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Potatoes: ensuring food for the future

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Introduction

Potato (*Solanum tuberosum* L.) is originally a native of South American continent, where it used to grow as wild plant right from about 7000 to 9000years ago. In India, it was introduced by Portuguese during early 17th century; further British took potato to hills in Northern India. It is the single most popular vegetable-tuber crop grown in more than 100 countries of the world. With global production of 356million tonnes, India is producing over 45million tonnes of potatoes at an average productivity of 23tonnes per hectare (2013-14) which is second only to China. Potatoes are one of the staple foods of the world. It have been used as emergency food rations in Ireland when the crops were burned, and hoarded in Russia where is called "second bread". Potatoes are relatively easy to grow, provide complex carbohydrates for nutrition, can be stored, and are genetically complex that allows a diversity of genotypes for any climate, culture and conditions. Being a wholesome food rich in vitamins and minerals, potato will play an important role in this scenario. One of the reasons that potatoes are popular throughout the world is that they can be vegetative propagated. This allows growers, large or small, to save some of the crop to replant as seed potatoes to both increase the food supply, and maintain a desired variety. Potato produces highest food energy per unit of land. It's a short duration crop. It has become an integral part of the Indian diet and its usage is on the rise. It is no more a vegetable crop in view of its production potential and nutritional value. However, challenges are much greater than before as we have to feed 17% of the world population from declining land and water resources. With immense potential, Potato has been declared as a Future Food crop by FAO, Rome in the year 2008, and is the major contributor towards food security. Poverty, malnutrition of our burgeoning is persistent problem of the state and Nation. Asia has some of the highest levels of rural poverty globally, combined with high malnutrition rates for women and children under 5. Therefore food and nutritional security are important state/national priorities. Potato is the most important vegetable consumed by the people which have all virtues to address the above issues. Mostly, in India potato is cultivated for table, processing and seed production. Basically potato is a crop of temperate region. However, in the sub-tropical plains of India Potato crop is raised when maximum day temperature is below 33°C and night temperatures are not above 20°C. In India, is cultivated in almost all the states under very diverse conditions. Nearly 85-90% of potatoes are grown, in vast indogangetic plains of North India during short winter days from October to march. About 3-4% area under potato cultivation lies in the hills where crop is grown during longer summer days from April to October.

With increasing population, the country faces the challenges of ensuring food and nutritional security. Over million people of those living in Sub-Saharan Africa and Asian, which makes it these region with the highest proportion of undernourished in relation to the total population. Put together China and India are home to around 42% of the world's undernourished people. The world as a whole produces a sufficient amount of food. However, poverty, a lack of infrastructure, and a lack of land rights contribute to the current unequal distribution. For example, women lack the possibility of owning land or property, and therefore also lack access to credit, in many countries. This illustrates the lack of fulfilments of many richer countries' commitments to eradicating hunger and malnourishment.

Challenges in international agriculture

Asia today faces a tremendous food security challenge to feed its 4.3billion people. Many Asian countries are also some of the lowest lying and most vulnerable to the extremes of climate change. Over-intensification from monocropping, including poor irrigation practices, has compromised the quality of arable land. Frequent droughts and flooding have increased salinity, degrading soil quality further. Population growth over the next few decades will continue to be concentrated in cities, and precious farmland will increasingly be lost to roads and buildings. Asian economies and farming systems are inextricably bound to a small number of cereals, as are Asian diets: more than 500million of the absolute poor depend on rice. Rice, wheat, and other grains are traded internationally and are subject to market fluctuations, which have caused the price of food to spike dramatically in recent years. Poor populations also continue to experience nutrition vulnerability due to low levels of diet diversification with limited micronutrient content and the relatively low economic value of cereals. Asia has the highest concentration of poverty worldwide, and high malnutrition rates among women and children under five are responsible for high levels of infant and maternal morbidity and mortality. Economic and social exclusion, largely due to gender, caste, and ethnic discrimination, intensifies the problems of poverty and malnutrition. Strategies to address food and nutrition insecurity here are urgently needed.

Food security - improving access to safe and nutritious food

Many people and communities, mainly in rural areas, do not have physical or financial access to food year round. Undernourishment causes a downward spiral of bad health that frequently ends in death. Finding new ways to ensure food security is therefore important. One promising approach is increased potato cultivation (Figure 1).

Potatoes are either consumed directly or they are processed to give products such as chips and French fries, mashed and canned potatoes. Value addition of potato contributes to crop diversification, improves the farmer's income and nutrition and provides value export and additional employment. Potatoes with special attributes like colored skin/flesh having more anthocyanins, better taste or texture, nutritionally superior (zinc and iron rich, anthocyanin/carotene/

antioxidants rich) or having low glycemic index are also becoming popular. These specialty potatoes fetch premium prices in market this can be potential value added products in coming future.

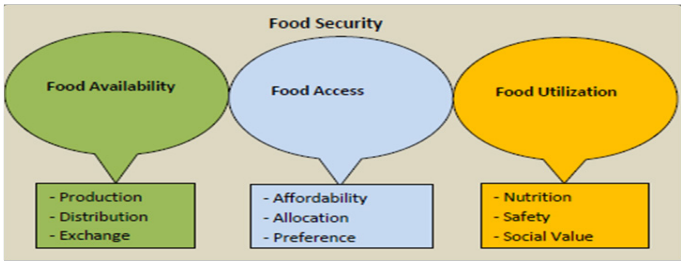

Figure 1 Basic components of Food security.

Potatoes can feed the hungry

The potato can provide nutritious food for the poor and hungry in the developing world. Potato cultivation is ideally suited to places where land is limited and labour is abundant, a picture in which many developing countries fit into. Compared with other major crops the potato produces more nutritious food more quickly, on less land and in harsher climate. Most of the potato plant is also edible human food. When people have access to a sufficient amount of nutritious food they are better equipped to make a decent living.

Poverty alleviation

Many farm families are caught in a poverty trap in which limited livelihood options conspire to keep them poor. Local markets are facing outside competition from a wide range of suppliers due to globalization and urbanization. This means that small scale farmers need to become more competitive and learn to engage with markets. Not only can potatoes feed the hungry they can also be an important source of income so that people can make a living.

Demand for potatoes is growing

Potato is the world's number one non-grain food commodity. World potato production has increased at an annual average rate of 4.5 percent over the last 10years. The growth in potato production has exceeded production of many other major food commodities in the developing world. While consumption of potato has declined in the rich countries, it has increased in the developing world. If we look back 20years the production in developing countries stood at around 20percent. In fact Sub-Saharan Africa is sometimes referred to as the main engine of potato growth. China is the world's biggest potato producer and the Chinese authorities are reviewing proposals for potato to become the country's major food crop. India is the world's second biggest potato producer and the Indian authorities are considering plans to double potato output in the next five to ten years. These plans are more than welcome considering that many of the world's undernourished people live in these countries.

The international year of potato, 2008 strategy

Of course one single year is not sufficient for solving world hunger and poverty. Therefore the International Year of the Potato should be seen as a first step or as a catalyst for long-term, country-driven development programmes around the world. Different ways in which the IYP work has been performed so far during the year and how it will be performed during the time that remains. The aim is to heighten global awareness of the role of the potato and to enhance appreciation among the public of agricultural, nutritional, environmental, social issues and food systems in general. Another point is to the right roughly involves technologies and management practices. The aim is to enhance mechanism for ensuring local empowerment and to enhance international cooperation related to potato production and agriculture (Figure 2).

In 2008, several international organizations highlighted the potato`s role in world food production, in the face of developing economic problems. They cited its potential derived from its status as a cheap and plentiful crop that grows in wide variety of climatic and locales. Due to perish ability, only 5% of the world`s potato crop is traded internationally; its minimal presence in world financial markets contributed to its stable pricing during the 2007-2008 world food price crises. The United Nation declared 2008 as the International Year of Potato, to raise its profile in developing nations, calling the crop a" hidden treasure".

Figure 2 Sustainable potato production.

Wild potato species in jeopardy

The growing temperature increase puts additional pressure on the potato's wild relatives. 16–22% of all wild potato species are threatened with extinction by the year 2055. This is a dangerous situation, since wild relatives are important gene pools for breeding new varieties.

Wild relatives play an important part in breeding abiotic stress tolerant varieties. Their great genetic variability makes them important genetic resources for producing the desired characteristics. Until now, wild relatives have rarely been used for breeding purposes because they frequently have many undesirable characteristics aside from the desired ones. Breeding with wild relatives still needs time to be further developed, since it requires sound experience. Climate change and other factors that additionally increase pressure on ecosystems are threatening the existence of many wild relatives. The establishment and maintenance of gene banks is intended to curb the loss of this diversity in varieties.

Climate change and its impact

Along with the familiar difficulties related to pests and diseases, potato farmers are increasingly confronted with abiotic problems. Farmers and researchers report an increase in water stress, changes in rainfall distribution and intensity, hail, and increasingly frequent frost and snowfall at high altitudes. The growing frequency of extreme

weather events is generally interpreted as clearly related to climate change. Global climate warming is an unequivocal fact. Projections by the IPCC predict a rise in global temperature by 1.8–4°C by the year 2100 due to the increase in greenhouse gases, depending on the scenario. This is expected to have grave consequences for mankind and the environment. The critical threshold is said to be around a temperature increase of 2°C. Approximately 15% of the total worldwide greenhouse gas emissions are caused by agriculture. An additional 11% result from deforestation, mainly for the purpose of gaining cropland. Carbon dioxide (CO_2) emissions in agriculture are chiefly caused by the use of fossil fuels during all kinds of agricultural activities, as well as tillage, burning of crop residues, and slash-and-burn deforestation. In addition, agriculture produces around half of the global methane (CH_4) and nitrous oxide (N_2O) emissions. These two greenhouse gases are many times more potent than carbon dioxide. The main sources of CH_4 are livestock production, irrigated rice cultivation, and storage of manure. N_2O is released into the atmosphere through the soil following the inadequate application of artificial fertilisers and manure. By taking appropriate measures, agriculture has the possibility of reducing greenhouse gas emissions and thereby actively contributing to the mitigation of climate change (Figure 3) (Figure 4).

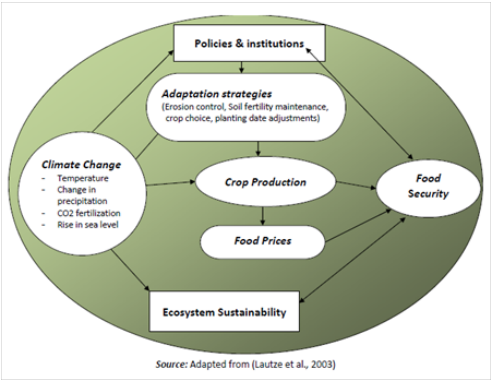

Figure 3 Climate change, yield and food security.

Figure 4 Consequences of flow chart.

Rising temperatures: A blessing and a curse…

A rise in temperature leads to increased transpiration in the plants, thus raising their demand for water. In many of the drier potato growing regions this will cause water stress, leading yields to decline. The effect will be further aggravated by changes in rainfall distribution. Where there is no possibility of irrigation in these regions yields will decrease even further, down to the extent where potato growing will become altogether impossible. For several countries, particularly in the tropics and subtropics, yield declines are expected to reach up to 20–30%. Overnight temperature has a crucial influence on starch deposition in potato tubers. The ideal temperature range is between 15 and 18°C. Overnight temperatures above 22°C severely hamper tuber development. By contrast, the impact of climate change on potato yields is expected to be favourable in cultivation areas at higher altitudes. In many of these areas the climatic conditions for potato growing are improving due to the rising temperatures. This boosts yields and leads to an expansion of potato production to both higher altitudes and higher latitudes. In some regions it will become possible to grow potatoes as a winter crop. However, the expansion of potato cultivation to higher altitudes also bears risks. High-altitude cropland is often situated on steep slopes, where growing potatoes can aggravate soil degradation due to the high degree of tillage involved. More research needs to be done regarding the effect that the stronger ultraviolet radiation at higher altitudes has on potatoes.

Transforming livelihoods with early-maturing potato

Several Asian countries are already diversifying their farming systems while making the intensification of existing systems more sustainable. This is helping to increase economic and nutritional value and ease the strain of food price inflation. Early maturing agile potato varieties, particularly a 70 to 90day potato resistant to heat and viruses and with good processing quality, are a profitable and nutritious complement to low-income cereals in sub-tropical lowlands and highlands of South China, North Vietnam, Bangladesh, India, and the plains of Nepal and East Pakistan. In Central Asia, the crop offers a valid alternative to fallow between two consecutive wheat crops, thus creating huge opportunities for potato cultivation.

It can be adapted to a wide range of cropping systems in subtropical, temperate, and highland environments to help low-income consumers cushion the impact of food price inflation and achieve higher incomes from on-farm and added- value options. These potato varieties provide flexible planting and harvesting times without putting undue pressure on dwindling land and water resources.

Climate change: pest and pathogens

The phrase 'Climate change' is growing in preferred use to 'global warming' because it helps to convey that there are (other) changes in addition to rising temperatures." In other words, "climate change" means major changes in temperature, rainfall, snow, or wind patterns lasting for decades or longer. Global warming is an average increase in temperatures near the earth's surface and in the lowest layer of the atmosphere. Global warming can be considered part of climate change along with changes in precipitation, sea level, etc. Global change is a broad term that refers to changes in the global environment, including climate change, ozone depletion, and land-use change. Climate change is affecting our agriculture due to average global increase in temperature in the last 100years and atmospheric CO_2 concentration increase from 280ppm in 1750 to 4000ppm in 2013. World-wide losses due to diseases range from 9 to 16% in rice, wheat, barley, maize, potato, soybean, cotton and coffee. This range is increasing year by year this might be due to climate change, through a number of interactions, take place among host, pathogen, potential vectors and the environment. Epidemiological measures *viz.*, temperature, rainfall, relative humidity, wind, atmospheric pressure, sunshine and Greenhouse gases *viz.*, CO_2 concentration, N_2O and CH_4 are the major factors responsible for plant disease development. Changes in environmental conditions are strongly associated with differences in the level of losses caused by a disease because the environment significantly (directly or indirectly) influences plants, pathogens

and their antagonists. The changes associated with global warming (i.e., increased temperatures, changes in the quantity and pattern of precipitation, increased CO_2 and ozone levels, drought, etc.) thus, may affect the incidence and severity of plant disease and influence the further co-evolution of plants and their pathogens. Fungal pathogens are often strongly dependent on humidity or dew for plant infection. Temperature can direct affect the multiplication of pathogenic bacteria, influencing the incidence of disease development. Viruses may be present in hosts while symptom expression is dependent on temperature. For example, CO_2 increases fungal spore production of *Colletotrichum gleosporides*. CO_2 reduces the pathogen- which enters through stomata *Phyllosticta minima* – Red maple 26.8ºC with more than 80% RH is congenial for *Phytophthora species*. Bacteria are highly favoured by high soil temperatures. Downey mildew occurs at high relative humidity (>90%) and low temperature (<24ºC). Powdery mildew occurs at higher temperature (27ºC) and low relative humidity (80%). Similarly mite population increases during driest month with warmer weather and low RH. Heavy rain depresses the mite population. Strong winds contribute to mite distribution. Some insect pathogens develop more rapidly by increasing temperature. For example Colorado beetle and Aphid population increased in high temperature. Leaf hopper increases its population during summer. Grass hoppers, snail and slug population increased during rainy season. From the beyond confer appraisal, temperature; relative humidity; rainfall; sunshine; elevated CO_2 are the major factors responsible for the disease development as either they are increases or decreases. This information is indicating the role of climate change factor on plant disease development.

Discussion

The potato is a wholesome food with all the extremely important and necessary dietary constituents which are need for health and growth. Compared to other roots and tubers and also many cereals, potato tubers have a high ratio protein to carbohydrates with a high nutritional value of the protein. Although potatoes have been traditionally used as food after baking, boiling or roasting, their commercial value has increased considerably when they are processed into edible product that appeal to consumers due to flavour; texture, appearance and most of all convenience. Potato is a highly nutritious, easily digestible, wholesome, unique food, because it can be consumed as boiled or fried or processed, all with equal culinary delicacy, perhaps no other food crop has such an inherent capacity as the potato to produce so many different processed products, which can be enjoyed across the generation gaps. The majority of the world's potatoes are grown in India and China, though its cultivation is better suited to cooler climates. With the climate heating up, those areas may soon be forced to grow alternative crops. If we look to potato, it has been thermo-sensitive and was only productive under long day conditions in temperate climate. Temperature controls the plant growth, development and yield and day degrees are normally used to quantify its effect.

Climate change, a global phenomenon, is a concern for food and nutritional security of growing population, expected to be 9.5billion at the end of 2050, and has attracted global, regional and national dialogues for mitigation and adoption strategies. The likely effects stipulated are occurrence of drought and floods, change in rainfall pattern and sudden change in temperatures, which will have impact on the growth pattern of plant, flowering, fruiting and yield and quality of produce, besides increasing vulnerabilities to pest and diseases. Growth stages are shortening, leading to early maturity and reduction in yield. It will also impact on the viability of rainfed potato production and demand for supplemental irrigation. Because of increases in temperature, future potato yields could decrease in many regions. In some regions, mainly intemperate regions, yield decline can partly be avoided through adaptation. Yields may even go up at high latitudes because of a lengthening of the growing season.

Climate change scenario is supposed to adversely affect potato production and productivity in India. Modelling research at CPRI suggests that by the year 2020 potato yield is estimated to fall by 19.65% in the state of Karnataka followed by Gujarat (18.23% fall) and Maharashtra (13.02% fall) with an overall fall of 9.56% at national level if needed steps are not taken to mitigate the effects of climate change. The situation is expected to further worsen by the year 2050 when the national level potato production is expected to fall by 16% in the absence of needed steps. However, the potato production fall may be much severer in the states of Karnataka (45% fall), Gujarat (32% fall), Maharashtra (24.5% fall) and Madhya Pradesh (16.5% fall) if preventive steps are not taken.

In the future, higher summer temperatures and elevated CO_2 levels should provide more favourable growing conditions. But reduced summer rainfall, coupled with an increased frequency of extreme events and higher energy and fertiliser costs, will inevitably threaten rain fed and irrigated yields. For growers, climate change presents an opportunity to increase potato yield, but getting the right amount (and timing) of both water and fertiliser applications will be key. To achieve this, growers will need better information to manage climate uncertainty and match crop demands to environmental conditions. Changes in soils and agroclimatic conditions will influence cultivar choice, agronomic husbandry practices, and the economics of production. If rainfed production becomes limiting due to excessive draughtiness, then securing access to water for irrigation will become essential. The genetic variability in heat tolerance, pest and disease resistant among different potato varieties is limited and it is unlikely that more heat-tolerant potato varieties will be available to farmers in the near future. Water shortages due to current over-use of resources, an increasing demand for water from other sectors and possibly climate change are likely to restrict irrigation and increase costs of irrigating potatoes across India in future. These should further encourage potato farmers to adapt practices, such as planting times, in order to optimise water use efficiency. It is clear that the most likely changes in production practices to adapt to climate change are related to planting time, crop duration and water management, which are all interrelated with technological developments. Both researchers and farmers see an urgent need for breeding new potato varieties that are better adapted to the changing climatic conditions. Particular efforts in this respect are made at the International Potato Centre (CIP), where the main focus is on breeding short-season varieties. Due to their shorter vegetation periods, these varieties make it easier for farmers to avoid unfavourable conditions such as hot or dry periods and react to modified rainfall patterns. Developing of new cultivars tolerant to high temperature and producing better yield under stress conditions will be the main strategies to meet these challenges. We also assume that growers will introduce and use varieties with an earliness or lateness such that their growth cycle matches that of the shortened (winter) or lengthened (summer) seasons. Keeping in view the nature of crop, its sensitivity level and the agro-ecological region, the crop-based adaptation strategies need to be developed, integrating all available options to sustain the productivity. Developing strategies

and tools to comprehensively understand the impact of climate change and evolve possible adaptation measures in horticultural crops is less understood. To enhance our preparedness for climate change and to formulate a sound action plan, we need to identify gaps in vital information, prioritize research issues from point of view of farmers, policy-planners, scientists, trade and industry. It is imperative to visualize likely changes which can happen in next 50-100 years, how these changes could affect growth, development and quality of horticultural crops, what are the technologies which shall help to mitigate the problem and what kind of innovative research should be done to overcome the challenges of climate change. Thus, policy issues, adaptation strategies and mitigation technologies could be worked out and challenges could be converted into opportunity. Considerable efforts are required to develop the knowledge and capacities to make climate smart horticulture a reality.

Finally, there should be a greater commitment of the various stakeholders and significant investments and expenditures in the agricultural sector to reduce the adverse impacts of climate change in Asian sub-continent. We must have also to enhance the knowledge to address all the strategies which can convert the challenges into opportunity.

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Conflict of interest

The author declares no conflict of interest.