MANAGEMENT OF DATE PALM PESTS

Geoinformatics Applications

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INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN DRY AREAS

Management of Date Palm Pests: A Guide for Development

Chapter IV

Geoinformatics applications in management of pests and diseases

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Geoinformatics application in mapping and management of pests and diseases

Abstract

Global change is become a norm and pose a serious threat to food and nutritional security with increased concerns of pests and disease risks. The date palm are prone to several pests, and some are invasively lethal to palm species worldwide. The foremost preventive measures is to quantify vulnerability of palms to pest risks in advance and across the scales (space-time) with innovative use of geoinformatics, big-data and commination technologies (Geo-ICTs). This research demonstrated application Geo-ICTs from in-situ observations to big-data analytics and precision decision making for ecologically and economically sound implementation of the integrated pest management practices to reduce risk and economic damages.

1. Introduction

Global change (climate variability and change as well as framing system) is become a norm and pose a serious threat to food and nutritional security with increased concerns of agricultural vulnerability to pests and disease risks. The nature and magnitude of the vulnerability of crops to insect pest and diseases risks and threats are not yet well-defined and uncertain in terms of spatio-temporal distribution under ever changing bio-physical and plant physiological conditions further hinders the effective implementation of the pest management strategies and planning of integrated pest management. One of the foremost preventive measures is to map vulnerability of crops to specific pests and diseases and its hotspots (spatial) and hot-times (temporal) to curb and mitigate the risk in advance and/or take action on the already prevailing outbreaks to check the further spread. At the larger scales, often, fundamental ecological concepts that address factors governing species distribution has been taken as a foundation in development of pest risks and vulnerability maps at the regional to global scales. However at the much local scales, such as farm level management of the pests requires use of the regular and in-situ monitoring protocells to better understand risks for proper management at field scales.   The spatial model combined geo-spatial climate data, crop and host phenology, persistence of pests and similarity conditions in conjunction with in-situ observations. Such risk analysis helps measure the persistence of the pests at a given time and location to development of the potential risks, vulnerability and subsequent epidemic outbreaks in a given location.

Geoinformatics tools and technology (GIS, RS, GPS, modeling, web apps) can be used to collect, archive, analyze and visualize of the pest and dieses efficiently an economically for the integrated pest and disease management practices. In this chapter we outline the geoinformatics technology and its potential application in mapping, monitoring and management of the pest risks to help effective implementation of the IPM and managers/decision makers at farm level to overarching leads to understand the variably of the risks at a spatio-temporal scales and decide when and where to use IPM practices and relevant control measures to reduce the risk and economic damages.

2. Geoinformatics

Geospatial science, technology and applications have become indispensable tools for modern day research, especially in natural resources and sustainable agro-ecosystem studies. The use of spatial data in agricultural research has recently proliferated due to: a) recent advances in satellite sensor technology, b) guaranteed availability of quality time-series data, c) open (free) access to high quality satellite sensor images, d) advances in processing and handling of large amounts of data, e) rapid increase in computational power, processing chain and storage/archiving mechanisms, f) decreases in cost of proprietary software, and g) ease and increasing expertise in handling these complex datasets.

Over the last 5 years, there has also been increased release of high quality datasets into the public domain, resulting in greater use of spatial data and the development of machine learning algorithms for thematic research. This trend is likely to increase in coming years and has ushered in a new era of 'open access.'

2.1 Increased resolution

The recent development of advanced sensor technology (e.g., specific bands, red-edge, yellow bands), platforms (e.g., spaceborne, airborne, UAVs), satellite constellation (e.g., increased orbital speed (WorldView2), multiple-clone satellites (RapidEye), onboard capacity and grounding stations, etc. has opened another new era--that of remote sensing applications. Just 3 years ago, it was a dream to get very high resolution images on a daily basis. Today, one can get satellite imagery on a near-real time basis at sub-meter (<60cm) each day for any given location. The quality and details of the imagery and therefore of the inherent information has increased dramatically. Simultaneously, software companies and open-access platforms are developing necessary calibration and processing tools to make such information easily available to a range of end-users.

2.2 Improved processing

Armed with increased computational power and speed for faster image processing, better GIS infrastructure, and a host of tools including new algorithms for modeling, the geoinformatics community can now study and characterize agricultural production systems at scales ranging from the field to the globe. One of the primary objectives of the CRP on Dryland Systems is to develop detailed, baseline databases for different "action sites" to characterize and understand the current status and extent of different production systems in terms of land use and land cover types, as well as various processes such as land degradation, water use, etc. These databases will allow researchers and stakeholders to track the progress and assess impact of various program interventions. For example, the capability to identifying different land management units or production systems through their associated spectral properties is a major step forward in our ability to classify and monitor dryland systems.

Ameliorated computational storage, processing power, and automated machine learning algorithms have been playing a greater role in enhancing pixel-based image analysis of high resolution data acquired over complex and highly variable agro-ecosystems. To be sure, there are still certain limitations associated with time-variant identical spectral characteristics among different land use and land cover types. However, the combined use of higher spatial, spectral and temporal resolution images has enabled us to produce better thematic maps with higher classification accuracy.

2.3 Decreased cost of operations

In the past, operational cost of Geoinformatics was one of the major bottle necks in adopting the technology to a wide array of applications. A major portion of the cost used to be associated with satellite image acquisitions, followed by the cyber infrastructure for processing and handling the satellite data, and high prices of major software packages and expertise. However, such overhead costs have been declining in the last few years due to increased open access to data, open source program and algorithms, decreased cost of the mass storage and increased computational efficiency.

The drastic reduction in the operational costs have led researchers to use geoinformatics tools and technology across wide areas of application in agricultural research starting from molecular level research to landscape level assessment in ensuring food and environmental security.

3. Approaches

There are several ways and approaches to map and monitor pest risk at field to landscape and regional level. Here we discuss geoinformatics approaches to map pest risks and associated parameters for better management of insect pests and disease.

Farm managers, extension workers and often farmers need to know where are the insect pests or disease infestation on their fields and their precise location, how abundant they are, what direction and magnitude they are moving over the time, etc. to make good timely decisions about control measure, use of chemicals and deployment of the teams. Without treatment on time and specific location, the insect populations can grow and cause substantial economic yield reduction. Alternatively, if an excessive amount of chemicals and/or IPM practices is needlessly applied to areas that have little to no threat of insect damage, then unnecessary spray costs and other disruptions can occur and vice versa where location of real risks are missed out in the control application. Which could happen without knowledge of the on the location of the pests on the spatio-temporal scales. Taking in to these points in consideration as well as size of the farm holdings, crop types, management network, extension systems in place, one has to decision a monitoring tool which is cost effective and ease of use from data collection to visualization and decision making.

Evaluating risk of a particular pest or disease can be done based on the source of the information (point based) or ecological niche modelling for broader scale. The information intensive hotspot approach is one of the best and accurate methods to track and quantify the risk hotspot at spatio-temporal scales. The following assumptions was used to identify these hotspots:

- risk is directly proportional to the presence of the vulnerable host (e.g., crop, dateplam);
- risk associated with presence of the of the virulent agent or pests (e.g., insects, virus)
- risk is associated with climate and biophysical conditions (temperature and precipitation patterns) being similar to the one in the areas where the pest/disease has been epidemic;

3.2 Ground truthing:

Geotagging of the field data for the assessment of the risk associated with several variables. The simple approach is identification of areas at higher risk than others. There are factors that are to be taken into consideration for risk analysis and management. One of the easy and economical option is to use the smart phone or tablets, embed with GPS and or use smart extension diary enabled with google APIs. Using the google earth high-resolution images as background with GPS enabled devices to mark the trees with decent position accuracy. Other approaches is use existing or already collected field survey data and geotagged those data with farm coordinates to GIS field boundary to assess at farm level.

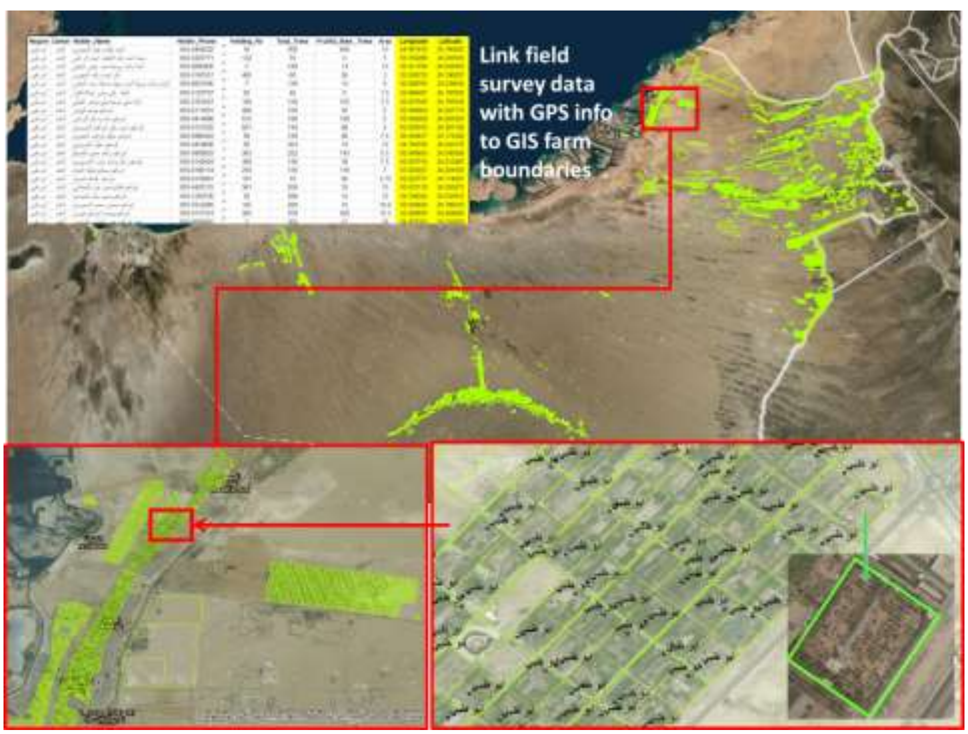

Fig. 1. Geotagging of the field data to GIS field boundary.

Fig. 2. Geo-tagging individual trees using mobile devices and apps

3.3 Spatial modeling

Field Data Correction and GPS Integration

Lack of geo-referenced information (GPS reading) in the field survey is one of the major limitation for the risk analysis at spatio-temporal scales. Many instances field data collected won't have GPS coordinates, and/or collected as separate information with no common fields to link to main data. The foremost step is to correct the data and link the GPS to facilitate generation of point level spatial database. One can use point level data to assess the pattern of the data or link these point level data field boundary in GIS domain to assess the farm level.

Layal, can elaborate a bit?

Hotspot analysis and rink mapping

Field data points or field boundary polygons creates a map of statistically significant hotspots using GIS based hotspot matric using Getis Gi statistics (ArcGIS). It evaluates the characteristics of the input feature class to produce optimal results. The analysis generates spatial matrix using parameters derived from characteristics of field survey and input data. The optimized hotspot analysis in GIS domain interrogates data to obtain the settings that will yield optimal hotspot maps. Using the distribution of the weighted features, the tool will identify an appropriate scale of analysis.

The corrected shapefile of the date palm data needs to be projected to any metric coordinate systems such as transverse mercator or polyconic. This is because chordal distances are based on a sphere rather than the true oblate ellipsoid shape of the earth. Given any two points on the earth's surface, the chordal distance between them is the length of a line, passing through the three dimensional earth, to connect those two points. Then run the spatial analysis to identify statistically significant spatial clusters of high values (more risk) and low values (low risk). It automatically aggregates incident data, identifies an appropriate scale of analysis, and corrects for both multiple testing and spatial dependence. This tool interrogates your data in order to determine settings that will produce optimal hot spot analysis results.

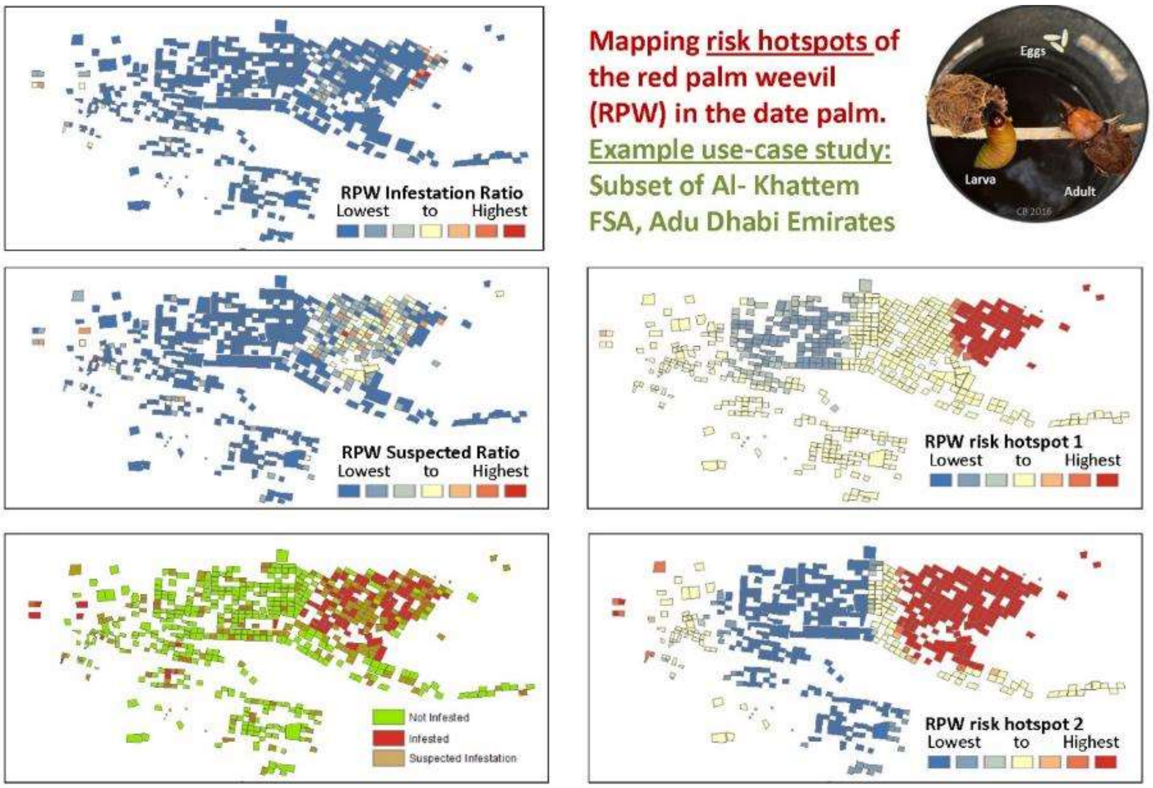

Figure 3 - Pilot case study of the Al Khattem Farmers Services Center area, Abu Dhabi showing the maps of the infected, suspected and hotspot risk pf RPW.

4. Conclusion

Recent advances in geoinformatics' tools and technologies have opened a new era for mapping and managing agricultural production systems and associated natural resources. Today, it is possible to dramatically better map and characterizes dryland production systems through of a) enhanced availability of very high resolution, remotely sensed data at reduced cost, b) increased institutional adoption of open-access data policies, and c) freely available geospatial data with spectral, spatial, and temporal attributes at medium to coarse resolutions. These allow better access to the knowledge needed by researchers, policy makers, and other stakeholders to improve food security and livelihoods across the developing world. The CRP on Dryland Systems is using these tools and technologies to move from mapping basic land units to quantitative description of the various components needed to improve overall system sustainability and productivity, and to develop and monitor key indicators across a range of cross-cutting themes needed to improved food security and livelihoods in dry areas of the world.