Optik 145 (2017) 66–73

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

Original research article

Habitat monitoring to evaluate crop disease and pest distributions based on multi-source satellite remote sensing imagery

Lin Yuan, Zhiyan Bao*, Haibo Zhang, Yuntao Zhang, Xi Liang

School of Information Engineering and Art and Design, Zhejiang University of Water Resources and Electric Power, Hangzhou 310018, China

ARTICLE INFO

Article history:
Received 25 March 2017
Accepted 19 June 2017

Keywords:
Disease and pest monitoring
Field scale
Worldview 2, Landsat 8, Fisher's linear discriminant analysis (FLDA)

ABSTRACT

Habitat monitoring can be used to evaluate the potential occurrence and distribution of plant diseases and pests in a region. Here, we present a new method for monitoring crop diseases and pests based on Worldview 2 and Landsat 8 satellite data. As a case study, the method was applied to wheat fields in Zhou Jiazhuang, Jinzhou City, Hebei Province. Crop growth indices (GNDVI and $VARI_{red\text{-}edge}$) and environmental features (Wetness, Greenness, and LST) were used describe habitat, and an independent *t*-test was used to evaluate the performances of these five features in representing crop diseases and pests. Field measurements were used to evaluate the validity of the method. An FLDA model incorporating both vegetation and environmental indices was more accurate for monitoring crop disease and pest occurrence compared with a model based on vegetation indices alone (71% vs. 82% accuracy). Future work should include multiple forms of information (e.g., meteorological data and web sensor networks) to further improve regional-scale monitoring of crop diseases and pests.

1. Introduction

Dramatic changes in temperature, precipitation, humidity, and other climatic factors due to climate change have increased the potential occurrence and severity of crop diseases and pests, thereby threatening crop production [1]. Early and accurate detection of crop diseases and pests is important for limiting crop damage, pesticide use, and environment pollution. The development of information technology and satellite imagery has greatly improved habitat monitoring, and thus detection of crop diseases and pests.

At present, crop disease and pest monitoring by remote sensing is mainly conducted at the leaf, canopy, and field levels. For example, hyperspectral and multispectral aerial data have been used to monitor tomato late blight disease and rice glume blight disease, respectively [2,3]. Huang et al. (2007) analyzed the spectral characteristics of yellow rust and its influences on winter wheat based on multi-temporal Pushbroom hyperspectral imagery (PHI) [4], and used a regression model to successfully predict the severity of yellow rust. Li et al. (2012) classified orange citrus with an accuracy of 60% based on airborne hyperspectral imagery [5]. However, information on crop disease and pest monitoring is still sparse because large-scale detection is difficult.

* Corresponding author.
E-mail address: yuanl_rs@163.com (Z. Bao).

http://dx.doi.org/10.1016/j.ijleo.2017.06.071
0030-4026/

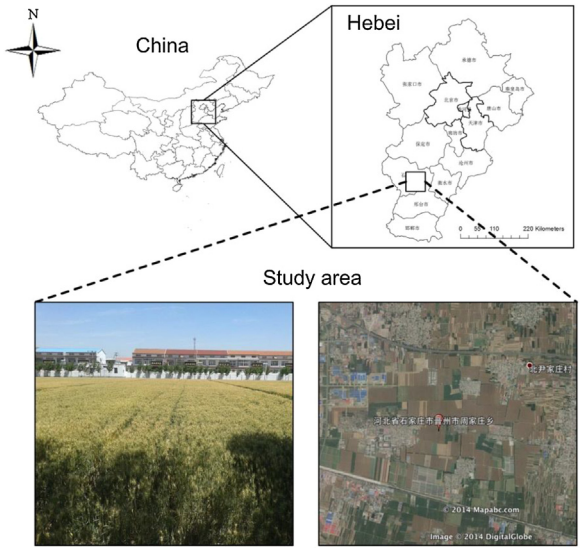

Fig. 1. Location of experimental region in Jinzhou, Hebei Province.

Processes such as reproduction, transmission, and infection of pathogen spores require appropriate environmental conditions, and monitoring of diseases and pests is thus linked to environmental factors. In recent years, the spatially continuous characteristics of remote sensing data and abundant information from different bands have greatly facilitated the obtainment of crop growth and environmental information, which may in turn be used for crop disease and pest monitoring [6]. Several scholars have used remote sensing data indirectly to analyze early-stage changes in the physiological state of plants due to diseases [7,8] and to obtain environmental information such as habitat characteristics [9–11]. In addition, some studies have reported spatial variation in land surface temperature (LST), soil water content (SWC), and other habitat parameters based on remotely-sensed thermal infrared information (10 and 11 bands in Landsat 8) and applied these parameters to monitor crop diseases and pests [12]. Thus, the integration of habitat and crop information may improve prediction of the occurrence of diseases and pests.

The occurrence of powdery mildew and aphids is strongly related to habitat conditions (e.g., temperature and humidity). However, most existing models for predicting crop diseases and pests by remote sensing are based on spectral data and do not include habitant characteristics. The increasing amount of remote sensing data with significantly improved band sets and spatial/spectral resolutions provides a significant data source for monitoring of habitat parameters, but it is necessary to evaluate whether these data can be used to accurately describe and characterize habitat inflicted with crop diseases and pests. In this study, we used satellite remote sensing imagery from Worldview 2 and Landsat 8 to monitor the occurrence of powdery mildew and aphids in wheat fields in Zhou Jiazhuang, Jinzhou City, Hebei Province. The research objectives were: (1) to propose a method for monitoring crop disease and pest habitat based on two types of remote sensing data; and (2) to evaluate the effectiveness of the method with synchronous ground survey data.

2. Study area and datasets

2.1. Study area

The study site (115°5.88′ E, 38°1.38′N) was located in Hebei Province in the northern part of the North China Plain, which is the main wheat production region in China (Fig. 1). This region has a temperate humid continental monsoon climate with four distinctive seasons, abundant sunshine, and suitable temperature, making it suitable for crop growth. The study site in Zhou Jiazhuang, Jinzhou City has concentrated areas of farmland, and the main crop is spring wheat. Due to its unique agricultural management practices, this area is an ideal location for remote sensing monitoring. According to the local agricultural management department, powdery mildew and aphids, which are sensitive to local climate and environmental conditions, are common diseases and pests in this area. A widespread survey of wheat diseases and pests was conducted in cornfields throughout the study site during the filling stage. Observational data (including GPS data, types of diseases and pests, and degree of infestations) and two sets of satellite images (Worldview 2 and Landsat 8) with different spatial resolutions and channel settings were obtained for the region.