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Incidence Mapping of Calamansi Pests and Diseases in Victoria, Oriental Mindoro Through Geographic Information System (GIS)

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Abstract

The study was conducted to develop a Geographic Information System (GIS) – based approach for Calamansi pests and diseases monitoring and management. It aims to determine the current status of citrus pests and disease incidence in Victoria, Oriental Mindoro. Detailed maps of the prevalent pests and diseases were generated which can serve as a basis for the management and implementation of control measures. Results showed that the most widespread calamansi disease in the area is the citrus canker while the areas with the most incidences of citrus diseases are Alcate, Antonino, and San Antonio. Moreover, the most prevalent insect pest affecting citrus production in the area is the citrus rind borer while the areas with the most incidences of insect pests are San Gelacio and Alcate. Furthermore, the areas of concern with the most incidences of pests and diseases are the biggest plantation areas in the municipality with San Antonio having 21-30% share and Alcate with 16-20% share.

Keywords: Calamansi plantation, Citrus canker, Citrus rind borer, GIS application

Introduction

Native to Southeast Asia, the citrus fruit calamansi (*Citrus microcarpa B.*) is most widely consumed and grown in the Philippines. Calamansi is widely used in Filipino cuisine and has become prominent in the flavor industry due to its appealing flavor profile and naturalness. Due to its ability to flourish in a variety of environmental circumstances, it is the most widely cultivated citrus species in the nation. Its uses range from normal household to pharmaceutical ones, where it is used as a cough treatment and antiphlogistic (Palma et al., 2019).

Records show that the amount of calamansi produced from July to September 2022 was 56.40 thousand metric tons. It dropped by -6.2% from a production of 60.10 thousand metric tons during the same time in 2021. The MIMAROPA Region produced the most calamansi, accounting for 31.43 thousand metric tons, or 55.7% of the nation's total production. Central Luzon and CALABARZON came in second and third, respectively, with 11.3 percent and 5.4 percent of the market (PSA, 2022).

The main source of calamansi in Luzon is the MIMAROPA Region, specifically the province of Oriental Mindoro. Nearly all of the region's calamansi production—nearly 99 percent—is owned by the province. According

to Bureau of Agricultural Statistics (BAS) data, the average output volume per hectare is 17.46 MT, greater than the region's average of 13.74 MT, and 7,325 calamansi plants were planted in 2011, producing 104,416.27 MT (Agri-Info Hub, n.d.).

Among the 14 municipalities in Oriental Mindoro, Victoria contributes the most to calamansi production in terms of volume, cultivated hectares, and average yield. Peak production was 7,325.5 MT, or 58.58% of total production in the province. Additionally, the town was said to have the highest average output of 13.1 MT per hectare, according to reports (Agri-Info Hub, n.d.).

In the Philippines, eight citrus viruses and virus-like illnesses have been identified. Citrus tristeza virus (CTV), huanglongbing (leaf mottling/greening), exocortis, psorosis, xyloporosis, tatterleaf, woody gall/vein enation, and bud union crease of sweet orange on rough lemon rootstock are some of these. The most devastating citrus disease, huanglongbing, is responsible for the trees' eventual demise. Almost all citrus kinds planted in the country suffer damage from it, which is essentially present in every citrus-growing region. The widespread prevalence can be accounted for due to the usage of tainted planting materials that also contained insect vectors (Molina, et al., 1998).

Numerous diseases brought on by fungi, bacteria, and nematodes also hamper citrus yield in the Philippines in addition to graft-transmissible diseases. Powdery mildew, citrus scab, pink disease, melanose, anthracnose, stem-end rot, blue/green molds, and diseases caused by *Phytophthora spp*. such as root rot, foot rot, gummosis, brown rot, and shoot blight are among the main diseases brought on by fungal pathogens (Molina, et al., 1998).

Furthermore, according to the field surveys, citrus rind borer, was the most devastating insect pest. The greenish caterpillar eats its way through the fruit's rind, causing gall to develop over the tissues it has harmed. Other pests with lower population numbers and less severe damage included aphids, citrus thrips, fruit flies, leaf miners, and scale insects (Evangelista, 2008).

Meanwhile, a Geographic Information System (GIS) is a collection of tools for managing, manipulating, analyzing, modeling, representing, and displaying geo-referenced data (Ranjan and Vinayak, 2020). A study found that comparing maps is a typical GIS application (Foody, 2007). Data collection, management, analysis, and display are common tasks in GIS operations (Chang, 2016). The gathering of geographically referenced data is a clear requirement for any spatial analysis. Examples of this type of data include paper maps, remotely sensed data, digital line graphs, and field-gathered point data (Liebhold, 1993).

Likewise, data on the current pests and diseases in a particular area can be accurately collected, represented, and evaluated with the use of GIS. This information can then be used as the basis for future plans and pest and disease management systems. Through forecasting systems for insects and plant diseases in agroecosystems, farmers can also be alerted to potential outbreaks and take quick action to apply bio-control agents, mechanical means, and pesticides. This can be used as a tool for precision farming and to lower production costs (Ranjan and Vinayak, 2020).

As one of the major producers of calamansi, the presence of various pests and diseases poses threats to the calamansi industry in Victoria, Oriental Mindoro. Local farmers also lack pest management plans or proper control strategies to manage pests and diseases in their farms and tend to continuously use chemicals or pesticides that might not be effective against the actual pests and diseases present in the area. Data monitoring can also be vague when represented only as words and numbers which can also lead to errors and poor analysis. With the current status of the calamansi industry, proper monitoring and control systems of the prevalent pests and diseases in farms and plantations should be established and developed.

Generally, the study aims to develop a Geographic Information System (GIS) – based approach for Calamansi pests and disease monitoring. Specifically, it aims to determine the current status of citrus pests and diseases in Victoria, Oriental Mindoro; assess and create a detailed map of dominant calamansi pests and diseases in the municipality using GIS; evaluate other factors that can contribute to the presence of calamansi pests and diseases in the area and formulate recommendations based on the results.

This study can help farmers in detecting recurring citrus pests and diseases and in planning management techniques to control these to reduce possible losses and maximize production. Specifically, gathered data can be

properly represented and analyzed if shown as maps so that the actual situation in the area can be easily visualized. Likewise, the details and records can also be properly documented and possible patterns of cases can easily be checked through the use of GIS maps. As a result, recurring diseases can be detected earlier and possible outbreaks can also be prevented or controlled faster considering accurate and sufficient records of historical data. Moreover, this can also be a basis for the promotion of Integrated Pest Management (IPM) and other control measures that will help the farmers to effectively manage pests and diseases and provide options that are safe for both the people and the environment

Materials and Methods

Data Source

The paper used secondary data from a study conducted by Mindoro State University from April to August 2021 entitled, "*Study on Pest and Diseases of Calamansi: Paving Ways for the Sustainability of Calamansi Industry in Oriental Mindoro"*. This includes the profiling of 13 calamansi-producing municipalities in Oriental Mindoro and the classification of the existing calamansi pests and diseases in the area made available through the application called CalamanSeek (MinSU, 2022). Researchers of the study conducted questionnaire surveys for the farm profiling and field surveys and inspections to determine the incidence of pests and diseases per municipality. Inspections were done through visual inspection of calamansi trees selected randomly. Samples are also collected for further analysis in the laboratory.

Study Area

For this study, incidence maps were generated specifically for Victoria, Oriental Mindoro. Victoria is a landlocked municipality in the province of Oriental Mindoro. The municipality comprises of 32 barangays and covers 146.23 square kilometers accounting for 3.45% of Oriental Mindoro's total land area (PhilAtlas, 2022).

Consolidation of Pests and Diseases Incidence

Based on the available data, existing pests and diseases in calamansi farms of Victoria, Oriental Mindoro were collected and analyzed. The incidences of common pests and diseases are recorded per barangay in order to know the most prevalent pests and diseases in the municipality. Then, these data are used as inputs for the generation of maps through ArcGIS 10.3 application. Thus, calamansi pests and diseases distribution maps served as outputs.

Plantation Area

Data for the calamansi plantation area in the municipality was collected from the Municipal Agriculture Office of Victoria.

Analysis of Generated Maps

Generated maps are then correlated with other factors such as plantation area and prevailing climate in the location. Through the use of GIS-generated maps, the data can easily be compared and analyzed. It can also serve as the basis for recommendations for management and control. Additionally, a forecast can also be formulated by checking the trend or pattern of a specific disease or pest occurrence upon collection of a sufficient amount of data for years.

Results and Discussion

Predominant calamansi pests and diseases

Available data shows that the common diseases affecting the citrus industry in Oriental Mindoro are citrus huanglongbing, tristeza, citrus canker, sooty mold, gummosis or foot rot, citrus scab, and dieback. Furthermore, the common citrus insect pests in the province are citrus aphid, Asian citrus psyllid, mealybug, white fly, citrus rind borer, thrips, and citrus scale.

The distributions of the common citrus diseases in the municipality of Victoria are shown in Figure 1. Based on the generated maps, the most widespread citrus disease is the citrus canker with incidences in eight barangays namely; Alcate, Antonino,

San Gabriel, Loyal, San Antonio, San Gelacio, San Isidro, and Leido.

Study found out that leafminer infection (citrus canker), citrus scab, huanglongbing (HLB)/citrus greening, Tristeza virus (CTV) symptoms, sooty mold, and leaf canker are the most common calamansi diseases observed in Oriental Mindoro. In most of the farms surveyed, leafminer infection (citrus canker) is widespread. Citrus scab and HLB/CTV symptoms are the other two diseases with at least 1,000 cases (Masagca, Jr. et al., 2021).

Citrus canker is mostly a leaf spotting and fruit rind blemishing disease, although infections can cause defoliation, branch dieback, and fruit drop when conditions are ideal for infection (Gottwald & Graham, 2005). The majority of canker spread by wind and rain occurs over small distances, such as within trees or to neighboring trees. Canker grows more aggressively on the side of the tree that is exposed to wind-driven rain. Severe weather events such as tropical storms can cause the spread over greater areas, up to many miles (Gottwald & Graham, 2005). Thus, the prevailing climate in the province can be a factor in the spread of the disease. Additionally, Oriental Mindoro experiences two climate types: Type I and Type III. Type I has two distinct seasons, dry from November to April and wet the rest of the year. Type III climate is comparable to Type I climate, however, the seasons are not as distinct. Moreover, due to Mindoro's location, while certain areas are shielded by mountain ranges, the province is nevertheless affected by rains brought in by the Habagat and tropical storms (GGGI, 2021).

Figure 1 shows the citrus disease incidence summary for the different barangays in Victoria, Oriental Mindoro. The barangays with the most incidences of citrus diseases are Alcate, Antonino, and San Antonio.

Controlling citrus canker in areas where it is a serious problem necessitates the incorporation of appropriate cultural practices such as sanitation, windbreaks, and leafminer control. Windbreaks can help to minimize disease transmission and severity while leafminer management is especially critical on young trees (Gottwald & Graham, 2005).

On the other hand, the incidences of common insect pests affecting citrus production in the municipality of Victoria are

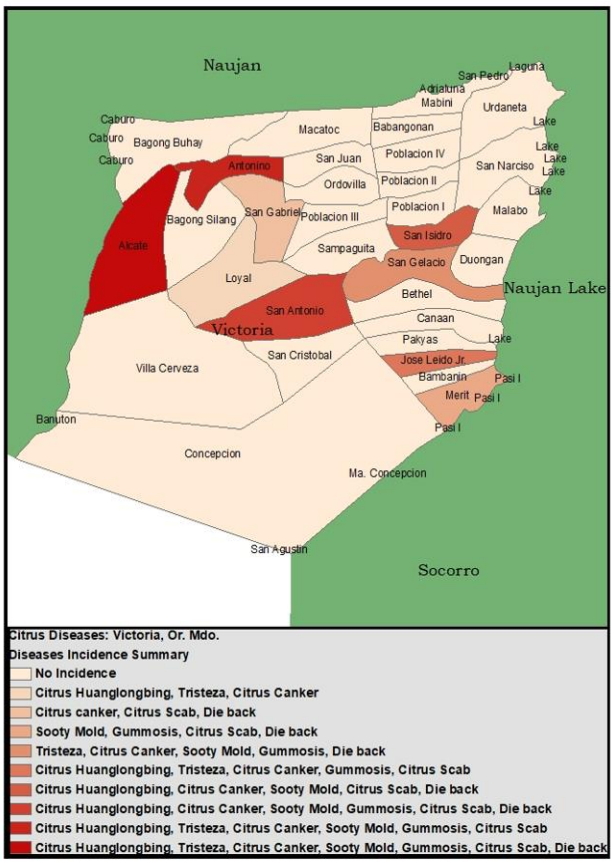

Figure 1. Citrus Disease Incidence

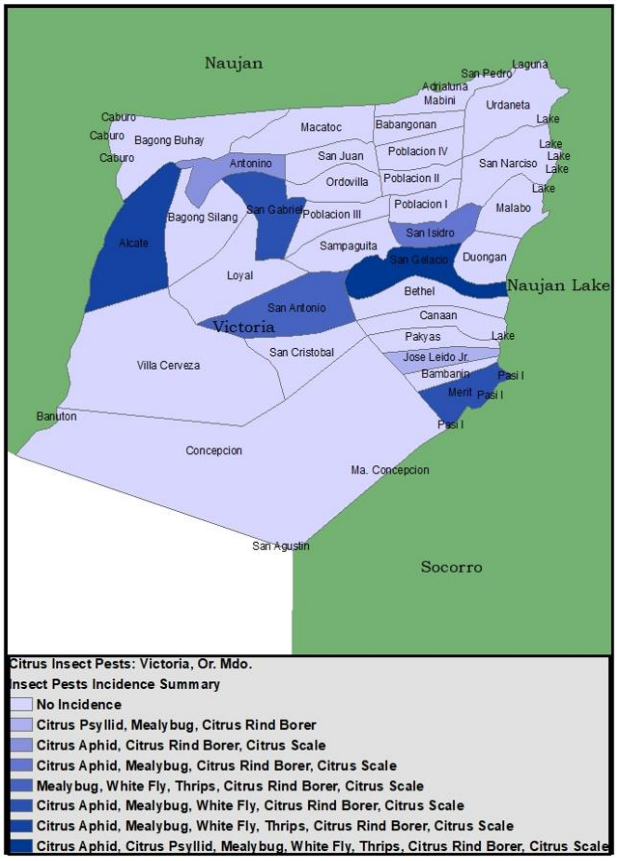

Figure 2. Citrus Insect Pests Incidence

shown in Figure 2. Based on the generated maps, the most prevalent insect pest affecting citrus production in Victoria, Oriental Mindoro is the citrus rind borer with incidences in eight barangays namely; Alcate, Antonino, San Gabriel, San Antonio, San Gelacio, San Isidro, Leido, and Merit. The barangays with the most incidences of insect pests are San Gelacio and Alcate

Generally, citrus rind borer (40.13% of sampled trees) is the most common pest found in most calamansi plantations in Oriental Mindoro, followed by thrips, beetle, leaf miner, and mealybug. Citrus rind borer is the most common insect pest detected in investigated trees, indicating that its distribution is widespread or that its impact on trees is more extensive than that of other insect pests discovered (Masagca Jr. et al., 2021).

Calamansi plantation areas

For the calamansi plantation area, the map showing the percent share of each barangay to the total plantation area is shown in Figure 3. This shows that San Antonio holds the largest share of plantation area with 21-30% followed by Alcate with 16-20% share. For the production volume, no specific data are available for each barangay thus, the study was only able to consider the production area.

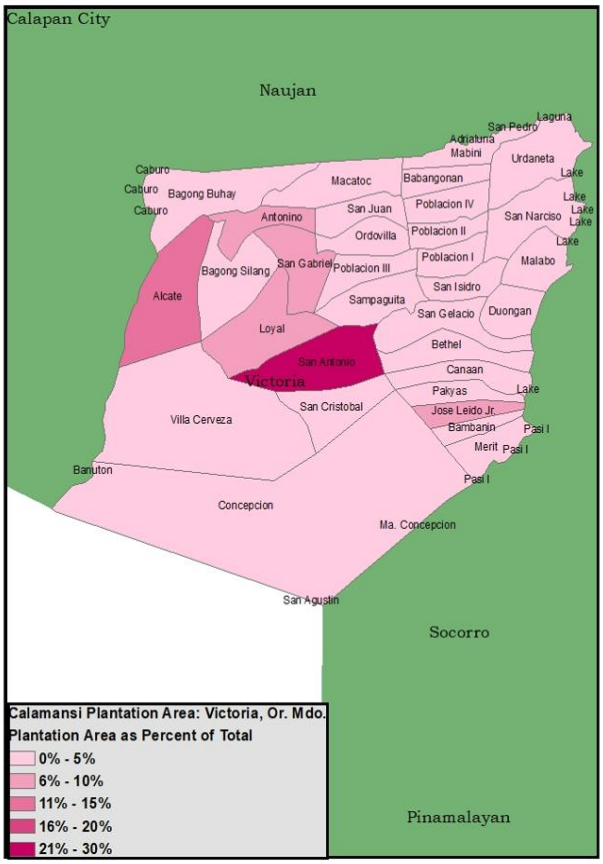

Figure 3. Percent Plantation Area for each Barangay

Conclusions

The study conducted shows the distribution of the common insect pests and diseases of citrus, specifically, calamansi in the municipality of Victoria, Oriental Mindoro. Results showed that the most widespread calamansi disease in the area is the citrus canker while the areas with the most incidences of citrus diseases are Alcate, Antonino, and San Antonio. Moreover, the most prevalent insect pest affecting citrus production in the area is the citrus rind borer while the areas with the most incidences of insect pests are San Gelacio and Alcate.

Furthermore, in relation to the plantation area, the areas of concern with the most incidences of pests and diseases are the biggest plantation areas in the municipality with San Antonio having 21-30% share and Alcate with 16-20% share. With this, proper monitoring and control management of pests and diseases should be conducted and implemented in these areas in order to reduce the possibility of incurring high losses due to pests and diseases.

Additionally, it is recommended to conduct more and regular field surveys to have detailed data on the incidences of insect pests and diseases in the area. Regular monitoring should be done in order to get sufficient records of the distribution status so that possible patterns and trends will be checked and eventually, pests and disease outbreaks forecast can be generated in the future based on years of historical data.

Before and after status of pests and disease incidences should also be documented upon implementing control strategies or measures in order to check the effectiveness of the measures applied. Also, other factors that may contribute to the occurrence of insect pests and diseases should be checked and studied to control and

prevent possible pests and disease outbreaks. Lastly, using primary data and conducting primaryl field surveys is recommended to have more detailed and complete results

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References

Agri-Info Hub. (n.d.). *AGRI-PROFILE: VICTORIA*. http://orminagri.com/victoria1.html

Chang, K. T. (2016). Geographic information system. *International Encyclopedia of Geography: People, the Earth, Environment and Technology,* pp. 1-10. doi.org/10.1002/9781118786352.wbieg0152.

Evangelista, C.C. (2008). Development of integrated pest management for citrus. *Agris. Food and Agriculture Organization of the United Nations*. https://agris.fao.org/agris-search/search.do?recordID=PH2008000829

Foody, G.M. (2007). Map comparison in GIS. *Progress in Physical Geography*, 31(4), pp. 439-445.

Global Green Growth Institute. (2021). Climate Vulnerability and Risk Information System (CVRIS) for Agricultural Value Chain in Oriental

Mindoro. https://gggi.org/wp-content/uploads/2022/01/Policy-Advisory-Report-for-the-Development-of-Climate-Vulnerability-and-Risk-Information-System-CVRIS-for-Oriental-Mindoro-1.pdf

Gottwald, T.R. and Graham, J.H. (2005). Citrus canker. *The American Phytopathological Society*. https://www.apsnet.org/edcenter/disandpath/prokaryote/pdlessons/Pages/CitrusCanker.aspx

Liebhold, A.M., Rossi, R.E., Kemp, W.P. (1993). Geostatistics and geographic information systems in applied insect ecology. *Annual Review of Entomology*, 38(1), pp. 303-327.

Masagca, Jr. M., Jatico, W., Terones, L., Horlador, C.D., Bangalisan, H., Cueto, J., Gumba, M., Garachico, N.J., and Alfonso, Jr., C. (2021). Challenges of the Calamansi Industry in Oriental Mindoro: Pests and Diseases Management. Policy Brief Series 2021, No. 1.

Mindoro State University. (2022). CalamanSeek Guide for Farmers. Department of Agriculture-Philippine Rural Development Project. Google PlayStore.

Molina, A.B., Roa, V.N., Bay-Petersen, J., Carpio, A. T., and Joven, E.A. (1998). Managing banana and citrus diseases. *Proceedings of a regional workshop on disease management of banana and citrus through the use of disease-free planting materials*. https://swfrec.ifas.ufl.edu/hlb/database/pdf/00001180.pdf

Palma, Claire E.; Cruz, Philip S.; Cruz, Don Theon C.; Bugayong, Adrienne Marrie S.; Castillo, Agnes L. (2019). Chemical composition and cytotoxicity of Philippine calamansi essential oil. *Industrial Crops and Products*, 128(), 108–114. doi:10.1016/j.indcrop.2018.11.010

PhilAtlas. (2022). *Victoria Province of Oriental Mindoro*. https://www.philatlas.com/luzon/mimaropa/oriental-mindoro/victoria.html

Philippine Statistics Authority. (2022). *Major Fruit Crops Quarterly Bulletin, July-September 2022*. https://psa.gov.ph/fruits-crops-bulletin/calamansi

Ranjan, R., Vinayak, S. (2020). Application of remote sensing and GIS in plant disease management. In Precision Agriculture and Sustainable Crop Production, Chourasia, H. K., Acharya K., Singh, V. K. (eds.). *Today & Tomorrow's Printers and Publishers, New Delhi-110002 (India)*, pp. 509-522