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Optimal Nitrogen Management Techniques for Cacao Nursery Production Using Sensor-Based Smart Agriculture

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Abstract

Given the difficulties posed by nutrient run-off, reducing fertilizer costs and ensuring environmental sustainability are crucial issues. In order to accomplish these objectives, smart technologies like optical sensors are absolutely necessary. This study used optical sensor technology to monitor the chlorophyll content of cacao samples taken in a nursery setting to determine the most effective fertilizer regime. The slow-released fertilizer 8N-3P-9K was applied at 15 grams, 15 grams (supplemented with +15 grams applied twice), 15 grams (+15 grams), 30 grams (+15 grams applied twice) and 45 grams (+15 grams applied twice). Over the course of six months, the plant height, number of leaves, total nitrogen of leachate samples and the total nitrogen and total carbon contents of the leaf and soil samples were evaluated. Chlorophyll content was measured using optical sensors like atLEAF, normalized difference vegetation index (NDVI) and soil plant analysis development (SPAD). The findings indicate that cocoa plants can be supplied with the necessary nutrients and runoff contamination at a lower rate when nitrogen fertilizer is applied less frequently. Through nutrient run-off, using 45 (plus 15 g applied twice) results in additional pollution. This study demonstrates the significance of handheld sensor technology in determining the most effective nitrogen management practices for fruit nurseries to reduce fertilization overuse, save money and reduce pollution in the environment at the same time.

Keywords: Theobroma cacao L • Normalized difference • Vegetation index • SPAD-502 • Chlorophyll meter

Introduction

Cacao, which is also known as cocoa (Theobroma cacao L.), originated in South and Central America. It is currently grown on over 17 million acres (6.9 million hectares) of land in 58 nations around the world. With an annual value of more than $4 billion, this highly valuable crop significantly contributes to the global economy. Nurseries rarely cultivate cocoa plants in Florida; However, Southern Florida is expanding production for research purposes. Research on nitrogen management practices is essential for the successful cultivation of these valuable trees in Southern Florida because of the economic significance of cacao production. Nitrogen (N), a component of chlorophyll (Chl) in leaves, is a macronutrient that is essential to plant growth and development. Cl levels can have an impact on every growth parameter, including plant size, transpiration rate and leaf weight and area. Plant quality, productivity, and, most importantly, scalability can all be impacted by a low nitrogen content. Overabundance is likewise not attractive as it might cause N harmfulness, hindered development and an inferior quality plant. Most importantly, nursery producers incur additional costs as a result of over fertilizing and nutrient run-off causes environmental problems like algal blooms. One acre of nursery production land can typically accommodate up to 300,000 containers, many of which are fertilized excessively. This is an essential driver in declining water quality all through Florida, which at last adds to algal blossoms.

Literature Review

Due to the issues with nutrient run-off that accompany over-fertilization in plant production in Southern Florida, it is crucial to make use of technologies like optical sensors to reduce the cost of over-fertilization and ensure environmental sustainability. As a type of remote sensing, optical sensors are positioned close to or in close proximity to the leaves and plants. The radiation or indirect measurements of indicator compounds that are sensitive to crop N status are provided by handheld sensors, which do not directly measure the amount of nitrogen present in plant tissue. Non-destructive leaf status determination using optical devices. Optical sensors offer huge advantages on business ranches, for example, their capacity to be utilized at any phase of the development cycle, low work necessities and similarity with manure dynamic strategies. Certain sensors are confined to single-point estimations, while others have the ability to gauge enormous agent surface areas of foliage ceaselessly. Because of these qualities, they are excellent candidates for a practical assessment of the nitrogen status of plants [1].

As a result, the purpose of this work was to determine the most effective methods for managing nitrogen by monitoring the chlorophyll content using smart agricultural technology and optical sensors. This approach has the potential to reduce run-off contamination while simultaneously providing sufficient nutrients for plant growth. Nitrogen is an essential nutrient for all plants because it is the core of amino acids, proteins, enzymes, nucleic acids, chlorophylls and hormones, as well as a crucial part of plant metabolism. As a result, any lack of nitrogen has a rapid impact on plant growth. There are a number of possible routes through the cacao agricultural ecosystem following the application of nitrogen fertilizers to the soil, such as rapid tree uptake or leaching and/or volatilization. In order to increase production, producers are using a lot of pesticides, fertilizers and herbicides, frequently in higher concentrations than is normal or recommended for these products. Higher portions of manures speed up the contamination of the air and water [2].

Discussion

It is in this way fundamental to adjust the nitrogen use with crop interest to have the option to upgrade N manure applications. It might be possible to quickly and frequently assess the nitrogen status of the farm's crops, which would allow for quick adjustments to the nitrogen supply. A wide variety of non-invasive monitoring tools that can be used to assess crops nitrogen status include proximal optical sensors. The objective of this experiment was to determine the most effective fertilizer application rates for cocoa as a standard

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for nursery owners. Additionally, the collected data can be used to assess the suitability of the SPAD, atLEAF and Green SeekerTM fertilizer application rate estimation devices based on leaf nitrogen measurements. Hardin noticed that the SPAD meter gave a good idea of the amount of nitrogen in the leaves of some pecan cultivars. According to Dunn and Goad, ornamental cabbage plants leaf N can be correlated using either SPAD or atLEAF sensors [3-5].

The number of leaves, the normalized difference vegetation index (NDVI) and the relative chlorophyll content by SPAD were all found to be unaffected by treatment in this study. This may be because ornamental cabbage and *Justicia brandegeana* have insufficiently different biomasses from one another. These results are different from those of Khoddamzadeh and Dunn, who tested two Chrysanthemum cultivars at various dates after fertilizer treatment during the vegetative stage and found significant differences in NDVI and SPAD values [6].

Conclusion

All of the lower nitrogen fertilizer treatments provided the cocoa plants with the necessary nutrients for growth while also reducing nutrient runoff pollution. 45 grams (plus 15 grams in November and March; through nutrient runoff, T5) increases contamination. This study demonstrates the significance of smart agriculture and other technologies like optical sensors for nitrogen monitoring in determining the best nitrogen management practices for fruit trees in nursery settings. It also serves as a foundation for subsequent research. They would be equipped with the immediate tools they need to avoid over-fertilizing in fruit nurseries, thereby avoiding additional expenses and harm to the environment.

Acknowledgement

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Conflict of Interest

None.

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