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Multispectral Imaging for Cranberry Production Improvement

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Understanding Remote Sensing

Jyostna Mura's team is currently engaged in the development of remote sensing technologies specifically tailored for the cultivation and monitoring of cranberries. Remote sensing is the use of images captured by satellites and aircraft, allowing for the evaluation of field conditions from a distance without making physical contact with the target. Since cranberry beds are larger than a human field-of-view, we can't make observations of the entire bed simultaneously. However, this limitation can be overcome through remote sensing techniques.

Different Kinds of Remote Sensing

1. Visual Imaging: This method captures images as they are perceived by our eyes.

2. Multispectral Imaging: Captures specific wavelengths, offering more than what's visible.

3. Hyperspectral Imaging: Provides high-resolution images across many contiguous spectral bands.

4. Thermal Imaging: Focuses on detecting heat, revealing images based on temperature variations.

Comparative Analysis of Imaging Techniques

This table (right) summarizes the key elements of each imaging technique, allowing cranberry growers to make informed decisions about which technology to employ for their specific needs.

Imaging Techniques	Advantages	Disadvantages
Visual	– Intuitive – Similar to human perception – Easy to interpret	– Limited to visible spectrum –Might miss underlying issues
Multispectral	– Captures specific wavelengths – Detects issues invisible to the naked eye – less computer processing power required vs hyperspectral	– Limited to certain bands –Less detailed than hyperspectral
Hyperspectral	– Detailed across many bands – Potential to identify varied issues	– Complex data analysis – Requires advanced software
Thermal	– Detects temperature differences – Ideal for spotting heat-related stress or diseases	– Solely temperature-focused analysis

Vegetation Indices and Their Importance

Vegetation indices, like NDVI and ADVI, are numerical markers derived from remote sensing to assess vegetation's health and vigor.

NDVI (Normalized Difference Vegetation Index): This is a human-created ratio used to make plant status differences easy to notice. At its core, NDVI measures the difference between how plants absorb and reflect light, specifically in the red and near-infrared spectrums. Chlorophyll, essential for photosynthesis in plants, strongly absorbs visible light in the red portion of the spectrum, while the cell structure of the plants reflects near-infrared light. This means that a plant with a high concentration of chlorophyll will absorb more red light and reflect more near-infrared light, leading to a higher NDVI value.

As a general guideline:

High NDVI (closer to +1.0): Indicates healthier vegetation, with a dense concentration of chlorophyll. Typically represented by dark green colors on NDVI maps.

Medium NDVI: Suggests moderate vegetation health, perhaps due to factors like approaching maturity or stress. Often displayed as yellow on NDVI maps.

Low NDVI (closer to -1.0): Highlights sparse or stressed vegetation, which could be due to conditions like water scarcity, disease, or nutrient deficiency. These areas are usually represented in red hues on NDVI maps.

Understanding these variations allows for more effective crop management, as growers can pinpoint areas that might need more attention or different treatments.

ADVI (Advanced Differential Vegetation Index): Combining Visual and NDVI, ADVI paints a colorful portrait of the marsh's health. Red indicates trouble spots, green for healthy patches, and yellow for moderately stressed areas.

2023 Data Collection Insights

A closer look at the provided figures unveils the profound capability of these tools (images to the right).

Validating Remote Sensing Maps through Uprights and Soil Analysis

Following image collection and analysis, we identify stressed spots (Figure 3) and categorize them based

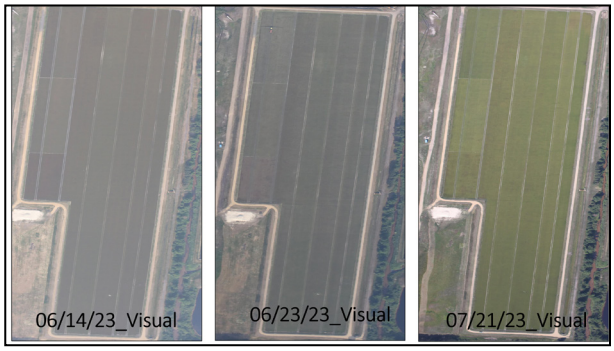

Figure 1. Visual Map: At a glance, the cranberry field appears uniformly thriving.

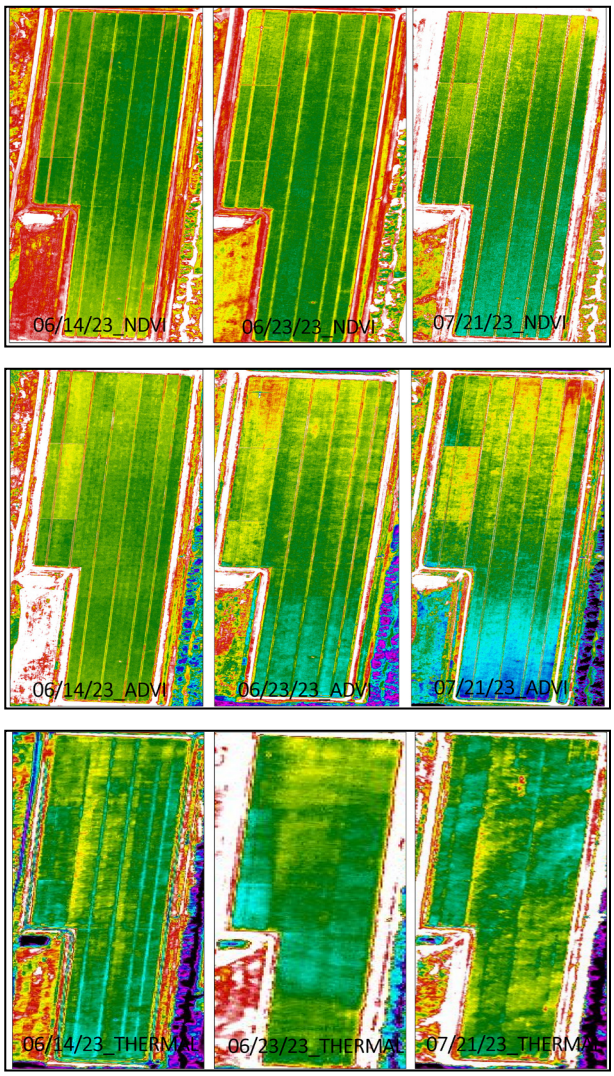

Figure 2. (a) NDVI, (b) ADVI, and (c) Thermal Maps: These time series maps reveal variations, underscoring both stressed and unstressed sections, way before any visible signs emerge.

on color as healthy (green), moderately stressed (yellow), or highly stressed (red) spots. As part of our comprehensive approach to validating the information presented in the remote sensing maps, we collect uprights and soil samples from each spot (including healthy regions). We analyze the samples for nutrients, biotic, and abiotic stress from each spot, and compare with remote sensing maps. We found that the information from the maps is consistent with the stress and health data.

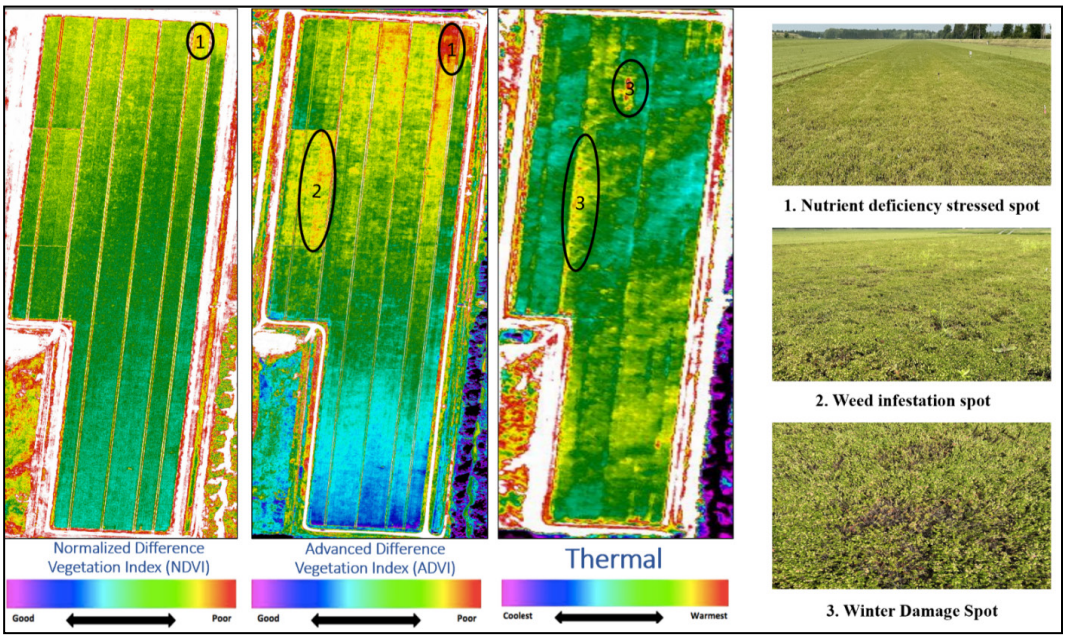

Figure 3. Detailing further the identification of stressed spots suing NDVI, ADVI and thermal maps. For full detailed image, click here.

Benefit to Cranberry Growers

These cutting-edge imaging technologies are invaluable to the cranberry industry. The integration of multispectral, thermal, and visual imaging techniques can transform cranberry crop management. This technology has the potential to identify problems at an early stage, thereby alerting growers to take the necessary precautions to ensure crop health and boost yields. It allows for a targeted approach to diseases, weeds, insect damage, abiotic stresses, and nutrient deficiencies, as you can easily identify the problem areas in a bed. Additionally, by understanding potential threats' exact nature and location, growers can optimize management, minimize waste, reduce environmental impact, and improve economic outcomes.

Beneficial Microbes Living Inside Cranberry Plants

By Bhagya C. Thimmappa, Lila Naouelle Salhi, Lise Forget, Matt Sarrasin, Peniel Bustamante Villalobos, Franz B. Lang, and Gertraud Burger

All plants host microbes, referred to as symbionts, that may live inside the plant or on its surface (mostly roots). Certain microbial symbionts improve the nutrient uptake of their host plants and help the plant to defend itself against pathogens. These actions are known as biofertilization and biocontrol. Much of the current research on plant symbionts focuses on pathogens. Therefore, we started investigating microbes beneficial for plants. More specifically, we isolated symbiotic fungi with biofertilization ability from field-grown cranberry plants and characterized them by microbiological and greenhouse experiments as well as by genomics and transcriptomics methods. We sequenced the genome of EC4 sequenced the RNA – RNA-Seq of EC4 when grown with cranberry plant roots.

The first paper we published in this subject area is on the isolation and taxonomic classification of bacteria and fungi living inside cranberries (Salhi et al., 2022). In our most recent research article entitled "Nuclear Genome Sequence and Gene Expression of an Intracellular Fungal Endophyte Stimulating the Growth of Cranberry Plants," we show that one of the fungal endophytes called Endophytic Champignon 4 (EC4) grows inside and outside of cranberry plant roots and, in greenhouse

tests, stimulates the growth of cranberry plantlets roots and shoots by utilizing potassium and tri-calcium phosphates sources. Its genome sequence reveals a large number of genes involved in nitrogen, phosphate and potassium nutrition and plant growth hormone production (Thimmappa et al., 2023).

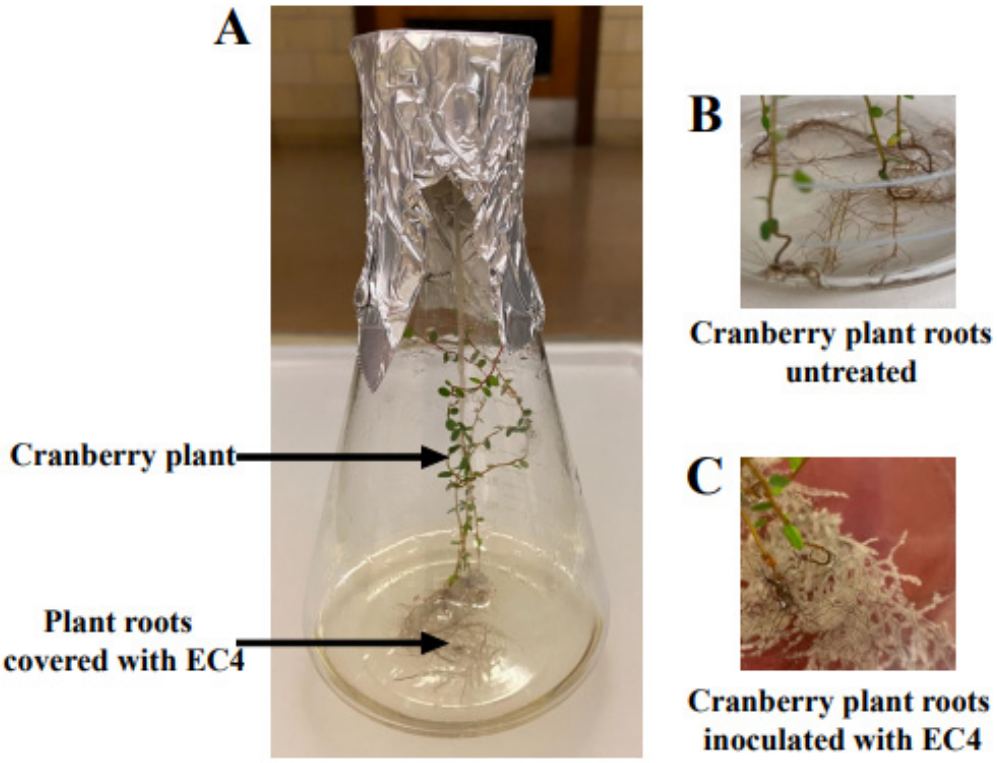

Figure 1. Cranberry plant inoculated with EC4 and cultivated in liquid medium. Microbe-free cranberry plantlets were first grown in a minimum mineral medium for three months, then transferred to a yeast-glycerol medium inoculated with EC4. (**A**) Experimental set-up. (**B**) Roots of control plant in medium without EC4. (**C**) Mycelium-covered plant roots in EC4-inoculated medium.

Field trials with EC4 are underway in Quebec, Canada, in collaboration with Atoka Inc., Pampev Inc., Gillivert Inc., and Transport Gas-ton Nadeau Inc. Knowledge gained in our study has the potential to deploy fungi as biofertilizing agents in cranberry farming, contributing to sustainable agriculture. There is increasing interest among consumers and farmers alike to find alternatives to agrochemicals that have a negative impact on the environment.

Interestingly, the fungus EC4 also controls the growth of many plant pathogens, including cranberry plant and fruit rot pathogens. Stay tuned for a report on EC4's biocontrol potential.

References

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Grower Updates

Flying Dollar Cranberry

By Seth Rice

With summer coming to a close and making way with fall, we are starting to see the berries size up more. This extra heat should help with fruit sizing. People are still dealing with flea beetle as well. Some growers try to help battle the heat with turning on their irrigation system and try to “cool off” the fruit. This can be a gamble either way with helping cool off or it could do damage potentially and scald the berry. Everybody has a different way of dealing with problems. Also, for the growers that produce early fruit they are about 2 weeks or so from early harvest. I hope we see some cooler nights and maybe get some color on the rest of the varieties that everyone has. Good luck and stay safe!

Vilas Cranberry

By Jeremiah Mabie

Hello everyone, hope you are all doing well and have enjoyed what seems like the shortest summer yet. I guess as they say time flies when you are crazy busy…I mean having fun!

All jokes aside it has been an interesting growing year with the weather and smoke haze. We have had some rain but are still very dry up north. Berries are sizing up but it’s been a slow painful process to watch, overall things are looking good for everyone this year though.

Bug pressure has been on and off, some fruit worm issues around but most of all it’s been flea beetle problems. Some growers having to control the whole marsh, others able to control with spot treatments.

The thought of harvest has been on everyone’s minds as all preharvest work has begun, ditches are being cleaned, harvest equipment being serviced and modified, and most importantly empty semi-trailers are starting to show up!

This is the time of the year I enjoy most, watching everything from the summer come together and the calm before the storm. I hope everyone has a bountiful and safe harvest this year!

Update from the Wisconsin Cranberry Research Station

By Wade Brockman and Beth Ann Workmaster

Transitioning from Summer Field Day to harvest preparation has kept the Research Station humming. Shawn Steffan installed bee condos to supplement the pollinator garden. Insect pressure and disease pressure are light overall this year. The Wisconsin Cranberry Research and Education Foundation is reviewing blueprints for a marsh shop. We are all looking forward to harvest.