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APPLICATION OF DRONE-BASED IMAGERY IN CORN STUNT DISEASE

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Abstract: Corn stunt disease, caused by the corn leafhopper (*Dalbulus maidis*), is a significant threat to maize production, causing physiological disruption and yield losses. This study evaluated the efficacy of a cysteine-derived bioactive compound in mitigating the impacts of this disease on two commercial maize hybrids (KWS and Agroceres). We used multispectral imagery collected by Remote Piloted Aircraft (RPA) throughout the crop cycle to monitor plant vigor regarding different treated plots. Results consistently showed KWS-treated plots demonstrating superior vegetative vigor and performance compared to the Agroceres plots. This research highlights the potential of RPA-based remote sensing to assess the effectiveness of protective treatments against biotic stress.

Keywords: corn stunt, *Dalbulus maidis*, corn leafhopper, multispectral images, precision agriculture.

USO DE IMAGENS DE DRONE NO CONTEXTO DO COMPLEXO DE ENFEZAMENTOS DO MILHO**Resumo:**

A doença do enfezamento do milho, causada pela cigarrinha-do-milho (*Dalbulus maidis*), é uma ameaça significativa para a produção dessa cultura, provocando distúrbios fisiológicos e perdas de produtividade. Este estudo avaliou a eficácia de um composto bioativo derivado da cisteína na mitigação dos impactos da doença em dois híbridos comerciais de milho (KWS e Agroceres). Foram utilizadas imagens multiespectrais coletadas por Veículos Aéreos Remotamente Pilotados (ARP) ao longo do ciclo da cultura para monitorar o vigor das plantas em parcelas com diferentes tratamentos. Os resultados mostraram consistentemente que as parcelas tratadas com o híbrido KWS demonstraram vigor vegetativo e desempenho superiores em comparação com as parcelas do híbrido Agroceres. Esta pesquisa destaca o potencial do sensoriamento remoto baseado em RPA para avaliar a eficácia de tratamentos protetores contra estresses bióticos.

Palavras-chave: enfezamento do milho, *Dalbulus maidis*, cigarrinha-do-milho, imagens multiespectrais, agricultura de precisão.

1. Introduction

Corn stunt disease, caused by a complex of phytopathogens transmitted by the corn leafhopper (*Dalbulus maidis*), poses a major threat to maize production in Brazil. The disease leads to severe physiological disruption, reduced photosynthetic capacity, and significant yield losses. In this context, the use of bioactive molecules - such as antioxidants, amino acid derivatives, or plant defense inducers - has gained attention as a strategy to enhance plant tolerance to biotic stress. These compounds can mitigate the effects of infection by improving redox balance, reducing oxidative damage, and supporting key metabolic pathways related to growth and productivity. Integrating such molecules into crop management programs may contribute to maintaining plant vigor and yield potential, especially in areas where chemical or biological control of the vector is limited or ineffective. Corn stunt disease leads to alterations in photosynthesis, chlorophyll content, and leaf architecture, resulting in distinct spectral patterns that can be captured by remote sensors mounted drones. The high spatial and temporal resolution of drone imagery allows for precise mapping of affected areas, facilitating the analysis of spatial distribution of the disease within fields and enabling faster, site-specific phytosanitary management decisions. Moreover, repeated drone flights throughout the crop cycle support temporal monitoring of disease progression, contributing to epidemiological studies and evaluations of different control strategies. When integrated with artificial intelligence and machine learning systems, these images can be used to train automated classification models, greatly enhancing large-scale diagnostic capacity. Therefore, the application of drones in the detection of maize stunt disease represents an innovative and efficient approach within precision agriculture, promoting sustainability, input efficiency, and a reduction in losses associated with the disease. Multispectral images obtained by cameras on Remotely Piloted Aircraft (RPA) are very common today to help detect pest and disease infestations in agriculture, including corn cultivation (Barbedo, 2019). Zhang et al. (2023) used vegetation indices (VI) obtained from RPA multispectral images to early detection and monitoring the severity of tar spot disease. Jia et al. (2024) used similar approaches, including, in addition to RPA multispectral images, also textural data and thermal images for detection of the sadiasme disease. Radócz et al. (2024) used VI obtained from RPA multispectral images for corn smut fungus detection, showing significant spectral differences between healthy and high-dose infected sweet corn. Regarding this context, the objective of this work was to use VI calculated from RPA multispectral images collected throughout the corn production cycle to evaluate a compound derived from the amino acid cysteine in mitigating the impacts cause by the corn stunt complex in two distinct commercial hybrids

Materials and Methods

The study was conducted in an experimental plot with approximately 0.1 ha of area located in National Reference Laboratory of Precision Agriculture (Lanapre) of Embrapa Instrumentation, located in Sao Carlos, São Paulo state, Brazil. The area is located at an altitude of 860 m, with geographic coordinates of 22° 00' 00" S and 47° 53' 27" W. The soil is classified as Dystrophic Red-Yellow Latosol (*Latossolo Vermelho Amarelo Distrófico*) (Sartorelli et al., 2007), with a clay loam texture (Abreu, 2019). The soil was previously amended based on a soil analysis and corrected according to the parameters established in IAC Bulletin 100. Sowing was carried out on August 12, 2024, and harvesting on January 7, 2025. Two hybrids were used for the trial: one from KWS (K7510) and another from Agrocères (AG7098) companies. The molecule was tested through a total of four foliar applications during the vegetative stage. Only basal and topdressing fertilization, as

well as herbicide application, were performed as crop management practices. No chemical or biological control of *Dalbulus maidis* infestation was carried out. The layout of the experiment was established considering 12 longitudinal strips (four treatments with three repetitions) for application of inputs, each approximately 1.8 m wide, which meant that each strip contained three planting lines (Figure 1).



Figure 1. Experimental plot layout considering four treatments (*labels agro_control_red, agro_nac_blue, kws_control_red and kws_nac_blue*). * *agro_nac_blue* (AG7098 hybrid treated), *agro_control_red* (AG7098 hybrid not treated), *kws_nac_blue* (K7510 hybrid treated), *kws_control_red* (K7510 hybrid not treated). Image: Danilo Rocha (Embrapa Southeastern Livestock).

Multispectral images were acquired using a RPA DJI Matrice 2100 equipped with a Sentera AGX 710 multispectral camera. This system facilitated the generation of reflectance values across five distinct spectral bands: Red, Green, Blue, Near-Infrared (NIR) and Red Edge. Eight missions were conducted throughout the maize crop cycle, from September 9 to December 12, 2024, with an approximate 15-day interval between each mission. A rigorous post-processing workflow was applied to multispectral imagery for each acquisition date to generate time-series of vegetation indices (VIs) indicative of crop evolution throughout the harvest period. First, geospatial adjustment was performed on each band using the Georeferencer tool in QGIS software. This process utilized six ground control points (GCPs), precisely fixed at field borders, with coordinates collected using Global Navigation Satellite System (GNSS) equipment with Real-Time Kinematic (RTK) technology. Next, individual band images from each date were combined into a single five-band multispectral image using the Mosaic tool in QGIS software. Subsequently, a vegetation-specific filter was applied to each multispectral image. This filtering process, implemented using the R-G-B bands within the FieldImageR package in R software, retained only pixels corresponding to vegetation. Using the same R package, the Normalized Difference Vegetation Index (NDVI), Normalized Difference Red Edge (NDRE), and Enhanced Vegetation Index 2 (EVI2) (Pipatsitee et al., 2023) were calculated for each filtered multispectral image. This resulted in eight images, each containing three bands representing the calculated VIs. Finally, for central planting line of each experimental strip, the mean and standard deviation were calculated for each VI on each acquisition date. This enabled the graphical visualization of timeseries data for each treatment, facilitating the assessment of crop development. Figure 2 (items a-d) illustrates the sequence of preprocessing steps performed on the images.

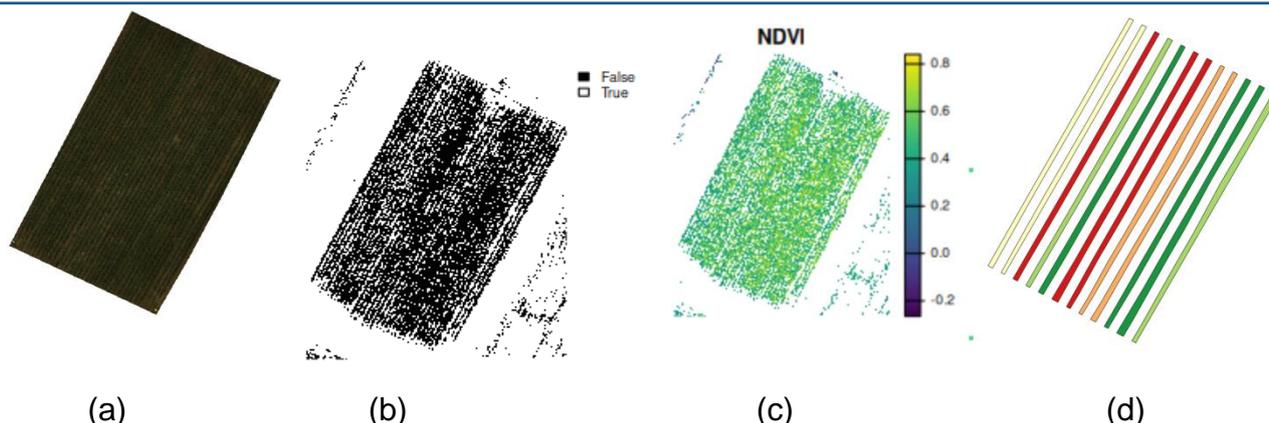


Figure 2. Results of pre-processing steps: original RGB image (a); binary image with marked vegetation pixels (white) (b); image with calculated VI (NDVI) (c); and vector strips with average VI values varying from red (low values) to green (higher values), considering only the central planting line (d).

3. Results and Discussion

The graphs of mean values for NDVI (Figure 3a), NDRE (Figure 3b), and EVI2 (Figure 3c) showed similar spectral responses of the crop throughout its development cycle. A progressive increase in VI values was observed until mid-November, indicating the crop's vegetative vigor. Subsequently, there was a reduction in values, attributed to leaf senescence and dehydration of the leaves as harvest approached. During the October 23rd flight, illumination inconsistencies led to the acquisition of anomalous data points within the time series, particularly affecting the NDVI and EVI2. Consequently, to maintain the integrity and accuracy of the subsequent analyses, data collected on this specific date were not considered. A consistent observation across all three graphs was the superior performance of strips treated with the *KWS* product compared to those receiving the *Agro* product. Despite minimal absolute differences in the Vegetation Index (VI) values, the *KWS* treatment consistently demonstrated enhanced vegetative vigor. This suggests a more favorable impact of the *KWS* product on crop development. Conversely, *KWS*-treated plots exhibited lower Vegetation Index (VI) values than *Agro*-treated plots on December 6th. This observation is likely attributable to delayed phenological development in the *Agro*-treated plots. Despite this, *KWS* plots demonstrated superior performance for both NDVI and NDRE indices on the latter date, suggesting a more favorable long-term impact on crop vigor. Objective analysis of the time series data derived from the VI consistently indicates superior protection and enhanced overall performance of the maize crop throughout its growth cycle when treated with the *KWS* product compared to the *Agro* product, despite the small differences observed in the mean VI values between treatments.

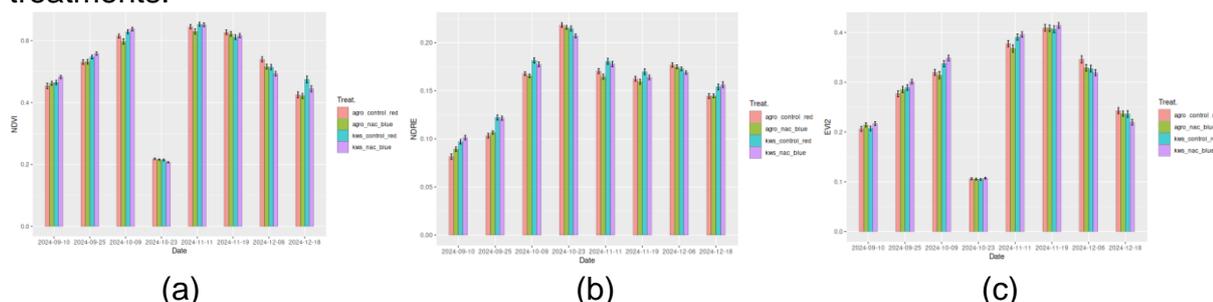


Figure 3. Graphs showing mean values of VI for each treatment throughout the time series of the crop cycle for NDVI (a); NDRE (b); and EVI2 (c).

4. Conclusions

This study demonstrates that drone-based multispectral imaging effectively monitors corn stunt disease progression, enabling precise and timely management decisions. Bioactive molecules, such as those in the KWS treatment, enhance maize tolerance to biotic stress, improving crop vigor and productivity under disease pressure. Vegetation indices serve as reliable indicators of physiological changes, aiding in the evaluation of treatment efficacy and disease impact. Integrating remote sensing with AI-driven analysis offers scalable solutions for early disease detection and precision agriculture in maize cultivation. This approach supports sustainable crop management by reducing yield losses and optimizing input efficiency in disease-affected regions.

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