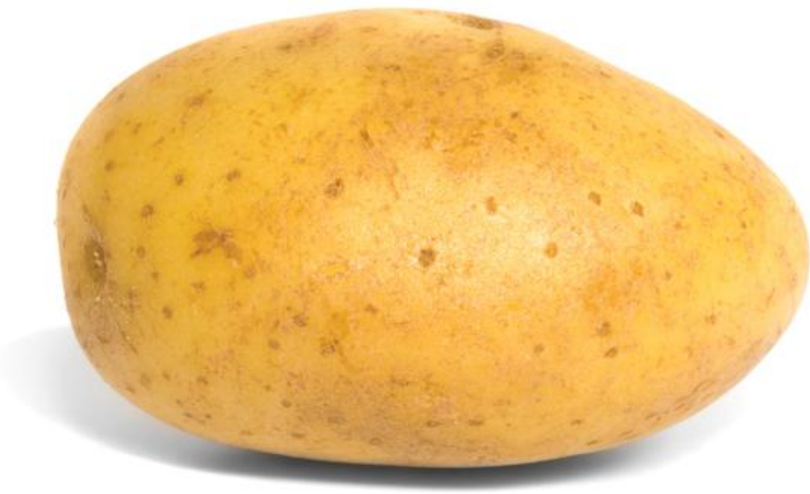
CHAPTER–VII

Summary and Conclusion



SUMMARY AND CONCLUSION

7.1 Summary and Conclusion

Late blight of potato (*Solanum tuberosum*), caused by the *oomycete* pathogen *Phytophthora infestans*, is considered to be the most devastating disease of potato in the world. In recent years there has been considerable amount of yield loss of potato in the Indo-Gangetic region. Unless there is timely and judicious application of chemical pesticides potato blight under congenial climatic conditions, can lead to complete crop damage within few weeks of infection. To avoid the risk of crop damage due to potato late blight disease profilactic (preventive) spraying is done indiscriminately which causes pollution to the soil and water environment and significantly increases in production cost. Advance warning with a regional perspective can be able to arrest the spread of the disease and its severity through judicious application of pesticides and altering the crop management practices. Satellite based remote sensing is the most efficient tool to identify the growth anomaly from vantage point and thus to monitor the spatial and temporal spread of the disease. The present research was aimed at developing an effective potato late blight disease monitoring system using integrated field observation and space technology during the crop growing season. The salient findings of the present investigation have been summarized below.

The investigation of spatio-temporal characteristics vegetation growth was studied using MODIS NDVI time-series data covering the two years period to have a basic understanding of the existing potato based cropping systems in annual crop rotation. Both double and triple cropped systems were identified from the time series of vegetation profile. Based upon the local crop calendar and satellite derived temporal vegetation indices profile (a surrogate of crop phenology) image pixels containing potato crop were classified. Both the start and end of growing season were also established to understand the duration of various phases of life cycle. The sowing time of potato crop in major part of study area was found during end of November and harvesting time during 2nd week of March. The average duration of active growing season of potato crop was found 88 days. In regional perspective the spatio-temporal variability of crop growth was found due to asynchronous sowing. In most of areas the phenological maxima of healthy potato crop was observed during the end of January till the beginning of February and the harvesting date is during last week of February to early of

March. Some variabilities across different districts are noticeable which could be attributed to availability of optimum soil moisture, harvesting date of kharif crop and logistic supports. Besides vegetation indices, canopy cover fraction i.e., the state of canopy closure was also estimated. The estimated crop area showed good matching with reported area given by Department of Agricultural, Government of West Bengal with mean bias error of 11.85 and 5.25 km^2 in the cropping year of 2012-13 and 2013-14 respectively.

Canopy cover fraction, phoenological development and crop microclimate are the important factors which could have impact on disease development and spreading.

Field spectroscopic study was performed to capture the minute details of healthy and disease infected potato canopy to compare the regions of spectral divergence. The purpose was to select the appropriate regions of the electromagnetic spectrum that could capture PLB disease initiation and temporal severity. The difference in bio-optical response between healthy and diseased canopy is discernible at red and NIR region, the spectral reflectance of the diseased canopies were less that of the healthy ones. The critical spectral regions in which the difference was prominent include, 700 and 740 nm (70.17%), 770-860 nm (77.00%) and 920–1040 nm (65.71%).

Out of all the spectral variables $NDVI_{705}$ and DWSI-5 showed very high negative correlation (0.87 and 0.84) with PLB severity which indicates that these indices are very sensitive to PLB disease severity. A multi-linear regression model was developed from the above mentioned spectral variables with low RMSE error (1.95) in between predicted and measured values of disease severity index. This study established a scientific disease severity scoring methodology for remote monitoring of potato late blight disease using hyperspectral remote sensing technology. The major advantage of this approach is its simplicity and low computational load as well as its non-invasive remote procedure that makes it suitable for real-time potato late blight disease monitoring system.

The efficiency of multispectral vegetation indices viz. NDVI, NDWI, ABDI, and PPCF to distinguish the disease affected potato crops from the healthy ones was evaluated using multi-Temporal AWiFS data. The significant changes of chlorophyll content in leaves was clearly noticeable in NDVI. The decreases of water content of leaves due to potato late blight was successfully identified using NDWI and ABDI. Based upon the analysis of multi-date

AWiFS derived vegetation indices, a rule was developed for diseased pixels and disease severity map was generated for the study region.

The estimated disease affected area from remote sensing was compared with the ground based measured area given by state agriculture departments. The RMSE were 6.38 and 10.47 as well as coefficient of determination (R^2) were 0.88 and 0.85 in 2012-13 and 2013-14 seasons respectively.

The present study showed that the NDVI and PCCF were having significant linear relation with late blight disease severity index (DSI), the R^2 ranging from 0.837 to 0.843 during the period of study (2012-13 and 2013-14). A multi-linear regression model using NDVI and PCCF indices was developed to predict the late blight disease severity. The low RMSE value (1.22) between measured and predicted disease severity established NDVI and PCCF as proximal indicators of PLB disease severity.

The satellite based study demonstrated systematic methods for monitoring the disease progress in spatial scale and severity scale using multispectral remote sensing imageries. The field spectroscopic study, on the other hand, captured the minute details of spectral divergence between healthy and diseased canopy in respect of some critical hyperspectral indices. The present technology has the potential in disease management over a large area having fairly uniform crop type in near real time basis. The satellite based disease monitoring system coupled with ground intelligence can prove to be an effective tool in judicious scheduling of pesticide application in order to reduce the cost of production and to minimize the environmental hazard.

7.2 Future Scope of the Study

The present study has demonstrated the potential of satellite based remote sensing to monitor potato growth and phenology as well as disease progress in spatial and severity scale. However, there were certain limitations with respect to satellite data availability as well as ground observations.

The medium resolution satellite data, AWiFS and MODIS have been used for capturing phenology as well as disease severity in the present exercise. A combination of new generation satellite images like Sentinnel-2, Landsat-8 etc. can help in capturing minute details of phenology as well as disease progress. The field spectroscopic observations could be linked to hyperspectral satellite imageries for establishing spectral disease indices that could capture the potato blight more efficiently.

The various biophysical factors like canopy temperature, leaf wetness duration, air humidity, soil moisture etc. that could have strong association with potato blight severity were not been studied in the present study. Similarly, it was not possible to study the details of crop management options adopted by farmers of the large study areas. However, inclusion of ground measured biophysical parameters and with satellite derived indicators coupled with crop management information can help in developing more robust and effective Disease Forewarning Model for the benefit of farming community at field scale as well as for the use of planners at a broad spatial scale.