APN Science Bulletin
Issue 2, March 2012
ISSN 2185-761x

ARCP2010-05CMY-LUCK

The Effects of Climate Change on Potato Production and Potato Late Blight in the Asia-Pacific Region

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ABSTRACT: The influence of climate change on potato production and the disease, Potato Late Blight, was assessed using two climatically distinct potato growing regions each in India's West Bengal (Nadia and Hooghly) and Bangladesh (Bogra and Munshiganj). Regional climate projections to the year 2050 were obtained for each location using IPCC climate scenario A1B for West Bengal and Bangladesh. Two regional forecasting models indicated an increasing trend (+0.2 to +0.6°C) for maximum and minimum temperatures by 2050. An increasing trend in rainfall was expected for 2050 but no difference in solar radiation was predicted compared to 1981–2010 data. The impact of climate change on potato production in the study areas in India and Bangladesh showed a yield decline of 23–32% by 2050. To assess the effect of climate change on Potato Late Blight, nine published models were tested for accuracy against ten years of West Bengal disease incidence records. The best model was only 25% accurate in predicting Late Blight outbreaks for that time period and, therefore, an alternative approach was developed by adapting the Jhulsacast model and applying fog-based rules. When climate change projections were incorporated, this modified model showed that the onset of Late Blight is likely to be earlier in the growing season for 2031–2040 but severity is likely to be 5–7% less than 1981–2010 records in the intensive potato growing areas of West Bengal. However, in northern Bangladesh, disease severity is predicted to increase by up to 12%, and reduce by 7% in central Bangladesh.

KEYWORDS: *Climate change, Potato Late Blight, food security, plant disease, yield, potato*

Introduction

Climate Change is expected to have significant consequences for agricultural productivity and the incidence and severity of diseases affecting these crops. To examine this more closely, we investigated the impact of climate change on an important disease of potato in the Asia-Pacific Region, Potato Late Blight (PLB). Data from six growing regions, two each from West Bengal, Bangladesh and Australia were analyzed in this study. In the interests of keeping this article brief, the data from Australia is not presented in this paper.

In 2008, India was the 3rd largest producer of potatoes in the world with the state of West Bengal accounting for more than one quarter of the total crop. In 2007, Bangladesh was the 4th largest producer in Asia. A growing concern for West Bengal and Bangladesh, however, is reduced productivity as a result of a lack of arable land, an increasing demand for food and the intensification of climate change and natural disasters. With a government drive to diversify agricultural crops and to improve agricultural output and income, the potato crop is ideal because of its ease of cultivation, high productivity per unit area and diversity of use.

Late blight of potato is caused by *Phytophthora infestans*, and is considered to be the most important disease of potato worldwide. Under favourable climatic conditions, the disease can destroy a potato crop within a few weeks (Figure 1). Late blight is a major disease of potatoes in India (Singh, 1996) and Bangladesh, and is very much a "weather-driven" disease, dependent on two major climatic factors: moisture and temperature.

The objective of the present study was to determine how future climates (projected by the IPCC) will affect the incidence of this disease. In order to identify the indirect effects on the disease, an initial assessment was made of the climate projections for potato growing regions across West Bengal and Bangladesh and its subsequent effect on potato production.

Methodology

Representative locations were selected within West Bengal (Nadia and Hooghly) and Bangladesh (Bogra and Munshiganj) to generate local daily data to run the potato

Figure 1. Bangladesh potato grower amidst a field of potatoes affected by Late Blight (source D. Hossain)

and late blight disease models. These locations were selected based on the presence of potato production and variability in climatic zones. The A1B scenario was used using two global climate models (EH5OM and HadCM3Q) downscaled respectively, by the RegCM3 and PRECIS regional models. We used EH5OM GCMs output in RegCM3 and HadCM3Q output in PRECIS using the A1B scenario. The Infocrop model and DSSAT models were used to predict future potato yields for the selected regions. PLB records collected from BCKV and BARI were used in conjunction with the Jhulsacast model (Singh *et al.*, 2000) to predict disease initiation dates under future climates.

Results

Climate Change Projections

For West Bengal and Bangladesh, both models showed an increasing and significant linear trend of 0.2 to 0.6°C for the maximum temperature and 0.2 to 0.5°C for minimum temperature per decade up to 2050 (Table 1 and Figures 2 and 3). Both the models also showed increasing trends for rainfall output from PRECIS which were higher than those from RegCM3. No difference in solar radiation was predicted compared to the present decade.

Climate change and potato production

Our analysis in West Bengal and Bangladesh concur with Singh, *et al.* (2009) with a trend towards yield decline by 2050 ranging from a 23–28% reduction using PRECIS and 30–32% reduction using RegCM3 at Nadia and Hooghly, respectively (Table 2). At

Table 1. Decade-wide mean projections for West Bengal and Bangladesh for minimum and maximum temperature, solar radiation and rainfall determined from the downscaled Regional Climate Models

Decade	RegCM3				PRECIS			
	TMIN (°C)	TMAX (°C)	SRAD MJ/m^2	RAIN (mm)	TMIN (°C)	TMAX (°C)	SRAD MJ/m^2	RAIN (mm)
2011–2020	18.8	29.4	18.2	2004	20.1	28.9	16.7	2203
2021–2030	19.0	29.6	18.1	2021	20.5	29.0	16.4	2432
2031–2040	19.5	30.1	18.2	2058	20.9	29.6	16.7	2371
2041–2050	19.9	30.4	18.2	2021	21.4	30.2	16.8	2505

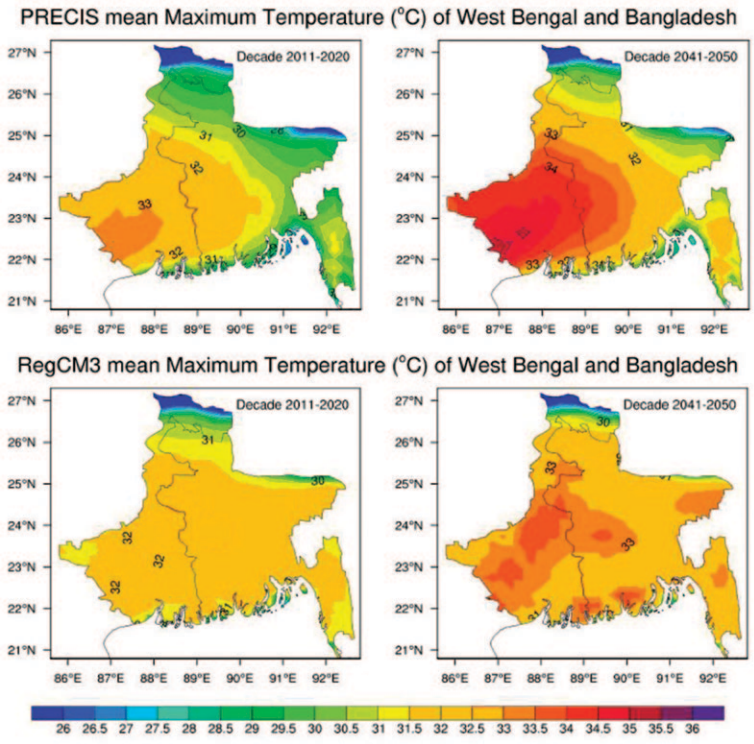

Figure 2. Maximum temperature projections for decades 2011–2020 and 2041–2050

Bogra in Bangladesh the PRECIS regional climate model indicated a lower yield loss (7.2%) compared to the RegCM3 regional climate model (26%). This was compared to Munshiganj which had an 18% yield reduction using PRECIS and a 31% yield reduction using RegCM3.

Climate Change and Potato Late Blight (PLB) Epidemics

To determine if PLB will have a compounding effect on potato losses in future climates, an evaluation of nine published PLB models was undertaken to test which model would be most applicable for the selected potato growing areas. The analysis, based on temperature, rainfall and relative humidity, using 10 year's disease and weather data from BCKV University, revealed that none of the published models worked well under the Gangetic alluvial region of West Bengal conditions. The historical data showed that rain is not a prerequisite for an outbreak of PLB in the Gangetic alluvial region of West Bengal and any model which had a primary component of rainfall was considered unsuitable for predicting late blight in this region. Hence, the majority of popular late blight models were not used in the present study.

Therefore, an alternative approach based on minimum temperature and the onset of morning fog was developed for predicting late blight of potato under the Gangetic alluvial region of West Bengal Jhulsacast (Singh *et al.*, 2000) model. This model has a published accuracy of 62% in India.

Disease initiation was simulated using

RCM	2011–2020		2040–2049		Difference	
	PRECIS	RegCM3	PRECIS	RegCM3	PRECIS	RegCM3
Nadia, West Bengal	18.3	18.4	14.2	12.9	-23%	-30%
Hooghly, West Bengal	16.4	17.5	11.7	11.9	-28%	-32%
Bogra, Bangladesh	21.3	19.2	19.8	14.2	-7.2%	-26%
Munshiganj, Bangladesh	20.3	17.6	16.6	12.2	-18%	-31%

Table 2. Summary of expected mean potato tuber yield (dry weight tonne/ha) for 2011–2020 and 2040–2049, and percentage change between the decades using the DSSAT-Potato crop model and downscaled daily data generated by the PRECIS and RegCM3 regional climate models

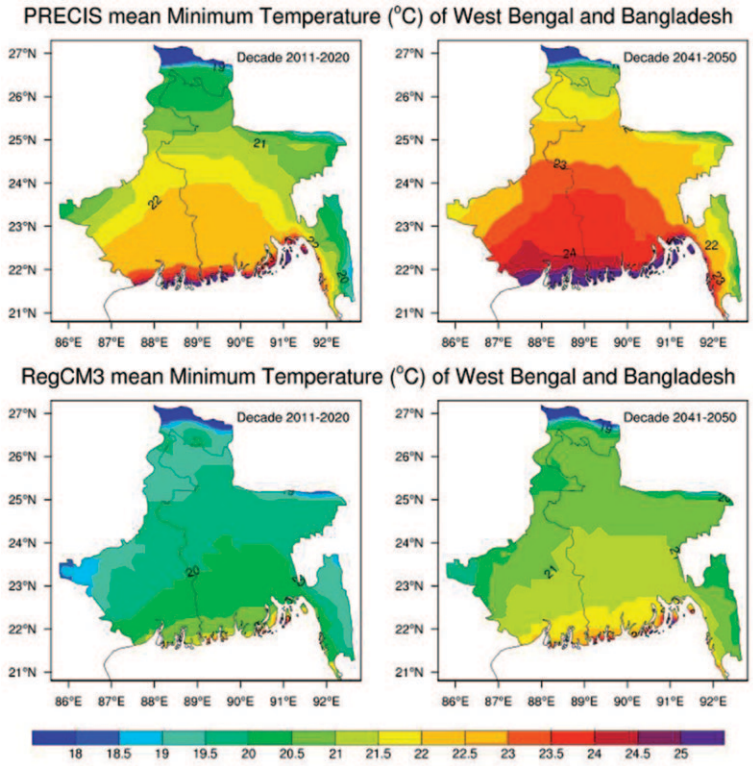

Figure 3. Minimum temperature projections for decades 2011–2020 and 2041–2050

RESEARCH HIGHLIGHTS

- For West Bengal and Bangladesh potato growing regions, the maximum temperatures will increase by 0.2–0.6 °C and the minimum temperatures will increase by 0.2–0.5 °C per decade up until 2050.
- Without adaptation, by 2040 potato yields will decline for all potato growing regions examined. Of the four regions studied, the most northern growing region, Bogra, is predicted to sustain the least yield impacts due to the relatively cooler conditions for production.
- Earlier sowing dates, new planting areas and high temperature-tolerant varieties will need to be considered by growers to adapt to future climate to minimize future yield losses.
- In the regions examined, the disease, Potato Late Blight, will not significantly increase under future climate scenarios; in some cases it will decrease.
- The onset of disease is predicted to be early in the growing season in 2040. This will require monitoring of climate conditions and appropriate timing of spray application to minimize the impact of disease.
- An interesting gap highlighted in this project was the absence of fog data, which is critical for predicting PLB. A routinely collected fog data set would allow the meteorology bureaus to issue fog-warnings for potato growers which could enable pre-emptive fungicide spray application to prevent major losses due to this disease.

the Jhulsacast model for the Chinsurah area for the period 1980 to 2040. Yearly data on average five day temperature preceding disease initiation summarized in decadal interval from 1981–1990 to 2031–2040 were plotted against the decadal average disease initiation dates. Figure 3 shows that the decadal average of 5-day Tmin preceding PLB initiation increased from 7°C (1981–90) to 12.8°C (2031–2040). A clear relationship was demonstrated between the increasing temperature and advancement of PLB initiation. The projected increasing temperatures that occur during the potato growing season will advance PLB initiation by 12 days compared to current temperatures.

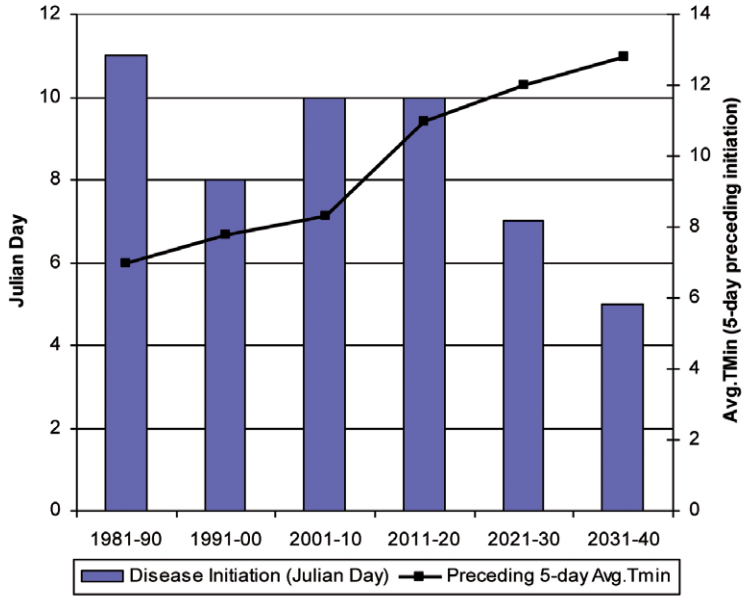

Figure 4. The relationship between historical and projected average minimum temperatures (5 days prior to disease initiation) and Late Blight disease initiation

The model indicated that PLB severity is likely to reduce by 5–7% from the 1981–2010 period to the 2031–40 period in the intensive potato growing areas of West Bengal, India. However, in similar intensive growing areas of Bangladesh, disease severity can increase up to 12% and reduce to around 7% in similar intensive growing areas of central Bangladesh. The onset of PLB is likely to be earlier in the growing season in future decades as compared to the present decade (2011–20).

Discussion and Conclusion

Our preliminary results demonstrate that potato yield will decline under future climate scenarios for all potato growing regions examined; Hooghly and Nadia in West Bengal and Bogra and Munshiganj in Bangladesh. Of the four regions studied, the most northern growing region, Bogra, is predicted to sustain the least yield impacts due to the relatively cooler conditions for production. Earlier sowing dates, new planting areas and high temperature tolerant varieties will need to be considered by growers to adapt to minimize future yield losses.

Our analysis of historical PLB incidence in West Bengal and Bangladesh and projected PLB incidence (to 2040) indicate that the disease will not significantly increase under future climates, and in some cases it will

decrease. However, the onset of disease is predicted to be early in the growing season in 2040. This will require monitoring of climatic conditions and appropriate timing of spray application to minimize the impact of disease.

An interesting gap highlighted in this project was the absence of fog data, which is critical for predicting PLB. A routinely collected fog data set would allow the meteorology bureaus to issue fog-warnings for potato growers which could enable pre-emptive fungicide spray application to prevent major losses due to this disease.

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Acknowledgements

We gratefully acknowledge the support of the APN for this project as well as co-funding from the Cooperative Research Centre for Plant Biosecurity and the in-kind support from the Department of Primary Industries Victoria and the University of Western Sydney. We thank the "All India Coordinated Research Project on Potato," West Bengal Centre and the "All India Coordinated Research Project on Agro-meteorology," West Bengal Centre for the use of their data. Finally, we dedicate this work to our APN project team member and friend, plant pathologist, Dr. Md. Delowar Hossain who represented the Bangladesh Agriculture Research Institute (BARI), who sadly passed away during this project.

ARCP2010-05CMY-LUCK

PROJECT TITLE

The Effects of Climate Change on Pests and Diseases of Major Food Crops in the Asia-Pacific Region

COUNTRIES INVOLVED

Australia, Bangladesh, India

PROJECT DURATION

2 years

APN FUNDING

US$ 78,240

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