Journal of Agrometeorology 20 (2) : 105-109 (June 2018)

Impact assessment of climate change on potato productivity in Assam using SUBSTOR-Potato model

B. GOSWAMI[1], R. HUSSAIN[1], P.V. KUMAR[2], U.S. SAIKIA[3]* and S. BANARJEE[4]

[1]*Department of Agricultural Meteorology, AAU, Jorhat 785 013, Assam*

[2]*Central Research Institute for Dryland Agriculture, Hyderabad 500 059*

[3]*ICAR Research Complex for NEH Region, Umroi Road, Umiam 793 103, Meghalaya*

[4]*Bidhan Chandra Krishi Viswa Vidyalaya, Kalyani 741 235, West Bengal*

**Email: ussaikia73@gmail.com*

ABSTRACT

Potato tuber yield were simulated at Jorhat, Assam under various Representative Concentration Pathways (RCPs) scenarios for 2020, 2050 and 2080 using DSSAT SUBSTOR-Potato model. The model was calibrated and validated for three potato cultivars, *viz.*, *Kufri Jyoti, Kufri Pokhraj* and *Kufri Himalini* with the experimental data collected during 2014-15 and 2015-16. Results revealed that if planting is delayed beyond November, all these cultivars are likely to record drastic reduction in tuber yield. Cultivar *Kufri Himalini* may incur tuber yield loss of 64 per cent in 2020 to 75 per cent in 2080, followed by *Kufri Jyoti* (57.6% in 2020 to 71.5% in 2080) and *Kufri Pokhraj* (45.2% in 2020 to 56.2% in 2080). Among the cultivars, Kufri Pokhraj may remain a viable cultivar up to 2050, but *Kufri Himalini* may lose its sustainability by 2020 itself. Hence, adjustment of planting time and development of improved adaptive potato cultivars only will ascertain future potato production in this region.

Key words: Climate change, RCP, potato yield variability, DSSAT SUBSTOR-Potato model

Potato is the most important non-grain field crop with a global production of 501 million tonnes in 2014 (FAO, 2014). However, potato production is likely to decline across many parts of the world by 2100 (Raymundo *et al.*, 2014). But, Stockle *et al.* (2010) indicated that, taking into account the positive effect of CO_2 and adaptation strategies on crop production might sustain the current production levels under future climate change conditions.The SUBSTOR-Potato model has been used extensively to evaluate effects of variability in climate (Patil *et al.*, 2018) nitrogen (Snapp and Fortuna, 2003) and water (Malkia *et al.*, 2016) for optimizing potato productivity and also for climate change studies (Franke *et al.*, 2013).

IPCC (2013) projected the global temperature change based on various Representative Concentration Pathways (RCP). Their assessment suggests that the temperature change at the end of the 21st century is likely to exceed 1.5°C relative to 1850-1900, for all RCP scenarios except RCP 2.6. Ravindranath *et al.* (2011) assessed the effects of climate change in the North East India with multiple socio-economic consequences and opined that since 80 per cent of the crop area is under rainfed agriculture in the region, present and future climate change and variability might potentially affect agriculture production here, by virtue of acute soil moisture deficit and lack of irrigation/water harvesting infrastructure. A study, based on standardized precipitation index, demonstrated the changes in overall seasonal proneness of the North East India to meteorological drying or wetting, and that most places of the region had suffered loss of monsoon wetness during 1991-2007 (Saikia *et al.*,2013). At Jorhat, Assam increase in both maximum and minimum temperatures, under different RCPs for 2020, 2050 and 2080, suggested increasing level of heat stress during crop growth period (Goswami *et al.*, 2016). Under these circumstances, this study was taken up to evaluate the impact of climate change on potato production in Assam, which is a major potato growing area in the state.

MATERIALS AND METHODS

Field experiment

The field experiment was conducted at Jorhat, Assam (26°44´N latitude, 94°10´E longitude and 91 m above mean sea level),respectively during *rabi* seasons of 2014-15 and 2015-16 in a sandy clay loam soil (Table 1) with three cultivars of potato, *viz.*, (*Kufri Jyoti, Kufri Pokhraj* and *Kufri Himalini*) and three dates of planting at 15 days interval (20 November, 6 and 22 December in 2014-15 and 19 November, 5 and 21 December in 2015-16) in a randomized

Table 1: Soil physico-chemical properties of the experimental site

Sl. No.	Parameters	Description			
1	Soil colour	Grey			
2	Soil texture	Sandy clay loam			
3	Drainage	Moderately well			
4	Soil series	Rowriah			
5	Soil classification	Fine, mixed, hyperthermic family of Humic Endoaquepts			
6	Slope (%)	Nearly level to very gently sloping			
		Soil layers (cm)			
		0-20	20-48	48-62	62-100
7	Clay (%)	24.4	35.4	41.4	35.2
8	Silt (%)	52.7	49.0	35.0	32.4
9	Sand (%)	22.9	15.6	23.6	32.4
10	p^H	5.2	5.1	5.1	5.0
11	CEC (Cmol Kg^{-1})	6.1	8.4	9.6	7.9
12	Organic C (%)	0.88	0.42	0.32	0.19
13	Soil moisture (%/v)	24.4	25.5	26.8	28.8

Table 2: Genotype coefficients of potato cultivars *Kufri Jyoti, Kufri Pokhraj and Kufri Himalini* at Jorhat

Symbol	Description	Genotype coefficients		
		Kufri Jyoti	*Kufri Pokhraj*	*Kufri Himalini*
G2	Leaf area expansion rate (degree days)	2000	2000	2000
G3	Potential tuber growth rate (g m^{-2} day^{-1})	25.5	25.5	18.0
PD	Index that suppresses tuber growth during the period that immediately follows tuber induction	0.5	0.6	0.5
P2	Index that relates photoperiod response to tuber initiation	0.8	0.4	0.8
TC	Upper critical temperature for tuber initiation (°C)	18	20	18

block design.Recommended dose of N, P and K fertilizers were applied. Row spacing of 50 cm was maintained with planting population of 10 plants m^{-2}. Daily weather data were collected from the agrometeorological observatory of the Assam Agricultural University, Jorhat located adjacent to the experimental plot.

Model calibration and validation

The SUBSTOR-Potato model uses five genotype coefficients to define growth and development characteristics of a potato cultivar. The model calibration was done for three different cultivars with three dates of planting using 2014-15 field data sets comprising of nine treatments and three replications. Validation was carried out with optimized genotype coefficients using 2015-16 field data sets. The calibration and validation were done with respect to fresh tuber yield. RMSE and d-stat values of summary results were examined to determine the agreement between observed and simulated values.

Climate change scenarios

Four RCPs (2.6, 4.5, 6.0 and 8.5) were used, which were generated using Hadley Global Environment Model 2-Earth System (HadGEM2-es) (Collins *et al.*, 2011). RCP projected climatic data on daily maximum and minimum temperature, rainfall and solar radiation for 2020, 2050 and 2080 were collected from Central Research Institute for Dryland Agriculture (CRIDA),Hyderabad. The simulated yields of different scenarios were compared with average observed yield of 2014-16.

RESULTS AND DISCUSSION

Calibration and validation

The optimized genotype coefficients of three potato

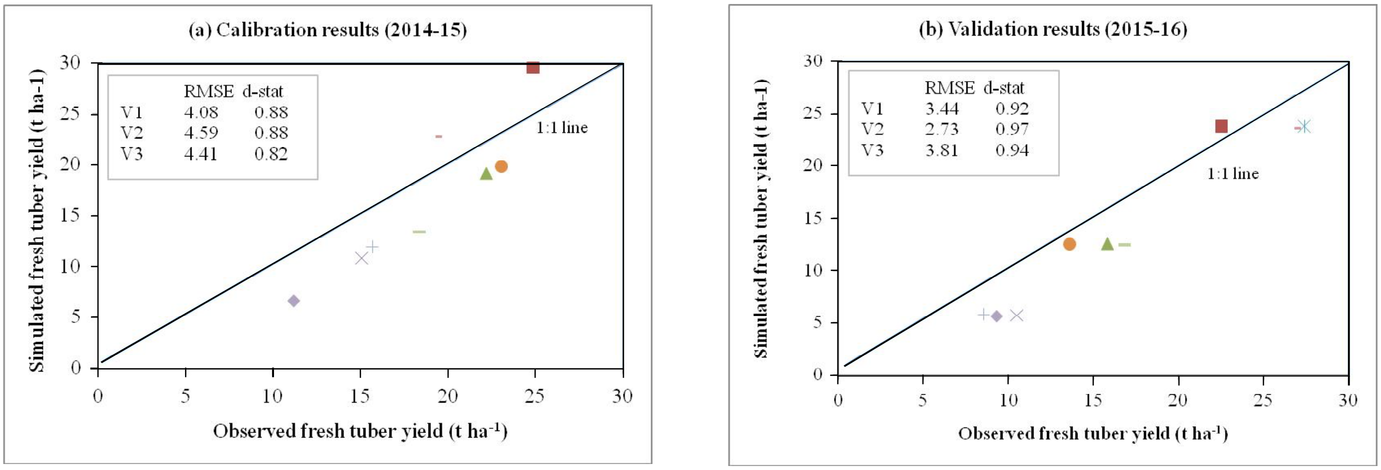

Fig. 1: Calibration (2014-15) and validation (2015-16) results of potato cultivars *Kufri Jyoti, Kufri Pokhraj* and *Kufri Himalini* at Jorhat (DSSAT SUBSTOR-Potato model)

cultivars, *viz.*, *K. Jyoti*, *K. Pokhraj* and *K. Himalini* for the SUBSTOR-Potato model are presented in Table 2.The calibration (2014-15) and validation (2015-16) results for fresh tuber yield of three potato cultivars under three dates of planting are presented in Fig. 1. Low RMSE and d-stat >0.5 was observed in most cases of calibration and validation, which signifies very good agreements between observed and simulated values.

Projected variations in fresh tuber yield of different cultivars

Projected variations in fresh tuber yield of different cultivars at Jorhat under different projection periods and dates of planting, considering all RCPs together, is presented in Table 3. This is expressed as per cent difference over current observed mean yield (2014-15 and 2015-16). In the 1st planting period (third week of November), the mean observed fresh yield recorded for *Kufri Jyoti* (V1), *Kufri Pokhraj* (V2) and *Kufri Himalini* (V3) were 23.7, 19.8 and 12.8 t ha^{-1}, respectively. In this option of planting, cultivar V1 is likely to perform best in all projection periods, followed by V2. There is likely hike of fresh tuber yield by 33.8 (2020) to 18.1 per cent (2080) over the current mean yield for V1. Similarly cultivar V2 is likely to gain between 18.8 (2020) and 10.8 per cent (2080). In contrast, cultivar V3 is set to face reduction in its fresh tuber yield by 2.1(2020) to 14.7 per cent (2080).

In the 2nd option of planting (1st week of December), the current mean tuber yields are 27.2, 18.3 and 12.1 t ha^{-1} for V1, V2 and V3, respectively. Under projected scenarios, fresh tuber yield of cultivar V1 is likely to reduce by 7.1 (2020) to 30.1 per cent (2080). The yield of cultivar V3 will further go down by 37.6 (2020) to 52.7 per cent (2080). Whereas, cultivar V2 will maintain its gain in tuber yield by 9.8 (2020) to 10.7 per cent (2050), but is likely to record a loss of 16.1 per cent in 2080 over the current mean fresh tuber yield.

If planting is further delayed to 3rd week of December, all these cultivars are likely to record drastic reduction in tuber yield. The V3 may record highest loss of 64 (2020) to 75 per cent (2080), followed by V1 (57.6% in 2020 to 71.5% in 2080) and V2 (45.2% in 2020 to 56.2% in 2080). All of the present cultivars may not remain sustainable under this option of planting period and tuber yield is likely to fall by over 50 per cent from the current mean values.The reduction in future tuber yield may be attributed to possible increase in temperature. Basu and Minhas (1999) observed that high temperatures negatively affected the allocation of glucose, stimulated the growth of above ground biomass and simultaneously reduced tuber accumulation though not necessarily inhibit tuber initiation. Patil *et al.*(2018) have also reported reduction in tuber yield of potato in Gujarat by 6-17 per cent due to increase in maximum and minimum temperatures during different months of potato growing season.

Though the potato cultivars are not differing much in current yield realization within themselves, even then if planting is delayed, *Kufri Himalini* may not remain suitable for planting beyond 2020 under all options of planting and *Kufri Jyoti* beyond 2050 under December planting in this region. *Kufri Pokhraj* is likely to remain as a viable cultivar under subtropical conditions of Jorhat till 2050 and can be planted up to Ist week of December.

CONCLUSIONS

Validation of DSSAT SUBSTOR-Potato model, with

Table 3: Projected variations in fresh tuber yield of potato cultivars under different projection periods and periods of planting over current mean observed yield (2014-15 and 2015-16) considering all RCPs together

Planting times (D)	Cultivars (V)	Mean observed yield ($t\ ha^{-1}$)	Change in tuber yield over current mean yield (%) 2020	2050	2080
3rd Week of November	*Kufri Jyoti*	23.7	33.8	30.5	18.1
	Kufri Pokhraj	19.1	18.8	18.5	10.8
	Kufri Himalini	12.8	-2.1	-1.6	-14.7
1st Week of December	*Kufri Jyoti*	27.2	-7.1	-5.7	-30.1
	Kufri Pokhraj	18.3	9.8	10.7	-16.1
	Kufri Himalini	12.1	-37.6	-38.2	-52.7
3rd Week of December	*Kufri Jyoti*	23.0	-57.6	-60.7	-71.5
	Kufri Pokhraj	17.6	-45.2	-46.3	-56.2
	Kufri Himalini	10.2	-64.0	-65.7	-75.0

respect to low RMSE and high d-stat values for all the treatments, suggests good agreement between the observed and simulated results for three potato cultivars *viz.*,*Kufri Jyoti, Kufri Pokhraj* and *Kufri Himalini* under subtropical conditions of Jorhat. At present, *Kufri Jyoti* is the best performing cultivar followed by *Kufri Pokhraj*, but *Kufri Himalini* may not remain suitable for planting beyond 2020 under all options of planting and *Kufri Jyoti* beyond 2050 under December planting. However, *Kufri Pokhraj* is likely to remain as a viable cultivar under subtropical conditions of Jorhat till 2050 and will be suitable for planting up to 1st week of December. Delayed planting beyond November is likely to be economically unviable for potato cultivation in future scenarios.

REFERENCES

Basu P.S. and Minhas J.S. (1999). Tuberization at high temperatures in different potato genotypes, *J. Ind. Potato Assoc.,* 26: 19–22.

Collins, W.J., Bellouin, N., Doutriaux-Boucher, M., Gedney, N., Halloran, P., Hinton, T., Hughes, J., Jones, C. D., Joshi, M., Liddicoat, S., Martin, G., O'Connor, F., Rae, J., Senior, C., Sitch, S., Totterdell, I., Wiltshire, A. and Woodward, S. (2011). Development and evaluation of an Earth-System model–HadGEM2. *Geosci Model Dev*, 4: 1051-1075, doi:10.5194/gmd-4-1051-2011.

FAO (2014). FAO Stat, http://www.fao.org/faostat/en/#data/QC as seen on 07-09-2017.

Franke, A.C., Haverkort, A.J. and Steyn, J.M. (2013). Climate change and potato production in contrasting South African agro-ecosystems 2: Assessing risks and opportunities of adaptation strategies, *Potato Res.*,56: 51–66.

Goswami, B., Hussain, R., Rao, V.U.M. and Saikia, U.S. (2016).Impact of climate change on rice yield at Jorhat, Assam. *J. Agrometeorol.*, 18(2): 252-257.

IPCC. (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1535.

Malkia, R., Hartani, T. and Dechmi, F. (2016). Evaluation of DSSAT model for sprinkler irrigated potato: A case study of Northeast Algeria. *African J. Agril. Res.*, 11: 2589-2598.

Patil, D. D., Pandey, V., Acharya, R. R. and Baraiya, L. N. (2018). Effect of intra-seasonal variation in temperature on tuber yield of potato in middle Gujarat using SUBSTOR model. *J. Agrometeorol., 20(1): 22-27.*

Ravindranath, N.H., Rao, S., Sharma, N., Nair, M. Gopalakrishnan, R. Rao, A.S., Malaviya, S., Tiwari, R. Sagadevan, A., Munsi, M, Krishna, N. and Bala, G. (2011). Climate change vulnerability profiles for North East India. *Curr. Sci.*, 101(3):384-94.

Raymundo, R., Asseng, S., Cammarano, D. and Quiroz, R. (2014). Potato, sweet potato, and yam models for climate change: Areview, *Field Crops Res.*,166: 173–185.

Saikia, U.S., Goswami, B., Rajkhowa, D.J., Venkatesh, A., Ramachandran, K., Rao, V.U.M, Venkateswarlu, B. and Ngachan, S.V. (2013). Shift in monsoon rainfall pattern in the North Eastern region of India post 1991. *J. Agrometeorol.*,15 (2) : 162-164.

Snapp, S.S. and Fortuna, A.M. (2003). Predicting nitrogen availability in irrigated potato systems. *Hort. Technology*, 13: 598–604.

Stockle, C.O., Nelson, R.L., Higgins, S., Brunner, J., Grove, G., Boydston, R., Whiting, M. and Kruger, C. (2010). Assessment of climate change impact on eastern Washington agriculture, *Clim.Change*,102: 77–102.

Received : September 2017 ; Accepted : March 2018