CLIMATE CHANGE AND POTATO PRODUCTION IN INDIA

J.P. Singh[1] and S.S. Lal[2]

[1]Central Potato Research Station, Jalandhar-144003, India; [2]Central Potato Research Institute, Shimla-171001, India

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ABSTRACT:

India produces about 24 million tonnes of potato from 1.32 million hectares under the crop. The Northern plains contribute about 84% of the total produce. The bulk of the produce comes from states of Uttar Pradesh (UP), West Bengal (WB), Bihar and Punjab contributing 40, 32, 6 and 6%, respectively. The area, total production and mean tuber yield at the national level increased during the period 1980 to 2007 by 92, 200 and 55 % respectively. The heat sensitive potato crop is mostly confined to Indo-Gangetic plains under irrigated conditions due to climatic constraints. Small scattered areas as rainfed crop are grown in hills during summers and in kharif season in plateau region, whereas winter season crop in the plateau region is irrigated.

1. INTRODUCTION

India produces about 24 million tonnes of potato from 1.32 million hectares under the crop. The Northern plains contribute about 84% of the total produce. The bulk of the produce comes from states of Uttar Pradesh (UP), West Bengal (WB), Bihar and Punjab contributing 40, 32, 6 and 6%, respectively. The area, total production and mean tuber yield at the national level increased during the period 1980 to 2007 by 92, 200 and 55 % respectively. The heat sensitive potato crop is mostly confined to Indo-Gangetic plains under irrigated conditions due to climatic constraints. Small scattered areas as rainfed crop are grown in hills during summers and in kharif season in plateau region, whereas winter season crop in the plateau region is irrigated.

Climate change and global warming is now an acknowledged fact and reality. The rate of global warming in last 50 years is double than that for the last century. As many as 11 of the past 12 years were warmest since 1850, when records began. The threshold value of temperature rise is 2 ^{O}C for devastating, dangerous and irreversible consequences of warming to manifest world over. Global warming is witnessing shifting pattern of rainfall and increasing incidents of extreme weather events like floods, droughts and frosting along with increasing soil salinity and impaired quality of irrigation water.

The current level of CO_2 (369 ppm) in the atmosphere the main GHG is 35.4% more than the pre-industrial level and is rising. The CO_2 level is predicted to be 393, 543 and 789 ppm in year 2020, 2050 and 2080, respectively. The corresponding rise in temperature would be 1, 3 and 5 ^{O}C approximately during main potato growing winter season in India.

The climate change and global warming will have a profound effect on potato growth story in India affecting not only production and profitability, but seed multiplication, storage, marketing and processing of this perishable vegetatively propagated crop (Singh et al., 2009). Under the impact of future scenarios of climate change and global warming the growth projections of potato in India might be arrested or even reversed, unless effective adaptation measures are evolved for timely intervention.

In view of the above, potato productivity and production in India was estimated under future climate change scenarios.

2. MATERIALS AND METHODS

Current climate data sets of normal weather for 20 representative sites in major potato growing areas in India were assembled and used as baseline climate scenario. Potato tuber yield was simulated for all the selected sites without adaptations ie with recommended date of planting and optimal management practices for the current and future climates of varying temperature and CO_2 concentrations. A validated INFOCROP-POTATO model (Singh et.al., 2005) was used for tuber yield simulations. Weighted mean of potato productivity in different states were extracted from simulated tuber yield at different locations in each state. Potato production in India at current and future climates was estimated based on relative contribution of different states in total potato production currently. Similarly, simulations were also made with simple adaptation measure of change in the date of planting (DOP) to assess its effect on production. The effect of advancing planting (-5 days) and delaying it by (+5 & +10 days) from optimum DOP from in the current and future climate scenarios on tuber yield of potato were simulated for all the sites.

3. RESULTS AND DISCUSSION

3.1 Potato tuber yield

Potato productivity is likely to increase in Punjab, Haryana and Western UP by 7 and 4 % in the year 2020 and 2050, respectively.

In other states productivity is likely to decrease by 2 to 19% and 9 to 55 % in the year 2020 and 2050, respectively (Table 1). All India estimates of production based on current relative contribution of different states in total production, showed decline in production from the current levels by 3.16 and 13.72 % in the year 2020 and 2050, respectively (Fig. 1). Currently the winters are severe in Punjab and Haryana and western UP witnessing frosting in December and January. In future climate scenarios warming may ease the chilling conditions in these regions to favour potato productivity, while in other regions with cooler winter season the warming from current levels may prove detrimental. The all India estimates of potato production at various levels of rise in temperature and CO_2 concentration is given (Table 2)

States	**Change (%) from current productivity**	
	Future climate (year)	
	2020	**2050**
Uttar Pradesh (UP)	-1.61	-9.08
West Bengal (WB)	-4.86	-16.11
Bihar	-3.01	-11.50
Punjab & Haryana	+7.31	+3.66
Madhaya Pradesh (MP)	-6.64	-20.63
Gujrat	-16.75	-55.10
Maharashtra	-8.82	-35.29
Karnataka	-18.68	-45.73

Source: (Singh et al., 2009)

Table 1: Assessment of impact of climate change on tuber yield productivity in major potato growing states of India without adaptations under optimal management.

Atmospheric CO_2 conc. (ppm)	**Rise in Temperature (^{O}C)**					
	Nil (current)	1 (2020)	2	3 (2050)	4	5 (2080)
369 (current)	0.0	-6.27	-17.09	-28.10	-42.55	-60.55
400 (2020)	3.40	-3.16	-14.57	-25.54	-58.63	-58.63
550 (2050)	18.65	11.12	-1.25	-13.72	-30.25	-49.94

(Values in parentheses are likely years for associated CO_2 levels and temperature rise)

Table 2. Change (%) in potato production in India from current levels as affected by elevated CO_2 and rise in temperature without adaptations.

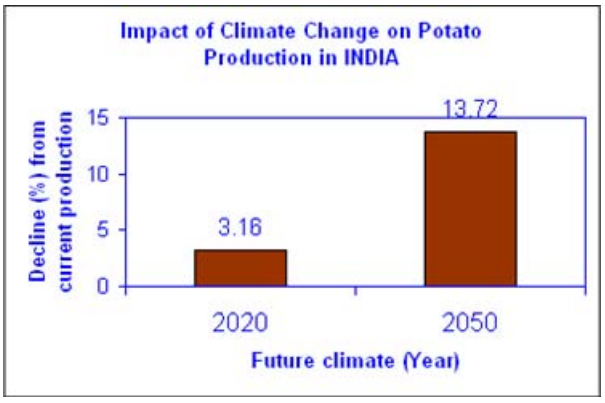

Figure 1. Impact of Climate Change and Global Warming on Potato Production in India

Potato growth and development is affected at high temperatures. No potato crop growth is possible below 2 ^{0}C and above 30 ^{0}C. The minimum (0-7 ^{0}C), optimum (16-25 ^{0}C) and maximum (40 ^{0}C) temperatures for net photosynthesis are reported. Potato requires cool night temperature to induce tuberization. Although photosynthesis in potato is suppressed by high temperature, it is not as sensitive to temperature as tuberization and partitioning of photosynthates to tuber. The radiation use efficiency (RUE) is suppressed under high temperatures. High temperature reduces tuber number and size (Ewing, 1997).

3.2 Adaptations to climate change

In potato the optimum date of planting (DOP) is highly location specific even within small states and varies appreciably according to local weather conditions, soil and cropping systems. Therefore, a general recommendation to advance or delay in future climate scenarios is impractical. However, adaptation studies on change in DOP indicate possibility and extent of sustainable potato production in future climate scenarios by modification in DOP. In Punjab and Western UP the delayed planting by 5-10 days generally increased or sustained the tuber yield in warmer 2020 and 2050 (Table 3). In these frost prone areas in the current climate the prime concern was to escape the frosting period in late December and early January by selecting an optimum planting date (OPT) allowing at least 75-90 days of growing period. Even in the current climate during frost free years delayed planting was found beneficial but is not recommended due to enhanced risk of frost damage. In Eastern UP and Bihar the delayed DOP by 5 to 10 days might sustain the potato production with only minor losses (0-10%) in tuber yield in future climate scenarios. In West Bengal (WB) there is no advantage from delayed planting and recommended DOP is the best option with a loss of 4-8% only. In WB, other adaptation measures like heat tolerant varieties, mulching etc. may prove beneficial. Similar was the situation in plateau and South India with yield losses of 4-100% depending upon the location (Table 3). Results indicate that for states of WB, plateau region and south India development of heat tolerant varieties and other adaptation measures need to be developed as change in DOP might not be very effective.

Indo-Gangetic Plains					Plateau Region and South India				
Location	DOP	Change (%) in yield			Location	DOP	Change (%) in yield		
		Current	2020	2050			Current	2020	2050
Jalandhar (Punjab)	-5	-5.6	6.7	-3.4	Indore (MP)	-5	-2.0	-8.4	-20.9
	OPT	0.0	7.3	3.7		OPT	0.0	-8.4	-17.3
	+5	15.1	18.1	13.8		+5	-0.2	-4.2	-12.0
	+10	19.4	21.7	18.9		+10	1.4	-14.1	-18.3
Agra (UP)	-5	0.6	-15.2	-36.9	Anand (Gujrat)	-5	-2.6	-21.3	-44.3
	OPT	0.0	-5.6	-7.7		OPT	0.0	-15.2	-47.6
	+5	11.2	1.3	-28.8		+5	-1.4	-18.5	-48.8
	+10	22.1	18.2	14.4		+10	1.2	-5.5	-43.8
Varanasi (UP)	-5	1.9	-0.2	-7.8	Hasan (Karnataka)	-5	4.7	-32.5	-99.0
	OPT	0.0	0.8	-5.5		OPT	0.0	-32.2	-81.9
	+5	-6.6	-4.5	-9.7		+5	-5.0	-42.1	-97.1
	+10	5.1	-3.2	-18.8		+10	-10.5	-49.4	-99.1
Patna (Bihar)	-5	-2.8	-11.8	-21.8	Pune (Maharashtra)	-5	-4.9	-20.6	-48.0
	OPT	0.0	-3.1	-10.1		OPT	0.0	-14.4	-47.6
	+5	2.4	-0.3	-2.3		+5	2.2	-7.9	-43.3
	+10	1.2	-1.7	0.7		+10	-1.4	-15.2	-39.9
Burdwan (WB)	-5	-1.4	-7.5	-19.8	Satara (Maharashtra)	-5	-3.9	-7.3	-10.7
	OPT	0.0	-3.9	-7.7		OPT	0.0	-6.6	-13.5
	+5	-8.6	-9.4	-15.5		+5	-3.9	-5.0	-12.5
	+10	-15.0	-19.6	-24.1		+10	-3.4	-10.1	-17.1

DOP-date of planting indicates decrement or increment of days from optimum for the location; OPT-optimum date of planting

Table 3: Effect of Adaptation Through Change of Planting Date on Potato Production in Few Important Locations of Potato Growing Areas in India

CONCLUSION

It may be concluded from the results that without adaptations the potato production under the impact of climate change and global warming may decline by 3.16 and 13.72 % in the year 2020 and 2050, respectively. Possible adaptations like change in planting time, breeding heat tolerant varieties, efficient agronomic and water management and shifting cultivation to new and suitable agro-climatic zones can significantly arrest the decline in the production.

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