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A multi-stage tracking for mustard rot disease combining surface meteorology and satellite remote sensing

B.K. Bhattacharya [a], C. Chattopadhyay [b,*]

[a] Crop Inventory and Agroecosystems Division, Agriculture-Forestry and Environment Group, Space Applications Centre (ISRO), Ahmedabad 380 015, India
[b] Directorate of Rapeseed-Mustard Research (ICAR), Sewar, Bharatpur 321 303, India

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ABSTRACT

Disease forecasting forms an integral part of crop protection for ensuring quality and quantity of production. In this paper, a new method of multi-stage tracking of Sclerotinia rot (*Sclerotinia sclerotiorum*) disease in a large mustard growing region over 5 km × 5 km (27.00–27.25°N; 77.25–77.50°E) in Bharatpur district of Rajasthan state of North-West India is demonstrated. In addition to surface weather data, *post-facto* analysis of 5-year (2003–2007) satellite-based data of surface reflectances in red (R), near infrared (NIR) and shortwave infrared (SWIR) bands, land surface temperature (LST) from Moderate Resolution Imaging Spectroradiometer (MODIS) AQUA at day (1:30 pm) and night time (1:30 am) LST, were done to characterize disease outbreak (stage-I) and persistence (stage-II). While stage-I evaluation was based on anomaly in minimum air temperatures and night time LST, stage-II evaluation was carried out using quadrant-based trapezoidal clusters between soil and canopy dryness indicators. Hyperspectral data on two dates from Hyperion sensor at EO-1 platform were used for two-step spectral discrimination to select bands and disease indices specific to rot. Among all the hyperspectral indices, a three-band rot index (ROTI) was found to be the better one in field scale rot discrimination (stage-III evaluation). The reduction in fractional canopy cover in diseased patches in 2005 as compared to a normal year (2007) indirectly validated the disease effect.

1. Introduction

The onset and spread of a crop disease are largely regulated by short-term weather anomalies during a crop growth cycle. Disease incidence levels above certain thresholds lead to a reduction in crop yield and reduce grain quality. Disease prediction on spatial scales depends on either synoptic weather observations from *in situ* measurements or satellite-based estimates (Green and Hay, 2002) or forecasts (Strand, 2000) from meso-scale models. Thus, disease risk zones can be defined as any place where weather parameters can trigger initiation of disease. A decision-support system using remote sensing and GIS, super-imposing favorable weather parameter can be useful for disease prediction followed by crop protection activities or disease management. In context of insurance claim of agricultural entrepreneurs within disease affected zones, satellite-based disease detection can make an important contribution. The different disease symptoms alter optical, thermal properties of leaves, canopies in different spectral regions through necrotic or chlorotic lesions, premature senescence or browning and canopy dryness (Malthus and Madeira, 1993; West et al., 2003). Hyperspectral observations over a number of bands (>200) at 5–10 nm intervals are quite promising in crop disease detection (Thenkabail et al., 2002; Laudien et al., 2004) as compared to few (4–7) multispectral bands (Kanemasu et al., 1974; Nageswara Rao and Rao, 1982; Franke and Menz, 2007). Spectral discrimination of different diseases was carried out using ground-based, airborne and satellite-based hyperspectral reflectance data for late blight (*Phytophthora infestans*) in tomato (Zhang and Qin, 2004), rice diseases (Qin et al., 2003) and sugarcane orange rust (Apan et al., 2004), respectively. The hyperspectral sensors (e.g. EO-1 Hyperion) have good spatial resolutions (30 m), but have limited swaths (~7 km) and low temporal resolution (16–25 days). These are only useful to assess the spatial extent of damage but not fit to address forewarning of disease incidence, spread and severity. The regular availability of land surface temperature (LST), surface reflectances in optical bands from Moderate Resolution (500–1000 m) Imaging Spectroradiometer (MODIS) holds the potential to formulate early indicators for disease outbreak and severity to provide epidemic alert to farmers (Tatem et al., 2004).

Mustard (*Brassica juncea*) is one of the important oilseed crops in India (FAO, 2011), which constitutes a major source of edible oil for human consumption. Major diseases of mustard crop in India are blight (*Alternaria* sp.), white rust (*Albugo candida*) and Scle-

* Corresponding author. Present address: Indian Institute of Pulses Research (ICAR), Kanpur 208 024, India. Tel.: +91 9453042439.
E-mail address: chirantan_cha@hotmail.com (C. Chattopadhyay).

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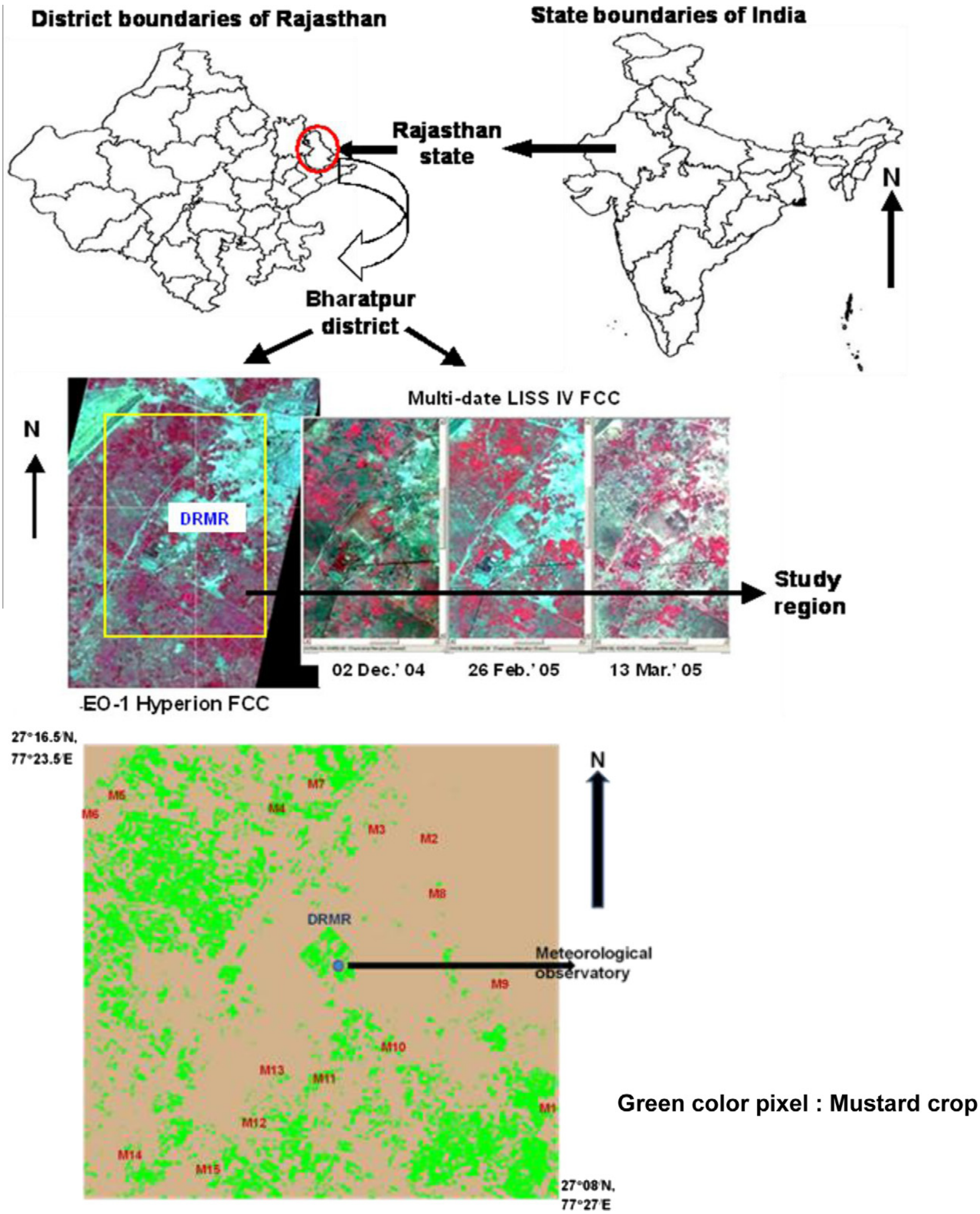

Fig. 1. Map of India indicating location of study area and False Color Composites (FCCs) of Hyperion and Resourcesat-1 LISS IV covering study region with site IDs for disease scoring.

rotinia rot (*Sclerotinia sclerotiorum*). These can cause damage to mustard crop and can result in yield loss up to 47% (Chattopadhyay et al., 2003; Chattopadhyay, 2008). The causal agent of mustard rot is a fungal pathogen (*S. sclerotiorum*), which is soil-borne particularly in the Indian sub-continent (Chattopadhyay et al., 2003). It is a sporadic disease, occurring on an average once in 5 years when weather conditions are favorable. It infects through its long-lived structures called 'sclerotia' that can tolerate temperature extremes. Fungal mycelia from 'sclerotia' in soil infect the stem in collar region at soil level, which cause stem rot, wilting and premature drying of the canopy. The airborne ascospores from 'apothecia' in sclerotia could infect flower petals that cause rotting from the top of the plant (common in temperate conditions) or could infect fallen petals on the ground that cause fast spread of the inoculum