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Impact of climate change on potato cultivation: A global perspective

Kumari Shiwani[1]*, Aanchal Chauhan[2] and Nirmal Singh[3]

[1&2]College of Horticulture and Floriculture, Thunag, Mandi, India

[3]KVK, Angad Guru Dev Veterinary and Animal Science, TaranTaaran

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The effect of climate change in the agriculture sector is distributed unevenly across the globe. This sector is contributing to climate change not only by anthropogenic emissions of greenhouse gases but also by conversion of non-agricultural land mainly forests into agricultural land. Climate change has been perceived as a threat and will have an impact on horticultural crops, due to erratic rainfall, more demands for water, and enhanced biotic and abiotic stresses. However, the changes will not only be harmful, as enhanced CO2 concentration may enhance photosynthesis, and increased temperature may hasten the process of maturity. Increased temperature will have more effect on reproductive biology and reduced water may affect productivity but adaptive mechanism like time adjustment and productive use of water shall reduce the negative impact.

Potato is a valuable food commodity from the nutritional and economic perspective that feeds more than a billion people worldwide. The leading continents in potato production are Asia (42.5%) and Europe (38.8%) which are dominating the world potato markets. Potato is well suited to cold climate. It is widely cultivated in temperate, subtropical, and cool tropical regions, as monocrop, in crop rotation or multiple cropping systems. In subtropical climate, potato is well adjusted in a range of cropping systems. In temperate zones, cold temperatures confine potato production to one growing season per year as a monoculture. In northern Europe and North America, potato production is generally carried out with intensive farming practices such as high rates of fertilization, pesticide use, and necessary irrigation.

At high altitudes areas of India, global warming will probably lead to changes in the time of planting, the planting of late-maturing cultivars, and a shift of the location of potato production. In many of these regions, changes in potato yield are likely to be relatively small

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in the initial stage but expected to trigger in the coming era of global warming. Shifting planting time or location is less feasible at lower altitudes, and in these regions, global warming could have a strong negative effect on potato production. The past projections and historical trends estimated that growth rates in potato production in developing countries for the period 1993–2020 are between 2.02–2.71%. The potato production will be directly affected by climate change, while there would be several indirect effects on various facets of supply, storage, utilization, and acreage of the crop in future climate scenarios

Impact of climate change on potato

Potato crop cycle is sensitive to changes in temperature and humidity, which ultimately have direct and indirect effects on its productivity. The first notable expression of climate change relates to higher temperatures. Apart from temperature, disease, and pest build-up, under elevated temperature and CO2 can significantly affect potato production globally.

Rise in temperature

An increase in temperature has most likely adverse effects on potato yield as it affects the growth and development of potato. For several countries (especially in tropics and subtropics) up to 20–30% yield declines are expected. The temperature during the night plays a crucial influence on starch deposition in potato tubers. Night temperatures above 22°C severely hamper tuber development. The highest tuber yield of potato is obtained under short-day (12 hr photoperiod) condition at 20ºC. The higher temperature throughout the season resulted in a shorter growth cycle in the Netherlands A study reported that, due to the rise in temperature, 16–22% of all wild potato species are on the verge of extinction by the year 2055. It is an alarming situation, as wild relatives are crucial gene pools for breeding new varieties. Hijmans (2003) predicted that without adaptation, most of the leading potato-producing countries of the world would suffer losses in potential yield. Results (for selected countries) showed that potential potato yield could be severely affected if no adaptation to variation is allowed (19-32%) whereas with adaptation the potential yield decreases (2–24%), but more significant differences between regions exist. Here, adaptation is defined as changes in the month of planting or the maturity class of the cultivar. Simulation studies carried out in India indicate that rise in temperature will result in a change in potato productivity in selected

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parts of Bihar, Madhya Pradesh, and West Bengal under future climate scenarios of 2020 over the baseline scenario, whereas some parts of Punjab will get the advantage in terms of high potato yield due to temperature rise in 2020.

Higher yields due to higher CO2 concentration

Effect of elevated CO2 level in controlled experiments conducted in Open top chambers (OTC), free air carbon enrichment (FACE), and growth chambers suggest a positive effect on growth and yield of potato with only a few negative influences. Increase in tuber yield is estimated to be approximately 10% for every 100 ppm increase in CO2 concentration. These positive effects are attributed to increased photosynthesis from 10 to 40%. Simulation analysis indicated that CO2 levels of 700 ppm could increase tuber yield (20- 30%) while FACE studies showed an increase in tuber yield by >40% at the rate of 10% per 100 ppm increase in CO2. In potato, considerable response to rising atmospheric CO2 is expected due to its large below-ground sinks for carbon and efficient phloem loading mechanism. CO2 concentration and assimilation are positively correlated in potato. Few adverse effects of elevated CO2 concentration include a reduction in chlorophyll content in leaves, particularly during the later growing season after tuber initiation. Then in the season, leaf photosynthesis is also likely to decrease progressively in the higher CO2 environment due to senescence. Leaf N concentration is reported to deplete faster in the leaves grown under an elevated CO2 environment, which further supports the conclusion that leaf senescence gets accelerated in the plants grown under high CO2. The combined effect of temperature change and increased CO2 from simulation studies in India shows that the productivity of potato cultivars will not be affected in 2020 over the baseline scenario, but might decline slightly in 2055 at Punjab, whereas in West Bengal and Bihar, the combined effect of temperature and increased CO2 shows that potato productivity will decrease to a high level.

Impact of diseases and pests on potato

Many potato growing regions of the world will face an increase in temperature and precipitation which ultimately make warmer and wetter conditions, favorable for late blight (especially in temperate areas). Work in Finland has predicted that for each 1oC warming late blight would occur 4-7 days earlier, and the susceptibility period will be extended by 10-20

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days. Late blight is also expected to expand into areas that have previously been relatively safe

from this disease. According to an estimate, the yield loss would be 2 t/ha for each 1°C increase in temperature. Further, fungicide applications (1-4) will be required to manage the disease, thereby increasing both farmer costs and environmental risk. Insects (aphids and whiteflies) are the vector of many viral and mycoplasmal diseases of potato. A 2°C rise in temperature in temperate climate zones could result in one to five additional life cycles of certain insects per season. An increase in temperature (2°C) may result in a shift of certain insects such as aphids, whiteflies, leafhopper population which can bring an increase in the geographical area in the range of their infestation. Experiences from Peru (Canete Valley) revealed that whiteflies could develop resistance to pesticides and multiply fast at high temperature. The multiplication rate of most of the potato viruses is expected to rise with the increase in temperature. By the end of this century when average temperatures are expected to increase by about 3°C, there is a tremendous possibility of a widening of viral and mycoplasmal diseases. Studies carried out in Holland has revealed that during 12 years (1994-2008), new viral strains (PVYntn, PVYnw) have been detected and similar results have also been reported in India. Apart from these, heavy rains might lead to outbreaks of late blight disease and pests (armyworms and beetles), which can result in a 2.4 to 2.7-fold increase in the use of pesticides by 2050.

Conclusion

Research and development in the potato will always look forward to continuous contribution, given its high productivity per unit of land and time and value as both a staple and a cash crop, increasing stress tolerance has a great potential to contribute to food and income security, mitigate poverty and farmer's risk in minimizing vulnerable agricultural environments in the era of global climate change. Sustainable potato production under climate change scenario much depends on the successful breeding of new varieties and adaptive crop management strategies. If researchers succeed in breeding more stress (drought, heat, salt, pests, etc.) resistant varieties that produce sufficient yields under climate change conditions (such as rise in temperature and CO2 concentration and disease and pest outbreak, etc.) then the wholesome potatoes will keep continuing to be grown in many regions in future.

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