato chips has become a companion of everybody in their busy lifestyle. Three main ingredients are used for making potato chips; potato, oil and salt. All these three ingredients are easily available throughout the world, hence, reliable supply of raw materials is not a big issue for the processing industry. With the rise of Asia as the leader of potato production, it is expected that Asia will also be a leader in providing raw material for the global potato chips market. The industry has started developing new healthy product lines for health conscious consumers such as potato chips with reduced fats, fortified chips, gluten-free chips and non-GMO potato chips.[293] The distribution channels include super and hyper markets, specialty food stores, convenience stores, online stores and others. It is expected that United States, United Kingdom, Russia, China and India will be major potential markets for potato chips.[293]

ISSUES AND PROPOSED SOLUTIONS

Pakistan potato processing industry is an amalgamation of industry giants like Pepsico and other small and medium processors. The industry is thriving at a consistent pace but the availability of quality raw material is still an issue along with other issues. The issues and proposed solutions are discussed in this section.

LACK OF PROCESSING VARIETIES FOR THE INDUSTRIES

Though Pakistan's processing industry is relying heavily on exotic varieties of Lady Rosetta, Hermes, Santana and Asterix, there is a need to develop varieties which can ensure the year round supply of raw material to the industry. In this regard the processing industry has neglected the province of Khyber Pakhtunkhwa where three crops of potato are available. Moving small manufacturing units to the province of Khyber Pakhtunkhwa will help not only the industry but also the farmers. Any such move will help in catalyzing the potato industry in the province.

The major crops of potato from Autumn season are harvested up to March. The next few months from April to August is the period where the processing industry started feeling the shortage of raw material. If the processing industry develop smaller units in other provinces that would ensure fresh raw material for the industry. In Pakistan we also need to develop late varieties for processing industry which can help in shortening the period of supply to the industry during summer months and rainy seasons. We would also need to develop early maturing varieties that can replace the early potatoes which have not developed skin and hence not fit for French fries.

To have a share in frozen potato processing markets, Pakistan also need to develop heat insensitive varieties for processing that can brave the summer season and higher temperatures and have the ability to resist late blight at the end of season.

Another issue of potato varieties is *cold-induced sweetening* which is phenomenon of accumulation of reducing sugars which makes these stored potatoes unsuitable for processing due to their tendency to develop unwanted brown coloration during processing. This asks for storing potatoes at a higher temperature of 10 to 12℃ instead of desired 2-4℃. Pakistan also need to work on developing such varieties that can sustain the cold-induced sweetening. The current varieties are susceptible to cold-induced sweetening and hence cannot be stored long for processing industry.

Pakistan further needs to carryout research and development activities for developing zone specific varieties, though NARC has done some work in this regard along with Hazara Agriculture Research Station (HARS), there is a need to develop varieties specifically for Pakistan's southern and northern geo-ecological zones.

FRENCH FRIES IS THE CALL

As discussed earlier, the global potato processing sector was dominated by the growth of frozen processed potatoes. The growth helped the Netherlands and Belgium double their exports during last decade. The trend is now moving towards Asian countries.[294] Pakistan can benefit from the situation by developing and cultivating the varieties suitable for frozen processed potato products including French fries. Pakistan needs to develop French fries' specific varieties that has certain quality attributes including oblong shape, more than 75mm length with shallow eyes and having dry matter more than 20% with reducing sugar content less than 1%.[291] If we succeed in developing such varieties it will not only help the domestic processing industry but also the world giants in fast food like McDonalds may turn their face towards Pakistan for their fast food restaurants.

YIELD ENHANCEMENT IS THE ONLY WAY FORWARD

Though Pakistan has achieved more than the world average per hectare yield but still we have covered only the half way in per hectare yield development. Pakistan needs to develop high yielding varieties to meet domestic as well as international fresh and processed potato demand. According to Food and Agriculture Organization (FAO) there is still room for increasing potato yield in temperate and subtropical regions. Currently, there is an enormous inconsistency in potato yield throughout the world depending on seasons of production in different countries. Actual yield ranges from 10 to 65 tonnes per hectare. The real challenge is to realize the potential which ranges from 40 to 140 tonnes per hectare.[295] The yield potential in temperate and subtropical regions is illustrated in the figure below;

Yield potential in temperate and subtropical regions				
	Season	Actual tonnes/ha	Potential tonnes /ha	Actual/ Potential %
Washington, USA	12/3-15/10	65	140	46
The Netherlands	1/4-1/10	45	100	45
Egypt	1/1-1/5 1/9-1/1	20 15	60 45	33 33
Tunisia	15/2-1/6	15	70	21
Pakistan	15/1-1/5	15	50	30
Saudi Arabia	1/1-1/5 1/10-1/1	15 12	45 40	33 30

Figure 91 Yield Potential in Temperate & Subtropical Regions; Courtesy: FAO

The figure above shows that Pakistan with actual yield of 15 tonnes per hectare in 2008 has the potential of producing 50 tonnes per hectare, which means Pakistan has 30% more potential of increasing its per hectare yield.

POTATO SEED PRODUCTION

According to Food and Agriculture Organization (FAO), the countries located above 40° has the likelihood of producing the good seed multiplication system because generally they have the low aphid population despite the fact that they can still have a range of soil borne diseases. In the same high altitudes in countries that are located between 30° to 40° latitude including Pakistan have almost the same climatic conditions of countries located above 40° and hence they too have low aphid population. This situation makes such countries suitable for seed production during their winter season.[295] Extensive research is needed in this area for developing seed multiplication systems in higher altitude places in Pakistan such as in the province of Khyber Pakhtunkhwa and Baluchistan.

SECTION 6: GLOBAL TRADE (EXPORTS/IMPORTS)

INTRODUCTION

Potato in its raw form falls in Chapter 7 of Harmonized Tariff System with 4-digit code of 0701. The 6-digit prefix for frozen, preserved and prepared including French fries fall in Chapter 20- 200410. Unfrozen potato prepared or preserved with vinegar or acetic acid also falls in Chapter 20 with 6-digit code of 200520.

WORLD POTATO (RAW) EXPORT

Global potato export touched the figure of around US$5 billion in 2019 for raw potatoes including seed. Overall, the export of raw potatoes showed an increase of 34.30% from 2015 when the global export of raw potatoes was recorded at US$3.61 billion.[296] More than 65% of the export of raw potatoes is carried out by top six countries as shown in the table below;

Table 14 Top Potato (Raw) Exporters 2019

Rank	Country	Value	%Share in World Export
1	Netherlands	US$1.0 billion	21.2%
2	France	US$815.8 million	16.8%
3	Germany	US$436.2 million	9.0%
4	China	US$398.1 million	8.2%
5	Egypt	US$259.6 million	5.4%
6	United States of America	US$255.5 million	5.3%
7	Belgium	US$234.2 million	4.8%
8	Canada	US$228.8 million	4.7%
9	United Kingdom	US$182.2 million	3.8%
10	Spain	US$175.5 million	3.6%
11	India	US$72.2 million	1.5%
12	Italy	US$70.5 million	1.5%
13	Denmark	US$68.5 million	1.4%
14	Cyprus	US$54.1 million	1.1%
15	Israel	US$50.9 million	1%
Source: WTE			

Among these countries the fastest growing exporters of raw potatoes were France, China, Spain and Netherlands that showed growth in export by 74.9%, 74.7%, 66.9% and 64.8% respectively. Israel was the only country that showed a decrease in its export during past five years by -39.1%.[296]

On an average the world exported around 7.5 million tons of fresh or chilled potatoes for an average average value of around US$3.3 billion. The export of fresh or chilled potatoes in 2019 is recorded as 12 million tons with a compound annual growth rate (CAGR) of 76% in terms of value. The world export of fresh or chilled potatoes for last 10 years (2010-2019) is shown in the figure below. The detailed table is attached as Annex-IX.

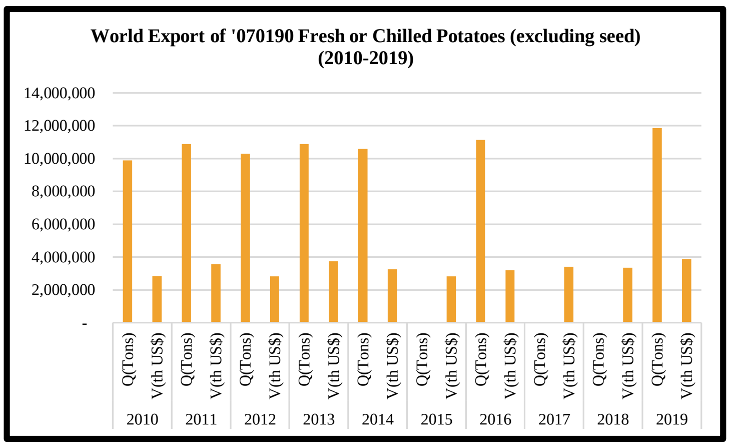


Figure 92 World Export of Fresh or Chilled Potatoes (excluding seed) (2010-2019)

WORLD POTATO (PREPARED OR PRESERVED) EXPORT

The value addition products including frozen French fries added another US$12.80 billion. The French fries made 80.8% of the overall export of prepared or preserved potato export. Another segment of prepared and or preserved potatoes (unfrozen) added US$2.5 billion representing around 19% of the prepared and or processed potato export market.[296]

Table 15 Top Potato (Prepared and or Preserved) Exporters

Rank	Country	Value	%Share in World Export
1	Belgium	US$2.57 billion	24.8%

2	Netherlands	US$2.27 billion	21.9%
3	United States	US$1.5 billion	14.7%
4	Canada	US$1.2 billion	11.3%
5	France	US$495.4 million	4.8%
6	Germany	US$470 million	4.5%
7	Poland	US$312.2 million	3%
8	United Kingdom	US$266.5 million	2.6%
9	Argentina	US$218.9 million	2.1%
10	New Zealand	US$69.7 million	0.7%
11	Austria	US$63.1 million	0.6%
12	Turkey	US$52.7 million	0.5%
13	Egypt	US$31.1 million	0.3%
14	India	US$29.6 million	0.3%
15	China	US$31.9 million	0.3%
Source: WTE			

The above countries contributed 92.4% of all exports of prepared and or preserved potatoes during 2019 whether frozen or not. The fastest growing exporters among the above countries whether frozen are not were Turkey, India, Poland and Belgium that registered an increase of 526%, 228%, 61.2% and 60% respectively. Egypt and China registered a decline in their exports by -53.1% and -14.4% respectively.[296]

The export market of prepared or preserved potatoes increased with a CARG of 65% and 70% for export quantity and value respectively during last 10 years (2010-2019). In 2019 alone the world exported around 8 million tons of prepared or processed potatoes for a value of around US$8.3 billion. The world export of prepared or preserved potatoes for last ten years is shown in the figure below. The detailed table is attached as Annex-X.

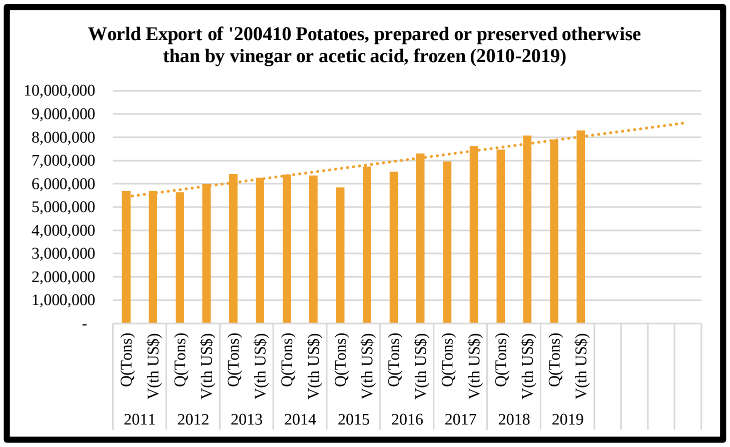


Figure 93 World Export of Prepared or Preserved Potatoes (2010-2019)

WORLD POTATO IMPORT

In 2019, the world imported raw potatoes of an estimated cost of US$7.81 billion registering an expansion of 36% since 2015 when the world purchased raw potatoes amounting to US$3.8 billion. Year over year, the import of raw potatoes expanded by 11.8% from 2018 to 2019. As a whole the European countries purchased 69.2% of world's imported potato amounting to US$3.6 billion. Second on the importing tier were Asian countries which imported 14% of world's raw potatoes followed by North America with 7.5%. It means that more than 90% of exported potatoes were purchased by the above mentioned three continents.[297] A list of top potato importing countries in 2019 is given in the below table.

Table 16 Top Potato (Raw) Importing Countries

RANK	IMPORTER	RAW POTATOES IMPORTS	%WORLD TOTAL
1.	Belgium	US$769million	15%
2.	Netherlands	US$463.4 million	9%
3.	Germany	US$348.4 million	6.8%
4.	Spain	US$338.9 million	6.6%
5.	Italy	US$244.2million	4.8%

6.	United States	US$220.3 million	4.3%
7.	France	US$157.7 million	3.1%
8.	United Kingdom	US$148 million	2.9%
9.	Russia	US$132.7 million	2.6%
10.	Portugal	US$120.2 million	2.3%
11.	Greece	US$111.4 million	2.2%
12.	Vietnam	US$109.5 million	2.1%
13.	Canada	US$107.7 million	2.1%
14.	Poland	US$105.5 million	2.1%
15.	Egypt	US$104.4 million	2.0%
Source: WTE			

Of the above-mentioned countries, Vietnam took the lead by registering an increase of 838.1%, Poland 243.3%, Belgium 149.6% and Netherlands 111.5% in imports since 2015. While Russia registered a decline of -47.5% in imports from 2018 to 2019, overall these countries purchased 67.9% of all potatoes imported in 2019.[297] Searchable list of potato importing countries can be visited here.

The world import of prepared or preserved potatoes is given the figure below and detailed table for import of prepared or preserved potatoes for last 10 years is attached as Annex-XI.

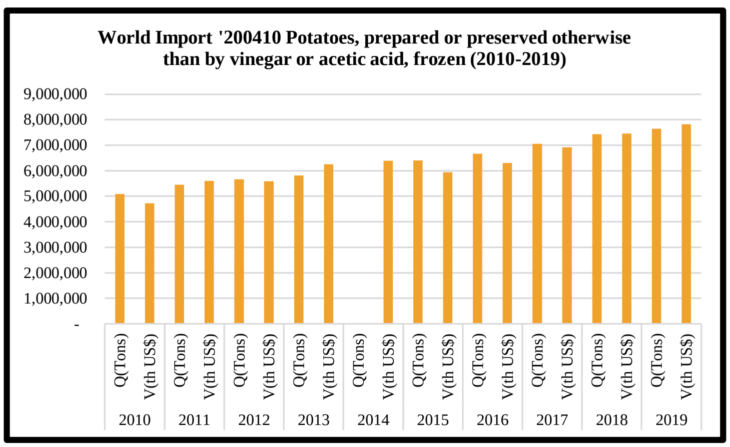


Figure 94 World Import of Prepared or Preserved Potatoes (2010-2019)

BELGIUM

Belgium ranked first in importing countries during last five years with an average import of more than 2 million tons of potatoes for an average value of US$441 million. Major suppliers for Belgium remained within the EU region including France (54%), Netherlands (23%), Germany (15%), UK, and Spain. Egypt is the only country out of EU exporting to Belgium in top ten suppliers. Import of Belgium during last 10 years with a quick analysis of top supplier partners is annexed as Annex-XII, and is given in the figure below;

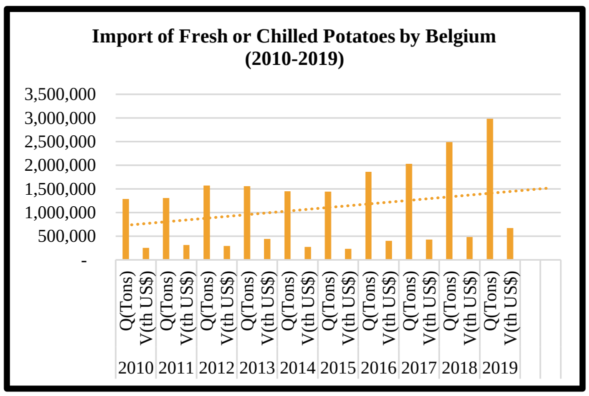
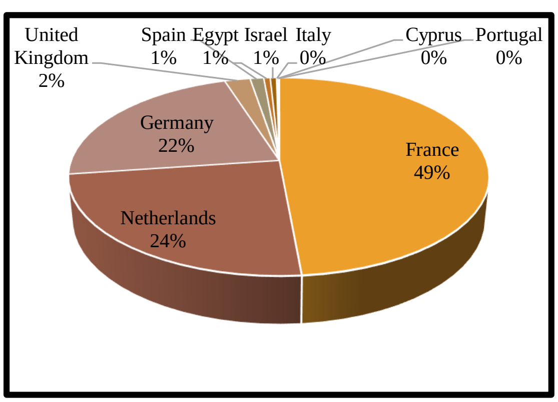


Figure 95 Suppliers Markets for Potato to Belgium (2010-2019)

Belgium registered a CAGR of 47% and 42% with respect to quantity and value of importing potatoes during last 10 years. The major suppliers of fresh or chilled potatoes to Belgium remained from the EU region including France, Netherlands and Germany. More than 90% of Belgium import of fresh or chilled potatoes was from aforementioned three countries.



SPS and other regulatory measures for exporting to Belgium are same as other EU countries. For reiteration the same are reproduced beneath and should be considered for all EU destinations;

EXPORT REQUIREMENTS FROM PAKISTAN

P 400- Prohibition of re-exports of goods in their original and unprocessed form

IMPORT REQUIREMENTS BY BELGIUM:

The import requirements by Germany and Spain for fresh and or chilled potatoes include 17 measures. The detail of these measures is given below with links to the guiding rule/regulation for better understanding;

a. A 120- Geographical restrictions on eligibility
b. A 130- System Approach
c. A 140- Special Authorization requirement for SPS reasons
d. A 190- Prohibitions/restrictions of importers for SPS reasons not elsewhere specified
e. A 210-Tolerance limits for residues of or contamination by certain (non-microbiological substances
f. A 220- Restricted use of certain substances in foods and feeds and their contact materials
g. A 410- Microbiological criteria of the final product
h. A 420- Hygienic practices during production
i. A 630- Food and feed processing
j. A 830- Certification Requirements
k. A 840- Inspection Requirements
l. A 850- Traceability Requirements
m. A 851- Origin of Materials and Parts
n. A 852- Processing History
o. A 853- Distribution and Location of Products after Supply
p. B 140- Authorization Requirements for TBT reasons
q. B310- Labelling Requirements

NEHTERLANDS

In the top ten importing countries Netherlands ranks 2nd after Belgium. However, the first position between EU members remained flexible between Belgium, Netherlands, and France. On an average Netherlands imported more than 1.6 million tons of potato from 2010 to 2019 on an average import value of US$313 million. Major suppliers of fresh or chilled potatoes to Netherlands are from EU region including Germany, Belgium, and France. Israel, Egypt and Morocco are the other major suppliers out of EU region. Import of Netherlands during last ten years is shown in the figure below;

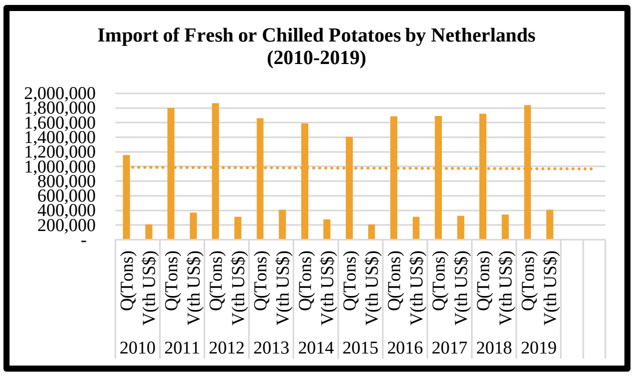
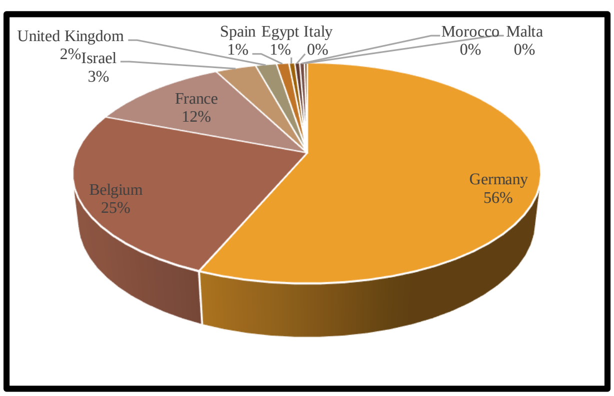


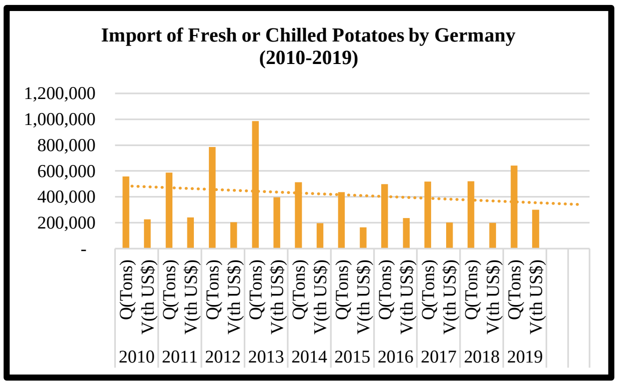
Figure 96 Supplying Markets for Potato to Netherlands (2010-2019)

Like Belgium, major suppliers to the Netherlands are from EU region. The top suppliers including Germany (56%), Belgium (25%) and France (12%) supply more than 90% of fresh or chilled potatoes to the Netherlands. The import requirements for Netherlands are same as other EU countries as mentioned above.

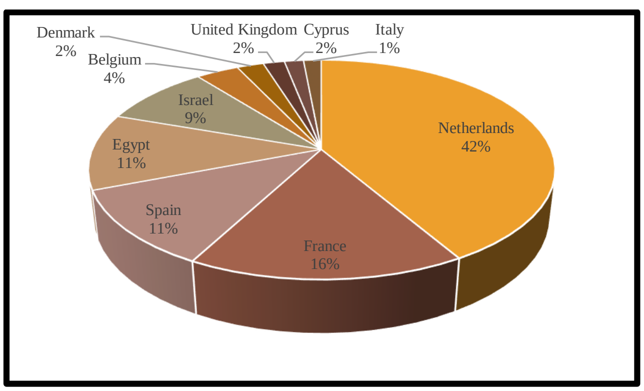


GERMANY

With an average import of around 0.5 million tons of potatoes at an average price of around US$209 million during last five years. Major suppliers include countries from EU region such as Netherlands, France, Belgium, and Spain. Egypt and Israel are two countries supplying fresh or chilled potatoes to Germany out of EU region. The importing requirements for Germany are same as rest of the EU region for fresh or chilled potatoes. Import of Germany during last 10 years is shown in the figure below;



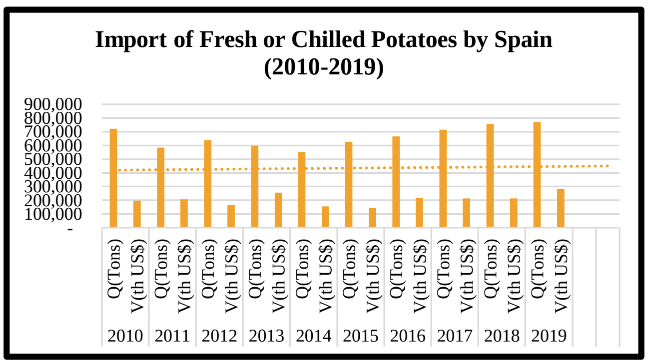
The major suppliers to Germany are from EU region including the Netherlands (42%), France (16%), Spain (11%), Belgium (4%) and the United Kingdom (2%) as shown in the figure below;



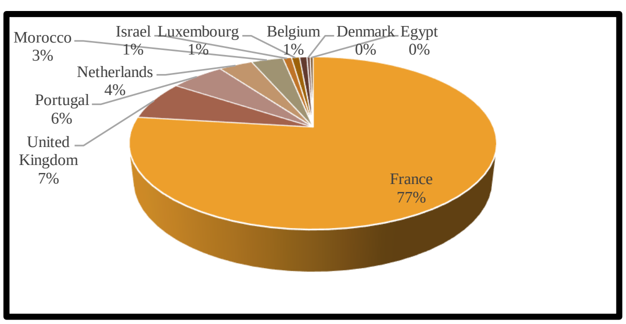
During last 10 years, Germany has shown increase of CAGR of 87% in quantity and 77% in value. More than 80% of Germany's potato import is from EU region where the Netherlands (37%), France (24%), and Spain (6%) are major partners. Only, Egypt (9%) and Israel (6%) are major suppliers from out of EU region. As per feedback provided by Pakistan Embassy in Germany, the reason behind export from Egypt is the use of German potato seed by Egypt.

SPAIN

Spain is also among the top ten importing countries with an average import of around 660 thousand tons of fresh or chilled potatoes during last 10 years at an average value of US$205 million. Like other top importers, Spain sources mainly from EU countries including Netherlands, France, Spain and Belgium. The countries sourcing fresh or chilled potatoes to Spain out of EU region are Egypt and Israel where Egypt is showing a consistent growth in export to Spain. During last 10 years Spain has shown an increase in both quantity and value at CAGR of 94% and 72% respectively. Spain has the same SPS and import regulations as other EU countries as mentioned above. Import of Spain during last 10 years is shown in the figure below;

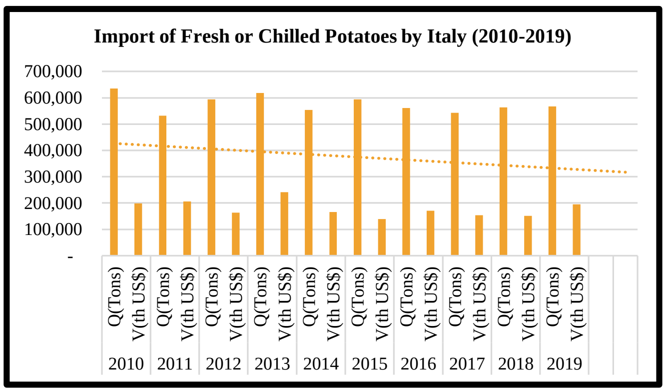


Spain, as one of the largest importers of potatoes has registered the growth in import of ptoatoes at CAGR of 94% by quantity and 72% by value during last 10 years. During the same period, major suppliers of fresh or chilled potatoes remain from within the EU region including France (77%), the United Kingdom (7%), the Netherlands (4%) and Portugal (6%) as shown in the figure below;

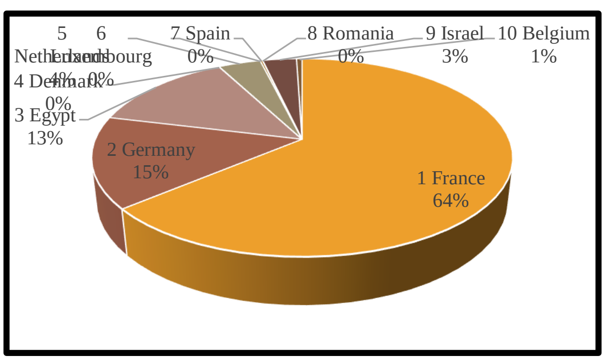


ITALY

Italy is among the top importing countries with an average import of 575 million tons for an average importing price of US$158 million from EU countries such as France, Germany, Netherlands, Spain and Belgium. Italey has shown the highest growth in import quantity and value at the CAGR of 110% by quantity and 102% by value. Egypt and Israel again the are countries out of EU region supplying fresh or chilled potatoes to Italy. Egypt is showing a consistent growth in export to Italy during last 10 years. Import of Italy during last 10 years is shown in the figure below;

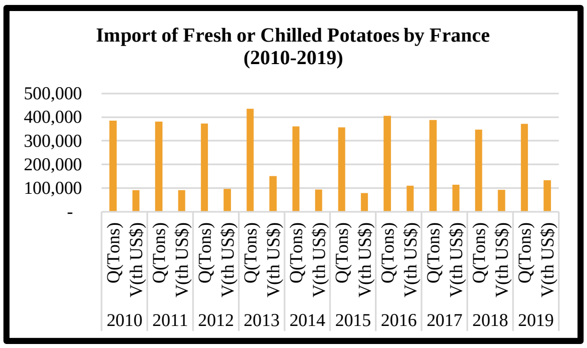


Major suppliers of fresh or chilled potatoes are from EU region as mentioned above with France being the leading exporter by supplying 64% followed by Germany (15%). Egypt has succeeded in capturing 13% of the market outside of EU region as shown in the figure below;

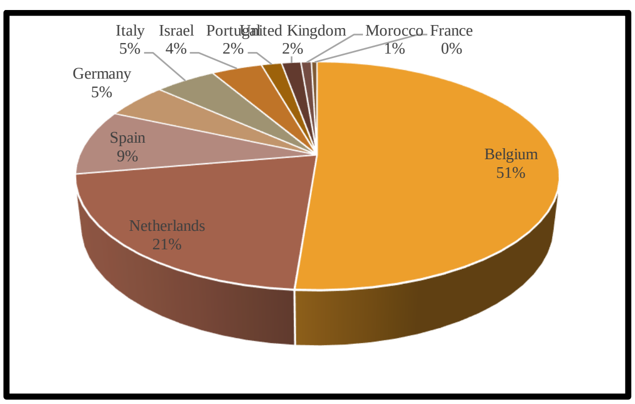


FRANCE

France as an importer sources mainly from EU countries including Belgium, Netherlands, Germany and Spain. With an average import of around 0.35 million tons of fresh or chilled potatoes for an average import value of US$104 million. After Italy, France has also shown a growth both in quantity and value of import during last 10 years with a CAGR of 103% by quantity and 71% by value. The import quantity and value of fresh or chilled potatoes by France during last 10 years (2010-2019) is shown in the figure below;

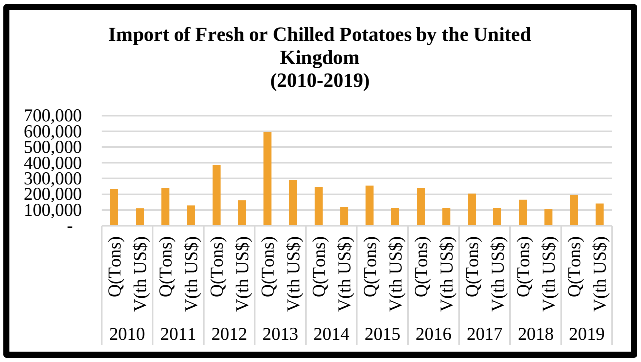


Out of EU major suppliers to France are Israel (14%) and Morocco (11%). Major exporting markets to France within EU are Belgium (51%), the Netherlands (21%), Spain (9%), and Germany (5%). The import requirements for France are same as other EU countries. The percentage share of different suppliers of fresh or chilled potatoes to France is shown in the figure below;

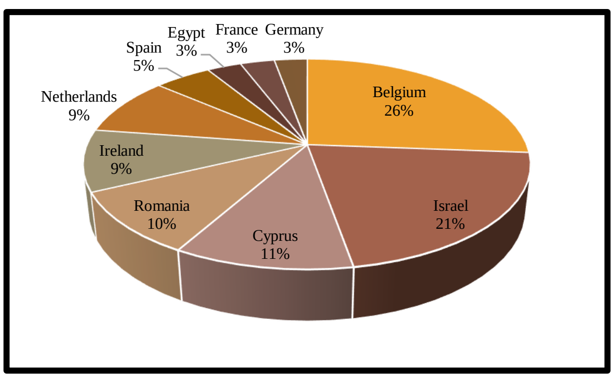


UNITED KINGDOM

At the time of writing this report, United Kingdom is the part of EU until the implementation of Brexit on 31st December 2020. By that time the trade between UK and other EU countries is being considered according to pre-Brexit era.[298] According to the figures available at ITC, the United Kingdom imported fresh or chilled potatoes from EU region of an average quantity of more than 275 thousand tons at an average value of more than US$138 million. During last 10 years, the United Kingdom has shown increase in quantity and value at CAGR of 117% for quantity and 80% for value. The import of the United Kingdom during last 10 years is shown in the figure below;

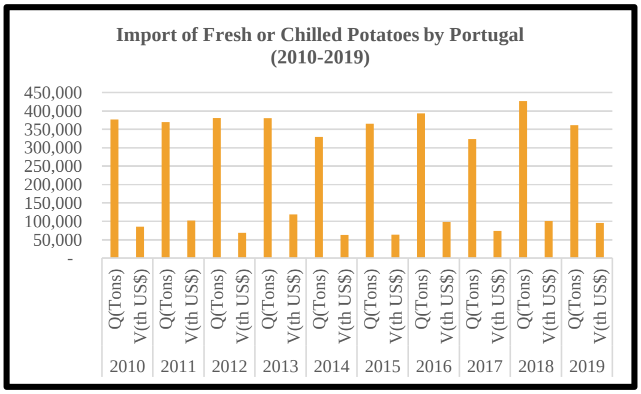


Major suppliers to the United Kingdom remained Belgium (26%), Cyprus (11%), Irelan (9%), Netherlands (9%) and Isreal (21%) from outside EU region. Until the implementation of Brexit, the EU import rules are applicable on export of fresh potatoes to the UK. Import of the United Kingdom during last 10 years with percentage share in the United Kingdom market is shown in the figure below;

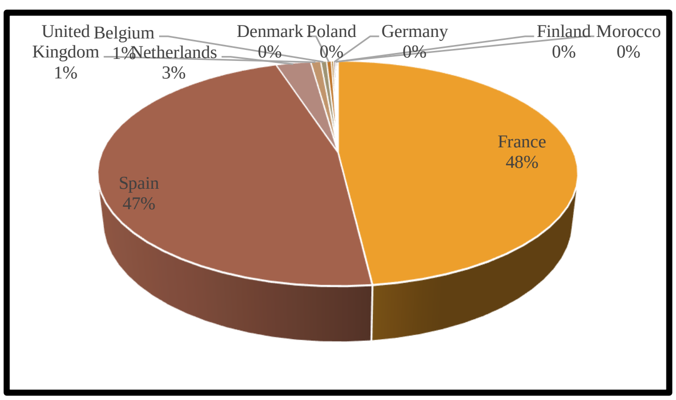


PORTUGAL

Portugal is also included in top ten importing countries. With import of an average 0.37 million tons at an average import price of US$87 million. Portugal imports largely from EU countries including France, Spain, Netherlands and the UK. No other region than EU is included in the suppliers' list for Portugal. The import regulations are same as other EU countries. Import of Portugal during last 10 years is shown in the figure below;

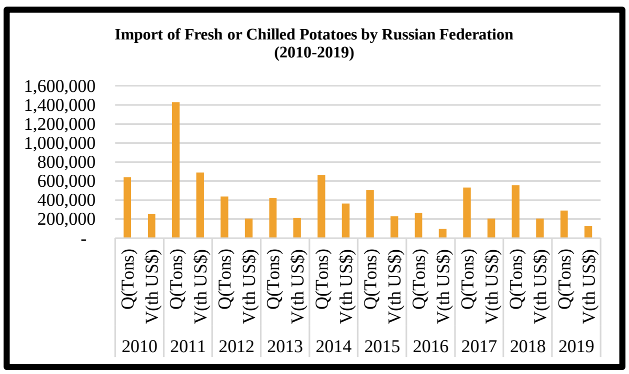


Portugal has shown a consistent growth with CAGR of 104% in quantity and 90% in value. Major suppliers to Portugal are from the EU region including France (48%), Spain (47%), and Netherlands (3%). Percentage share of major suppliers in Portugal market is shown in the figure below;

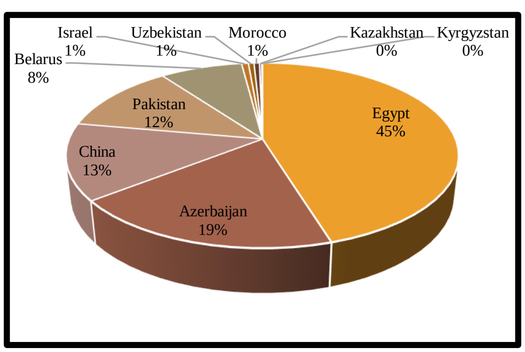


RUSSIAN FEDERATION

Russian Federation is among the top ten importers in the world with an average import of 0.42 million tons of fresh or chilled potatoes at an average value of US$191 million. Russia mainly imports from Egypt, Azerbaijan, China and Pakistan and some other Central Asian States. The SPS and import regulations for exporting to Russian Federation has already been mentioned in this report. As is evident from the table below, Egypt is dominating the market with export of more than around 300 thousand tons. China is also another important partner but as seen in the table below, Pakistan is struggling to maintain its position in this regard. Import of the Russian Federation during last 10 years is shown in the figure below;

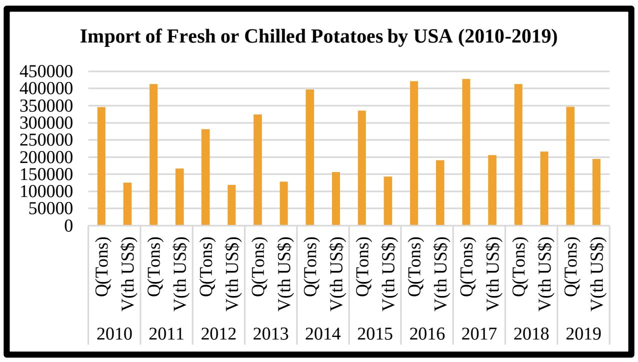


Russian Federation has shown inconsistent growth at CAGR of 75% and 77% with respect to quantity and value. Major exporting partners to Russian Federation are Egypt (45%), China (13%), Pakistan (12%) and Izerbaijan (19%).

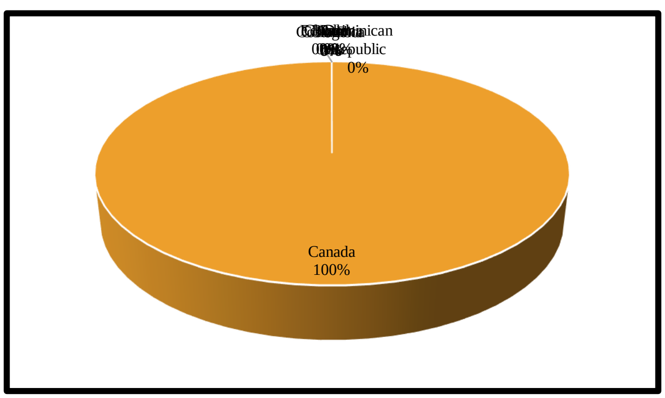


USA

Out of EU and Russian Federation regions, USA in the largest importer of fresh or chilled potatoes. On an average, USA has imported around 0.37 million tons of fresh or chilled potatoes during last 10 years at anaverage value of US$ 164 million. USA has registered a growth in import of fresh or chilled potatotes by CAGR of 100% by quantity and 67% by value during last 10 years. The import of USA for last ten years is shown in the figure below;



Major exporting market to USA is Canada.No other country has shown any progress in capturing significant market share in USA market as shown in the figure below;



Under the arrangements of preferential tariff for GSP countries, Pakistan has 0% applied tariff for export of fresh or chilled potatoes to USA. The applied tariff for MFN status countries whom Pakistan is also a beneficiary with 0.5 cents per kg. USA does not apply any trade remedies for import of fresh or chilled potatoes from Pakistan. The import requirements for exporting fresh or chilled potatoes from Pakistan to USA are given below;

There are 46 regulatory requirements or measures to fulfill/comply for exporting fresh or chilled potatoes from Pakistan.

a. A120- Geographical Restrictions on eligibility
b. A140- Special Authorization Requirements for SPS Reasons (1,2)
c. A150- Registration Requirement for Importers
d. A190- Prohibition/restrictions of imports for SPS reasons n.e.s
e. A220- Restricted use of certain substances in foods and feeds and their contact materials (1,2,3,4,5,6,7,8,9)
f. A310- Labeling Requirements (1,2,3,4)
g. A330- Packaging Requirements (1,2,3,4)
h. A410- Microbiological criteria of the final product
i. A420- Hygienic Practices during production
j. A510- Cold/Heat Treatment (1,2,3)
k. A530- Fumigation (1,2,3,4)
l. A630- Food & Feed Processing (1,2)
m. A820- Testing Requirements
n. A830- Certification Requirements
o. A840- Inspection Requirements (1,2,3)
p. B310- Labeling Requirements (1,2)
q. B330- Packaging Requirements
r. B600- Product Identity Requirements
s. B700- Product Quality or Performance Requirements (1,2)
t. B800- Conformity Assessment Related to TBT
u. B820- Testing Requirements

HISTORICAL GROWTH ANALYSIS

The world showed an increased average annual growth of +2.8% from 2007 to 2019 in fresh and or chilled potato export with some noticeable fluctuations.[299] The world exported 13 million tons of fresh and or chilled potatoes for US$4.34 billion with an average unit value of US$319.

WORLD

In last five years from 2015 to 2019, the world potato export of fresh and or chilled potatoes recorded an increase of 24.51% in terms of quantity and 46.56% in terms of value. Historical growth of world export is given in table in Annex-IV.

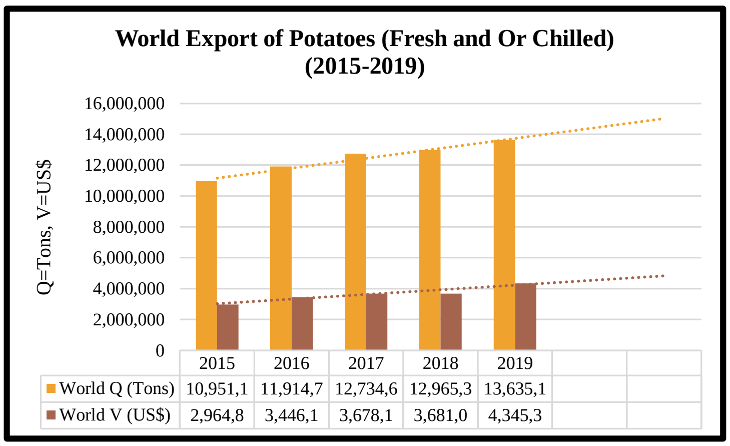


Figure 97 World Potato (Fresh & Or Chilled) Export (2015-2019) Source: ITC

FRANCE

In the top exporting countries France stood at first position during the analyzed period with export of 2 million tons for a value of 646 thousand US$.

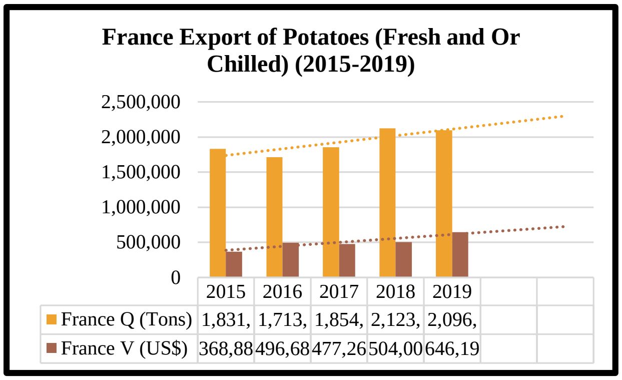


Figure 98 France Export of Potatoes (Fresh and Or Chilled) (2015-2019) Source: ITC

France registered a growth of 14.47% in terms of quantity and 75.18% in terms of value during 2015 to 2019. France also registered a growth of 53% in its per unit export value increasing from US$216 per ton to US$331 per ton.

NETHERLANDS

During 2015 to 2019, Netherlands export of fresh and or chilled potatoes reached to around 1.3 million tons for a value of around 446 thousand US$. Netherlands registered a growth of more than 96% in terms of quantity and more than 151% in terms of value.

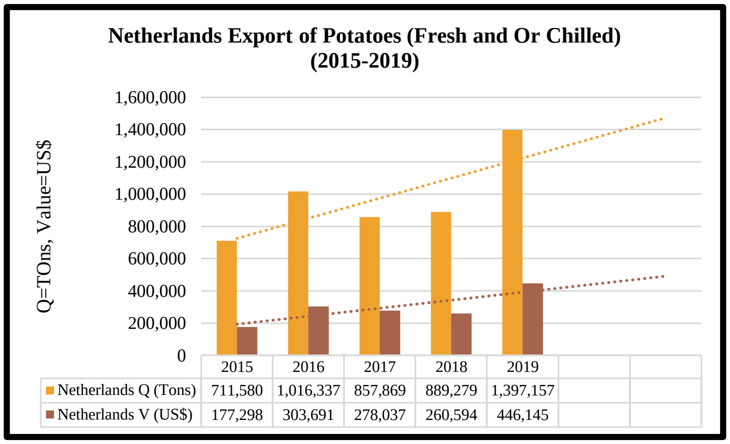


Figure 99 Netherlands Export of Potatoes (Fresh and Or Chilled) (2015-2019) Source: ITC

Netherlands registered per unit value increase in export of fresh and or chilled potatoes from 249 US$ per ton in 2015 to US$319 in 2019 showing an increase of 28% in value terms.

GERMANY

During the last five years on an average Germany exported around 1.7 million tons of fresh and or raw potatoes on an average value of 320 thousand US$. From 2015 to 2019, Germany registered a growth of 8.82% in terms of quantity and 63.24% in terms of value with a unit value of US$218.

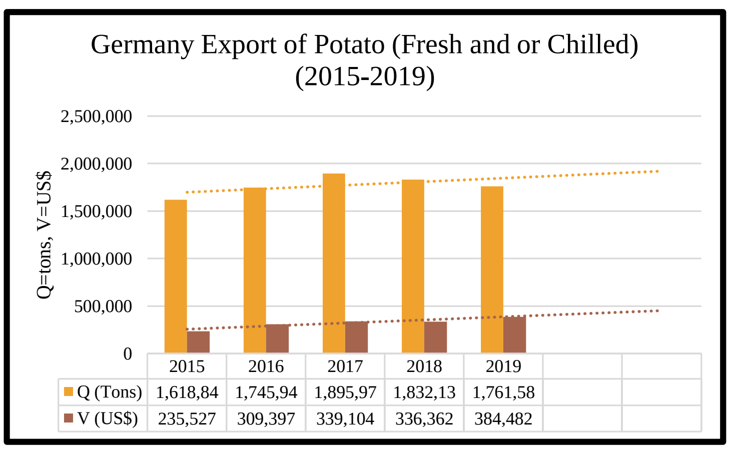


Figure 100 Germany Export of Fresh Potatoes (2015-2019) Source: ITC

USA

From 2015 to 2019, the USA exported around 469 thousand tons of fresh and or chilled potatoes at an average price of 211 thousand US$. USA registered an increase of around 32% in terms of quantity and around 32% in terms of value with a unit value of US$466 and annual growth rate of 8%.

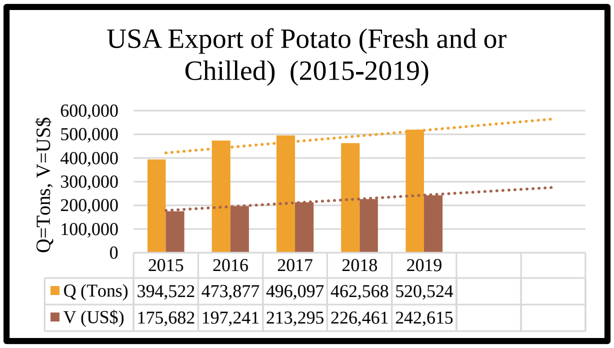


Figure 101 USA Export Potato (Fresh and or Chilled) (2015-2019) Source: ITC

CANADA

From 2015 to 2019, Canada showed a decrease of 2.27% in quantity. However, it showed an increase of more than 33% in terms of value with an annual growth of 7% at the unit value of US$540. The decrease in quantity was recorded from 2018 to 2019. The reason for this decrease is mainly attributed to the drought situation that hit Canada in 2018.

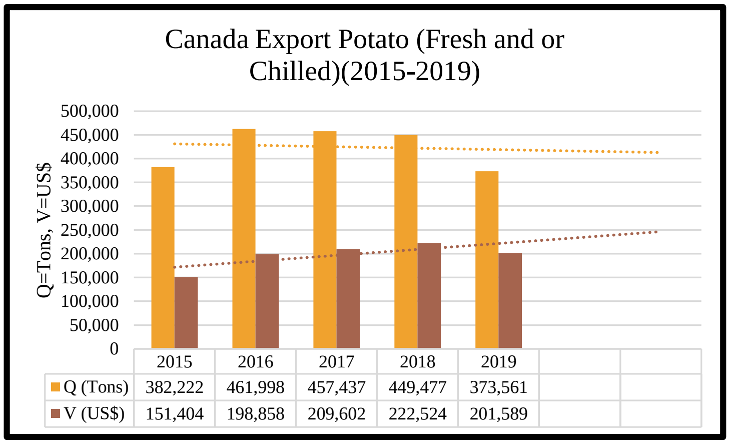
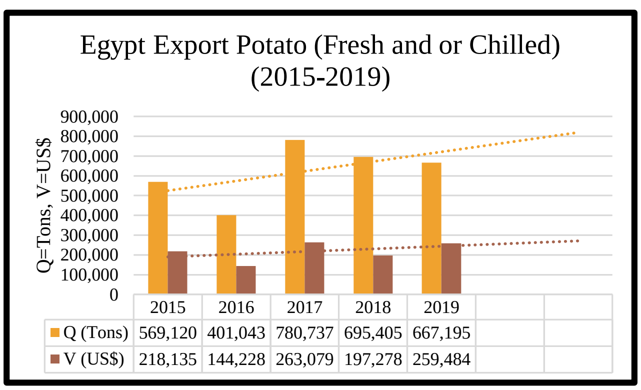


Figure 102 Canada Export Potato (Fresh and or Chilled) (2015-2019) Source; ITC

EGYPT

From 2015 to 2019, Egypt showed an increase of more than 17% in export quantity and more than 19% in export value. Annual growth rate for Egypt export was 7% with its 7% share in world fresh and or chilled potato export. Egypt exported potatoes with a unit value of US$389.

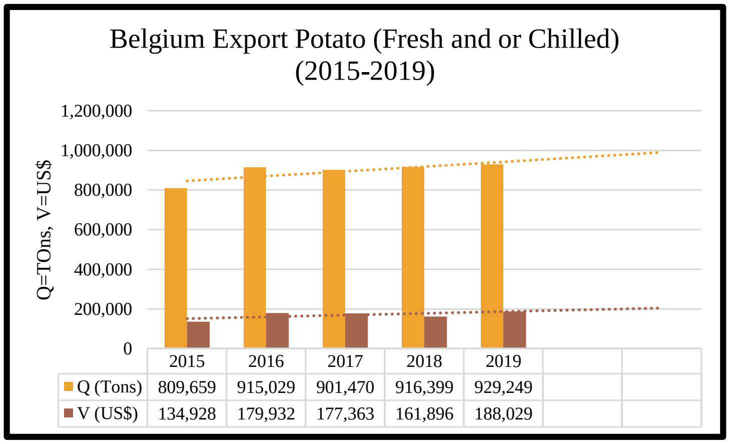
Figure 103 Egypt Export Potato (Fresh and or Chilled) (2015-2019) Source: ITC



BELGIUM

From 2015 to 2019, Belgium exported fresh and or chilled potatoes of an average quantity of 894 thousand tons at an average value of US$168 thousand. Belgium registered an annual growth of 6% with a unit value of USD202. Overall Belgium showed an increase of more than 14% in quantity and more than 39% in value.

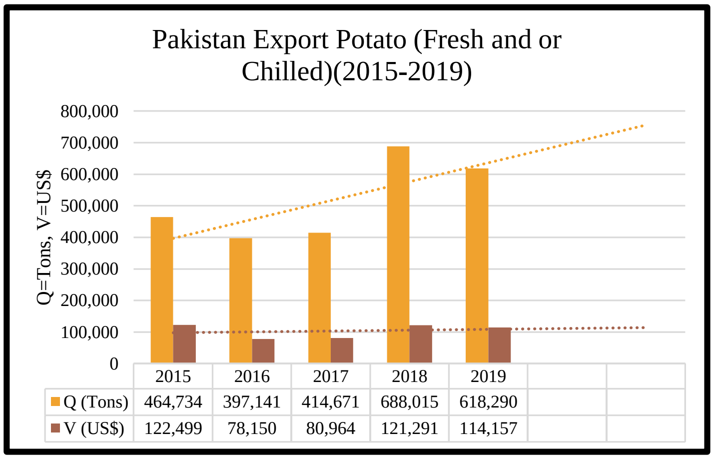
Figure 104 Belgium Export Potato (Fresh and or Chilled) (2015-2019) Source: [ITC]



PAKISTAN

From 2015 to 2019, Pakistan showed an increase of more than 33% in export quantity. Unfortunately, during the same period Pakistan has registered a decrease of more than 6% in value. Averagely, Pakistan exported around 516 thousand tons of fresh and or chilled potatoes for an average value of 103 thousand dollars. However, overall Pakistan registered an annual growth rate of 3% during the same period with a unit value of US$185. Pakistan has an export share of 3% in world potato fresh and or chilled potatoes.

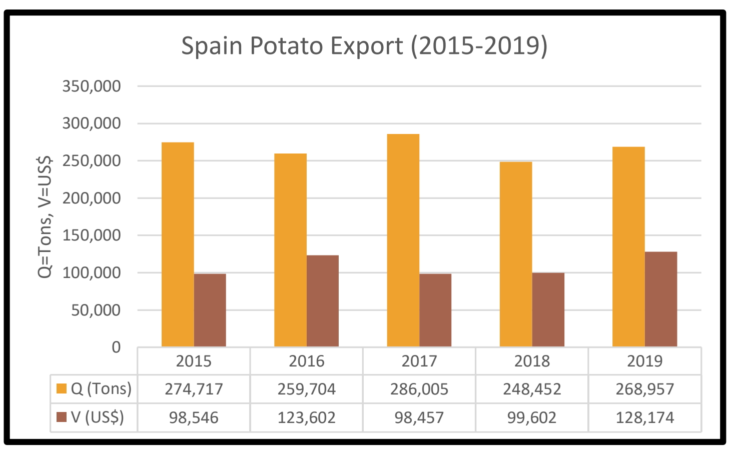
Figure 105 Pakistan Export Potato (Fresh and or Chilled) (2015-2019) Source: ITC



	2015	2016	2017	2018	2019
Q (Tons)	464,734	397,141	414,671	688,015	618,290
V (US$)	122,499	78,150	80,964	121,291	114,157

SPAIN

From 2015 to 2019, Spain showed an increase of more than 30% in value terms but a decrease of more than 2% in quantity. Overall, Spain registered an annual growth of 3% with a unit value of US$477. Spain also has a share of around 3% in potato world export.



	2015	2016	2017	2018	2019
Q (Tons)	274,717	259,704	286,005	248,452	268,957
V (US$)	98,546	123,602	98,457	99,602	128,174

Figure 106 Spain Export Potato (Fresh and or Chilled) (2015-2019) Source: ITC

UNITED KINGDOM

United Kingdom registered a growth of around 31% in quantity and more than 47% in value of export of fresh and or chilled potatoes from 2015 to 2019. Overall, the United Kingdom showed a growth rate of 8% per annum with unit rate of US$450.

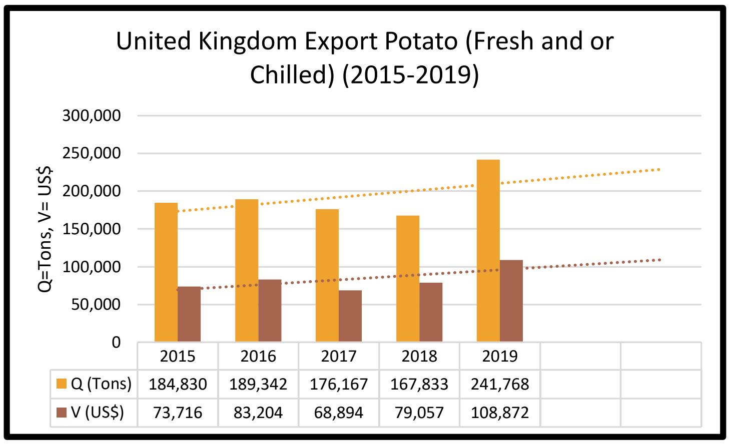


Figure 107 United Kingdom Export Potato (Fresh and or Chilled)(2015-2019) Source: ITC

A comment may be made on per unit price of exported potato from Pakistan in comparison with other countries particularly in our region or developing/under-developed countries.

GLOBAL IMPORTS: QUANTITY AND VALUE (TOP 10-20 IMPORTING COUNTRIES, THEIR SPS REQUIREMENTS, THEIR VARIETIES (IF AVAILABLE))

INTRODUCTION

SECTION 7: PAKISTAN'S TRADE OF PRODUCT

The export of potatoes from Pakistan has become a regular feature in Pakistan's foreign trade. Potato export from Pakistan has shown a consistent growth from around 0.34 million tons in 2015 to 0.66 million tons in 2018-19. The figure below illustrates the consistent growth in export of potatoes from Pakistan.

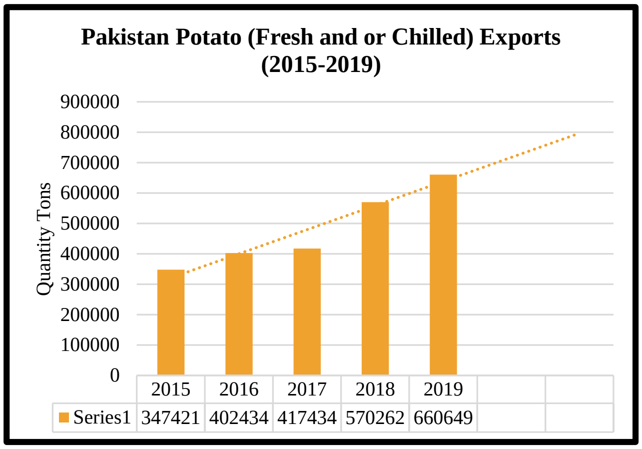


Figure 108 Pakistan Potato Export (2015-2019) Source: MNFSR Data

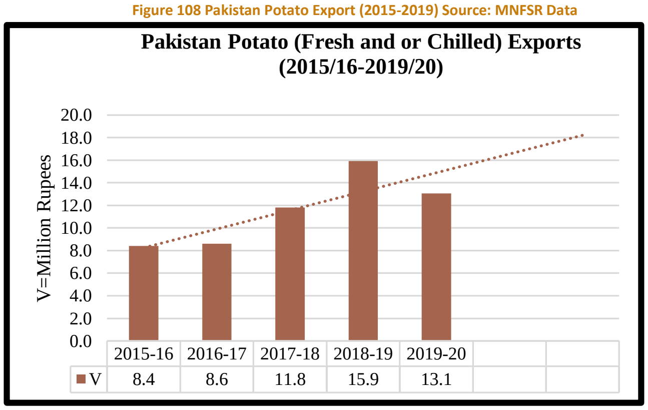


Figure 109 Pakistan Potato (Fresh and or Chilled) Exports

The major import partners for Pakistan are UAE, Afghanistan, Sri Lanka, Malaysia, Oman and Qatar. The export of potatoes fresh and or chilled from Pakistan during last five years is shown in the figures below;

Commented [SI8]: This is repetition of Fig 96 except with addition of one year

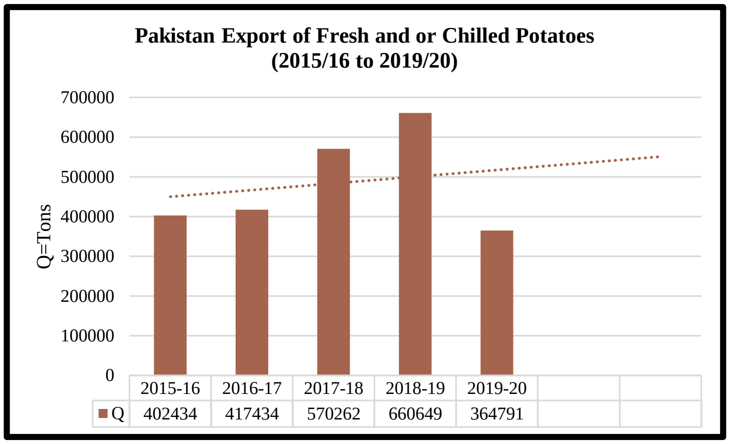


Figure 110 Pakistan Potato (Fresh and or Chilled) Exports

The data of export of fresh and or chilled potatoes from Pakistan shows different figures at national and international level. The logical reason for this discrepancy is division of year into fiscal year (from July to June) and calendar year (January to December) by national and international organizations respectively. However, fortunately both data sets provide insights into the commodity import export and other related issues. For the purpose of this report, hence the data is being used from ITC. It will also help readers out of Pakistan to understand the movement of commodity from Pakistan.

Export of Fresh or Chilled Potatoes by Pakistan (2010-2019)

Importers	2010		2011		2012		2013		2014		2015		2016		2017		2018		2019	
	Q(Tons)	V(th US$)	Q(Tons)	V(th US$)	Q(Tons)	V(th US$)	Q(Tons)	V(th US$)	Q(Tons)	V(th US$)	Q(Tons)	V(th US$)	Q(Tons)	V(th US$)	Q(Tons)	V(th US$)	Q(Tons)	V(th US$)	Q(Tons)	V(th US$)
World	215,436	47,878	443,046	102,111	300,049	83,463	487,682	130,263	153,663	51,196	464,734	122,499	397,141	78,150	414,671	80,964	688,015	121,291	618,290	114,157
Afghanistan	102,712	24,779	233,586	60,513	185,176	62,492	251,769	78,330	90,488	35,428	191,901	70,501	75,914	26,970	229,008	52,060	305,234	60,997	113,279	23,004
Sri Lanka	76,732	15,923	48,444	10,099	68,020	11,112	69,043	12,092	19,212	4,820	78,046	14,234	87,260	15,002	46,767	7,539	106,018	16,353	112,214	20,863
Malaysia	21,314	4,307	4,755	1,023	16,675	2,788	25,974	6,192	2,112	658	22,027	4,012	32,801	5,829	19,605	3,911	25,866	4,358	44,490	7,469
Iran, Islamic Republic of	10,572	1,977	756	92	52	8	72	13	48	21	-	-	-	-	-	-	-	-	-	-
Singapore	2,188	472	1,113	243	764	156	1,448	358	136	41	3,069	583	4,805	879	2,365	367	6,695	1,061	9,110	1,946
Russian Federation	1,000	231	116,960	23,705	19,869	4,940	47,727	16,139	2,065	776	48,984	13,031	6,241	1,369	3,034	812	18,236	3,454	35,126	6,845
United Arab Emirates	363	68	2,470	415	4,510	676	65,103	12,080	25,664	5,919	83,954	13,797	127,115	17,783	71,465	9,542	113,546	16,387	133,724	21,629
Thailand	204	44	28	6	-	-	-	-	-	-	30	6	-	-	-	-	55	8	-	-
Bahrain	195	43	57	10	367	50	5,959	1,248	1,527	417	7,820	1,482	11,355	2,007	6,821	1,020	13,370	1,935	15,198	2,682
China	56	12	-	-	61	13	-	-	51	28	-	-	-	-	-	-	-	-	-	-
Qatar	48	10	21	6	300	104	2,775	334	286	64	8,605	1,620	20,184	3,190	16,489	2,680	42,241	6,772	49,158	9,807
Maldives	20	3	-	-	7	3	57	8		-	197	36	283	40	33	3	262	4,373	969	7,697
Oman	16	3	77	12	140	17	13,693	2,653	5,447	1,339	12,468	1,909	18,965	3,189	11,928	1,825	27,272	44	40,440	208
United Kingdom	7	2	3	1	87	16	56	13	-	-	1	1	-	-	-	-	-	-	2	1
Australia	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26	5	-	-
Myanmar	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kuwait	-	-	168	24	132	26	2,910	525	5,508	1,246	7,198	1,171	9,485	1,341	2,485	341	8,942	1,655	16,123	3,407
Kazakhstan	-	-	4,642	740		-	20	3	204	73	-	-	-	-	80	39	1,999	383	13,166	1,998
Iraq	-	-	484	70	1,285	216	78	14	-	-	-	-	-	-	2,980	473	11,133	2,012	11,187	2,196
Turkey	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9,105	1,502
Q & V of Top 15 Importing Countries	215,437	47,876	413,564	96,959	297,445	82,617	486,684	130,002	152,748	50,830	464,300	122,383	394,408	77,599	413,060	80,612	680,895	119,797	603,291	111,254
% of total export (Q&V) to top 15 countries	100.00	100.00	93.35	94.95	99.13	98.99	99.80	99.80	99.40	99.29	99.91	99.91	99.31	99.29	99.61	99.57	98.97	98.77	97.57	97.46
Average quantity	412,183																			
Average value	91,993																			
CAGR(Quantity)	40%																			
CAGR(Value)	47%																			

The most interesting fact emerging from the analysis of the movement of commodity is that Pakistan has been exporting potatoes mostly to its region and during last five years Pakistan has added Kazakhstan, Iraq, Singapore, Turkey and Uzbekistan to its list of potato importers. On the other hand, more than 90% of Pakistan's fresh and or chilled potatoes is directed towards the below mentioned top 9 importing countries including Afghanistan, UAE, Russian Federation, Sri Lanka and Malaysia. By and large Pakistan's potato export is directed towards ME region with UAE being the largest importer followed by Qatar, Oman and Kuwait. The data shows that there are chances of increasing Pakistan's potato export to Singapore, Iraq, Kazakhstan and Uzbekistan. As a whole Pakistan has established import markets in the above mentioned countries which needs to be reinforced through marketing campaigns and trade delegation visits.

Pakistan' export to existing destinations is given in the table below;

#	Countries	2015		2016		2017		2018		2019	
		Tons	US$	Tons	US$	Tons	US$	Tons	US$	Tons	US$
	World	464,734	122,499	397,141	78,150	414,671	80,964	688,015	121,291	618,290	114,157
1	United Arab Emirates	83,954	13,797	127,115	17,783	71,465	9,542	113,546	16,387	133,724	21,629
2	Afghanistan	191,901	70,501	75,914	26,970	229,008	52,060	305,234	60,997	113,279	23,004
3	Sri Lanka	78,046	14,234	87,260	15,002	46,767	7,539	106,018	16,353	112,214	20,863
4	Qatar	8,605	1,620	20,184	3,190	16,489	2,680	42,241	6,772	49,158	9,807
5	Malaysia	22,027	4,012	32,801	5,829	19,605	3,911	25,866	4,358	44,490	7,469
6	Oman	12,468	1,909	18,965	3,189	11,928	1,825	27,272	4,373	40,440	7,697
7	Russian Federation	48,984	13,031	6,241	1,369	3,034	812	18,236	3,454	35,126	6,845
8	Kuwait	7,198	1,171	9,485	1,341	2,485	341	8,942	1,655	16,123	3,407
9	Bahrain	7,820	1,482	11,355	2,007	6,821	1,020	13,370	1,935	15,198	2,682
10	Kazakhstan	0	0	0	0	80	39	1,999	383	13,166	1,998
11	Iraq	0	0	0	0	2,980	473	11,133	2,012	11,187	2,196
12	Singapore	3,069	583	4,805	879	2,365	367	6,695	1,061	9,110	1,946
13	Turkey	0	0	0	0	0	0	0	0	9,105	1,502
14	Uzbekistan	0	20	0	32	320	46	1,230	1,071	4,406	884

Source: ITC

The picture of Pakistan's fresh and or chilled potatoes becomes clearer from the below chart which illustrates that more than 40% of Pakistan's potato export is directed towards Afghanistan now.

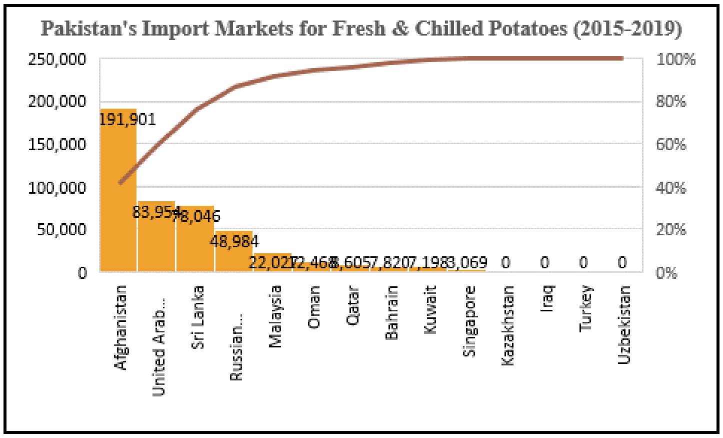
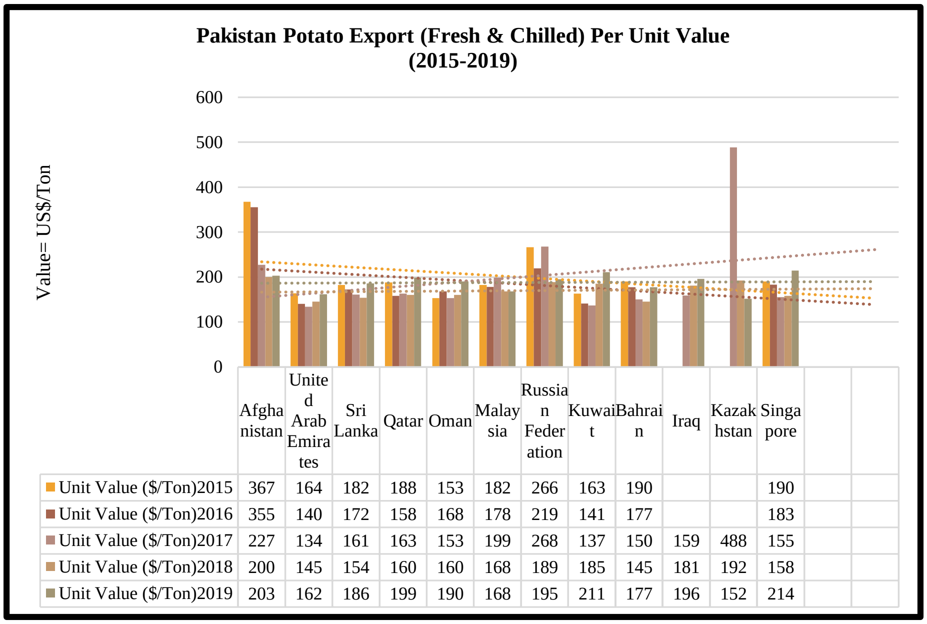


Figure 111 Pakistan's Import Markets for Potato (2015-2019)

As mentioned earlier, Pakistan's 90% potato export is directed to top five to six importing countries. The above figure indicates that Pakistan has yet to tap high-end markets for potato. There is however another interesting factor that emerges from analysis that out of these markets Pakistan started off with a very good per unit cost but gradually brought it down to a level of less than US$ 200 per ton from US$ in US$367. Furthermore, Pakistan is now exporting potatoes to almost all destinations at almost the same rate. This phenomenon needs further research as the mode of delivery and distance of these markets is different which should have been reflected in the per unit value.



	Afghanistan	United Arab Emirates	Sri Lanka	Qatar	Oman	Malaysia	Russian Federation	Kuwait	Bahrain	Iraq	Kazakhstan	Singapore
Unit Value ($/Ton)2015	367	164	182	188	153	182	266	163	190			190
Unit Value ($/Ton)2016	355	140	172	158	168	178	219	141	177			183
Unit Value ($/Ton)2017	227	134	161	163	153	199	268	137	150	159	488	155
Unit Value ($/Ton)2018	200	145	154	160	160	168	189	185	145	181	192	158
Unit Value ($/Ton)2019	203	162	186	199	190	168	195	211	177	196	152	214

Figure 112 Pakistan Potato Export (Fresh & Chilled) Per Unit Value Source: ITC

The above figure also illustrates that Pakistan has lost the per unit value in each captured market with the only exception of unit value in 2017 of US$227 that ended up at one time shift to US$488 for Kazakhstan. The possible reason for this could be the drought that hit the area in 2017-18.

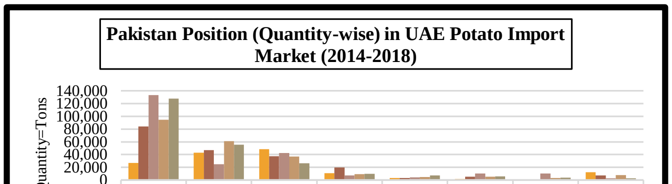
PAKISTAN POSITION IN EXISTING MARKETS

INTRODUCTION

Pakistan has been following export-led growth strategy for several years now. The strategy implies that Pakistan should export maximum number of products to maximum number of countries. Historically, Pakistan is not following its export-led strategy and its small range of products is concentrated towards a smaller number of countries. On the other hand, Pakistan's import range is expanding each year causing a huge trade deficit. The main reason for this trade discrepancy is tendency of Pakistan exports to its preferred trade partners with a selected range of commodities. The historical analysis of Pakistan's exports shows that for more than three decades now, Pakistan's more than 80% exports are concentrated to merely 25 countries.[300] This section will discuss Pakistan position vis-à-vis its competitors in potato import markets.

UNITED ARAB EMIRATES

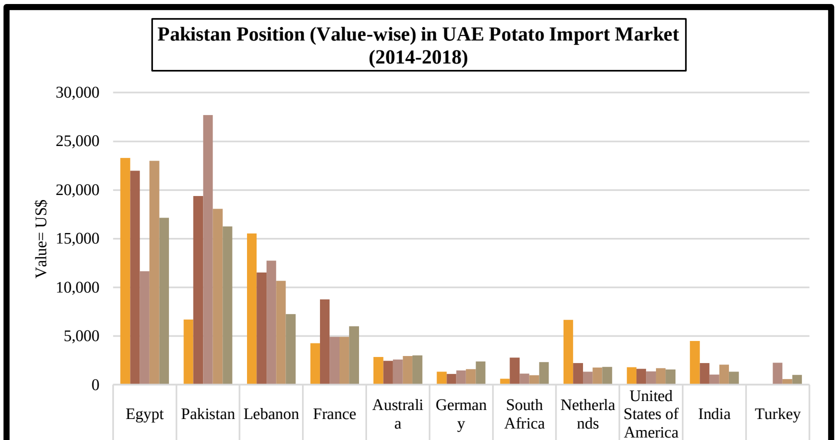
United Arab Emirates is one of the major importing partner country. Pakistan has been supplying potatoes to UAE market for a long time now. Quantity-wise, Pakistan is the largest trade partner of Pakistan for potatoes followed by Egypt, Lebanon and France from 2014 onwards. Pakistan's position vis-à-vis its competitors in UAE market is shown in the figure below;



	Pakistan	Egypt	Lebanon	France	Germany	Iran, Islamic Republic of	Turkey	India
2014	26,782	42,792	48,563	10,706	3,252	2,037		12,512
2015	84,075	47,246	37,398	19,925	3,272	5,315	113	7,216
2016	133,327	25,165	42,310	7,621	4,371	10,269	10,459	2,895
2017	94,828	61,207	37,015	9,224	5,006	5,320	3,132	7,855
2018	127,724	55,472	26,603	9,948	7,324	5,658	3,984	2,974

Figure 113 Pakistan Position (Quantity-wise) in UAE Potato Import Market (2014-2018); Source: ITC

As this research has established, Pakistan is losing its position to Egypt on value fronts. Lebanon and France are behind Pakistan but trends show that soon they will be able to equal Pakistan on value fronts. If Pakistan's position is analyzed both for quantity and value, Pakistan has a strong position in quantity but value-wise it has yielded to Egypt on value fronts as is shown in the figure below;

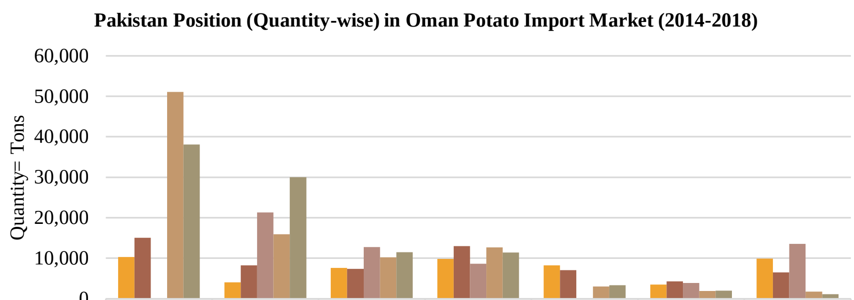


	Egypt	Pakistan	Lebanon	France	Australia	Germany	South Africa	Netherlands	United States of America	India	Turkey
2014	23,292	6,685	15,533	4,280	2,858	1,335	614	6,679	1,814	4,502	0
2015	21,966	19,385	11,541	8,778	2,471	1,097	2,794	2,217	1,626	2,227	56
2016	11,675	27,680	12,753	4,931	2,576	1,458	1,134	1,347	1,372	1,045	2,254
2017	23,000	18,075	10,663	4,925	2,949	1,617	985	1,761	1,687	2,063	575
2018	17,132	16,246	7,246	6,006	3,027	2,409	2,326	1,844	1,586	1,344	1,028

Figure 114 Pakistan Position (Value-wise) in UAE Potato Import Market; Source: ITC

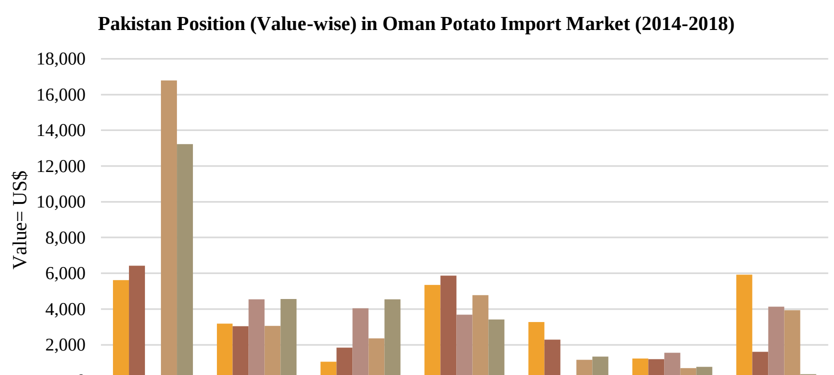
OMAN

Oman is another good importing destination for Pakistani potatoes where Pakistan enjoys 2nd position after United Arab Emirates. Pakistan's export of potatoes to Oman shows a growth trend in export of potatoes as is illustrated in the figure below. Pakistan is gradually gaining space in Oman market. In this market too Pakistan is losing at value fronts to India. While quantity-wise Pakistan potato exports to Oman are well placed after UAE, but ironically, India is earning more foreign exchange than Pakistan by exporting almost half the quantity of Pakistan's potato exports. Egypt as competitor both to Pakistan and India is posing threat to both countries not only on value but also quantity fronts. Pakistan needs to revisit its potato value chain to Oman to capture more market share before it goes to India and Egypt.



	United Arab Emirates	Pakistan	India	Egypt	Belgium	Germany	Lebanon
2014	10,337	4,074	7,626	9,861	8,214	3,508	9,871
2,015	15,040	8,229	7,382	12,988	7,080	4,296	6,498
2016		21,291	12,729	8,646		3,909	13,564
2017	51,099	15,941	10,193	12,646	3,031	1,920	1,791
2018	38,112	30,038	11,512	11,414	3,322	2,002	1,148

Figure 115 Pakistan Position (Quantity-wise) in Oman Potato Import Market (2014-2018); Source: ITC

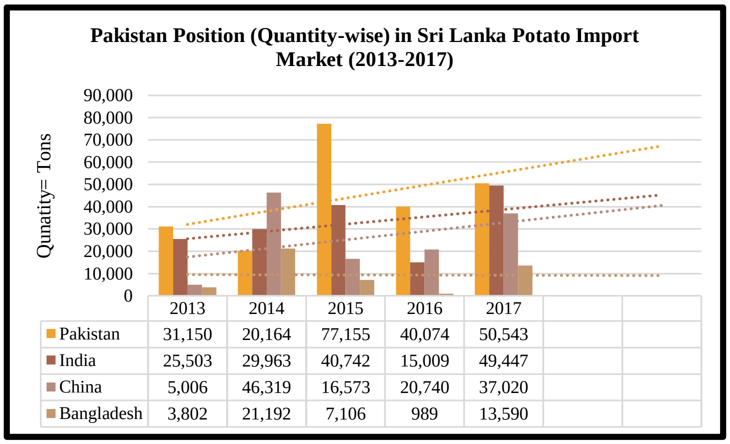


	United Arab Emirates	India	Pakistan	Egypt	Belgium	Germany	Lebanon
2014	5,619	3,192	1,047	5,346	3,279	1,232	5,928
2015	6,420	3,044	1,833	5,866	2,281	1,189	1,612
2016	0	4,543	4,041	3,693	0	1,546	4,125
2017	16,783	3,063	2,353	4,777	1,155	697	3,932
2018	13,233	4,567	4,542	3,409	1,332	773	349

Figure 116 Pakistan Position (Quantity-wise) in Oman Potato Import Market (2014-2018) Source: ITC

SRI LANKA

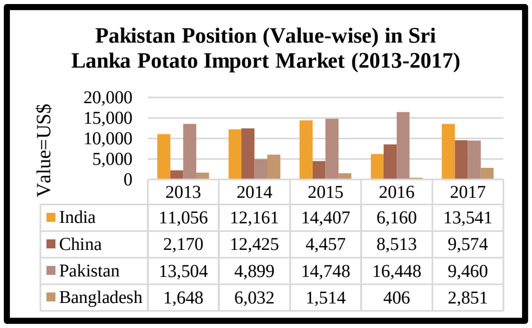
Export of potatoes to Sri Lanka is being carried out under Pak-Sri Lankan Free Trade Agreement, wherein Sri Lanka has granted Pakistan a quota limit of 1000 metric tons of duty-free potato during each calendar year but it is applicable only during Sri Lanka's off-season. As per FTA, Pakistan can export 2/3 of quota during June and July and rest of the 1/3 during October and November each year.[301] Pakistan needs to keep its position in this market and try to utilize as much as of the quota provided. On the other hand, Pakistan should try to win more quota or even duty free status for export of potatoes to Sri Lanka.



	2013	2014	2015	2016	2017
Pakistan	31,150	20,164	77,155	40,074	50,543
India	25,503	29,963	40,742	15,009	49,447
China	5,006	46,319	16,573	20,740	37,020
Bangladesh	3,802	21,192	7,106	989	13,590

Figure 117 Pakistan Position (Quantity-wise) in Sri Lanka Potato Import Market (2013-2017) Source: ITC

Value-wise, Pakistan has already lost its position to China and India. The analysis shows that Pakistan is exporting potato to Sri Lankan market at much less price than its competitors. This shows that exporting community in Pakistan is not realizing the true potential of the market.

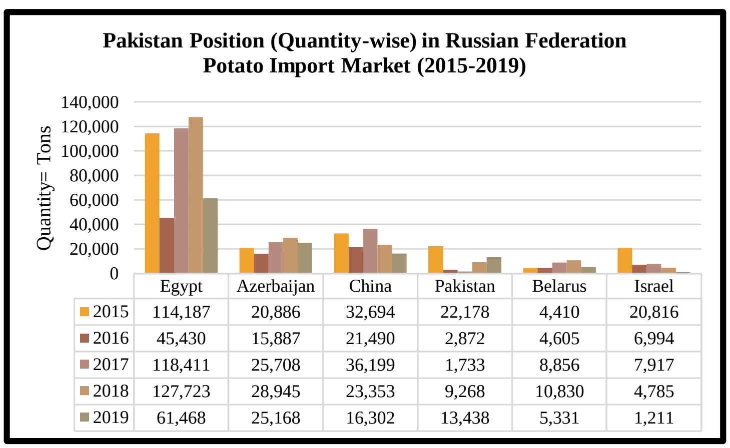


	2013	2014	2015	2016	2017
India	11,056	12,161	14,407	6,160	13,541
China	2,170	12,425	4,457	8,513	9,574
Pakistan	13,504	4,899	14,748	16,448	9,460
Bangladesh	1,648	6,032	1,514	406	2,851

Figure 118 Pakistan Position (Value-wise) in Sri Lanka Potato Import Market (2013-2017) Source: ITC

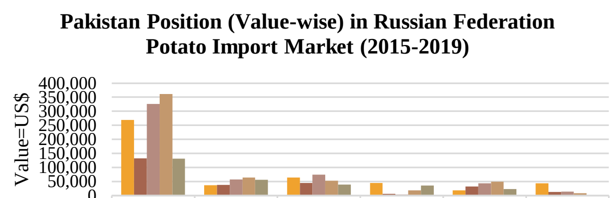
RUSSIAN FEDERATION

According to Russian Federation Customs figures, Pakistan's export to Russian Federation was around $313 million in 2018. Pakistan's export during 2109 was expected to be increased by 20% showing that Pakistan's trade with Russian Federation is rising consistently. Potato and kinnow are considered one of the major fruits and vegetables exported to Russian Federation.[302] The statistics from ITC however show that Pakistan has yet to realize its potential in Russian market with respect to export of potatoes. While in Pakistan everybody talks about exporting potatoes to Russia the figure below shows that we are far behind Egypt (one of our competitors in regional markets too), China and Azerbaijan are far ahead of Pakistan in export of potatoes. The same is the case at value-fronts.



	Egypt	Azerbaijan	China	Pakistan	Belarus	Israel
2015	114,187	20,886	32,694	22,178	4,410	20,816
2016	45,430	15,887	21,490	2,872	4,605	6,994
2017	118,411	25,708	36,199	1,733	8,856	7,917
2018	127,723	28,945	23,353	9,268	10,830	4,785
2019	61,468	25,168	16,302	13,438	5,331	1,211

Figure 119 Pakistan Position (Quantity-wise) in Russian Federation Potato Import Market (2015-2019) Source: ITC

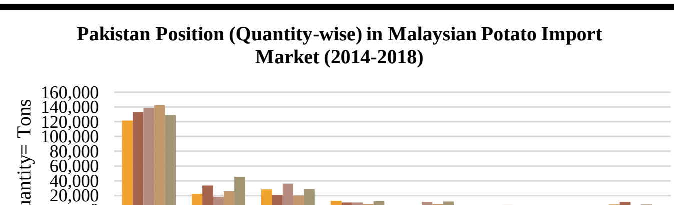


	Egypt	Azerbaijan	China	Pakistan	Belarus	Israel
2015	269,002	36,598	64,426	44,235	18,761	43,169
2016	132,989	37,818	44,344	6,212	32,503	12,581
2017	326,064	57,135	74,316	3,735	44,115	13,618
2018	361,400	64,466	53,077	18,359	48,859	8,017
2019	131,591	55,847	38,884	35,272	23,340	1,943

Figure 120 Pakistan Position (Value-wise) in Russian Federation Potato Import Market (2015-2019) Source: ITC

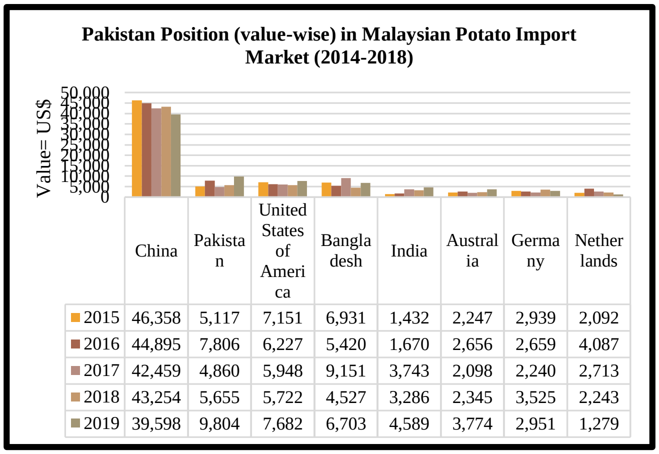
MALAYSIA

Pakistan and Malaysia entered into Free Trade Agreement (FTA) in 2007. At that time, it was the first bilateral FTA between two Muslim countries. It was Malaysia's first agreement in Southeast Asian region. Under this agreement, Pakistan was able to export potatoes to Malaysia with zero duty. Since then Pakistan's export of potatoes to Malaysia is showing a fluctuated but growing trend, as is shown in the figure below;



	China	Pakistan	Bangladesh	United States of America	India	Germany	Australia	Netherlands
2015	121,785	22,090	28,150	12,496	3,795	7,175	2,706	7,750
2016	133,462	33,442	20,655	10,412	4,446	6,856	3,412	11,275
2017	139,135	18,414	36,012	10,406	11,207	5,777	2,168	6,316
2018	142,372	25,516	19,830	8,765	8,584	7,627	2,612	7,713
2019	129,243	45,375	28,654	12,436	11,919	7,000	5,309	3,911

Figure 121 Pakistan Position (Quantity-wise) in Malaysian Potato Import Market (2014-2018) Source: ITC



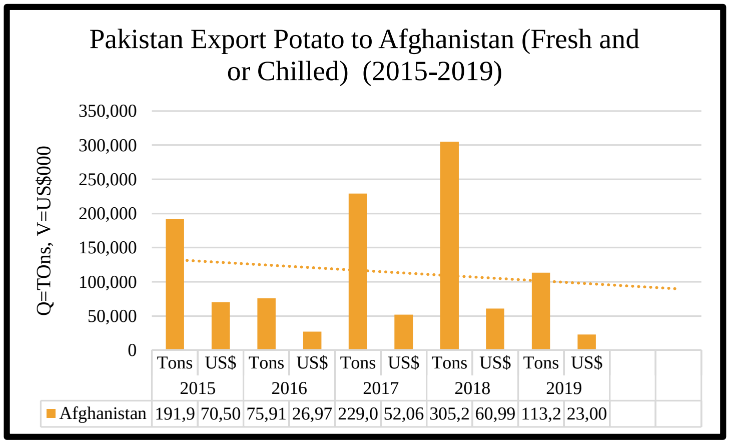
	China	Pakistan	United States of America	Bangladesh	India	Australia	Germany	Netherlands
2015	46,358	5,117	7,151	6,931	1,432	2,247	2,939	2,092
2016	44,895	7,806	6,227	5,420	1,670	2,656	2,659	4,087
2017	42,459	4,860	5,948	9,151	3,743	2,098	2,240	2,713
2018	43,254	5,655	5,722	4,527	3,286	2,345	3,525	2,243
2019	39,598	9,804	7,682	6,703	4,589	3,774	2,951	1,279

Figure 122 Pakistan Position (Quantity-wise) in Malaysian Potato Import Market (2014-2018) Source: ITC

Thanks to duty free status, Pakistan has not given up its value-wise position.

AFGHANISTAN

Pakistan has no competitors in Afghanistan market. Yet Pakistan's export of fresh and or chilled potatoes is showing a decreasing trend. This could be due to law and order situation. With no competitors and the highest unit value price in comparison to other markets, Afghanistan can prove the largest market for export of potatoes from Pakistan.



	Tons	US$	Tons	US$	Tons	US$	Tons	US$	Tons	US$
	2015		2016		2017		2018		2019	
Afghanistan	191,9	70,50	75,91	26,97	229,0	52,06	305,2	60,99	113,2	23,00

Figure 123 Pakistan Export of Potatoes (Fresh and or Chilled) to Afghanistan (2015-2019) Source: ITC

NATIONAL TARIFF LINES

INTRODUCTION

The tariff lines are the codes under use of a country at national level. These codes extend beyond the 6 digit Harmonized System (HS). National tariff lines are different from one country to another.[303] The national tariff lines are introduced to make the classification of the products more specific and it is commonly referred as the national tariff line level.[304]

Pakistan exports potatoes under different tariff lines specific for each product raw or processed originated from potato. A summary of national tariff lines used for export of product potato other than fresh or chilled is given below;

- 070110-00 POTATO SEEDS
- 071010-00 POTATO, FROZEN
- 110510-00 FLOUR, MEAL&POWDER OF POTATOES
- 200410-00 POTATO, PREP/PRSV, O/TH VINGERS
- 200520-00 POTATO PREP O/TH VING NOT FROZ

070110-00 POTATO SEEDS

Under the above tariff line Pakistan exports seed potatoes. Pakistan's export of seed potato remained meagre in numbers as is shown in the table below;

Table 17 Pakistan Potato Seed Export (2016-2019)

	2016		2017		2018		2019	
	Quantity (Tons)	Value (US$000)	Quantity (Tons)	Value (US$000)	Quantity (Tons)	Value (US$000)	Quantity (Tons)	Value (US$000)
World	82	37	262	133	748	347	6,235	1,472
United Arab Emirates	48	24	51	22	132	58	2,311	473
Oman	0	0	1	1		0	1,397	248
Sri Lanka	0	0	0	0	0	0	755	146
Afghanistan	0	0	114	43	0	0	388	116
Sudan	0	0	0	0	0	0	384	204
Qatar	34	13	0	0	0	0	293	55

Saudi Arabia	0	0	0	0	41	0	221	96
Source: ITC								

071010-00 POTATO, FROZEN

The data from Pakistan Bureau of Statistics show that Pakistan has entered into the export of frozen potato. In Pakistan export it is comparatively recent phenomenon. The figures below show that Pakistan again is concentrating into its traditional markets. Most of the markets are same as of fresh and or chilled potato export from Pakistan. Another factor emerging from the below table is that Pakistan is fetching more value from its frozen potato export. The average export for the mentioned year was more than 51 thousand tons with an average value of around 2 billion rupees.

Table 18 Pakistan Export of Potatoes (Frozen) (2018/19-2019/20)

	2018-19		**2019-20**	
	Q (Tons)	V (Mil Rs)	Q (Tons)	V (Mil Rs)
Afghanistan	46827	1732	41226	1661
Bahrain	517	10	787	24
Jordan	29	1	0	0
Kazakhstan	968	22	517	13
Kuwait	86	2	524	17
Malaysia	240	6	438	20
Maldives	146	3	116	4
Oman	2946	52	3224	95
Qatar	2058	39	2774	89
Total	**53815**	**1866**	**49605**	**1924**
Source: **FBS**				

110510-00 FLOUR, MEAL&POWDER OF POTATOES

The statistics from PBS show that Pakistan has started exporting potato flour, meal and powder from this year. The good news about this development is that Pakistan has included high-end market of Canada in its list of importers as is shown in the table below;

Table 19 Pakistan Export of Potato Flour, Meal & powder (2019-20)

	2019-20	
	Q(Tons)	V(Mil Rs)
Canada	8.1	0.578
Qatar	3.00	0.142
United Arab Emirates	698.4	35.56
Source: **FBS**		

The above table shows the importance of value addition in potato sector. Pakistan is fetching more than 35 million rupees for exporting only 709 tons of the value-added product.

200410-00 POTATO, PREP/PRSV, O/TH VINGERS

The table below shows that potential of export in the subject product tariff line. However, the factor of market diversification is missing and Pakistan again is concentrating towards its traditional markets.

Table 20 Export of Potato Pakistan (Prep/Presv, o/th Vinegar) (2018-2019)

	2018-19		2019-20	
	Q(Tons)	V(Mil Rs)	Q(Tons)	V(Mil Rs)
Afghanistan	37.643	11.506	0	0
Australia	0.072	0.023	0	0
Canada	0.485	0.072	0	0
Malawi	0	0	0.055	0.016
Qatar	4.117	1.235	0	0
United Arab Emirates	7.775	1.922	2.9	0.79
Total	**50.092**	**14.758**	**2.955**	**0.806**
Source: **FBS**				

200520-00 POTATO PREP O/TH VING NOT FROZ

Under the subject tariff line, Pakistan is exporting value-added products of potatoes. As per European Customs portal, this tariff line may include thin slices of potato, cooked in oil or fat, whether salted or not packed in airtight packaging suitable for immediate direct consumption but not frozen.[305]

Table 21 Pakistan Potato Export (Prep o/th Ving not Frozen) (2018/19-2019/20

	2019-20		2018-19	
	Q(Tons)	V(Mil Rs)	Q(Tons)	V(Mil Rs)
Afghanistan	389	148	630	202
Australia	30	20	43	15
Bahrain	6	3	10	4
Canada	18	11	21	9
Malaysia	36	23	37	17
Philippine	22	12	0	0
Qatar	509	327	2	1
Source: FBS				

EXPORTS AS A PERCENTAGE OF TOTAL PRODUCTION

Pakistan's production of potato has been showing an inconsistent growth trend for past five years, but its export of potato is showing a consistent growth. The export from Pakistan of fresh and chilled potatoes is showing a growth 3.73% as is shown in the table below;

Table 22 Pakistan Export as Percentage of Total Production

Potato	2015		2016		2017		2018	
	Production (Tons)	Export (Tons)	Production (Tons)	Export (Tons)	Production (Tons)	Export (Tons)	Production (Tons)	Export (Tons)
	3998000	347421	3978000	402424	3853000	417434	4592000	570262
Export as %age of Production	8.69		10.12		10.83		12.42	
Average	10.51%							
Source: ITC								

PAKISTAN'S IMPORT OF HORTICULTURE PRODUCT (QUANTITY AND VALUE IMPORTED IN THE LAST 05YEARS) TO DETERMINE WHETHER PAKISTAN IS NET IMPORTER OR EXPORTER.

The data below establishes that for last 5 years, Pakistan is a net exporter of fresh and chilled potatoes but a net importer of seed potatoes. The import of potatoes (fresh & Chilled) and seed potatoes is given in the table below;

Table 23 Pakistan Import of Fresh and Seed Potatoes (2015-2019)

Commodity	2015		2016		2017		2018		2019	
	Q (Tons)	V (US$000)	Q (Tons)	V (US$000)	Q (Tons)	V (US$000)	Q (Tons)	V (US$000)	Q (Tons)	V (US$000)
Fresh & Chilled Potatoes	2,297	722	356	64	133	23	206	39	132	23
Seed Potatoes	4,602	3,084	7,138	4,903	7,812	5,847	5,183	4,418	5,809	4,622
Source: ITC										

LOCAL EXPORTERS (FIRMS/COMPANIES/INDIVIDUALS WITH THEIR RESPECTIVE BUSINESSES AND CONTACT DETAILS)

As already mentioned in this report, export of goods from Pakistan including fresh produce is covered under chapter 12 of Foreign Policy Manual by State Bank of Pakistan (SBP). According to this manual registration of exporters is not required. Major exporters of fresh fruits and vegetables have registered themselves with the All Pakistan Fruits and Vegetable Exporters, Importers and Merchants (PFVA). It is a trade association of more than 200 members from all over the country. Established in 1986, the trade body is registered with D.G.T.O and Securities and Exchange Commission of Pakistan SECP) as a not-for-profit body. The association collects and disseminate information among its members on regular basis and reports the issues related to the export and import of fresh fruits and vegetables to the Government of Pakistan. The association has its head office in Karachi and zonal office in Sargodha (Bhalwal).[306] The list reproduced here is derived from PFVA website. The data given is reproduced with honesty and author does not take any responsibility of the business practices of any exporter mentioned in the list. The list of exporting firms/companies and individuals along with their business and contact details is attached as Annex-V.

LOCAL PRODUCT IMPORTERS (FIRMS/COMPANIES/INDIVIDUALS WITH THEIR RESPECTIVE BUSINESSES AND CONTACT DETAILS)

Seed is one of the major determinants of the potato productivity. Recently, Pakistan has reduced its import of seed potatoes by 50% as a result of strong public-private partnership for production of locally-certified potatoes with the help of planning and technical assistance of National Agriculture Research Centre, Islamabad. Growers in Pakistan are getting a yield of 20 tonnes per hectare even from the informal seed system.[307]

Keeping in view the food security and reducing the input costs for Pakistani growers and for establishing the seed industry in Pakistan, the Dutch seed sector is encouraging Pakistani companies for multiplication of Dutch potato seed. Pakistani growers have decade-old business relations with Dutch potato seed sector.[308] Eventually, out of 20 well-known varieties being cultivated in Pakistan, more than a dozen is from the Netherlands.

In 2019, the Variety Evaluation Committee (VEC) of Pakistan Agriculture Research Council (PARC) recommended eleven (11) out of twenty-four (24) new varieties to be cultivated commercially in Pakistan. Four (04) of these recommended varieties were from HZPC namely; Allison (white), Hermes, Alverstone Russet (white) and Sababa.[309]

Table 25 Elverstone Russet Courtesy; PotatoPro

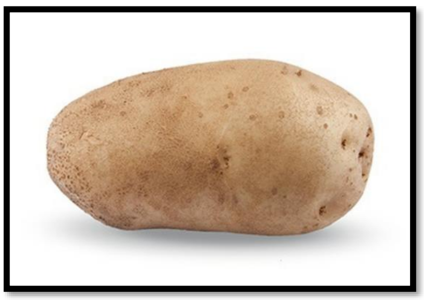
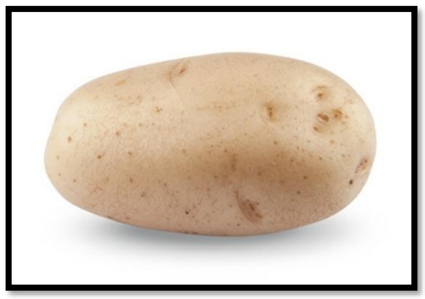


Table 24 Allison Courtesy; PotatoPro



There are several companies in Pakistan that are involved in import of potato seed. A brief overview of a few such companies is give here.

HUNZA SEEDS

Based in Islamabad, Hunza Seeds is an importing company of Dutch potatoes associated with Stet Holland for importation of all approved varieties of Stet Holland for fresh and processed potato varieties. Further details about the company can be found here.

RAFIQ AGRICO

Rafiq Agrico is based in Sahiwal, the most prominent area of potato production. The company imports basic and certified seeds from Holland. Rafiq Agrico are associated with HZPC and AGRICO Holland. Further details about the company can be found here.

INTERNATIONAL MARKET PREFERENCES (PRODUCT SPECIFICATIONS AND TASTE PREFERENCE) AND TASTE LIKING FOR PAKISTANI PRODUCE (FROM MISSIONS)

EXPORT PROCEDURES (SPS REQUIREMENTS, CUSTOMS REQUIREMENTS, PROCESSING/PACKAGING REQUIREMENTS AND DOCUMENTATION REQUIREMENTS ETC.)

The export from Pakistan initiated under Government of Pakistan Notification Nos. I (6)-ECS/48 and I (7) ECS/48 dated July 1st, 1948 and further chapter 12 of the Foreign Exchange Regulation Manual by the Federal Board of Revenue emphasizing the need of using the Incoterms by ICC for exports of goods from Pakistan. The Export Trade Control Regulations cover the exports of goods from Pakistan laying down policies from time to time. Under these regulations Pakistanis are not allowed to export to Israel. Under the same rules the registration of exporters is no more required vide S.R.O. No. 490(1)/2002 dated 5th August, 2002 by the Ministry of Commerce, Government of Pakistan repealing the Registration Order 1993 (imports and exports). After this the exporters are no more required to register themselves with the Trade Development Authority of Pakistan (TDAP). In the absence of registration number, the exporters and or their authorized dealers can use GIR No or NTN number and or CNIC numbers for administration of Form 'E'. In case of non-tax payer exporter, the administration of Form 'E' will be carried out according to Income Tax Circle No as provided in the Form 'E'.[310,311] Currently, the export of goods from Pakistan is governed by Export Policy Order 2016 with certain amendments.[312]

As mentioned earlier no export license is required to export goods from Pakistan. Initially the following documents are required to begin the export of goods from Pakistan;

- National Tax Number (NTN): This number is issued by the Income Tax Department on filing of an application with attested copy of individual's CNIC.
- Sales Tax Registration (STR): Though commercial exporters are not required to register them in the Sales Tax Department, it is in the best interest of the commercial exporters to register themselves in Sales Tax Department so that they can claim back the taxes paid on their inputs. However, it should be kept in mind that you must submit your monthly sales tax return whether you did any sales tax transaction or not.
- Bank Account: A current bank account in a commercial bank is required for export proceedings and documentation.
- Membership of Chamber of Commerce and Industry: The exporting entity needs to register with relevant chamber of commerce and industry or any other relevant trade association.

Though this is not a mandatory clause, the exporters should have such memberships for their own benefit.

For export documentation, the exporter needs to hire the services of a clearing and forwarding agent. For clearance of export shipment from exit point, the following documents are needed to be provided to the clearing agent;

- Packaging list
- Commercial invoice
- Letter of Credit (L/C) (not in the case of perishable goods)
- Certificate of origin which is normally issued by the relevant chamber of commerce and industry. In case of fruits and vegetables, the phyto-sanitary certificate issued by the Department of Plant Protection (DPP) has the clause of product origin in the certificate.
- National Tax Number certificate
- Form ‘E’

The export of potatoes from Pakistan is carried out through letter of credit owing to its not so perishable nature.

INTERNATIONAL CERTIFICATIONS – MARKET SPECIFIC WHERE AVAILABLE

Socio-economic and environmental sustainability is the priority agenda both of the consumers and retailers in bid to assure the transparency of the production practices for food and health safety. This transparency is not limited only to food and health safety standards but also social standards. Retailers now a days are asking for more than one standard. Today, the growers and exporters are asked to comply with different standards by different buyers along with specific brand/store related requirements though even today most of the data demanded is paper-based. Today, entrepreneurs are serving more time in filling in such data as the governments, certifying bodies, clients and even banks are asking for more insight into the production and export system to ascertain the safety and sustainability of the food. Interestingly, in several instances, these certifications and standards ask for the same piece of evidence.[313] There is a long list of voluntary standards that are being demanded by retailers and consumers including ISO certifications, food safety certifications, product certifications, social certifications and security certifications.[314] For potato production and export the most related international standards are GLOBAL G.A.P. Fruits and Vegetable Standard and IFS.

The GLOBAL G.A.P. standard was initiated by the retailers from the Euro-Retailer Produce Working Group. It is one of the world's leading farm assurance programs that translates the consumer requirements into Good Agriculture Practice (GAP).[313] The standard covers fresh fruits and vegetables along with propagation material, integrated farm assurance (dairy, poultry, livestock etc.), aquaculture, tea, coffee and flowers, ornamentals.

The GLOBAL G.A.P. Fruits and Vegetable Standard encompasses all stages of production including pre and post-harvest activities including handling, packaging and storing. The standard has been successfully assessed against the GFSI Benchmarking Requirements and has the GFSI recognition; farming of plants and pre-processing handling of plant products.[315]

INCENTIVES GIVEN FOR PRODUCTION/EXPORTS

Agriculture incentives are the government support provided to agribusinesses, farmers, agriculture organizations for supplementing their income, better management of supply chain of agriculture commodities and for influencing the supply and cost of these commodities in domestic as well as international markets. The major purpose of such subsidies was stabilizing market and help the farmers in rural development. Beginning from Agriculture Adjustment Act (AAA) in USA to the European Common Agriculture Policy (CAP), the incentives on agriculture commodities were regulating the supply and demand of agriculture products in the society. Even the European Commission promotes the government incentives for farmers by adding in the act that EU ensure that its farmers have a reasonable living, keeping the rural economy alive and promoting jobs in agriculture, agribusiness and other related sectors.

Despite World Trade Organization (WTO) observations on agriculture incentives[316], the world has been involved in providing agriculture incentives The latest example of such incentives is the Coronavirus Food Assistance Program (CFAP) by USDA through which the government is going to provide assistance to farmers of different crops including potatoes in bid to reduce the losses incurred by these farmers due to Corona Virus pandemic.[317] In 2010, EU disbursed €57 billion for agriculture development and out of this amount €39 billion were given in direct support to the farmers and other stakeholders. Recently, EU has decoupled its agriculture incentive from production side but until now EU provides subsidy under Single Farm Payment initiative.[318]

ISSUES AND PROPOSED SOLUTIONS

The major issues related to Pakistan's trade of potato are narrow export market, narrow varietal options, lack of marketing infrastructure, inadequate storage facilities, inadequacy of transportation infrastructure and capacity building of all stakeholders in the supply chain.

Pakistan needs to expand the range of its exporting markets. Currently, Pakistan is exporting potatoes only to four to five export markets. There is need to analyze other markets for export with the help of trade and investment officers in Pakistan embassies in different potential markets. The world has been following establishing marketing infrastructure in different existing and potential markets, Pakistan still lacks on this front. Pakistan needs to engage marketing companies in existing and potential markets for better marketing of its product. The potato growing areas in Pakistan lack proper cold storage facilities to keep the product fresh and in exportable condition.

The post-harvest losses in Pakistan's supply chain shows that Pakistan needs to work on transportation of potato product from field to storage facilities and markets.

Majority of stakeholders in potato supply chain especially farmers lack the production technology knowledge and follow the traditional methods of production.

The middlemen and contractor also need to understand that harvested potato is a living entity and should be handled with care. In this regard, people working in fruits and vegetable markets should be educated for product handling as in most of the markets the sacks are thrown from the top of the vehicle on the ground damaging the product. The people handling storage facilities should be aware of the required parameters for storage of potatoes especially in the hot summer days in Pakistan.

SECTION 8: MARKETING FOR MORE

INTRODUCTION

Around 2% to 3% of the world potato production is traded internationally and more than 80% of this trade is from and to the developed countries. Though the developing world including Pakistan contributes around 50% of the world production their export is not more than 17% of fresh and processed potatoes together.[319] There are several constraints involved in export of potatoes from developing world including Pakistan. The detailed surveys of the potential export markets along with infrastructure development at national level for exports including cold storages, transportation, shipping facilities are needed. These factors are essential components for developing a successful export regime in the county. There is a need to develop a database for exporters on potato export including prices in the export market, grades and standards, phyto-sanitary certifications, processing standards, seed standards and consumer preferences to be readily consulted by exporters.[319]

Ironically, the countries in Europe have only one potato season during their summer season whereas countries like Pakistan produce potatoes throughout the year but their export performance does not correspond with their production. Several factors contribute towards this poor trade performance including lack of proper marketing, trade barriers, insufficient seed systems, and inadequate market intelligence. Like other countries in the region, Pakistan imports potato seed mainly from the Netherlands. Though these seeds are doing well in Pakistan they are not developed according to climatic conditions in Pakistan. Another constraint is government policies regarding food items including potatoes where the governments find it hard to target a certain commodity for exports. Nevertheless, Pakistan's potato export has kept it in top 10 exporting countries despite the fact that Pakistan's export is concentrated to certain traditional markets. Pakistan's trade potential largely lies in six regions namely; South Asia, Middle East, ASEAN, East Europe, Central Asia and EU & West Europe and others.

The export potential for fresh potatoes from Pakistan to different markets is summarized below. For further understanding of the export potential in existing and future markets, the regulatory requirements, tariff regimes and other requirements are also included.

The chart below shows the top 25 potential markets (rank-wise) for export of potatoes from Pakistan including existing and new/potential markets.

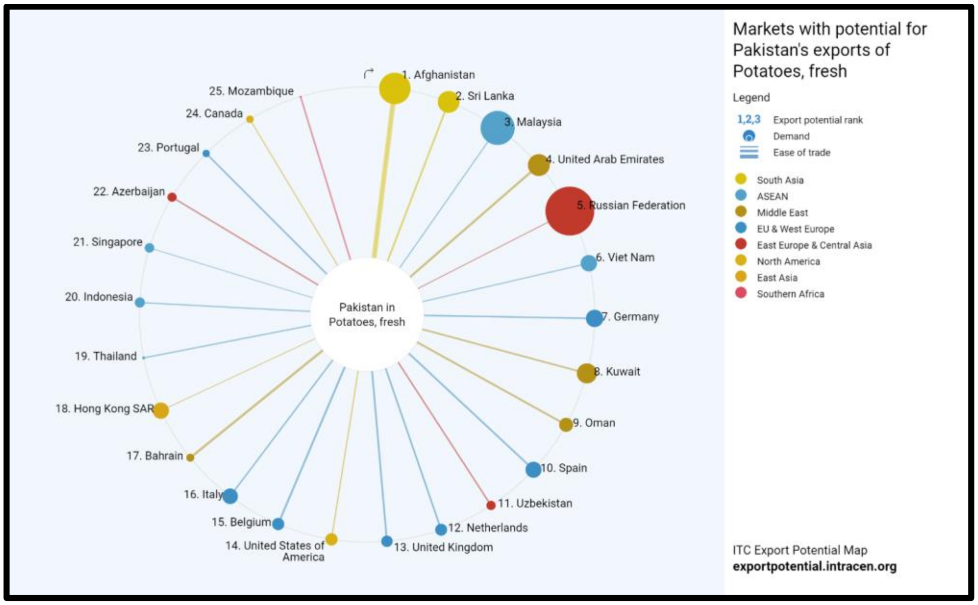


Figure 124 Top 25 Markets with Potential for Export of Potatoes (Fresh) for Pakistan; Source: ITC

A list of comparison of applicable tariffs throughout the world on export of fresh potatoes from Pakistan is attached to this report as Annex-VI.

EXISTING MARKETS

Pakistan has six major existing markets, Afghanistan, UAE, Oman, Sri Lanka, Russian Federation and Malaysia. Pakistan's 99% export of potato is directed to these markets. Pakistan has untapped export potential in its traditional markets, whereas Pakistan has the potential to add new markets into its potato export list. Pakistan has the largest export potential in Afghanistan, Sri Lanka and Malaysia.[320]

AFGHANISTAN

For Pakistan, Afghanistan has the largest absolute difference between actual exports and potential exports in value terms. There is room for realizing the untapped potential of $33 million in this market.

Pakistan's actual export of potato to Afghanistan is US$ 51.4 million with an export potential of US$84.4 million leaving untapped potential of US$33.5 million. Afghanistan imports fresh and or chilled potatoes worth US$66 million. Applied tariff for export of fresh potatoes to Afghanistan is 20%. Afghanistan also stands first in demand and ease of trade terms for export of potatoes from Pakistan. Afghanistan does not apply any trade remedies on import of fresh potatoes from Pakistan.

There are five (05) regulatory requirements to be met for exporting potatoes to Afghanistan. The regulatory import requirements by Afghanistan include product registration which means registration of certain pesticides and compounds and its maximum residue limit. Testing requirements is the second regulatory measure which means product exported from Pakistan needs to be tested for MRL for example testing a sample of kinnow exported to Afghanistan. Certification requirements means having certification of conformity such as material used for packaging of product. Afghanistan also has the regulatory requirement of passing of the product from the designated entry point and custom office for inspection of the product. Lastly, Afghanistan has discretionary licensing procedure where the issuing authority has the discretion of approving the license for import of goods.[321]

SRI LANKA

Second in the rank with respect to export potential is Sri Lanka that is one of the traditional markets of Pakistan for export of potatoes. Pakistan has an export potential of US$17.5 million. Pakistan's actual export of fresh potatoes to Sri Lanka is around US$13 million leaving room for US$4.5 million. Sri Lanka imports fresh potatoes of worth US$31.3 million. Sri Lanka has an applied tariff of 28% for export of fresh potatoes from Pakistan. Sri Lanka has also imposed quota on Pakistani exports to safeguard its own production. Sri Lanka stands at 2nd position with respect to demand and ease of trade with Pakistan. Sri Lanka has applied MFN tariff regime in import of potatoes from Pakistan.

There are thirty-one (31) regulatory measures to be adopted for exporting potatoes from Pakistan. These measures include; special authorization requirements for SPS, registration requirement for importers, restricted use of certain substances in foods and feeds and their contact materials (1, 2, 3,4,5,6), labeling requirements (1,2,3,4,5,6,7), hygienic requirements, hygienic requirements not elsewhere specified, certification requirement, inspection requirements, authorization requirements for TBT reasons, authorization requirements for importers for TBT reasons, labeling requirements

(1,2,3,4,5), production or post-production requirements, certification requirements, inspection requirements.

MALAYSIA

Malaysia is the third largest potential market for exports of potatoes from Pakistan. It has an export potential of US$14.6 million for Pakistan. Pakistan's actual export of fresh potatoes to Malaysia is around US$ 4.9 million having a room of US$9.7 million. Malaysia imports fresh potatoes of worth US$69.1. Importantly, Malaysia has an applied tariff of 0% for import of fresh potatoes from Pakistan. In terms of demand and ease of business Malaysia stands at 3rd position for Pakistan's potato exports.

Malaysia does not apply any trade remedies for import of fresh potatoes from Pakistan. There are seventeen (17) regulatory requirements for exporting potatoes to Malaysia. These requirements include; special authorization requirement for SPS reasons (1981, 1985), restricted use of certain substances in food and feeds and their contact material (1,2), labeling requirements (1,2), packaging requirements (1,2), storage and transportation conditions, certification requirements, inspection requirements, authorization requirements for TBT reasons, labeling requirements (1,2), product identity requirement, product quality or performance requirement, requirement to pass through specific port of customs.

UNITED ARAB EMIRATES

United Arab Emirates is the fourth largest potential market for export of potatoes from Pakistan. With an export potential of US$10.4 million Pakistan has captured the most part of the market and supplying the market with potatoes of worth US$5.9 more than its actual potential. UAE has 0% applied tariff on import of fresh and or chilled potatoes from Pakistan under MFN status for Pakistan. In demand and ease of trade terms, UAE is at 4th place with respect to export of potatoes from Pakistan. UAE has no trade remedies for the import of fresh potatoes from Pakistan.

There are fifty-two (52) regulatory import requirements applied to the export of fresh potatoes from Pakistan to the United Arab Emirates. These regulatory requirements include; system approach that combines two or more independent SPS measures for the same product. These measures are a combination of inter-related measures that apply on a product at its stages of production (1,2,3), special authorization requirements for SPS reasons, prohibitions/restrictions of imports for SPS reasons not elsewhere specified, tolerance limits for residues of or contamination by certain (non-microbiological substances (1,2,3), restricted use of certain substances in foods and feeds and their contact materials (1,2), labeling requirements (bio-label, expiry date and nutrition, prepackaged food stuff, registration and labeling, quantity information), marking requirements, packaging requirements (packaging not of plant origin, registration and inspection, special packaging for organic foods), microbiological criteria of the final product (for food stuffs, registration and inspection), hygienic practices during production, hygienic requirements not elsewhere specified, treatment for elimination of plant and animal pests and diseases (treatment for plant pests and diseases, special standards for veterinary products), plant growth processes (organic), food and feed processing, storage and transport conditions (1,2), other requirements on production or post-production processes, not elsewhere specified (additives permitted), product registration requirements, testing requirements (quantity testing, registration and inspection, phyto-sanitary certificate, production and marketing conditions), certification requirements (certificate of conformity, sanitary certification), inspection requirements (1,2,3,4), origin of materials and parts (1,2), processing history (1,2), distribution and location of products after delivery, quarantine requirements (1,2), labelling requirements, pre-shipment inspection, import monitoring and surveillance requirements and other automatic licensing measures, regulation concerning terms of payment for imports, and the most important regulation about the labeling requirements for all goods that all labeling must be in Arabic language containing all the relevant information such as name, nature, components, date of production or packaging, expiry date, net weight, country of origin and the country of export.

RUSSIAN FEDERATION

With an export potential of US$9.3 million, actual exports of US$5.3 million, Russian Federation is the fifth largest potential market for export of fresh potatoes from Pakistan to tap the remaining US$4 million potential. Russian Federation imports fresh potatoes of worth US$189.2 million. The applied tariff for import of fresh potatoes from Pakistan is 7.5%.[320] In demand and ease of trade terms, Russian Federation stands at number 5 with respect to export of potatoes to Russian Federation. Russian Federation is the market with the highest demand potential.

Russian import of fresh potatoes from Pakistan is covered under MFN status given by Russian Federation to Pakistan in 2016. According to MFN status the applied tariff was 10% but under preferential tariff for GSP countries, potato exported from Pakistan has the applied tariff of 7.50%. The Russian Federation (EAEU) for Developing Countries agreement is carried out under non-reciprocal arrangements with the scope of unilateral country group. There is no trade remedy from Russian Federation on import of potatoes from Pakistan.

The regulatory regime includes twenty-four (24) measures. These measures include; systems approach (HACCP), tolerance limits for residues of or contamination by certain (non-microbiological) substances (heavy metals, MRL of residue substances of pesticides), restricted use of certain substances in foods and feeds and their contact materials (meat products, dietic clinical and nutrition, food additives and flavours), labeling requirements (purpose of use, name & ingredient etc.), marking requirements, packaging requirements, microbiological criteria of the final product, food and feed processing, storage and transport conditions, product registration/approval requirements, testing requirements (1,2), certification requirements, traceability requirements, conformity assessment related to SPS, labeling requirements (1,2), requirements to pass through specific port of customs (1,2), consumption taxes.

OMAN

With an export potential of US$4.5 million, Oman is another potential export market from the traditional markets. Pakistan's potato export to Oman is US$3 million and hence Pakistan still has room for tapping US$1.4 million in this market. Oman has 0% applied tariff for fresh potatoes from Pakistan under MFN status and it has not applied any trade remedies for import of fresh potatoes from Pakistan.

Oman has twelve (12) regulatory requirements for import of fresh potatoes from Pakistan. These measures include; special authorization requirement for SPS reasons, registration requirement for importers, labeling requirements, packaging requirements, product registration requirements, testing requirements (1,2), certification requirements (1,2), inspection requirements, quarantine requirements, authorization requirements for TBT reasons.

Other existing markets for export of fresh potatoes from Pakistan include Bahrain, Kuwait, Qatar, Iraq, Kazakhstan, Singapore and Uzbekistan.

NEW MARKETS

As mentioned earlier, Pakistan has concentrated its exports of potato to few traditional markets. These markets do not include any high-end market. It is need of the hour that Pakistan looks for new markets to increase its share in world export by tapping new high and low end markets. This report has identified 03 countries where Pakistan can put efforts to increase its exports adopting market diversification strategies.

VIET NAM

By 1970, potato was a minor crop for Vietnam. The typhoon damage in those days motivated the Vietnamese farmers to utilize their lands other than rice during dry season from November to February for cultivation of potatoes. The Vietnamese adopted shorter time rice varieties to give enough time to the potato crops. Most of the crop is cultivated in lowland areas of Red River.

Adoption of early rice varieties also benefited the farmers for having two rice crops in eight months and adopting rice-potato rotation. Other areas for potato cultivation are highland of Dalat.[322]

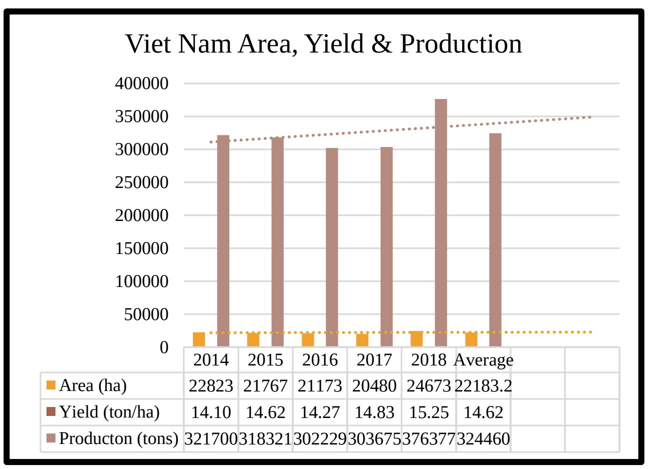


Figure 125 Viet Nam Area, Yield & Production (2014-2018); Source: FAO

According to the Ministry of Agriculture and Rural Development of Viet Nam, the processing industry in Viet Nam needs around 180,000 tons of potatoes annually for processing but the domestic market provides only 40% of the need of processing factories.[323]

With a production of around 325 thousand tons, Viet Nam exports around 1500 tons of potatoes to the world. The major importing partners are Malaysia, Singapore, Thailand and interestingly Pakistan. Viet Nam imports around 35,000 tons of potato from the world. The supplier countries include China, Germany, USA and Bangladesh. The supplying countries are providing potatoes to Viet Nam at an average US$445 per ton. This is the area where Pakistan has the competitive advantage of price and can supply potatoes to Viet Nam market for quite less price.

Exporters	Imported value in 2014 (US$000)	Imported value in 2015 (US$000)	Imported value in 2016 (US$000)	Imported value in 2017 (US$000)	Imported value in 2018 (US$000)
World	11256	10380	15287	21318	16476
China	10325	9652	14029	18792	13957
Germany	103	549	731	1429	1093
United States of America	509	72	87	157	857
Australia	0	0	408	7	521
Bangladesh	196	107	19	0	44
France	110	0	1	0	5
Korea, Republic of	0	0	12	0	0
Netherlands	14	0	0	20	0
India	0	0	0	914	0

Figure 126 Potato Exporters to Viet Nam (Value-wise) (2015-2019); Source: ITC

Pakistan has the export potential of US$7.2 million in Viet Nam which imports potatoes of around US$56 million. With an applied tariff of 20% under MFN status, Viet Nam does not apply any trade remedy for import of fresh potatoes from Pakistan. Pakistani exporters have to comply forty-nine regulatory measures to export fresh potatoes from Pakistan. The detail of regulatory measures can be found here.

the National Plant Protection Organisation (NPPO). Authorities in producing countries have to be able to declare a region pest-free or check on specific areas and product treatments. There is priority for pests that have the most severe impact on the EU territory. These are XYLELLA FASTIDIOSA, the Japanese beetle, the Asian long-horned beetle.

However, pests in fruit and vegetables is not a unique issue in the European Union. It is a global issue and attention for plant health is increasing worldwide. The Food and Agriculture Organization (FAO) estimates that every year up to 40% of food crops are lost due to plant pests and diseases. This is one of the reasons why the FAO declared 2020 the International Year of Plant Health (IYPH). Through this declaration, they wish to express their ambition to raise awareness. They will also strengthen efforts against the risks. The IYPH 2020 Promotional Video explains this and several other objectives.

One can only hope that all this attention will lead to more concrete help in prevention. This includes implementing integrated pest management (IPM) and complying to the stricter regulations. A good example of such an initiative is the COLEACP Fit for Market SPS project. This addresses the struggle of farmers in ACP countries, a group of countries in Africa, the Caribbean and the Pacific, to comply with phytosanitary market requirements.

European importers understand the need for strict phytosanitary control. At the same time, they are concerned that many of their supplying countries are not ready for the stricter regulations. This emphasizes the need for exporters to prepare well when entering the European market.

GERMANY

Germany is one of world's leading importer as well as exporter. During last five years, Germany has imported on an average around 523 thousand tons of potato from the world, thus making it the third largest importer of fresh potatoes in the world with a share of around 7% in world imports. Major suppliers include mostly the EU countries including the Netherlands, France, Spain, Belgium and Italy. From our competitors Egypt and China are providing fresh potatoes to Germany. The highest per unit value is registered by Honduras, China and Costa Rica amounting to more than US$2000.

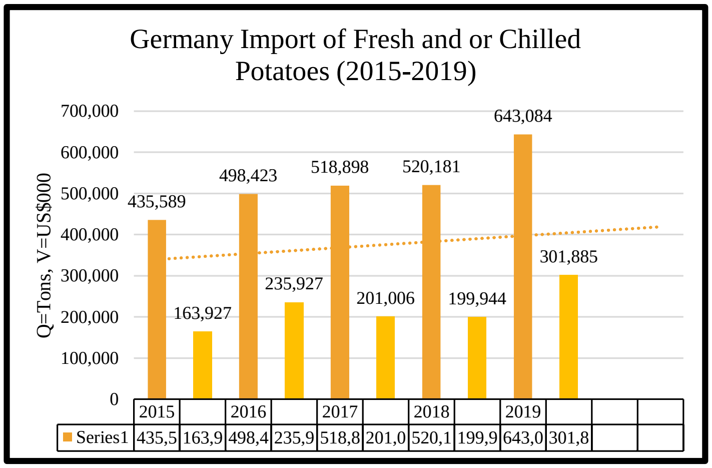


Figure 127 Germany Import of Fresh Potatoes (2015-2019); Source: ITC

Exporters	Imported value in 2015(US$000)	Imported value in 2016(US$000)	Imported value in 2017(US$000)	Imported value in 2018(US$000)	Imported value in 2019(US$000)
World	163927	235927	201006	199944	301885
Netherlands	29824	49178	45912	52584	72637
France	30805	33644	35635	41056	55827
Spain	31059	41093	32726	24509	52584
Egypt	19047	37099	26869	28589	32522
Israel	10837	21560	16878	13979	29866
Belgium	13683	15323	14055	13794	15227
Cyprus	7080	9888	7659	7628	10914
Italy	9149	9056	7636	4736	6889
Slovenia	570	2598	1739	794	5582
United Kingdom	2080	2213	1100	2026	5579

Figure 128 Supplying Markets for Fresh Potato to Germany (2015-2019); Source: ITC

According to Trade Map (ITC), Pakistan has the export potential of US$4.6 million in Germany which is still untapped. The main reasons for Pakistan not exporting to EU countries especially Germany is the requirement of food safety standards mandatory for exporting fresh fruits and vegetables to Germany. Some of these certificates and standards include GLOBAL G.A.P, IFS, and BRC. While Germany has no trade remedies against Pakistan's export to Germany, the standards and regulatory regime are the main hurdles. Further information on export of fresh fruits and vegetables including potatoes to EU countries including Germany can found at the following websites namely; Trade in Plant and Plant Products from Non-EU countries, Trade Help Desk, Fresh Fruits and Vegetables-Buyers Requirements. Germany has an applied tariff of 0% for potato import from Pakistan. Information from Trade and Investment Council from Pakistan Embassy in Germany does not support the above analysis.

SPAIN

Spain is among the top 20 largest producers of potatoes and 9th among the largest exporters and 5th among the largest importers of potatoes.

The entry date of potatoes into Europe is unknown but in the most probability it entered into Europe from Spain's Canary Islands where it was being cultivated from mid-1500s and it was served to the patients in hospitals in late 1500s. Earlier prized for its flowers the humble tuber as patata became the mainstay of Spain in early 20s with an annual production of more than 5 million tons in 90s. After that like other countries in Europe, the area and production started falling and by 2018, the area harvested has shrunken to around 67 thousand hectares, while production has decreased up to 2 million tons. Interestingly, one of the major producer and exporter of the past is now one of the major importer of potatoes. The major suppliers are France, Germany, Italy and Morocco. The imports have been exceeded to 1 million mark in 2018.[324]

	Area (ha)	Yield (tons/ha)	Production (tons)
2014	75,956	33.5	2,543,930
2015	71,676	31.9	2,284,073
2016	72,136	31.1	2,246,204

2017	70,878	31.6	2,239,470
2018	67,488	29.8	2,010,933

Figure 129 Spain Area, Yield & Production (2014-2018); Source: FAO

While ITC finds an export potential of US$3.8 million for Pakistan in potato export to Spain, the main hurdle remains the same like Germany. Meeting the standards and import requirements for exporting potatoes to Spain**.** Further information on export of fresh fruits and vegetables including potatoes to EU countries including Spain can found at the following websites namely; Trade in Plant and Plant Products from Non-EU countries, Trade Help Desk, Fresh Fruits and Vegetables- Buyers Requirements. Spain has an applied tariff of 0% for potato import from Pakistan. Under GSP+ arrangements, Pakistan has 0% applied tariff for export of potatoes to Spain.

Exporters	Imported value in 2015 (US$000)	Imported value in 2016 (US$000)	Imported value in 2017 (US$000)	Imported value in 2018 (US$000)	Imported value in 2019 (US$000)
World	106767	160062	157038	163656	207097
France	67067	113715	109913	118983	151318
United Kingdom	23436	22331	21944	25700	22958
Netherlands	6706	11318	10924	7934	13760
Portugal	4224	5662	6529	6028	11924
Belgium	2032	2800	3917	1427	1963
Morocco	0	145	255	189	1382
Luxembourg	840	1168	1172	646	1238
Denmark	1068	1622	1078	1049	925
Germany	374	505	147	822	634
Cyprus	171	176	161	228	509

Figure 130 Suppliers of Fresh Potatoes to Spain (2015-2019); Source: ITC

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MARKET PENETRATION STRATEGIES

Attention for plant health is increasing worldwide. In Europe, high interception rates for pest-infested fruit led to a decision to introduce extra phytosanitary measures. In December 2019, the new phytosanitary rules came into force in Europe. This had significant consequences for plant protection organisations and fresh fruit exporters.

The new European regulation requires all plants and living plant parts from non-EU countries to have a **phytosanitary certificate.** This guarantees they have been properly inspected, are free from quarantine pests and are in line with EU plant health requirements. Regulation (EU) 2019/2072 provides the details for the implementation of protective measures against plant pests. Only five fruits do not require a phytosanitary certificate for import: pineapple, banana, coconut, durian and dates.

The new rules require action from producers, exporters and The European potato market during pandemic is showing an increased impact on its domestic trade. While the Europe is still facing an uncertainty in trading future due to restrictions of movements across borders. There is need to understand that the EU market is going to change with long-term adjustments and changes in trade within EU and out of EU.[325]

Domestically, we need to look into product development strategies including product certifications such as GLOBAL G.A. P and other related certifications such as BRC and IFS before thinking about penetrating into EU markets.

The short term strategy should be market development such as in markets of Oman and Kuwait. Market penetration strategy in the current scenario is suitable only for Viet Nam. In this regard, the exporters who are exporting potatoes to Malaysia should be encouraged for sending sample consignments to Viet Nam. Few voice from exporters community have also suggested for tapping this potential market through delegation visits and sending sample shipments.

The market development strategy is also suitable in the event of changing attention of the world towards plant health to the extent that 2020 is declared as the International Year of Plant Health. The EU has introduced extra phyto-sanitary measures in December 2019 which has consequences for exporters of fresh fruits and vegetables to EU. The new regulations require that all non-EU countries have a phyto-sanitary certificate to the extent of *guaranteeing* the absence of quarantine pests and conformity with EU plant health requirements.[326]

These new rules ask for taking drastic measures with the help of the National Plant Protection Organization (NPPO). At domestic level. we need to develop pest-free regions and have checks on specific areas and product treatment.

ISSUES AND PROPOSED SOLUTIONS

The most prominent issue of Pakistan's export of potatoes is concentrated in few markets. There is need to expand the range of importing markets. Pakistan has Afghanistan, Sri Lanka, Malaysia, United Arab Emirates, Russian Federation and Oman as its major export markets.

Secondly, we have not yet developed the potato sector as an export oriented sector. Pakistani exporters and growers want to export what they produce. In this competitive world, buyers want what they need. No doubt potato is one of the most in demand product worldwide but importing countries want to buy potatoes according to their culinary and processing needs. Pakistan needs to expand the production of in demand varieties so that we can capture maximum of the traditional markets.

Thirdly, though Pakistan is one of the major exporters of potatoes in the world. The growth trends in comparison to other exporting countries is showing a completely opposite position. While all the exporting markets are registering growth trends in quantity as well as value, Pakistan is showing growth trend in quantity but negative growth in value terms. It means with each passing year Pakistan is exporting more and more potatoes at lesser prices. In almost all of its import markets, Pakistan has been consistently giving way to its competitors on value terms. Malaysia is the only market where Pakistan has not given away its position with respect to value otherwise in all other markets Pakistan is exporting at far less price than its competitors. The reason might be Zero duty on imports by Malaysia consequent to FTA between two countries. This phenomenon needs further research. The plausible reasons could be under invoicing and deterioration in quality that bars Pakistan from asking premier prices for its product.

As Pakistan is mostly cultivating Dutch varieties, the importer finds no charm in importing varieties that they can get from their neighboring countries. There is a need that Pakistan market its product with the unique features that these varieties have adapted. Selling Lady Rosetta to Germany is of no use. Pakistan needs to brand its potato in export markets.

In its existing markets, Pakistan has not yet realized its export potential. There is need to develop a short-term strategy to strengthen these markets and in long-term strategy we should look for new markets.

Pakistan has the greatest export potential in Russian Federation and Afghanistan. Pakistan government should look into formalizing the payment channels in both countries by taking policy measures to facilitate exporters who are willing to export in these markets. Promotional campaigns such as in Russian Federation can also help if arranged during March, April when the newly harvested crop is available for sampling.

A feedback from exporters may be more useful in adopting future course of action,

SECTION 9: OPERATIONAL RISK MATRIX

INTRODUCTION

In the wake of increasing global competition, demanding consumers, decreasing product lifecycles due to global warming, and decreased lead times for provision of fresh produce to the consumers, the sectors such as fresh fruits and vegetables are increasingly linking to supply chain networks. The development of these networks was a move to counteract the above mentioned factors. This developed a sector's dependency on these supply chain networks thus making them more vulnerable as these sectors expose themselves to looming risks which are associated with these networks of supply chain.[327]

In this scenario it is imperative that all players in supply chain network has the ability to evaluate the operational risks associated with the chain.[327] According to English dictionary risk is defined as a situation that involves exposure to danger, on the other hand, business dictionary defines risk as the probability of loss and or negative impact resulting from internal or external vulnerabilities that can be avoided or mitigated through anticipatory measures.

Supply chain risk is defined as the probability or possibility of disruption in supply chain resulting from external or internal sources that can impact the supply chain network negatively[328] and thus resulting in the inability of the chain to meet the consumer satisfaction.[329] Supply chain risk management (SCRM) is identifying and managing risks in the supply chain network through a coordinated approach among all actors of supply chain.[330] The objective of SCRM is to assess the potential risks and develop strategies to avoid or mitigate them. There are four interrelated constructs of SCRM as shown in the figure below;[328]

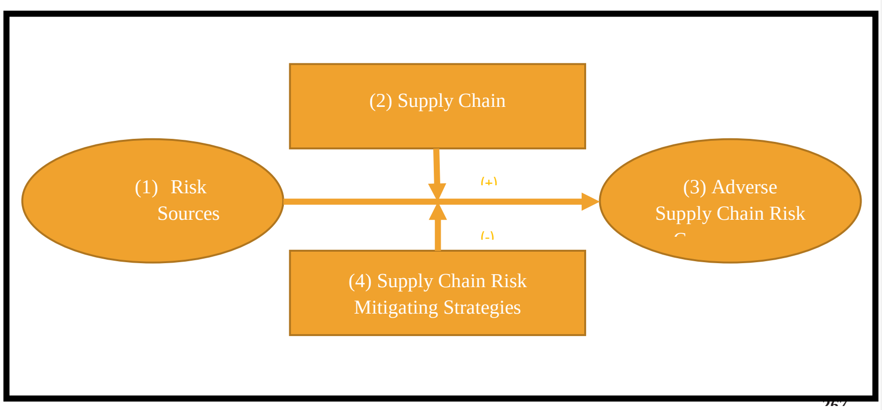

Figure 131 SCRM Basic Constructs; adapted from Juttner et al. 2003

RISK ASSESSMENT OF THE SUPPLY CHAIN (KEY AREAS THAT NEED TO ADDRESSED)

For the risk assessment of the supply chain a practical approach should be adopted by realizing the supply chain risks as known and unknown risks. The known risks are possible to counter and manage such as low yields of the crop, transportation issues and financial issues.[331] There is need to identify risks in team collaboration and document these risks for management strategy. The collaborative efforts can help in identifying grey areas that are hard to define and or understand. Unknown risks such as natural disasters, pandemics and other such events are hard to foresee. The only way of responding to such events is the speed with which one responses to such events and gain competitive advantage such as re-routing product from one destination to other in the wake of any such event at the port of destination.[331]

Let us take practical example of exporting fresh and or chilled potatoes from Pakistan to the identified markets of Viet Nam, Germany, and Spain. This report will also take into consideration the market development in countries like Kuwait and Oman.

The potato value chain advances with each player adding value to the chain at different nodes. It is imperative to first identify these supply chain nodes that would help in identifying risks associated with them.

OPERATIONAL RISK ASSESSMENT OF THE 3 IDENTIFIED NEW MARKETS.

In the below figure, the researcher has deduced his own framework from the discussions in above sections. It may not be a complete picture of the product and information flow but it could at least be used as a theoretical framework for future research in this regard.

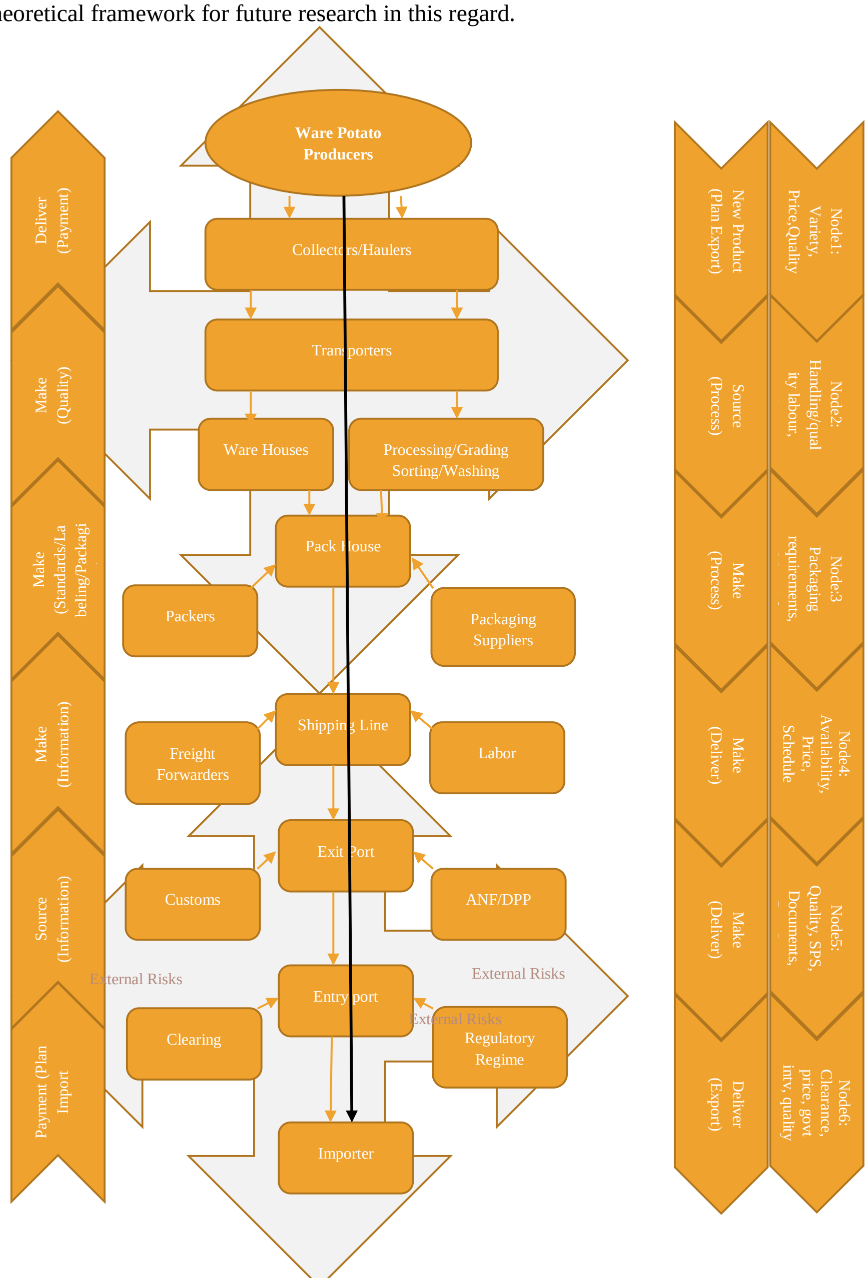

Figure 132 SCRM Export of Potatoes: Author's Theoretical Framework

In Pakistan's perspective, the export flow starts from negotiation of exporters with the grower for the product. In case of grower cum exporter the individual decides about sending the consignment to the certain market. In this case the scenario will be discussed assuming Pakistan's market penetration in Viet Nam, Germany and Spain.

NODE1: CHANGING MACROECONOMICS ENVIRONMENT, QUALITY ISSUES, DISEASES ATTACKS

At the first node of the supply chain, the exporter comes across the risks of the selection of variety for export, price of the raw potato in the sourcing region and quality of the produce. In certain cases, the producer may demand higher prices due to changing macroeconomic environment. There could be risk of lower yield, disease attack, failure in meeting regulatory requirements of quality in importing country.

The continuous monitoring of the process from seed cultivation to maturity needs to be adopted for mitigating the risk at this stage.

NODE 2: SUPPLY SHORTFALL/FAILURE, TRANSPORTATION FAILURES, MIS-HANDLING OF PRODUCT, PROCESSING QUALITY

From the farm the produce is collected by collectors or haulers and transported to the exporter's warehouse/processing plant (in Pakistan's case, the exporters hire processing plants and or warehouses in production area for the season). The product is then sorted, graded, washed and packed for the export. The risks involved at this stage are transportation of produce from farm to processing plant. The transporters' strike can halt supply. Breakdown of vehicles can stop supply and lastly mishandling at farm level loading may become a risk. At the processing level, the grading plant may not have country approval or other quality measures required by the importing country.

The exporters need to hire reliable transporters for delivery of produce and engage skilled labour for handling the product at farm level especially during the process of loading and unloading as most of product losses related to quality occur at these stages. The choice of grading plant should be made after having views from previous customers/users and if the exporter owns the processing plant it should ensure the cleaning of the plant from debris of earlier processed produce, dust and other foreign materials that may contaminate the produce.

NODE 3: SHORTAGE OF PACKAGING MATERIAL, QUALITY OF PACKAGING MATERIAL, LABELING AND PACKAGING REQUIREMENTS

At the packaging stage, the exporter's risk involves shortage of packaging materials, quality issues related to packaging material, issues related to packaging being according to the packaging requirements of the importer/importing country.

It is imperative to understand for all players of the supply chain that sharing of information among the players help in serving the customers efficiently and effectively. In sourcing of agriculture products like potatoes, this may include the production status, packaging material availability and material quality, packaging requirements including size, shape and volume of the packaging. The most importantly this information needs to be flowed from well informed players to less informed players for better coordination.[332]

In order to mitigate risk at this node, the exporter and importer need to develop a mechanism of information sharing about all the requirements in importing countries. It is common practice in the industry that information is not shared well in time or properly that makes things difficult at the exit and entry port regarding regulatory and quality requirements. Hence information sharing is considered the top logistics challenge in business environment.

NODE 4: AVAILABILITY OF SHIPPING LINE, SCHEDULE, PRICE AND TIME

From this node onwards, the risk becomes external as the exporter has no control on the processes involved. The most common risks are non-availability of vessels for the destined port, unsuitable schedule of delivery and time taken and lastly the freight charges.

The risks involved at this node can only be mitigated by well in time planning. If an exporter is interested in sending a consignment of potatoes to Viet Nam he must have checked with the shipping line for the schedule, price and time taken and same should also be shared with the importer. If the exporter fails in planning ahead of time it will cost him more time, effort and money.

NODE 5: QUALITY OF PRODUCT, SPS REQUIREMENTS/CERTIFICATIONS, GOVERNMENT INTERVENTIONS

At this node, the risks are also external. The quality of product must pass through the National Plant Protection Organization's (NPPO) set rules and regulations. The SPS certificates should be according to the prescribed formats and lastly the exporter should be aware of any government policy regarding export of the commodity out of the country.

For mitigating risks at this point, again the flow of information should be the primary focus. If the exporter is well informed about the government interventions, he may not send the consignment to the exit point. In the same way having information about the SPS requirements for country NPPO is essential to avoid non-issuance of phyto-sanitary certificates.

NODE 6: CLEARANCE, QUALITY, GOVERNMENT INTERVENTIONS, SPS REQUIREMENTS

At this node though the risk is external, it would have been initiated from the beginning of the export process. Clearance of product at the exit port needs complete and in order documents. If the exporter and rest of the players of the supply chain have put in a coordinated effort then clearing will not be a problem, but if there was lack of coordination, the clearance would become a time consuming process that may affect the product quality and cost more to the importer or exporter as per terms agreed.

Mitigating risk at this point may become beyond the capacity of exporter and importer if there is any discrepancy in the attached documents. It is hence necessary for mitigating risk at this point by planning ahead, sourcing according to the quality and quantity requirements of the import and taking care that the product meets all regulatory measures of the importing country. A brief summary of regulatory requirements in the identified markets is given below;

VIET NAM:

Viet Nam is one of the growing economies in Southeast Asia and despite increased consumption of processed potatoes, the potato is still a small crop in Viet Nam cultivated on a smaller area. The Red River Delta (as mentioned earlier) is the largest area of potato production accounting for more than 95% of production. In Viet Nam potato is called '*khoai tay*'.[333]

EXPORT REQUIREMENTS FROM PAKISTAN:

P 400- Prohibition of re-exports of goods in their original and unprocessed form.

IMPORT REQUIREMENTS BY VIET NAM:

The import requirements by Viet Nam for fresh and or chilled potatoes include 49 measures. The detail of these measures is given below with links to the guiding rule/regulation for better understanding;

a. A 140 Authorization requirements for SPS reasons for importing certain products
b. A 210 Tolerance Limits for residues of or contamination by certain (non-microbiological) substances (1,2,3,4)
c. A 220- Restricted use of certain substances in foods and feeds and their contact materials
d. A 310- Labeling Requirements (1,2,3,4)
e. A 330- Packaging Requirements
f. A 810- Product Registration/ Approval Requirements (1,2)
g. A 820- Testing Requirements (1,2,3)
h. A 830- Certification Requirements (1,2,3,4,5,6)
i. A 840- Inspection Requirements (1,2,3,4,5,6,7)
j. A 851- Origin of materials and parts
k. A 860- Quarantine Requirements (1,2)
l. A 890- Conformity Requirements related to SPS, n.e.s (1,2,3,4)
m. B 310- Labeling Requirements (1,2,3,4,5,6,7,8)
n. B 420- TBT Regulation on Transport and Storage
o. B 490- Production or Post-production Requirements n.e.s
p. B 810- Product Registration/Approval Requirements
q. E 100- Non-automatic import-licensing procedures other than authorizations covered under SPS and TBT chapters (1,2)

Other than the above-mentioned 49 measures, Viet Nam import requirements applied to all goods imported in Viet Nam include;

a. B 830- Certification Requirements (1,2,3,4)
b. G 900- Finance Measures, n.e.s
c. H 900- Measures affecting Competition (1,2)

GERMANY & SPAIN:

Germany is one of the largest importers as well as exporters. With an average production of more than 10 million tons for last 10 years, Germany ranks in top five producing countries. On the other hand, with an average export of around 1.7 million tons of potato, Germany is standing among the top five exporters. At the same time Germany imports million tons potatoes with value of around US$348 million each year. The above figures make Germany a lucrative market for supplier countries including Pakistan.

EXPORT REQUIREMENTS FROM PAKISTAN

P 400- Prohibition of re-exports of goods in their original and unprocessed form

IMPORT REQUIREMENTS BY GERMANY & SPAIN:

The import requirements by Germany and Spain for fresh and or chilled potatoes include 17 measures. The detail of these measures is given below with links to the guiding rule/regulation for better understanding;

r. A 120- Geographical restrictions on eligibility
s. A 130- System Approach
t. A 140- Special Authorization requirement for SPS reasons
u. A 190- Prohibitions/restrictions of importers for SPS reasons not elsewhere specified
v. A 210-Tolerance limits for residues of or contamination by certain (non-microbiological substances
w. A 220- Restricted use of certain substances in foods and feeds and their contact materials
x. A 410- Microbiological criteria of the final product
y. A 420- Hygienic practices during production
z. A 630- Food and feed processing
aa. A 830- Certification Requirements
bb. A 840- Inspection Requirements
cc. A 850- Traceability Requirements
dd. A 851- Origin of Materials and Parts
ee. A 852- Processing History
ff. A 853- Distribution and Location of Products after Supply

gg. B 140- Authorization Requirements for TBT reasons

hh. B310- Labelling Requirements

By the time of development of this report none of the above links is opening from Pakistan.

RISK ASSESSMENT OF THE SUPPLY CHAIN POST COVID-19 ERA

INTRODUCTION

COVID-19 has taken the world by surprise just like a typical black swan event. The world is going through the difficult times of the century with millions affected by the diseases and deaths have also crossed million mark. The new normal is not being expected before April 2021. The full impact of the pandemic has yet to be realized but one thing is for sure, the global supply chain will felt its ramifications for years to come especially the countries that are providing raw material for finished products.[334] It might have proven a catalyst for the world to revisit their supply chain strategies and move from traditional to digital supply chain networks models by adopting the capabilities to meet the challenges ahead.[334]

As a sourcing country, exporters in Pakistan need to understand the challenges ahead. Below are given few points for the consideration of exporters from Pakistan especially the exporters of fresh and or chilled potatoes from Pakistan;

UNDERSTAND THE DEMAND RELATED TO YOUR PRODUCT

As an exporter you need to understand the demand dynamics of your commodity. It could be simply a shift in demand and or lost demand. It is imperative to understand the positive and negative shifts in demand and update the business strategies accordingly.

SYNCHRONIZE WITH SHORT TERM DEMAND SUPPLY SCENARIO

There may be significant fall or increase in the demand of your commodity, you should be ready to respond to both scenarios from export and operational perspective. The importers may ask for smaller supplies to reduce their inventory and in certain cases, they may ask for a mix of commodities. In all these situations, you need to synchronize your operational systems at home country.

CHANNEL SHIFTS

The world has observed an unprecedented increase in demand of fresh food and groceries using online channels. This also has posed challenges to several companies dealing in groceries and fresh food. As an exporter you should ready for a shift of channel from traditional export to online sale directly to the customers.

CHANGING LOGISTICS OPTIONS

The epidemic has also exposed the way world was planning its logistics. In new normal, there will be significant port congestions, delayed flights, increased air freights and shortage of road transport. In this situation as an exporter you need to plan your exports in the regions where you have chances to avail logistics options easily.

PROMISED CAPABILITY

There is need to understand that accumulating inventory may not help in new normal. You must plan your export in such a way that you can promise capability instead of showing accumulated inventory. In this regard working together with your importer you need to have confirmation of consumer and product priorities and export accordingly. It is also applicable for UAE market where Pakistani exporters accumulate their fresh commodities glutting the market. The pandemic has also taught us not go for *first come first serve* but a new approach of *fair share* (proportional to volumes that are expected from the market) or you may adopt *differentiated* product approach.

FREQUENT CHANNELS OF COMMUNICATION

As mentioned earlier, communication is in the heart of supply chain. Try to build up as many as channels available for communication with your key customers for prompt flow of information up and down stream. You should also be ready to face potential extra costs if your contractual commitments are not covered under *force majeure*. Even in new normal you should expect such things happening at least for the near future.

PREPARE FOR CANCELLATIONS

In new normal there would be greater chances of cancellation of your orders at the last moment. As an exporter you should be ready to take it as a normal. Prepare yourself for extra channels of sales in such situations. Keep the domestic retail and chain stores in contact to deal with any such situation where you need to dispose-off your consignment domestically. You may also think of other channels if there is a re-routing desired or needed.

WATCH & WATCH

The timing is going to become crucial in new normal. In a global perspective as an exporter you need to have a watch on timing and volumes in the supply chain. The more your supply chain is visible the lesser is your risk by having the visibility of potential supply chain problems. Get your extended supply chains visible, use of artificial intelligence such as google maps and other social media applications may increase your visibility. One way of having extended supply chain networks under your watch could be use of CCTV cameras from farm level to warehouse, grading, packaging and transportation. These solutions are not innovative but their use in the new normal will be critical for your supply chain. An illustration of the shifting of traditional supply chain to digital supply chain is given below for better understanding of the concept;

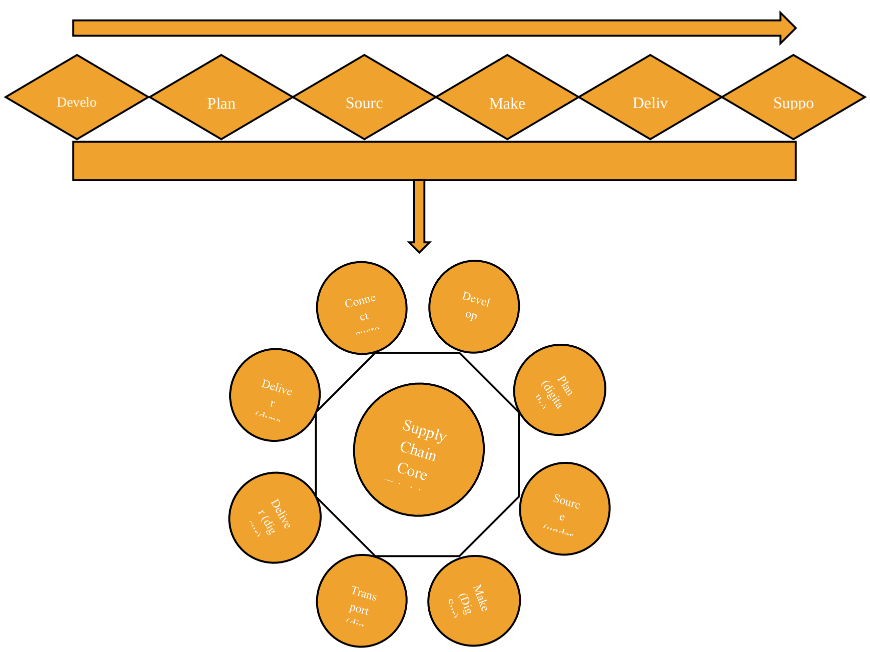

Figure 133 Shift of Traditional Supply Chain to Digital Supply Chain

SECTION 10: SWOT ANALYSIS

Strategic planning is the essence of an organization's productivity that help it in allocating resources for achieving the organizational goals. The organizations and sectors need to have their internal and external analysis to achieve the desired goals. This analysis is commonly known as SWOT analysis.[335] The external analysis helps in identifying the critical threats and opportunities in certain competitive environments examining the evolution of the competition and resulted threats and opportunities. External analysis takes into account the environmental threats and opportunities. Internal analysis provides an insight into the organizational or sectoral strengths and weaknesses. It also helps in identifying the resources that may provide competitive advantage to the organization or sector.[335] The theoretical illustration of SWOT is presented below;

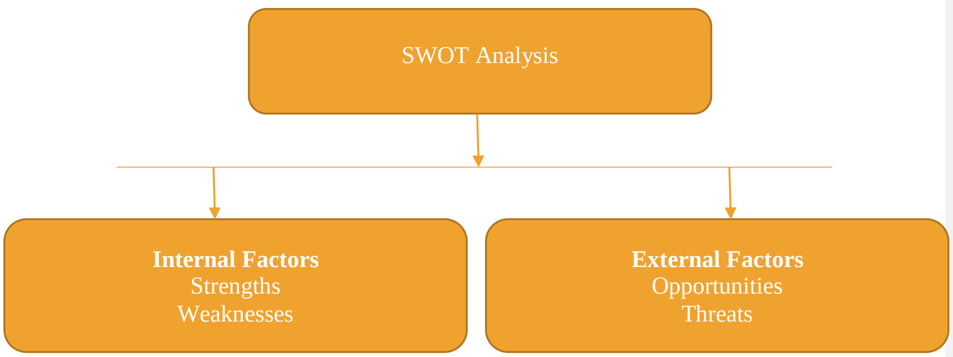

Figure 134 Theoretical Illustration of SWOT Analysis

INTERNAL FACTORS

The internal factors of a SWOT analysis include strengths and weaknesses of the sector from within.

STRENGTHS

- Fertile Lands for cultivation of potatoes
- Availability of three (03) seasons for potato production
- More than world average per hectare yield in past few years
- More than region per hectare yield (China, India, Bangladesh)
- Consistency in area for cultivation
- Growth in production trends
- Increased trend of contractual growing coupled with cold storage facilities by contractors
- Cheap labor at farm level

- Potato-maize crop rotation pattern suitable for potato growing lands

WEAKNESSES

- Dependence on the imported seed as more than 90% of the seed is imported from Holland. Local seed produced by tissue culture technology has not proven to be as successful as imported seed in terms of yield and re-sowing.
- Lack of disease resistant varieties
- Lack of coordination between agricultural research /extension institutes and potato farmers
- Lack of high yielding and disease resistance clones and non-availability of proper gene pool
- Lack of processing facilities in other than Punjab province
- Concentration of export in a small number of importing markets
- Lack of value-addition industry especially frozen potato industry
- Lack of R&D in public and private sector

EXTERNAL FACTORS

The external factors include environmental and social factors in which the sector performs. The external factors include threats and opportunities on the way of sector.

THREATS

- Good performance of cotton crop that may urge farmers to switch from potato to cotton.
- Pest and disease attacks reducing per hectare yield
- Decrease in availability of irrigation water
- Energy crisis in the country
- Price fluctuation rather price inflation of inputs
- Variation in prices at different domestic markets
- Increasing share of competitors in exporting markets
- Lower prices in export markets

OPPORTUNITIES

- Increasing demand of quality fresh produce in domestic and international market
- Gradual increase in processing industry
- Chances of market diversification
- Potential for export of value-added products

SECTION 11: RECOMMENDATIONS (*GROW FOR EXPORT)*

The International Food Policy Research Institute (IFPRI) along with International Potato Center (CIP) estimated that the world potato production would be around 403 million tons by 2020. Though these estimates proved quite reasonable, the world was unable to touch the 400 million mark. The world demand of potato for food was estimated to increase by 40% by 2020. However, the Food and Agriculture Organization (FAO) revisited its figures in 2020 to announce that world potato production will map at the production quantity in 2018 of around 368 million tonnes. For achieving the target of 400 million, the world is facing several challenges that include increasing population, decreasing arable land, reducing water supply, increased purchase power giving way to increased food demand, environmental degradation, reduction in resources for agriculture.

These challenges ask for producing more food from less resources of land, water, energy and time. In simple words, the world need to produce more food per unit of water, land, time and energy. Other challenges include a wide range of pests attacking potato crops, difficulties in production of potato and distribution of quality seed, inadequate transport and cold storage facilities, increased use of pesticides causing environmental issues, mutation and emergence of pests and lastly the price fluctuation. All these challenges ask for adopting strategy for increasing potato production in an environmentally friendly, socially and economically sustainable way.

PRODUCTION

The potato crop needs some basic precautions against diseases including crop rotation, tolerant varieties, and healthy seeds. Unfortunately, there are no chemical controls against bacterial and viral diseases. Regular monitoring of aphid vectors and spraying can help against these diseases. Few of the fungal diseases such as late blight can spread in favourable weather conditions if left unattended. Insect pest can also create a wreak havoc in the potato crops. Protecting natural enemies of these pests can help. Colorado potato beetle, one of the major pests of the crop can be tackled by destroying the pest, its eggs and larvae earlier in the phase of attack. Other precautions include proper sanitation, crop rotation and growing resistant varieties to control the spread of nematodes. Pests and diseases of potato crop include late blight (phytophthora infestans, mycoplasma pathogens, cyst nematodes of Rhizoctonia, Verticillium, Softrot and Scab.[128]

Yellowing of leaves and easy separation of tubers from stolons are the indication of maturity of the crop. While leaving the crop in the soil thickens the skin which is helpful against storage diseases and shrinkage but leaving the crop in the soil for too long may also increase the risk of fungal incrustation such as black scurf.[336]

In order to make harvesting easier, it is recommended that potato vines are removed two weeks earlier than digging up the crop. It is necessary to avoid bruising during the harvesting which may prove an entry point for storage diseases.[336]

SEED CONSTRAINTS

Propagation of potatoes are carried out vegetative which results in dissemination of viruses and pathogens in tubers. The attacking viruses are categorized depending on the mechanisms of its transmission including mechanical transmission, aphid transmission and soil-borne. The most important viruses of Pakistani potatoes include potato leaf roll virus, tobacco rattle, mop top and A, M, S, X and Y viruses. The chemical control of viral diseases is largely dependent on the mechanism of its spraying or spread in the field. However, potato as a crop plays an important role in the spread of potato viral diseases and hence development of seed certification programs are getting popularity. Certified virus-free tuber cultivation throughout the world has shown very promising results in controlling the virus disease. Genetically resistant breeders are another cost effective method of controlling virus diseases in potatoes. There is however emergence of recombinant and new viruses that has posed new challenges to pathologists throughout the world. At Pakistan level we can take following steps;

a. Providing support for emergence of local quality seed suppliers.
b. Elaboration of Potato Seed Legislation and development of necessary regulations and statutes
c. Development of a consultative mechanism for seed production in the light of soil characteristics and pathogens identified.
d. Introduction of the mechanism of seed traceability be by seed producers. The information should include producer/manufacturer name, date of packaging, location and other related information including the instructions and conditions for use of such seeds.

e. Working on establishment of our natural and formal seed production system beginning from North for seed production for Punjab. It would help in catering the dormancy issue in imported European seed.
f. Dissemination of working of Federal Seed Certification & Registration Department on potato seed and its statistics at national level.[50]

IMPROVING PRODUCT QUALITY

The demand for new varieties of improved taste and convenience will remain in demand. It is also important in the wake of the truth that consumption of other foods such as pasta is on the rise, it is imperative to use disease resistant, varieties that consume less water and fertilizers. A system of quality assurance should be in place for better grading and phyto-sanitary controls. There should be grades and standards set for the potato industry. In Pakistan, we also have the scope for increasing per hectare yield through progressive farming and imparting relevant knowledge and training. The following interventions in collaboration with private sector may help in product improvement;

a. Improvement in farm management practices aiming at better quality and high yields
b. Introduction of new cultivars with respect to target specific export markets
c. Introduction of new cultivars suitable for processing industry such as French fries, Potato chips
d. Production of seed potatoes for domestic and export market.[50]

TECHNICAL ASSISTANCE & EXTENSION SERVICES

There is a need for some regulatory authority coming forward such as DPP to establish a consensus among all stakeholders for establishing a technical assistance package. The package should also support the training programmes chalked out by federal and provincial governments. An army of private extension services is required which is currently far from the inception idea. It is observed that pubic extension services at provincial level do not have qualified technicians to provide services to horticulture growers especially crops like onion and potato.[50]

STORAGE

Storage is only one stage of the production system. The losses occurred in storage stage arise from previous stages of harvesting and pre-harvesting which ultimately influence the tuber preservation considerably. Different varieties have different resistant characteristics to harvesting, handling and mechanical damages along with plague resistance, sprouting and rest period. The cultural practices affect the physical and physiological conditions of the tuber and its sanitary at the time of harvest. In order to reduce the chances of lesions and other diseases, it is recommended that foliage should be removed two to three weeks prior to the harvesting by using a contact herbicide rather than cutting the foliage. Cutting the foliage may propitiate signs of some diseases but that can affect the tuber. If the farmers decide not to eliminate foliage, then it is advisable to delay the harvest until the tubers are very mature.[40] After the harvesting of the tuber, it is important to save them from direct sun exposition as intense sunlight makes tubers verdant and hence diminish their quality. The crop for storage should be properly dried as humid product will be vulnerable to different fungi and bacteria causing different diseases and rottenness. It is important to dry the tubers for a good preservation through good circulation of environmental air.[40]

It is imperative to remember that newly harvested potatoes are living tissues and hence very much prone to deterioration, hence, we need proper storage to avoid post-harvest losses and ensure the adequate supply of seed tubers for the next season. The basic aim of storage should be preventing 'greening', the accumulation of chlorophyll in the peel. The greening of the peel is related to the toxic alkaloid solanine which results in loss of quality and weight. It is suggested that crop should be stored at a temperature of 6℃ to 8℃ in a dark and well ventilated storage place with a relative humidity of 85% to 90%. Seed tubers however need different storage conditions of diffused light for maintaining the germination capacity and vigorous sprout development.[60]

PACKAGING

In order to conserve the tubers whether through sprouting inhibitors or refrigeration, utilizing packaging that allow good air circulation and easy handling is imperative. It is recommended that 50 Kg sacks of open weft are used with a superior quality air circulation. Other recommended packaging is use of boxes of 50 to 100 kg capacity to pack the potato sacks with lateral openings for superior airflow.[40]

TRANSPORTATION

Transportation of the tubers should be completed soon after the harvesting to avoid sun damage. The recommended containers are bottom rigid and flat baskets, padded pails and padded wire baskets.

Most of the injuries to the tubers occur at the time of transferring potatoes into sacks unless the task is performed quite carefully.

The transportation of potatoes through trucks and trailers has a greater importance as it may cause mechanical damage to the tubers which will become evident at the time of storage. To avoid these mechanical damages, the persons handling the crop should be educated not to throw the potato inside the container but place them properly. The helpers should not stand on the potato sacks but the platform of the vehicle. The sacks should not be thrown and discharge from trucks. It is recommended that a straw bed should be used or made from sewn sacks with a small quantity of straws inside. If the sacks are placed on these beds the chances of bruising will be reduced significantly. Secondly the truck load should be tied securely to reduce the movement of sacks during transportation. To avoid bruising it is necessary that potatoes should be handled for an absolute minimum number of times. The increased number of handling potatoes would definitely increase the proportion of damages. The labor involved should be supervised properly to guarantee an appropriate operation.[40]

VARIETAL ISSUES

As mentioned earlier, Pakistan uses potato varieties from the Netherlands, Ireland and United Kingdom. These varieties are not purely adapted for Pakistan's climatic conditions. Currently, Pakistan hase a few new locally produced varieties but their cultivation is not adopted at large scale leaving Pakistan for using exotic varieties. The reason for There is a need to develop more commercially viable varieties of potato to switch from exotic varieties. Two of local varieties Raja and Lal-e-Faisal are getting prominence but their cultivation is still not at large scale. The northern areas have also developed varieties that are suitable to the climatic conditions in the north of the country.

MANAGEMENT OF PLANT HEALTH

Insect pests, diseases and weeds are real enemies of potato crop. They are the major constraints in the way of achieving full yield potential of a potato crop. As per estimates, the losses from these enemies (biotic stresses) are around 40%. If the post-harvest losses estimation of 20% also be considered the situation becomes alarming both for producers and exporters.[319] The indiscriminate use of pesticides and fungicides have posed other environmental threats such as emergence of new and mutant pests developing resistance against the use of pesticides, issues of residuals in product, food and potable water. This phenomenon is also posing threat to ecological balance as the use of pesticides also kill the beneficial insects and micro-organisms.

The above situation asks for having managing these biotic stresses through ecofriendly measures and manners coupled with judicious use of chemicals. This could result in achieving higher economic returns without misbalancing the environment. In this regard, Integrated Pest Management (IPM) is the most economically viable solution for sustainable potato crops.

The potatoes are propagated from tubers that increases the risk of contamination from alien pathogens and pests through seed tubers. Matter of the fact is that most of the pests and diseases prevalent in potato crops are transferred through seed. One of the diseases potato late blight caused by *Phytophthora infestans* has the potential of causing around 40% to 50% damage to the crop.[319] There is need to prioritize our research and development activities against late blight. Development of late blight resistant varieties is another option.

The use of pesticides to tackle late blight farmers has been posing threats of groundwater pollution, increased residual levels and table potatoes. There should be a country-wide campaign on the use of need-based pesticides and fungicides. The use of botanical agents such as friendly insects should be encouraged at all levels.

NARC and CABI may be the partners in such exercise

PRODUCTION SYSTEM MANAGEMENT

Sustainable food production is on the world agenda now-a-days. Degradation of environment, water and soil are emerging as a major concern throughout the world. The use of biofertilizers is an option for ecofriendly production. Another factor is use of water resources. There is need to develop a '*crop per drop*' approach for sustainable use of water resources. The approaches of micro-irrigation and fertigation have been proved successful in potato cultivation. The unnecessary use of water resources is increasingly causing the problem of salinity. Potato needs around 300 to 500 mm of water in a single growing season. Water resources are increasingly diminishing. The global warming phenomenon is also causing stress on potato cultivation as the precipitation is increasing even to the point of drought at the critical stages of potato harvesting.[319] There is need to construct minor irrigation structures in rainwater harvesting areas and use of drip irrigation should be encouraged at all levels. Another option is cultivation of short duration varieties that can mature in 80 to 90 days and fit well in intercropping systems.

EXTENSION IN SHELF LIFE

The potato crop is grown during summer seasons in European countries and hence the product is stored in cold winter season. On the other hand, in East Asia region including Pakistan, the crop is produced in winter season and stored in summer season. Potato being a semi-perishable vegetable starts rotting during high temperatures. The required temperature for potato storage is 2 to 4℃ which spoils the culinary properties of the spud. The storage needs a lot of energy consumption during hot summer days. There is a need to develop technologies for storing potatoes at higher temperatures to avoid. This could be a sprouting inhibitor. In this context, Pakistan can learn from India.

India has developed a technology for storing potatoes at 10 to 12℃ using Chlorpropam (CIPC) which has been helping Indian potato sector in storing potatoes with less use of energy.[319]

PROCESSING & VALUE ADDITION

World-wide, the potato processing is increasingly becoming an agricultural subsector. Despite this fact, the potato processing industry in Pakistan is not up to the mark. Only 5 to 7% of the crop is used for processing in Pakistan in comparison to 55 to 60% in the Netherlands and more than 50% in the United States not mentioning Belgium that has become a world leader in potato processing industry especially in frozen potato industry. There is need to develop indigenous potato varieties suitable for potato processing in the country. Secondly, the integration of supply chain is necessary to streamline potato production in northern areas of the country for processing facilities. The government should encourage the initiatives taken in this regard by supporting these initiative through public-private partnership.

CONTRACT FARMING

In the wake of the liberalization of the global economy, several national and multinational companies involved in marketing of table, seed and processed potatoes have started contract farming in different countries including Pakistan. This type of farming can enable small farmers' participation in the market economy. It seeks not only to transform the small farmer into a viable commercial producer but also links production with consumption. Contract farming has the potential of reducing the risk and uncertainty of the fluctuating potato price by creating links with a stable and sustainable market. It also contributes to technology transfer by providing new and better farming skills to the contract farmers. These companies also offer economies of scale to the mainly small and marginal farmers through providing opportunities for processing, value addition and export. Keeping in view the advantages of contract farming, the government must provide adequate policy support to this system of farming. Adequate safeguard measures also need to be taken to monitor the production activities of these companies so that the farmers are not exploited.

CAPACITY BUILDING

The potato growing region in Pakistan especially in Punjab have low levels of literacy. The labour used for collection of harvested produce are mainly women and children. The use of technology in potato fields is low. There is need to develop skilled labour in these areas. In this regard, the government should intervene for capacity building of the labour involved in potato production especially women. This move will help in poverty alleviation in rural areas and provision of sustainable labour for potato production.

Pakistan has established research stations in potato growing areas including Sahiwal and Sialkot where scientists and agriculture extension staff is working on potato production technologies, disease control and dissemination of information among the stakeholders. National Agriculture Research Center (NARC) in Islamabad is also working on varietal issues and development of new varieties. In this regard, there is need to establish arrangements at institutional level for sharing of information and knowledge among the stakeholders.

Institutions like PHDEC should come up with mechanisms as adopted by AHDB, covering all products by creating different separate portals for each product for information and knowledge dissemination. The government (MNFS&R/NARC, Provincial agriculture departments, PHDEC) should collaborate with private companies involved in input supplies for dissemination of information and capacity building workshops. Practical training workshops during the sowing and harvesting season should be arranged to train manpower involved in potato production. There is also need to develop a potato cooperative movement involving growers, processors, exporters and development agencies to bring the potato sector in national limelight.

Lastly, like other Asian countries, the potato consumption in Pakistan is very low (approx. 15 kg/year) in comparison to world average of more than 33 kg/year. It is astonishing that despite potato having all the ingredients of a wholesome food, the wrong notions especially linking potato with obesity has damaged the image of potato as a food, a food that ranks first in global food security. There is need to develop campaigns at national level to educate masses on the nutritional value of potato to increase consumption at domestic level.

CONCLUSION

The humble tuber is one of the most important tuber vegetable but its role in global food systems is extremely under-appreciated despite the fact that it is contributing towards meeting the energy and nutritional requirements of more than a billion people throughout the world. World-wide, potato production, harvesting, storage and trade has created jobs for millions of people. Potato produces more food per unit area, time and energy than other staple crops such as rice, wheat and maize. It is imperative to understand the full agriculture potential of the potato crop by Pakistan.

Though Pakistan's per hectare yield of potato crop is more than world average, it is far below the realized yield of more than 40 tons/ha. There is wide gap in per hectare yield in different provinces in Pakistan. A national level campaign is needed to disseminate information about the adoption of new production technologies in all provinces. There is need for developing a national level strategy for increase in per hectare yield, especially in the province of Khyber Pakhtunkhwa where three crops of potato are grown round the year. Developing yield potential in KPK may help Pakistan in developing more disease resistant varieties.

Another constraint in potato production is the availability of suitable varieties according to the agro ecological zones. A strong varietal improvement program needs to be developed for specific locations such as agro ecological zones on priority basis.

Pakistan is mostly depending on Dutch varieties for production of potatoes and very less attention is given to the development of seed at national level. Another factor is lack of information dissemination in this regard. A national level campaign is needed for adopting local seed and varieties for cultivation. An effective integration of input suppliers, progressive growers, processors, exporters and NGOs is needed for furthering the case of adoption of local seed. There is need for capacity building of research and extension department officers on the subject of crop management skills so that they can train potato growers. Organizations like PHDEC should come up with a program of publishing quality training material and involve research and extension departments for training of trainers and farmers. In this regard, Pakistan can benefit from the training materials developed by CIP for different countries adapting it for use in Pakistan.

There is a need to improve the skills and knowledge of research and extension officers in the country along-with the crop management skills of potato growers. This could be achieved by professional development of scientific and extension personnel, on-farm training, seminars, field days, study visits and publications. Moreover, farmer education and demonstration of available technologies in farmers' fields is very important. CIP and the FAO Regional Vegetable IPM Programme published good quality training materials in 2006 and these should be put to good use in potato production training of trainers and farmer education programmes. Therefore, efforts in this direction need to be considered. LIFDC countries could be prioritized in case external assistance is needed.

There exists a major opportunity to introduce potatoes in rotation with cereal crops to increase the availability of potatoes to meet food security. More specifically, potatoes can increase total food production in rice-potato cropping systems and this kind of cropping system could be promoted where possible.

Pakistani farmers are using the chemical pesticides indiscriminately, this has resulted in emergence of more aggressive insect pests and diseases, residual problems in produce and drinking water, ecological imbalance and extinction of beneficial microorganisms and friendly insects. There is need to develop campaigns for use of ecofriendly measures to mitigate these biotic stresses. FAO's introduced Potato Integrated Pest Management (IPM) has been proved a successful and economically viable solution. FAO has conducted trainings of farmers and extension staff in the past, there is need to revive this trend at national level with the help of FAO and CIP.

The potato crop with early varieties of 80 to 90 days can fit well in various intensive cropping systems. India has already successfully demonstrated this practice through a number of early potato varieties. These Indian varieties could be utilized by other Asian countries having similar agroclimatic conditions. For this purpose, CIP could be entrusted to identify the available early varieties in the region and their suitability to similar agroclimatic conditions.

The world has turned its face towards organic food. Organic farming is the safest and sustainable approach for environmentally friendly agriculture. If we adopt this approach Pakistan can have its share in organic market that has the growth potential of 15% to 20% every year. In this regard, Pakistan can learn from China through information sharing and collaborative efforts for initiation of successful organic farming in Pakistan. National IPM programs should be developed to teach farmers the benefits of using ecofriendly methods and ultimately turning to organic farming. The government should develop a handholding mechanism for organic potato growers.

To avoid post-harvest losses another set of skilled labour needs to be developed that can take responsibilities of handling, storing and packaging systems to avoid post-harvest losses. Potato crop has different utilization patterns for different regions. In the north of the country where landholdings are small it adds to the value of farmer's income. Down the stream it is a vegetable to be used in every household. In urban areas, the processed products from potato are heavily consumed. There is need to turn our research and development focus on the crop with respect to its utilization patterns. The research should come up with varieties suitable for north, center and south parts of the country further dividing them in a way that semi-urban areas cultivate potato varieties suitable for processing industry.

Contract farming is the call of the day today and several multinational and national companies are engaging in contract farming. It is a win-win situation both for processors and farmers. While processors are getting their desired raw material closer to their production plants, the farmers are getting satisfactorily good prices for their produce. The governments at provincial level should have a mechanism of monitoring the activities of these firms involved with growers to safeguard the interests of the farmers.

On the trade fronts, potato is mainly traded within EU countries and other countries including USA, Canada, and Egypt. These few countries trade around 80% of the world's potato trade. On the other hand, countries in Asia like Pakistan has a meagre share of around 10 to 12% as a whole and 3 to 4% as a nation. It is ironic to note that the world that is growing potatoes only once in the year are far ahead in trade than countries like Pakistan that can supply potatoes round the year. Though factors like trade barriers, certification requirements, regulatory regimes and lack of marketing infrastructure have contributed towards lower trade volumes. The information on potato export figures, prices, standards, phytosanitary requirements, processing and social standards to meet is not readily available for exporters and importers. There is need to develop a database of requirements of other countries making a set of standards, quarantine regimes, grades, and other social and product certificates that are needed for exporting in certain countries. This will help our exporters to expand their market range as the knowledge of standards applicable to a set of countries would help them in finding more buyers in that set of countries. This should be done by PHDEC based on research carried in this report.

Pakistan and India can share a lot of knowledge about potato growing but the political terms do not allow such sharing. There is need to develop a forum under FAO or CIP where all countries in the Southeast Asia can share the information, knowledge and success stories for the benefits of whole region.

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APPENDICES

ANNEX-1

LIST OF ASSOCIATE MEMBERS OF POTATO GROWERS CO-OP SOCIETY OKARA.

Sr. No.	Name & Address	Contact Number	Sr. No.	Name & Address	Contact Number
1	Mian Muhammad Sadiq(P) Burj Jeeve Khan Okara	0302-536297	29	Ch Anwaar Ul Haq Sufi Gold Store Okara	0343-6775005
2	Mian Khalid Atteeq Burj Jeeve Khan Okara		30	Ch Akram Bhatti(Dir) Alsadiq GT Road Okara	0300-9460036
3	Ch Basheer Ahmed(SVP) 35/2ra Okara	0321-6969955	31	Haji Shafi Ur Rehman Zafar Housing Society Okara	0300-6954819 0333-4986519
4	Ch Maqsood Ahmed Jatt(VP) Sabri Coloney Okara	0333-69826410313-6982641	32	Malik Ali Qadir Abbas(Dir) Zakheera Bambay Ghashgori Okara	0300-9458250
5	Dr.Syed Afzaal Haider Rizvi(F.Dir) Theseel Road Okara	0300-8441132	33	Rao Khalil Ur Rehman 40/3r Okara	0342-1974624
6	Mian Abdul Ghfaar(Dir)Burj Jeeve Khan Okara	0300-7951241	34	Saibzada Ashfaq Ahmed(Dir) 22/GD Okara	0333-6982678
7	Mian Zahir Gfaar Burj Jeeve Khan Okara	0335-7022000	35	Syed Kousar Ali Rizvi Theseel Road Okara	0300-6959814
8	Mian Fiasal Haseeb Burj Jeeve Khan Okara	0306-7538504	36	Rao Farrakh Ahsaan (Dir) Ali Coloney Okara	0300-9411965
9	Mian Farooq Ahmed (Dir) Burj Jeeve Khan Okara	0301-8507211	37	Haji Abdul Gfoor Lala Zaar Coloney Okara	0300-6970321
10	Mian Annyaat Ali Burj Jeeve Khan Okara	0342-3637222	38	Ch Tariq Aziz(Dir) Aamir Coloney Okara	0300-6970678
11	Mian Khfait Ali Burj Jeeve Khan Okara	0314-9503223	39	Ch Asif Aziz Aamir Coloney Okara	0333-6995959
12	Mian Iqbal 49/3r Okara	0345-7491149	40	Rao Khrsheed U Zamaan Adoona Glass Factory Okara	0336-8656970
13	Mian Saeed Malik Mian Ameeer Umer Cold Store Sahiwaal	0300-8694114 0300-8694814	41	Rao Abid Zaheer Adoona Glass Factory Okara	0300-6964303
14	Mian Tariq Fareed 36-37 Okara	0333-6981144	42	Haroon Hotiana , 540GG, Phase IV DHA, Lahore	0300-6945755
15	Haji Liaqaat Bitalvi 48/3r Okara	0340-0218970	43	Ch M,Ashiq 2/4L Okara	0300-6973175
16	Ch Bashaaraat Bajwa 51/3r Okara.	0345-7548557	44	Malik Tariq Mehmood 23/GD Okara	0303-9588356
17	Peer Naseem U din 32/2ra Okara	0300-7950032	45	Mian Ghulaam Mohammad Watto Dipalpur	0300-4001986

18	Syed Mosa Raza Gillani 22/1AL Okara	0334-5032121	46	Haji Mohammad Saeed Shamsia Coloney Okara	0300-6961512
19	Syed Javeed Hassan Shah (Dir)Kot Walia Renala Okara	0300-6973080 0345-4092663	47	Ch Abdul Rauf Hinjra (Dir) 28/2L Okara	0333-6962828
20	Ch Abdul Hameed(Dir) Lailpur Farm Okara	0300-6969109	48	Ch Naeem Hafeez New Lala Zaar Okara	0300-6959897
21	Ch Abdul Rehman Sufi Gold Store Okara	0321-6959291	49	Mian Tariq Riaz 21/GD Okara	0333-6971234
22	Mian Latif Zafar Umer Din Town Okara	0345-8692320	50	Ashraf Bajwa	0301-7341031
23	Aslam Shah Mohammad 26/	0301-6927826	51	Qazi Sajjid	0300-6965152
24	Rafeeq Chishti Chak M Yaar Chishti Haveeli	0344-4777114 0333-3132326	52	Mian Asim Manieka Bonga Saleh Hayaat Okara	0300-7950600
25	Ch M Akram Haveeli	0336-7457237	53	M Javeeed 46/3r Okara	0347-7172082
26	Mazhar Iqbal Satghara Okara	0344-4583992	54	Ch Anwar Jatt	0300-4344738 0336-8249494
27	Ch Javeed Sira Kandowall Daakhana Hujra Thseel Dipalpur Okara	0301-8690909	55	Mian M Aslam Jilaal Choke Haveeli Dipalpur	0300-6968603
28	Malik Ashraf Channa Qadra Abad Okara	0300-6959822 0300-8747222	56	Malik Basheer Channa Qadra Abad Okara	0300-8747222

LIST OF MEMBERS POTATO GROWERS CO-OP SOCIETY OKARA.

Sr. No.	Name & Address	Contact Number	Sr. No.	Name & Address	Contact Number
1	Mian Ahsaan anjam 97/6R SAhiwal	0346-6910786 0300-0786022	29	Ch.Asif Sharif 17/SP Pak Patan	
2	Mian Abdulgafaar Burj Jevay KhanOkara	0300-7951241 0335-7022000	30	Sajjad Tariq 47 Chaman Zar Colony Okara	0300-8897554
3	Ch M Shreef Moaza Mancharian Dipalpur	0321-4403291 0300-4404291	31	Rao Khalil Ur Rehaman 40/3R Okara	0342-1974624
4	Ch Nazar Mohammad 48/3R Okara	03085621963	32	Ch.Sidque Mustfa 92/6R Sahiwal	0302-6538684
5	Syed Abass Raza Mouza Ameer Aman Ullah Depalpur	0300-8438483	33	Malik Zulfqar Ali son shahzad Haveli Lakha Depalpur	0333-6974782
6	Rao Khurshad u Zaman Quala Sora Singh Depalpur	0336-8656970	34	Ch. Maqsood Ahmad Jatt sabzmandi Okara	0333-6982641 0313-6982641
7	Meher Sajad Sittar Ghuslshan Arrian Okara	0300-4177514	35	Rana Muhammad saleem khan 87/6r sahiwal	
8	Ch.Haji Iftikhar Ahamd Qadri 48/3R Okara	0346-7412648	36	Rao Mukaram Ali khan Subhan Shah Dipalpur. 153 k Model Town Lahore.	0300-6959988 0322-6966707
9	Ch.Ghulam Sarwar Bohta 39/3R Okara	0342-6360703	37	Mian Anwer Ali (died) Son Hafeez Anwar 92/6R sahiwal	0302-6520592 0346-7517192

10	Ch.Abdul Sattar Thakidaar 39/3R Okara	0345-7544021	38	Rana Tahir Farooq 56-2L Karmanwala Okara	0321-7069901
11	Ch.Muhammad Sarwar 46/3R kayba Okara	0302-4907247	39	Ch. Muhammad shareef son Rafeq Mithoo Jatt 15/1al akhtr abad	
12	Rana Muhammad Azim 9/IAL Akthar Abad Okara	0321-7069901	40	Ch. Tariq Aziz 35/2ra Okara	0300-6970678
13	Rana Muhammad Ashraf 56/2L Hazrar Karmanwal Okara	0321-7069901	41	Khan Muhammad Muslim khan Awami Sapray centre gala Mandi 36,37/2ra Okara	0321-6992218
14	Ch.Riaz ul Haq 90/6R Sahiwal	0301-6901002	42	Ch.Dr Abdul Sattar 92/6R sahiwal	0301-6905992
15	Syed Javid Hassan Shah Kot Walia Renala Khurd	0300-6973080 0345-4092663	43	Malik Ali Qadir Abbas Bambi Gashkori Okara	0300-9458250
16	Ch.Asif Aziz 35/2ra Okara	0333-6980611	44	Mian Peer Abdul Rasheed(died) son ijaz Haveli Lakha Depalpur	0344-7277045
17	Ch.Bashir Ahmad 35/2ra Okara	0321-6969955	45	Ch. Abdul Rehman 36.37/2RA okara	
18	Haji Aziz Buksh 2/4L Okara		46	Haji Israr Ali21/GD Ada kaka gujar Okara	0300-7954270
19	Ch. Haji Nazir Ahmad 42c Housing society Okara	0345-8471180	47	Syed Maqbool Shah 34/2RA okara	
20	Syed Salman Hadir Rizve Tehsil Road Okara	0333-4643321	48	Syed Aftab Ahmad shah10/1AL Akhter Abad	
21	Ch.Muhammad Afzal Taaj Din Sabzi Mandi Okara	0300-6957317	49	Sahb zda Nazir Hussain (died) son sahib zada Tahir 22/GD okara	0333-6982678
22	Rao Nazir Hadir 40/3R Okara		50	Majer Muhammad Bashir (abroad) son Imran Bashir 66/GD Sahiwal	0300-4371760
23	Ch.Muhammad Siddque 48/3R Okara	0321-6950048 0300-4314911	51	Ch. Nusrat Ullah Bajwa (Rizi Sindhoo)55/2l Okara	0321-7097144
24	Mian M Asif Burj Javey Khan Okara	0333-4255799	52	Ch. Abdul Sattar Thakeedar 39/3R okara	0345-7544021
25	Rao Ali Athar Khan 40/3R OKARA Dr.Ali Azhar	0321-4457839 03227474139	53	Ch. Muhammad Aslam 24l2R okara	0301-6927826
26	Rao Arong Zab Mazhar Abad Depalpur-	044-2524003	54	Nawab Meher Ali Shah 43/2RA Okara	
27	Rao Ikram Ali Khan Sohbhan Shah Depalpur son Rao Ihtshaam	0301-8499114	55	Ch. Muhammad shafi jutt (died Malik Gulaam Mustfa Tiwana 40/3R Okara	0346-7434487 0346-7486441
28	Ch.Bahdhar Khan 39/3R OKARA	0321-6957757	56	Malik Muhammad Binyameen(died) Malik Ahsan 92/6R murshad abad sahiwal	0321-69022440300-9690950
57	Ch.Muhammad Siddique Pakistani 85/Lalazar colony Okara bhai Latif	0300-4004899	83	Mian Ahmad Nawaz Maneka Bonga Saleh Hayat Depalpur	
58	Rao Haymiun Khan 40/3R Okara	0322-6946707	84	Mian Muhammad Serwer	

				Khokher college road okara	
59	Meer Abdul Jalil 41/3R Okara	0321-6953374	85	Ch. Abdul Farooq 35/2RA Okara	
60	Mian Maqbool Ahmad Quaqe Bahwal Depalpur	042-35835111	86	Ch. Abdul Ghaffar Qurashi 83/a Housing society Okara	
61	Major Rao Khalil Akthar 40/3R	0300-4300105	87	Sher Bahadur chak no 225/eb Gago mandi veharri	
62	Major Rao Zaffar Iqbal Mazhar Abad Depalpur	0300-6962765	88	Mian khalid Haider Makan No 100 Jhung	
63	Rao Muhammad Aslam Mazhar Abad Depalpur Fiaz Aslam Rasheed monshi	0300-8484948 0301-8696948	89	Peer Naseem udeen 32/2R Okara	
64	Rao M.Ajmal Khan Burj Illyas Khan Depalpur		90	Ch. Saeed Ahmad wattoo Chart singh Depalpur	
65	Syed Arif Raza Rizvi Mouzia Ameer Aman Ullah Depalpur	0345-7500014	91	Haji liaqat Ali Sabzi mandi Okara	
66	Meer Sohial Rashid 41/3R Kashmari Wala Okara	0345-8551168	92	Rao Kashif Ikrar 16/a block Okara	
67	Mian Muhammad Sidsdque Burj Jeevay Khan Okara	0302-7536297 044-2860355	93	Zaidi trader sahiwal road okara	
68	Mian Muhammad Rafique Burj Javey Khan Okara son Mian Faisal Haseeb	0306-7538504	94	Abdul Raof Hinjra 28/2l okara	
69	Ch.Muhammad Aslam 24/2R Lahore Road OKARA	0301-6927826	95	Ch. Naeem Hafeez Faisal Abab road okara	
70	Ch.Muhammad Sarwar 96/6R SAHIWAL bhai Arshid	0445-=50431	96	Mian Farooq Ahmad Burj Jiway khan okara	
71	Ch.Abdul Haq 90/6R Sahiwal abroad cusion	0321-6911890	97	Ch. Muhammad Shareef 88/c Housing society okara	
72	Ch.Muhammad Anwar 46/3R kaba Okara	0302-4919112	98	Rao Farrukh Ahsaan Ali Coloney okara	
73	Ch.Abdul Khaliq 96/6R Sahiwal (died) Son	0300-9694992	99	Ch. Muhammad Akram 46/2l okara	
74	Ch.Abdul Majeed 90/6R Sahiwal	0302-6093390	100	Roa Muhammad Jalal khan Mazhar Abad Depalpur	
75	Rao Shifique ur Rehman Chairman 40/3R Okara	0302-3587952	101	Rao shehzad Ilyas 40/3R okara	
76	Ch.Anwar ul Haq 42/3R shell pamp wale Okara	0347-4494944 0343-6775005 044-2522300	102	Ch. Abdul Hameedlail pur zarae store okara	
77	Ch.Abdul Rehman 42/3R Sufi cold storge Okara	0321-6959291 044-2514345	103	Malik Nuisaar Ahmad phulerwan ruken pura baseerpur Depalpur	
78	Sahib Zada Ashfaq Ali 22/GD Okara (died) son Sahib Zada Tahir	0333-6982678 626692	104	Hafiz Muhammad Saleem c/o Haji sons Lahore road chanyot	
79	Rao Abid Zaaheer Adona Galas Factory Okara	0300-6964303 044-2554303	105	Farhat Abbas Shah Chman Haidery form Chanyot	
80	Ch.Muhammad Akram Bhatti G.T.Road Okara	0300-9460036 044-514440	106	Rao Zameer Sadiq F block okara	

81	Ch.Ghulam Rasool Harni 39/3 R Okara (died) son Tariq Harni	0333-6994591	107	Muhammad Waseem 122 Jinah Coloney Saman Abad Lahore	
82	Syed Shakeel Hadir Rizvi Mouzia Ameer Aman Ullah Depalpur	0300-8407003	108	Muhammad Rafiq Chishti chak Muhammad yarchishti heveli lakha depalpur	
109	Hajji Muhammad Irshad Jsok Thon Depalpur		125	Dr. Tariq Rehman Chodhery Chak No.92/6R Sahiwal	
110	Ch.Khali Irshad 87/6R SAHIWAL		126	Muhammad Asim Maniaka Bonga saleh Hayyat	
111	Ch.Muhammad Safdar 90/6R Sahiwal		127	Khalil-Ur-Rehman Khan Kakate Rata Khana Road Dipalpur	
112	Ch.Masood Ahmad 90/6R Sahiwal		128	Syed Shahid Gillani	
113	Ch.Zahid Rashid 90/6R Sahiwal		`129	Syed Ahmed Hassan Syed Plaza masood Road Dipalpur	0300-8600205
114	Ch.Naseer Ahmad 2/4L Okara				
115	Rao Nadeem Hadir Qila Tara Singh Depalpur				
116	Rao Moziam Ali Mouzia Subhan Shah Deepalpur				
117	Dr.Syed Afzal Hadir Rizve Mozia Ameer Aman Ullah Depalpur				
118	Syed Kauser Rizvi Mozia Ameer Am,an Ullah Depalpur				
119	Ch.Allah Ditta 90/6/6R SAHIWAL				
120	Mian Muhammad Munir Burj Javey Khan Okara				
121	Shahid Zaffar Zaffar Colony Okara				
122	Ch.Ghulazar Ahmad 99/6R Sahi-wal				
123	Ch. Muhammmad Sharif 31/2L OKARA				
124	Rao Javed Imrao Khan 17/SP Pak Patan				

List of associate members should follow the other list

ANNEX-II

UNECE Standard FFV-52 concerning the marketing and commercial quality control of early and ware potatoes

I. Definition of produce

This standard applies to early and ware potatoes of varieties (cultivars) grown from *Solanum tuberosum* L. and its hybrids, to be supplied fresh to the consumer, early and ware potatoes for industrial processing being excluded.

Early potatoes are obtained from early varieties and/or are harvested at the beginning of the season in the country of origin. Early potatoes mean potatoes harvested before they are completely mature, marketed immediately after their harvesting, and whose skin can be easily removed without peeling.

II. Provisions concerning quality

The purpose of the standard is to define the quality requirements for early and ware potatoes after preparation and packaging.

However, if applied at stages following export, products may show in relation to the requirements of the standard:

• a slight lack of freshness and turgidity

• a slight deterioration due to their development and their tendency to perish.

The holder/seller of products may not display such products or offer them for sale, or deliver or market them in any manner other than in conformity with this standard. The holder/seller shall be responsible for observing such conformity.

A. Minimum requirements

(a) Subject to the tolerances allowed, the tubers must be:

• of normal appearance for the variety, according to the producing area

• intact, i.e. they should not have had any part removed nor have suffered any damage making them incomplete

• sound; produce affected by rotting or deterioration such as to make it unfit for consumption is excluded

• practically clean

• firm

• free of external or internal defects detrimental to the general appearance of the produce, the quality, the keeping quality and presentation in the package, such as:

• brown stains due to heat

• cracks (including growth cracks), cuts, bites, bruises or roughness (only for varieties of which the skin is not normally rough) exceeding 4 mm in depth

• green colouration; pale green flush not exceeding one eighth of the surface area and which can be removed by normal peeling does not constitute a defect

• serious deformities

• grey, blue or black sub-epidermal stains; exceeding 5 mm in depth in the case of ware potatoes

• rust stains, hollow or black hearts and other internal defects

• deep common potato scab and powdery potato scab, of a depth of 2 mm or more in the case of ware potatoes

• superficial common potato scab, i.e. scab spots in all must not extend over more than a quarter of the surface of the tuber

• frost damage and freezing injuries

• free of abnormal external moisture, i.e. adequately “dried” if they have been washed

• free of any foreign smell and/or taste.

In the case of early potatoes, a partial absence of the skin shall not be considered as a defect. Ware potatoes must be covered with well-formed skin, i.e. the skin has to be fully developed and mature and cover the whole surface of the tuber.

In early potatoes, no sprouting is allowed. Ware potatoes must be practically unsprouted, i.e. sprouts may be no longer than 3 mm.

The development and condition of the early and ware potatoes must be such as to enable them:

• to withstand transportation and handling

• to arrive in satisfactory condition at the place of destination.

(b) Each package or lot must be free from waste, i.e. attached or loose earth, detached growth shoots, extraneous matter.

III. Provisions concerning sizing

Size of the tuber is determined by square mesh.

Tubers must be of:

• a minimum size such that they do not pass through a square mesh of:
• 28 mm x 28 mm for early potatoes
• 35 mm x 35 mm for ware potatoes
• 30 mm x 30 mm for long varieties of ware potatoes defined hereafter
• a maximum size such that they pass through a square mesh of 80 mm x 80 mm, or for long varieties, 75 mm x 75 mm.

Early and ware potatoes exceeding the maximum size shall be allowed, provided the maximum difference in size between the smallest and the largest tuber is not more than 30 mm and they are marketed under a specific denomination. Tubers of a size range between 18 mm and 35 mm can be marketed under the denomination of "mids" or an equivalent denomination.

Uniformity in size is not compulsory. However, in sales packages up to 5 kg net weight, the maximum difference allowed between the smallest and the largest tuber must not exceed 30 mm. A variety is considered as long if it is listed as long or long oval in the national list of varieties of the country where it has been bred.

The sizing requirements do not apply to long varieties of irregular shape (e.g. Stella, Ratte or Pink Fir Apple).

IV. Provisions concerning tolerances

At all marketing stages, tolerances in respect of quality and size shall be allowed in each lot for produce not satisfying the minimum requirements.

A. Quality tolerances

(a) Tubers not satisfying the minimum requirements shall be allowed:
• 4 per cent by weight of tubers of early potatoes
• 6 per cent by weight of tubers of ware potatoes.

However, within this tolerance, a maximum of 1 per cent by weight of tubers affected by dry or wet rot shall be allowed.

(b) In addition the following shall be allowed:
• 1 per cent by weight of waste for early potatoes
• 2 per cent by weight of waste, of which a maximum of 1 per cent of attached earth, for ware potatoes.

B. Size tolerances

A total tolerance of 10 per cent, by weight of tubers, not satisfying the requirements as regards sizing is allowed.

C. Tolerances of other varieties

2 per cent by weight of other varieties is allowed.

V. Provisions concerning presentation

A. Uniformity

The contents of each package (or lot for produce presented in bulk in the transport vehicle) must be uniform and contain only early or ware potatoes of the same origin, variety, quality, colour of the skin, colour of the flesh and size (if sized). The visible part of the contents of the package (or lot for produce presented in bulk in the transport vehicle) must be representative of the entire contents.

B. Packaging

Early and ware potatoes must be packed in such a way as to protect the produce properly and to ensure adequate ventilation.

The materials used inside the package must be clean and of a quality such as to avoid causing any external or internal damage to the produce. The use of materials, particularly of paper or stamps bearing trade specifications, is allowed, provided the printing or labelling has been done with non-toxic ink or glue.

In the case of early potatoes, special packaging materials (e.g. peat) may be used in order to better protect the produce during long-distance transport. Packages must be free of all foreign matter.

VI. Provisions concerning marking

Each package2 must bear the following particulars, in letters grouped on the same side, legibly and indelibly marked, and visible from the outside either printed on the package itself or on a label secured to the fastening. If the labels are placed inside the packages (string bags), this should be done in such a way that the indications concerning marking are readable from the outside.

For early and ware potatoes transported in bulk (direct loading into a transport vehicle) these particulars must appear on a document accompanying the goods, and attached in a visible position inside the transport vehicle.

A. Identification

Packer and/or dispatcher/exporter:

Name and physical address (e.g. street/city/region/postal code and, if different from the country of origin, the country) or a code mark officially recognized by the national
authority3 if the country applying such a system is listed in the UNECE database.

B. Nature of produce

• “Early Potatoes”, “New Potatoes” or equivalent denomination, or “Ware Potatoes” if the contents are not visible from the outside
• Name of the variety

1 The use of some packaging materials (e.g. peat) is not permitted in some countries.
2 These marking provisions do not apply to sales packages presented in packages. However, they do apply to sales packages (pre-packages) presented individually.
3 The national legislation of a number of countries requires the explicit declaration of the name and address. However, in the case where a code mark is used, the reference “packer and/or dispatcher (or equivalent abbreviations)” has to be indicated in close connection with the code mark, and the code mark should be preceded by the ISO 3166 (alpha) country/area code of the recognizing country, if not the country of origin.

• Specific denomination for early and ware potatoes exceeding the maximum size, where appropriate
• “Mids” or an equivalent denomination, where appropriate.

C. Origin of produce

• Country of origin4 and, optionally, district where grown, or national, regional or local place name.

D. Commercial specifications

• Size (if sized) expressed as minimum size followed by the words “and over” or as minimum and maximum size
• Optional indications: colour of flesh (e.g., yellow or white), colour of skin, shape of tuber (round or long) and cooking type (e.g., floury or firm).

E. Official control mark (optional)

Adopted 1961
Last revised 2011
Aligned with the Standard Layout 2017

The OECD Scheme for the Application of International Standards for Fruit and Vegetables has published an explanatory illustrated brochure on the application of this standard. The publication may be obtained from the OECD bookshop at: www.oecdbookshop.org.

4 The full or a commonly used name should be indicated.

ANNEX-III

s. #	FACILITY NAME	LOCATION
	LIST OF PROCESSING AND PACK HOUSES	
s. #	**FACILITY NAME**	**LOCATION**
1	M.K Potatoes Processing Unit	31-Kalsan Depalpur Road, Okara, Punjab, Pakistan
2	Lion Group	Main Siddique farm, Darbar Baba Ahmed Lang, Depalpur road, Okara Punjab
3	National Fruit Processing	5 KM Ajnala Road Bhalwal Pakistan 0301-8601455
4	Zahid Kinnow Grading & Waxing Plant	6, KILOMETERS, KOT MOMIN ROAD, BHALWAL. 0300-6021225
5	Shamza Pak	5-KM, Depalpur, pepli peri road Okara punjab
6	Punjab Cold Store & Potato Washing Processing Plant	3- KM Burewala Road , Arifwala Punjab 03003872000 0300-6994732
7	Souvenir Trading Company	38- D before Depal pur, pepli peri road okara punjab 0344-2001234
8	Sadruddin & Co	Plot # 3, Sector 8/F Korangi Industrial Area, Karachi 0300-8238307
9	Mian Siddique Farms	pepli pahar road, moza khark singh, depal pur punjab 0330233, 0346-6000994
10	Z.S Group	New International mandi, Argo petrol pump Depal pur district Okara Punjab 0300-6021066
11	Sun Shine Potato Plant	03-Km, Okara road, Dipalpur Punjab 0300-6965100
12	Qarmi International	Quaid-e-Azam Chowk, Basir pur road, near Rc Colla agency Dipalpur Distt Okara
13	Zulfiqar & Co.	Oipli phar road, near near pir deh hatti, Okara road Dipal pur Punjab 0322-4002325 0300-2451896
14	5PS INTERNATIONAL potato processing plant	2-KM Pipli road , Dipal pur Punjab 0343-5433821
15	Husnain Argo Commodities	Argo gold potato processing plant , Soba Ram stop near 38/D chor rasta Dipalpur Punjab 0344-4474419
16	JMB Processing Plant	MauzaAmli Moti Pakpatan road Depalpur, Okara Punjab 0300-8231763
17	Talha and Hamza Processing Plant	1-KM, Hujra Shah Muqeem road, Chor rastaMian Khan Depalpur Okara Punjab
18	Iftekhar Ahmed & Co	Plot No. 7, New Fruit & Vegetable Market, Super Highway, Karachi 0321-8272772
19	Afzal ModelFarm & Potato Processing Plant	High School road Rajuwal District Kasur Punjab
20	Chase International Potato Processing Plant	0.5 KM, Diamond rice mills peer di hatti peppli pahar road Okara Depalpur Punjab 0300-2018669 0302-2131354
21	Orient Enterprises Potato Processing Plant	Three star processing plant , Moza banga awan, Hujra shah muqeem Depalpur Okara Punjab
22	MZ Enterprises	M.A Jinnah road Okara Punjab 0322-6988800 0301-6988800
23	Imran Qasim Trading Est.	A-1 Bilawal Shah, Noorani Goth near suparco Karachi Sindh 0336-2350690 021-35975149
24	Shamsher &Sons Traders	Near Qaeri baseera Darbar Bher Sohdian Depalpur Road Tehseel chunian Kasur 0300-4728466, 0333-8230567
25	Muhammad Din Muhammad Sharif & Co	Plot no. 62, Dost Muhammad Jhunjar goth Behind new sabzi mandi super highway karachi 021-36870022 0333-4772777
26	Eman International Trading Co.	Unit 7-D Dharame Wala Depalpur Okara Punjab 0300-9444031 042-35869226
27	Haji & sons	Farm link Motorway road Chiniot Punjab 042-36619880
28	7 Star Agri Products (pvt) Ltd.	18- KM Depalpure Kasur road near Pakistan pull Depalpur Okara Punjab 0300-8711910
29	Sahi Brothers Potato Processing	Opposite Kashmir cng, 8km Kasur road Depalpur Okara Punjab 0300-7553438
30	Netro Potato Processing Facility	Chrasta 38- D, Tehsil Depal pur Okara Punjab 0302-8231763
31	Alabad Processing Plant	plot no 3 chak no 31/2 L, District Okara Punjab 0300-2018669 0302-2131354
32	Sapna Smv (pvt)Ltd	Mazhar rice mills c chorata86 D saba Ahmad land road Depalpur Punjab

33	Diamond Potato Processing Plant and Export	Pipli chowk Abdullah, Basti, Pipli Pahar road Depalpur Punjab 92444541919
34	A.z Potato Processing Plant	Basti roshan shah ratta khana road Depalpur Okara Punjab 0323-84884323 0311-0134323
35	Al Riaz Cold Storage	Moza Mirapur, Pakistan road Tehsil Depalpur Oakara Punjab 0300-8753631 0301-2701112
36	Ahmed Aaloo Processing Plant	Near KP restaurant Hujra shah muqeem road fareed court depalpur Okara Punjab 0332-9444479 0332-2444479
37	Simco Potato Processing Plant	Qilla Sondha processing plant 0321-9476408
38	Mahmood Foods and commission agent potato processing pland	Kutba shop Depalpur road Kasur 0300-6572996
39		moza 1 KM Depalpur road chowk hujra shah muqeem depalpur okara 0300-7536973 03008694287
40	Eman Grading and processing plant	7-KM Chichawatni road Burewala near Agriculture college Punjab 0300-6990483
41	Patron Industries	12-KM Depalpur road near pakistan pull depalpur Okara 0321-4176062

ANNEX-IV

World Export Growth (2015-2019)

Exporters	2015			2016					2017					2018					2019				
	Q(Tons)	V(US$000)	Share in World Export (%)	Q(Tons)	Growth (Q)2015-16	V(US$000)	Growth (V)2015-16	Share in World Export (%)	Q(Tons)	Growth (Q)2016-17	V(US$000)	Growth (V)2016-17	Share in World Export (%)	Q(Tons)	Growth (Q)2017-18	V(US$000)	Growth (V)2017-18	Share in World Export (%)	Q(Tons)	Growth (Q)2018-19	V(US$000)	Growth (V) 2018-19	Share in World Export (%)
World	No Quantity	2835230	100	11130219	N/A	3195052	N/A	100	No Quantity	N/A	3407768	N/A	100	No Quantity	N/A	3349521	N/A	100	11861429	N/A	3887376	N/A	100
France	1831475	394962	13.9	1713686	-6	531848	35	16.6	1854856	8	509233	-4	14.9	2123493	14	540541	6	16.1	2096550	-1	693398	28	17.8
Germany	1618843	235527	8.3	1745948	8	309397	31	9.7	1895972	9	339104	10	10	1832134	-3	336362	-1	10	1761585	-4	384482	14	9.9
Netherlands	711580	177298	6.3	1016337	43	303691	71	9.5	857869	-16	278037	-8	8.2	889279	4	260594	-6	7.8	1397157	57	446145	71	11.5
Belgium	809659	134928	4.8	915029	13	179932	33	5.6	901470	-1	177363	-1	5.2	916399	2	161896	-9	4.8	929249	1	188029	16	4.8
Egypt	569120	218135	7.7	401043	-30	144228	-34	4.5	780737	95	263079	82	7.7	695405	-11	197278	-25	5.9	667195	-4	259484	32	6.7
Pakistan	464734	122499	4.3	397141	-15	78150	-36	2.4	414671	4	80964	4	2.4	688015	66	121291	50	3.6	618290	-10	114157	-6	2.9
United States of America	394522	175682	6.2	473877	20	197241	12	6.2	496097	5	213295	8	6.3	462568	-7	226461	6	6.8	520524	13	242615	7	6.2
China	400081	227406	8	410299	3	226260	-1	7.1	509921	24	279997	24	8.2	447454	-12	259664	-7	7.8	503178	12	396697	53	10.2

India	191714	49572	1.7	218938	14	59226	19	1.9	335307	53	57901	-2	1.7	335041	0	56669	-2	1.7	417048	24	76026	34	2
Canada	382222	151404	5.3	461998	21	198858	31	6.2	457437	-1	209602	5	6.2	449477	-2	222524	6	6.6	373561	-17	201589	-9	5.2
Russian Federation	144394	13717	0.5	215114	49	212247	55	0.7	166737	-22	19995	-6	0.6	147652	-11	15740	-21	0.5	289383	96	31163	98	0.8
Spain	274717	98546	3.5	259704	-5	123602	25	3.9	286005	10	98457	-20	2.9	248452	-13	99602	1	3	268957	8	128174	29	3.3
Kazakhstan	3092			48920	1482				267574	447				141694	-47				256302	81			
United Kingdom	184830	73716	2.6	189342	2	83204	13	2.6	176167	-7	68894	-17	2	167833	-5	79057	15	2.4	241768	44	108872	38	2.8
South Africa	155667	38569	1.4	116595	-25	42190	9	1.3	147567	27	47030	11	1.4	145673	-1	42935	-9	1.3	158619	9	39522	-8	1
ITC	1	2	3	4	5																		

ANNEX-V

List of Potato Exporters

1	A.S Enterprises	Muhammad Hammad Akram	87/A-6R Madhalla Sharif Sahiwal	0321-8600006 0331-8600006	as_enterprises@hotmail.com.uk	Potato, Onion
2	Abdul Malik & Co	Abdul Malik	Survey # 165, Block (A) Ground Floor, Thouming Tappu, Junjhar Goth Karachi	0344-2001234	fazalkhaliqamb@gmail.com	Mango,Kinnow,Potato
3	Adnan Enterprises	Muhammad Adnan Ashiq	Off: 09, Block DA, 1 New Sabzi Mandi super Highway, Karachi	0300-7045700 0321-7045700	adnan@adnanenterprises.com.pk adnan.enterprises@yahoo.com	Mango,Kinnow,Onion,Potato
4	Agrica MDS International	Binyameen Yousuf	Shop NO. 1-16, BLOCK DA, New Sabzi Mandi, Super Highway, Karachi	0332-3000300	mdskarachi@hotmail.com	Mango,Potato,Onion
5	Agro Development	Muhammad Ismail	H.NO. 54-G, Tawakkal House, GUJAR CHOWK, Manzoor Colony, Karachi	0344-7100007	agro_007@hotmail.com agrodevelopment@gmail.com	Mango,Potato,Onion
6	Ahmad & Sons	Asif Ahmad	Plot # 7, New Fruits & Vegetables Market, Super Highway, Karachi	021-111866-422	iac@iac-fruit.com	Mango,Kinnow,Potato
7	Ahsan Waqas Trading Co.	Syed Abdul Hameed	SHOP NO. 77,78,79,80 BLOCK-D4, ONION POTATO SEC. NEW SABZI MANDI SUPER HIGHWAY KARACHI.	0300-3437054	Hameedladkana@gmail.com	Potato, Onion
8	Aisha Enterprises Exporter Importer & Commission Agent	Muhammad Akhter	SHOP # L-16, BLOCK A-5, OPP. BILAL MASJID, NEW FRUIT MARKET, SUPERHIGHWAY, KARACHI.	0300-9250346	aisha.enterprises@hotmail.com mona_enterprises@gmail.com	Dates,Mango,Kinnow Potato,Onion
9	Al Firdusi	Syeeda Suallah Khalid	B-52 Rizwan Society, Main University Road Karachi	0300-8251062	alfirdusi@cyber.net.pk	Mango,Kinnow Onion,Potato
10	Al Shareed Enterprises	Shahjauddin Bilal	Office # 304, 3rd Floor, R.B.S Mall (Resham Bazar) Near Safari Park,Main University Road Karachi, Pakistan.	0300-2100921	info@alshareed.pk	Mango,Kinnow Onion,Potato
11	Anchor Trading Company	Sadiq Rajani	Suit No. 104, Saigal Brothers, Building No. 25, West Wharf Road, Karachi.	0322-2736960	imex.prime@gmail.com info@anchorfruits.com	Mango,Kinnow,Onion,Potato
12	Ansa General Trading	Khadija	Plot # E/7-C, Super highway Pase-2, Gulshan-e-Maymar, Karachi	0300-2134914 0322-3676786	ansageneraltrading@gmail.com	Mango,Kinnow,Onion,Potato

13	Ansari & Co	Rashid Imran	M-11, 1239/C Street # 51, Jinnah Road Shershah, Karachi	0321-8219994 0321-8219997	baba.afridi77@gmail.com	Potato, Onion
14	Arshad & Co.	Muhammad Arshad	Plot # 10, Sector I-11/A, Fruit Market, Islamabad	0300-8543809	arshco_muhammad@yahoo.com	Mango,Kinnow,Potato
15	Awan Traders	Malik Abdul Qayyum	344 - D, Satellite Town Sargodha Pakistan	0300-9600820	awanpak27@hotmail.com	Mango,Kinnow,Onion,Potato
16	Ch. International Citrus	Ch Iftikhar Hussain / Ishtiaq Ahmed	Chak No 16, S.B.Tehsil Bhalwal, District : Sargodha	0300-6026300 0300-6035916	ch.intl.citrus@gmail.com	Mango,Kinnow,Onion,Potato
17	Chase International	Mohammad Hanif	Suit # 803, Q.M. House, Plot # 11/2, RY-9, Elender Road, Old Pwer House, Off I.I. Chundrigar Road, Karachi	0324-2568804, 0302-2131354	wahid@chase.com.pk hanif@chase.com.pk	Kinnow Mandarins, Potato
18	Citro Fresh Processing Unit	Chaudhry Majid Ahmed	6-K.M Anjala Road, Chak 10. N.B. BHALWAL.	0300-8600422	citrofresh@hotmail.com	Kinnow Mandarins, Potato, Mango
19	Easy Deal	Riaz Ahmed Malik	Suit # 122 & 123, Ground floor, West point Tower, 12th Comm. Street, DHA, Phase II, Karachi	0301-3310767 0335-2876342	riaz.malik@msn.com info@easydealpk.com	Onion & Potato
20	Fahad Traders	Fahad	Shop L/5, Block A-2, New Fruit Market, Super Highway, Karachi	0345-2206261		Mango,Kinnow,Onion,Potato
21	Haji Sons	Tahir Saleem	65/13, Cavalry Ground, Lahore Cantt.	0300-8413374	info@hajisons.pk	Potato
22	Haji Ghulam Nabi Haji Ramzan Baloch & sons	Haji Ghulam Hussain Baloch	Shop # 161-162 Block DB-5, Potato Onion Section New Sabzi Mandi, Super Highway, Karachi	0300-2118807 0322-2206002	grtrading1965@gmail.com	Onion & Potato
23	Iftekhar Ahmed & Sons	Nadeem Ahmed	Plot No. 7, New Fruit & Vegetable Market, Super Highway, Karachi	0321-2423130	iac@cyber.net.pk	Mango,Kinnow,potato,onion
24	Imtiaz Enterprises	Imtiaz Hussain	2 & 3 KARACHI MARKET, NEW FRUIT VEGETABLE MARKET, SUPER HIGHWAY, KARACHI.	0333-2111495	info@imtiaz.biz	Mango,Kinnow,Onion,Potato
25	Kath Traders	Sultan Kath	Room No. 206, 2nd floor, Jilani Tower, G.K. 7/100, M.A. Jinnah Road, Karachi	0321-2809086	kathtraders@gmail.com kathtraders@ymail.com	Mango,Kinnow,Onion,Potato
26	Kathiawar Trading Co.	Muhammad Sadiq	Shop No. 85/88, Block D-4, New Fruit & Vegetable Market Super Highway, Karachi	0345-2480107	sadiqyusuf@hotmail.com	Onion & Potato
27	M. Yusuf & Sons	Abdul Khaliq Yusuf	Shop # 89-92, Block D-4, Onions & Potatoes Section, New Fruit & Vegetable Market, Super Highway, Karachi	0300-8235270	pakagritrade1@hotmail.com	Garlic,Ginger,Onion,Potato

28	OK Enterprises	Mumtaz ali Mujahid	H. No, L-3092-C, Block-2, Matrovill Scheme 33, Gulzar e Hijri, Karachi	0321-2429202	okimpexx@gmail.com	Kinnow mandarins,Mango,potato,Onion
29	Pakstar Fruits Export Company	Abdul Malik	43-H Gujjar Chowk Manzoor Colony Karachi	0333-2141796	pakstarfruits@gmail,com	Mango,Kinnow,Potato
30	Rishad Mateen & Co.	Abdul Mateen Siddiqui	Office : 22, 3rd Floor Mian Chamber, Shahrah-e-Liaquat, Karachi	0300-8276284	info@rishadmateen.com	Kinnow,Mango,Potato,Onion
31	Roshan Enterprises	Khalid Eijaz Qureshi	B-51 Rizwan Society, Main University Road Karachi	0300-8251062	roshan@roshan.org.pk	Kinnow,Mango,Potato,Onion
32	Shahjahan & Sons	Waqar Ahmed	OFFICE : 2 & 3 KARACHI MARKET NEW SABZI MANDI, SUPER HIGHWAY KARACHI.	0300-8244072	joubt2001@yahoo.com	Mango,Kinnow Onion,Potato
33	Shangri-la Fruits Pakistan	Ch. Shoaib Ahmed	6 Km Ajnala Road Bhalwal Distt. Sargodha.	0300-8601455	nfpfbhl@yahoo.com	Mango,Kinnow Onion,Potato
34	Sohail Haroon Corporation	Sohail Haroon / Ahmed Jameel	A-193 Block-19, Gulshan E Iqbal, Karachi	0300-2171552, 0324-4127057	rehmetwala@hotmail.com sohailharoon@gmail.com	potato onion
35	Sohan Traders	Zeeshan Ashiq	c-30 Rufi green Land Abul Hassan - Isphani Road Gulshan-e- iqbal Karachi	0333-3325028 0301-2247505	chudharyshani507@gmail.com	potato
36	Souvenir Trading Company	Haji Said Badshah	Survey # 165, (B) 1 Floor, Thoming Tappu, Junjhar Goth, Sohrab Goth Karachi	0334-5818567 0345-8250937	souvenirtradingkarachi@gmail.com	mango potato onion
37	Sunny International	Masood Ahmed Malik	Sunny International Iqbal Colony Dalazak Road Peshwar	0300-5900952, 0300-8590723	sunnymgt@hotmail.com, sunnymgt@brain.net.pk	Mango,Kinnow Onion,Potato
38	Union Fruit Export Pvt Ltd	Abdul Malik	H.NO. 54-G, Tawakkal House, GUJAR CHOWK, Manzoor Colony, Karachi	0333-2141796	unionfruit@gmail.com	Mango,Kinnow,Potato

ANNEX-VI

Compare Markets
For product 070190 – Potatoes, fresh or chilled : Other

Exported from Pakistan

MARKET	MFN tariffs	Effectively applied tariffs	Pref. Margin	Tariff year	# NTLC in the HS6 code	HS Revision	Import value in 2018	# PTA	# NTM	Distance
Afghanistan	20%	20%	0%	2018	1	HS12		1		666
Albania	11.25%	11.25%	0%	2020	4	HS17				4759
Algeria	30%	30%	0%	2020	3	HS17				6236
Angola	50%	50%	0%	2020	1	HS17				7453
Anguilla	0%	0%	0%	2020	1	HS17				12781
Antigua and Barbuda	5%	5%	0%	2020	1	HS07				12780
Argentina	10%	10%	0%	2019	1	HS17		1		15375
Armenia	10%	7.50%	2.50%	2020	3	HS17		1		2708
Aruba	0%	0%	0%	2019	1	HS12				13748
Australia	0%	0%	0%	2020	1	HS17		1		10463
Austria	9.60%	0%	9.60%	2020	4	HS17		1	68	5142
Azerbaijan	15%	15%	0%	2020	3	HS17	835			2381
Bahamas	0%	0%	0%	2018	1	HS12				13067
Bahrain	0%	0%	0%	2019	1	HS17	3762			1985
Bangladesh	25%	25%	0%	2020	4	HS17		1		2076
Barbados	30%	30%	0%	2013	1	HS07				12906
Belarus	10%	7.50%	2.50%	2020	3	HS17		1		4395
Belgium	9.60%	0%	9.60%	2020	4	HS17		1	68	5931
Belize	3.38%	3.38%	0%	2019	1	HS17				14363
Benin	35%	35%	0%	2020	1	HS17				7489
Bermuda	0%	0%	0%	2020	1	HS17				11717
Bhutan	50%	50%	0%	2019	1	HS17		1		1886

Bolivia (Plurinational State of)	10%	10%	0%	2019	1	HS17				15406
Bosnia and Herzegovina	22.66%	22.66%	0%	2020	3	HS17				4917
Botswana	0.05%	0.05%	0%	2020	1	HS17				7508
Brazil	10%	10%	0%	2019	1	HS17		1		13362
Brunei Darussalam	0%	0%	0%	2019	2	HS17	68			5374
Bulgaria	9.60%	0%	9.60%	2020	4	HS17		1	68	4344
Burkina Faso	35%	35%	0%	2020	1	HS17				7697
Burundi	25%	25%	0%	2020	1	HS17				5640
Cabo Verde	30%	30%	0%	2019	1	HS12				9609
Cambodia	7%	7%	0%	2014	1	HS12				4017
Cameroon	30%	30%	0%	2019	1	HS17			14	6689
Canada	0.86%	0.86%	0%	2020	1	HS17		1	47	11148
Cayman Islands	0%	0%	0%	2019	1	HS02				13847
Central African Republic	30%	30%	0%	2017	1	HS12				6079
Chad	30%	30%	0%	2016	1	HS07				5949
Chile	6%	6%	0%	2019	1	HS17			33	16324
China	13%	4.50%	8.50%	2020	1	HS17		1	86	4314
Colombia	7.50%	7.50%	0%	2019	1	HS17			28	14640
Comoros	5%	5%	0%	2019	1	HS17				5365
Congo	35%	35%	0%	2015	1	HS12				7044
Congo, Democratic Republic of	10%	10%	0%	2019	1	HS12				6574
Cook Islands	0%	0%	0%	2020	1	HS17				14885
Costa Rica	45%	45%	0%	2019	2	HS17			68	14887
Croatia	9.60%	0%	9.60%	2020	4	HS17		1	68	5053
Cuba	4%	4%	0%	2019	1	HS17				13497
Cyprus	9.60%	0%	9.60%	2020	4	HS17		1	68	3579
Czech Republic	9.60%	0%	9.60%	2020	4	HS17		1	68	5135

Côte d'Ivoire	35%	35%	0%	2019	1	HS17			1	8253
Denmark	9.60%	0%	9.60%	2020	4	HS17		1	68	5483
Djibouti	1%	1%	0%	2014	1	HS07				3408
Dominica	150%	150%	0%	2020	1	HS17			7	12874
Dominican Republic	20%	20%	0%	2020	1	HS17				13227
Ecuador	20%	20%	0%	2019	1	HS17			48	15590
Egypt	5%	5%	0%	2019	1	HS17		1		3819
El Salvador	15%	15%	0%	2020	1	HS17			1	14775
Equatorial Guinea	30%	30%	0%	2007	1	HS07				7076
Estonia	9.60%	0%	9.60%	2020	4	HS17		1	68	4764
Eswatini	0.19%	0.19%	0%	2020	1	HS17				7440
Ethiopia	30%	30%	0%	2018	1	HS12				3931
Fiji	0%	0%	0%	2020	1	HS17				12633
Finland	9.60%	0%	9.60%	2020	4	HS17		1	68	4898
France	9.60%	0%	9.60%	2020	4	HS17		1	68	6063
French Polynesia	0%	0%	0%	2020	1	HS17				15721
Gabon	30%	30%	0%	2019	1	HS07				7182
Gambia	35%	35%	0%	2020	1	HS17				9004
Georgia	12%	12%	0%	2015	3	HS12				2831
Germany	9.60%	0%	9.60%	2020	4	HS17		1	68	5543
Ghana	35%	35%	0%	2019	1	HS17				7849
Greece	9.60%	0%	9.60%	2020	4	HS17		1	68	4450
Grenada	0%	0%	0%	2019	1	HS12				13145
Guatemala	15%	15%	0%	2015	1	HS12				14743
Guinea	35%	35%	0%	2020	1	HS17			7	8842
Guinea-Bissau	35%	35%	0%	2020	1	HS17				9002
Guyana	30%	30%	0%	2020	1	HS17			18	13253

Haiti	15%	15%	0%	2020	1	HS17				13381
Honduras	15%	15%	0%	2018	2	HS17			50	14572
Hong Kong, China Special Administrative Region	0%	0%	0%	2020	1	HS17			19	4391
Hungary	9.60%	0%	9.60%	2020	4	HS17		1	68	4839
Iceland	0%	0%	0%	2019	2	HS17				7220
India	30%	30%	0%	2019	1	HS17		3	54	1003
Indonesia	20%	20%	0%	2019	2	HS17		1	54	5491
Iran (Islamic Republic of)	10%	10%	0%	2019	1	HS17				1895
Ireland	9.60%	0%	9.60%	2020	4	HS17		1	68	6667
Israel	106.97%	106.97%	0%	2017	6	HS17			90	3439
Italy	9.60%	0%	9.60%	2020	4	HS17		1	68	5398
Jamaica	40%	40%	0%	2011	1	HS07				13722
Japan	4.30%	4.30%	0%	2019	1	HS17		1	9	6171
Jordan	17.50%	17.50%	0%	2017	2	HS17			12	3346
Kazakhstan	10%	7.50%	2.50%	2020	3	HS17	4423	1	81	2027
Kenya	25%	25%	0%	2019	1	HS17				4886
Kiribati	0%	0%	0%	2020	1	HS17				11232
Korea, Republic of	304%	304%	0%	2018	1	HS17		2		5268
Kosovo	10%	10%	0%	2020	3	HS17				4620
Kuwait	0%	0%	0%	2019	1	HS17	4910		39	2206
Kyrgyzstan	10%	7.50%	2.50%	2020	3	HS17		1	75	1381
Lao, People's Democratic Republic	5%	5%	0%	2019	2	HS17			20	3573
Latvia	9.60%	0%	9.60%	2020	4	HS17		1	68	4741
Lebanon	94.29%	94.29%	0%	2019	1	HS17			9	3373
Lesotho	0.05%	0.05%	0%	2020	1	HS17				7926
Liberia	10%	10%	0%	2018	1	HS17			12	8793

Liechtenstein	90.96%	90.96%	0%	2019	2	HS17		2		5705
Lithuania	9.60%	0%	9.60%	2020	4	HS17		1	68	4703
Luxembourg	9.60%	0%	9.60%	2020	4	HS17		1	68	5815
Macao, China Special Administrative Region	0%	0%	0%	2020	1	HS17				4142
Madagascar	20%	20%	0%	2020	1	HS17			4	5870
Malawi	25%	25%	0%	2019	1	HS17			5	6180
Malaysia	0%	0%	0%	2014	1	HS12	5717	2		4518
Maldives	0%	0%	0%	2020	1	HS17	155	1		2810
Mali	35%	35%	0%	2020	1	HS17			7	8125
Malta	9.60%	0%	9.60%	2020	4	HS17		1	68	5266
Mauritania	5%	5%	0%	2019	1	HS12				8614
Mauritius	0%	0%	0%	2020	1	HS17		1	4	5641
Mayotte	5%	5%	0%	2013	3	HS12				N/A
Mexico	75%	75%	0%	2018	1	HS12				14212
Micronesia (Federated States of)	3%	3%	0%	2019	1	HS17				8822
Moldova, Republic of	6.25%	6.25%	0%	2016	4	HS12				4129
Mongolia	20%	20%	0%	2019	2	HS17				3571
Montenegro	15%	15%	0%	2020	3	HS17				4728
Montserrat	10%	10%	0%	2020	1	HS07				12696
Morocco	40%	40%	0%	2020	4	HS17			240	7202
Mozambique	20%	20%	0%	2018	1	HS17				6669
Myanmar	15%	15%	0%	2019	2	HS17				2888
Namibia	0.05%	0.05%	0%	2020	1	HS17			13	8045
Nauru	0%	0%	0%	2019	1	HS17				10644
Nepal	10%	9%	1%	2020	1	HS17		1		1359
Netherlands	9.60%	0%	9.60%	2020	4	HS17		1	68	5871
New Zealand	0%	0%	0%	2019	1	HS17		1	17	13124

Nicaragua	15%	15%	0%	2020	1	HS17			34	14774
Niger	35%	35%	0%	2020	1	HS17			5	6886
Nigeria	35%	35%	0%	2016	1	HS12				7129
North Macedonia, Republic of	36.67%	36.67%	0%	2020	3	HS17				4620
Norway	64.11%	54.46%	9.66%	2020	6	HS17		1		5663
Oman	0%	0%	0%	2020	1	HS17	4346		12	1365
Palau	0%	0%	0%	2019	1	HS17				3456
Palestine, State of	55.22%	55.22%	0%	2017	6	HS17				3517
Panama	81%	81%	0%	2013	1	HS12				14750
Papua New Guinea	40%	40%	0%	2019	1	HS17				9117
Paraguay	10%	10%	0%	2019	1	HS17			32	14858
Peru	6%	6%	0%	2019	1	HS17			29	16052
Philippines	40%	40%	0%	2020	2	HS17			90	5525
Poland	9.60%	0%	9.60%	2020	4	HS17		1	68	4899
Portugal	9.60%	0%	9.60%	2020	4	HS17		1	68	7214
Qatar	0%	0%	0%	2019	1	HS17	600		42	1917
Romania	9.60%	0%	9.60%	2020	4	HS17		1	68	4338
Russian Federation	10%	7.50%	2.50%	2020	3	HS17	9268	1	69	3595
Rwanda	25%	25%	0%	2020	1	HS17			9	5516
Saint Kitts and Nevis	5%	5%	0%	2020	1	HS17				9999
Saint Lucia	0.81%	0.81%	0%	2020	1	HS12				12950
Saint Pierre and Miquelon	0%	0%	0%	2020	1	HS17				10033
Saint Vincent and the Grenadines	20%	20%	0%	2020	1	HS07				13031
Samoa	20%	20%	0%	2018	1	HS12				13401
Sao Tome and Principe	10%	10%	0%	2019	1	HS17				7472
Saudi Arabia	0%	0%	0%	2017	1	HS17	3491		45	2687
Senegal	35%	35%	0%	2020	1	HS17			9	8998

Serbia	30%	30%	0%	2020	3	HS17				4606
Seychelles	0%	0%	0%	2020	1	HS17				4044
Sierra Leone	35%	35%	0%	2020	1	HS17				8902
Singapore	0%	0%	0%	2020	2	HS17	1804		8	4706
Slovakia	9.60%	0%	9.60%	2020	4	HS17		1	68	4873
Slovenia	9.60%	0%	9.60%	2020	4	HS17		1	68	5169
Solomon Islands	10%	10%	0%	2020	1	HS17				10420
South Africa	0.05%	0.05%	0%	2020	1	HS17				7934
Spain	9.60%	0%	9.60%	2020	4	HS17		1	68	6650
Sri Lanka	28.14%	28.14%	0%	2020	1	HS17	16251	4	30	2618
Sudan	40%	40%	0%	2017	1	HS17				4209
Suriname	5%	5%	0%	2020	1	HS07				12717
Sweden	9.60%	0%	9.60%	2020	4	HS17		1	68	5286
Switzerland	61.35%	61.35%	0%	2019	2	HS17		2	120	5705
Syrian Arab Republic	50%	50%	0%	2013	1	HS12				3235
Taipei, Chinese	15%	15%	0%	2020	1	HS17				4985
Tajikistan	15%	15%	0%	2020	3	HS12	3771			1028
Tanzania, United Republic of	25%	25%	0%	2019	1	HS17				5290
Thailand	125%	125%	0%	2015	2	HS12				3547
Timor-Leste	2.50%	2.50%	0%	2016	1	HS12	48			7247
Togo	35%	35%	0%	2020	1	HS17			8	7624
Tonga	15%	15%	0%	2017	1	HS12				13409
Trinidad and Tobago	0%	0%	0%	2008	1	HS07				13250
Tunisia	36%	36%	0%	2015	3	HS12				5639
Turkey	19.30%	19.30%	0%	2020	3	HS17		2		3702
Tuvalu	0%	0%	0%	2017	1	HS17				12158
Uganda	35%	35%	0%	2019	1	HS17				5105

Ukraine	10%	10%	0%	2019	3	HS12	12			3861
United Arab Emirates	0%	0%	0%	2019	1	HS17	16246		51	1539
United Kingdom	9.60%	0%	9.60%	2020	4	HS17		1	68	6304
United States of America	1.07%	0.53%	0.53%	2020	2	HS17		1	92	12216
Uruguay	10%	10%	0%	2019	1	HS17			37	15010
Uzbekistan	0%	0%	0%	2020	3	HS17	7473			1278
Vanuatu	30%	30%	0%	2017	1	HS17				11612
Venezuela (Bolivarian Republic of)	10%	10%	0%	2019	1	HS17			40	13776
Viet Nam	20%	20%	0%	2019	2	HS17			98	4079
Wallis and Futuna	4%	4%	0%	2019	1	HS12				12956
Yemen	25%	25%	0%	2017	1	HS17				3092
Zambia	25%	25%	0%	2018	1	HS17				6586
Zimbabwe	40%	40%	0%	2015	1	HS12				6818

List of Viruses in the World			
Virus[a]	Genus, family	Transmission	Distribution
Potato virus Y (PVY)	*Potyvirus, Potyviridae*	Aphids	Worldwide
Potato virus A (PVA)			Worldwide
Potato virus V (PVV)			Europe, South America
Wild potato mosaic virus (WPMV)			Andes, only reported in wild potatoes
Potato virus X (PVX)	*Potexvirus, Alphaflexiviridae*	Contact	Worldwide
Potato aucuba mosaic virus (PAMV)			Worldwide, very rare
Potato leaf roll virus (PLRV)	*Polerovirus*	Aphids	Worldwide
Potato virus S (PVS)	*Carlavirus, Betaflexiviridae*	Contact, aphids	Worldwide
Potato latent virus (PotLV)		Aphids	North America, rare
Potato virus M (PVM)		Aphids	Worldwide
Potato virus H (PVH)		unknown	China
Potato virus P (PVP syn. Potato rought dwarf virus: PRDV)		unknown	Brazil & Argentina
Potato virus T (PVT)	*Tepovirus, Betaflexiviridae*	Contact, seed	Southern Andean region
Andean potato mottle virus (APMoV)	*Comovirus, Secoviridae*	Beetles	Andean region, Brazil
Potato black ringspot virus (PBRSV = TRSV-Ca)	*Nepovirus, Secoviridae*	true seed, nematodes	Peru
Potato virus U (PVU)		nematodes	Peru, only reported once
Potato virus B (PVB)		nematodes?	Peru, recently reported, relatively common
Cherry leaf roll virus (CLRV)		Nematodes, TPS, pollen?	Europe, North & South America
Lucerne Australian latent virus (LALV)		Unknown	Australia and New Zealand, rare in potato
Tomato black ring virus (TBRV)		Nematodes	Europe, rare
Cherry rasp leaf virus (CRLV)	*Cheravirus, Secoviridae*		North America, only reported once
Arracacha virus B (AVB)		TPS, pollen	Andes

Virus[a]	Genus, family	Transmission	Distribution
Tomato spotted wilt virus (TSWV)	*Tospovirus, Bunyaviridae*	Thrips	Worldwide
Tomato chlorotic spot virus (TCSV)			South America
Groundnut bud necrosis virus (GBNV)			India
Groundnut ringspot virus (GRSV)			Americas
"Tomato yellow fruit ring virus" (TYFRV)			Reported from potato in Iran
Impatiens necrotic spot virus (INSV)			Worldwide, reported in greenhouse grown potatoes in USA
Andean potato latent virus (APLV)	*Tymovirus, Tymoviridae*	Beetles	Andean region
Andean potato mild mottle virus (APMMV)			Andean region
Potato yellow vein virus (PYVV)	*Crinivirus, Closteroviridae*	Whiteflies	Northern Andean region, Panama
Tomato chlorosis virus (ToCV)			Brazil, Spain, India
"Potato yellowing virus" (PYV)	*Ilarvirus, Bromoviridae*	Unknown	Andean region
Tobacco streak virus (TSV)		Pollen, thrips	Worldwide, reported in potato in Brazil
Cucumber mosaic virus (CMV)	*Cucumovirus, Bromoviridae*	Aphids	Worldwide, sporadic in potato
Alfalfa mosaic virus (AlMV)	*Alfamovirus, Bromoviridae*	Aphids	Worldwide, sporadic in potato
Tomato leaf curl New Delhi virus (ToLCNDV)	*Begomovirus, Geminiviridae*	Whiteflies	India
Tomato severe rugose virus (ToSRV)			Brazil
Tomato yellow vein streak virus (ToYVSV=PDMV)			Brazil, Argentina
Tomato mottle Taino virus (ToMoTV)			Cuba
"Solanum apical leaf curl virus" (SALCV)			Peru, only reported once
Potato yellow mosaic virus (PYMV)			Carribean
Beet curly top virus (BCtV)	*Curtovirus, Geminiviridae*	Leaf hopper	Americas, Europe, Asia under dry conditions

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Virus[a]	Genus, family	Transmission	Distribution
Potato mop-top virus (PMTV)	*Pomovirus, Virgaviridae*	Spongospora	Americas, Europe, Asia in cool and humid environments
"Colombian potato soil-borne virus" (CPSbV)		Spongospora?	Colombia, isolated from potato soils; CPSbV could infect potatoes symptomless
"Soil-borne virus 2" (SbV2)		Spongospora?	
Tobacco rattle virus (TRV)	*Tobravirus, Virgaviridae*	Nematodes	Worldwide, common in cool climates, or Australia
Tobacco mosaic virus (TMV)	*Tobamovirus, Virgaviridae*	Contact	Worldwide, rare on potato
Tomato mosaic virus (ToMV)			Europe, Andes, rare on potato
Tobacco necrosis virus (TNV)	*Necrovirus, Tombusviridae*	Fungus	Worldwide, rare on potato
Sowbane mosaic virus (SbMV)	*Sobemovirus*, unassigned	Contact	Worldwide, rare on potato
SB26/29 "potato rugose stunting virus"	Torradovirus-like, *Secoviridae*	Psyllids	Southern Peru
Potato yellow dwarf virus (PYDV)	*Nucleorhabdovirus, Rhabdoviridae*	Leafhoppers	North America, has become rare
Eggplant mottle dwarf virus (EMDV)		Aphids	Europe, Africa, Asia, occasionally infects potatoes
Cauliflower mosaic virus (CaMV)	*Caulimovirus, Caulimoviridae*	Aphids	Intercepted once in potato from South America
Potato spindle tuber viroid (PSTVd)	*Pospiviroid, Pospiviroidae*	Contact, aphids (when co infecting with PLRV)	Worldwide
"Potato stunt virus" (PStV)	?	?	Europe

Figure 135 List of Potato Viruses Worldwide Courtesy: The Potato Crop

ODE TO THE POTATO

Potato,
you are called
potayto,
not potahto;
you were not born with a beard,
you are not Castillian.
You are dark
like
our skin;
we are Americans,
potato,
we are Indians.

You are
gentle and profound,
pure pulp, a pure
buried
white rose;
you flower there inside
the earth,
are showered by
original
earth
of wet islands,
by tempestuous Chile,
by the Chilean sea,
an emerald that pours
its green light
out upon the austral ocean.

Potato,
sweet
matter,
almond
of the earth,
the sediment
there
does not possess
dead metals;
there, in the obscure
softness of the islands,
no one fights for
copper and its submerged
volcanoes,
or the blue cruelty
of magnesium.
Hands planted you
in the moist ground
as though stocking a nest.
And when
the thunder
of that evil
war,
the Spanish
conquest,
black as an eagle of the grave,
sought savage gold
in the burning
matrix
of the Araucanias,
its greedy
ones
were exterminated,
its leaders
died,
and when

You are honorable
like
hands
that till the soil,
like
a hen
you're a member of the family,
are compact as a cheese
that the earth pours out
from its nourishing
udders;
enemy of hunger,
in all
nations
you've planted
your victorious and ready
banner,
in frozen land or in the ground
of burning coastlines
your anonymous flower
has appeared,
announcing the thick
and steady
birth rate of your roots.

Universal delight,
you don't await
my song,
for you are deaf
and blind
and buried.
Cooked in an inferno
of oil
you scarcely speak,
nor do you sing

the poor ruined captains returned to stony Castile in their hands they raised not a golden goblet but a potato from the Chilean sea.	in the fried-fish shops of the harbours; when close to the guitars you are silent, potato, meal of the subterranean night, interminable treasure-trove of the people.
Pablo Neruda	

ANNEX-IX

Continent/Country/Region	Distribution	Last Reported	Origin	First Reported	Invasive	Reference	Notes
AFRICA							
South Africa	Present		Introduced			Randall (2012)	Noxious weed
ASIA							
China	Present		Introduced			Flora of China Editorial Committee (2014)	
India	Present		Introduced			USDA-ARS (2014)	
Japan	Present		Introduced		Naturalized	Randall (2012)	Naturalized
Pakistan	Present, Only in captivity/cultivation					Flora of Pakistan (2014)	
Taiwan	Present					Taiwan Plant Names (2014)	
Turkey	Present					Holm et al. (1979)	
EUROPE							
Denmark	Present		Introduced			Randall (2012)	Cultivation escape
Finland	Present		Introduced			Holm et al. (1979)	Cultivation escape
Spain	Present					CABI (Undated a)	Present based on regional distribution.

Continent/Country/Region	Distribution	Last Reported	Origin	First Reported	Invasive	Reference	Notes
-Canary Islands	Present		Introduced		Naturalized	Randall (2012)	Naturalized
United Kingdom	Present		Introduced			Randall (2012)	
NORTH AMERICA							
Cayman Islands	Present, Only in captivity/cultivation		Introduced			Acevedo-Rodríguez and Strong (2012)	
Costa Rica	Present					Flora Mesoamericana (2014)	
Cuba	Present, Only in captivity/cultivation		Introduced			Acevedo-Rodríguez and Strong (2012)	
Dominican Republic	Present, Only in captivity/cultivation		Introduced			Acevedo-Rodríguez and Strong (2012)	
Haiti	Present, Only in captivity/cultivation		Introduced			Acevedo-Rodríguez and Strong (2012)	
Jamaica	Present, Only in captivity/cultivation		Introduced			CABI (Undated b)	
Mexico	Present					USDA-ARS (2014)	
Nicaragua	Present					Flora Mesoamericana (2014)	
Panama	Present					Flora Mesoamericana (2014)	
Puerto Rico	Present		Introduced			Acevedo-Rodríguez and Strong (2012)	

Continent/Country/Region	Distribution	Last Reported	Origin	First Reported	Invasive	Reference	Notes
United States	Present					CABI (Undated a)	Present based on regional distribution.
-Hawaii	Present		Introduced		Naturalized	Wagner et al. (2014)	Naturalized on Maui
-Missouri	Present		Introduced			Flora of Missouri (2014)	
-North Carolina	Present					Randall (2012)	Weed
OCEANIA							
Australia	Present		Introduced			Randall (2012)	
-Queensland	Present		Introduced			Randall (2012)	Environmental weed: cultivation escape
New Zealand	Present		Introduced		Naturalized	NZPCN (2014)	Naturalized in 1853
Papua New Guinea	Present, Only in captivity/cultivation		Introduced			Symon (1986)	
Vanuatu	Present					Randall (2012)	
SOUTH AMERICA							
Argentina	Present					USDA-ARS (2014)	
Bolivia	Present		Native			USDA-ARS (2014)	Chuquisaca, La Paz, Oruro, Potosi, Cochabamba
Chile	Present					USDA-ARS (2014)	

Continent/Country/Region	Distribution	Last Reported	Origin	First Reported	Invasive	Reference	Notes
Colombia	Present					USDA-ARS (2014)	Guarne, La Unión, Marinilla, Medellín, San Vicente
Ecuador	Present					USDA-ARS (2014)	Prov. Cañar, Carchi, Chimborazo, Cotopaxi, Galapagos, Napo, Pichincha, Sucumbíos, Tungurahua
Peru	Present					USDA-ARS (2014)	
Venezuela	Present					USDA-ARS (2014)	