ISSN No:-2456-2165

A Comparison of the Leaf Colour Chart Approach Versus the Image Sensing Method using Varied Nitrogen Levels in Tomato Plants Grown in Sri Lankan Tropical Greenhouses

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Abstract:- Protected culture is a solution for overcoming conventional agriculture issues and thus for feeding the rising world population. Hence soilless culture has become an integral part of the PC, and managing plant nutrition is important. Therefore, innovative intellective diagnostic systems for diagnosing nutrient deficiency symptoms are timely need. Hence this experiment was conducted to test the effectiveness of "image sensing" as a diagnostic tool for nitrogen deficiency in a fully intensive greenhouse located in WM2b (Mid-country Wet zone), Sri Lanka. This study was conducted to detect the color variation of tomato plant leaves, variety 'Sylviana' to varying nitrogen levels using image sensing method. In this study, five nitrogen fertilization levels were established. Of them, T1 was 200% N of the recommendation, T2 (control) was 100% N, and T3, T4, and T5 with 50%, 25%, and 12.5 % N levels. For detecting leaf color, leaf images were processed in "ImageJ software" to determine the green color intensity. Image analyzing results showed that there was a significant difference among treatments since the 3 rd. WAT (weeks after transplanting). The option of "use of Leaf color chart" for this purpose was found less effective According to the results, Diagnosis of N deficiency in tomato leaves could be effectively done with the use of Image sensing much earlier and effectively. Using leaf color chart is not much effective and time consuming. The positive results found with the image sensing method for the detection of N deficiency of tomatoes would be used to develop an effective and efficient method for leaf color-based diagnosis of nutrient deficiencies in large large-scale cultivations.

Keywords:- *Protected Culture, Tomato, Nitrogen Deficiency, Image Analyzing, Color Comparison.*

I. INTRODUCTION

Horticulture is one of the major branches of plant agriculture that deals with garden crops, generally fruits, vegetables, and ornamental plants. The word horticulture is derived from Latin hortus, "garden" and colere, "to cultivate" normally used to refer to intensive commercial production (Bailey, 1934).

The agriculture sector faces the daunting challenge of providing enough food and other necessities for a growing world population, which is targeted to be nine billion by 2050. Greenhouse crop production is highly related to horticulture. With the increasing global population, the demand for healthy fresh food is also increased. The greenhouse industry can play an important role in fulfilling the demand. Growing in hydroponic cultures under greenhouse conditions can be used as a solution for issues such as land scarcity, extreme weather conditions, and pest/disease infestation. These controlled environments ensure efficient resource usage as well (Timmermans et al., 2020). High efficiency of resource utilization, use of advanced technologies, higher production , stability of the production, and better-quality products can be taken as advantages of greenhouse crop production (Koukounaras, 2020). Currently, it is difficult to find skill labors bearing high labor costs. The best option is advanced technology.

In soilless culture, plants frequently appear to be nutritionally deficient, especially during the anthesis and fruit periods, which will significantly reduce the quality and number of the plants. A few techniques are employed in diagnosis. However, employing a chemical study of leaves to identify the deficient takes about a week. Although the enzyme-based diagnostic method is quick, it can only be used to identify the absence of certain trace elements. The leaves are where nutrient deficiency symptoms are most noticeable. Our research has revealed that the color and texture of leaves are the primary manifestations of plant nutritional deficiencies. However, in the early stages of disease, the symptoms are not clear, making it difficult for even experts to make a precise diagnosis. (Hao et al., 2001).

Considering greenhouse tomato cultivation, within the past century, the cultivated tomato has become one of the most popular and widely consumed crops with an annual world production approaching 80 million metric tons-(Kirimi et al., 2011). Tomato (Solanum lycopersicum L.) is popular in the fresh market and processing industries.

ISSN No:-2456-2165

Production of tomatoes under greenhouse conditions is gaining popularity in Sri Lanka. Because of field cultivation, tomato yields are limited by poor soil nutrition and nitrogen is the most limiting nutrient required in large quantities-(Kirimi et al., 2011).

Image sensing technology which is based on plant optical properties, can optimize crop yield by detecting deficiency symptoms and correcting them. For many years, image sensing technology has been successfully applied in studies of total green biomass and canopy cover and widely being used in crop yield predictions by detecting deficiency symptoms. The recent progress of imaging technologies allowed detection of various aspects of plant status remotely. (Hao et al., 2001). Normally, nutrient-deficiency symptoms are manifested mainly in the leaves. Some research shows that, symptoms of plant nutrient deficiency are first shown by color. Apart from nutrient deficiencies, diseases are also cannot be diagnosed at the early stages as the symptoms are not articulate resulting even the experts in trouble. Therefore, a diagnosing system for both plant diseases and plant nutrient deficiencies based on color analyzing methods can be much useful in addressing above difficulties. (Xu et al., 2011)

Considering all those facts, early detection of nitrogen deficit is essential for effective and precise crop management under greenhouse. This project was done to identify the best method for detecting Nitrogen deficiency of tomato plants under controlled environmental conditions. This study will be useful to determine the effectiveness of the image sensing method against to leaf color chart under greenhouse conditions and identify the applicability of image analyzing system for early detection of Nitrogen deficiency in greenhouse tomato crop. This was tested under tropical climatic conditions to achieve high yield and quality targets of tomatoes.

The objective of this research was a comparison between Image sensing method and leaf color chart method under different nitrogen levels of tomato plants under tropical greenhouse condition in Sri Lanka.

II. METHODOLOGY

➢ *Location of the Experiment*

The experiment was conducted using the greenhouse facility at the Agricultural Biotechnology Center, Faculty of Agriculture, University of Peradeniya. It is located in the agro-ecological region WM2b Sri Lanka. The minimum and maximum temperatures are 28^{O}C and 19^{O}C respectively and experience an annual rainfall of more than 2000mm. The Greenhouse was a fully-automated greenhouse with a double cladding, arch framed (curve) roof made of UV protected clear polythene film (gauge: 300 µ), keeping a 30 cm gap between two claddings. The greenhouse area was 1000 square feet. Insect-proof net covered side vents, an exhaust fan (a blower) with a misting system operated based on IoT technology were used as the internal environment control mechanism in this greenhouse (Relative humidity, Solar radiation and Temperature). The insect screened side vents (mesh size: 40) were able to fully or partially opened with the use of a roll-open type clear polythene cover (in the ridge sides of the greenhouse) which operated with the use of a geared motor. A blower (1380 mm in diameter) was fixed at one side of the gable side (opposite to the entrance) at gutter height to remove (exhaust) heated air.

➢ *Experimental Design and Treatments*

There were five treatments. Five Nitrogen rates in the nutrient solutions (N treatments). Nitrogen concentrations was varied in order to induce different N status in the plants. The electric conductivity was kept constant. For each and every treatment, stock solution was maintained. The treatments were applied two weeks after transplanting. To prepare these stock solutions, EC 0.30ds/m water was used. Treatment 01 was excess nitrogen, Treatment 02 was optimum level of Nitrogen and Treatment 03, 04, 05 were lower than critical levels of Nitrogen.

➢ *Planting Materials*

Commercially available, indeterminate, greenhouse tomato (Solanum lycopersicum) hybrid variety ‘Sylviana’ seeds distributed by ‘Agriculture Trending’ was used as planting material.

➢ *Nursery Establishment*

Coir dust was the nursery media. Media was autoclaved before seeding. Then Wet coir dust was placed inside properly cleaned and disinfected nursery trays and presoak tomato seeds was sown in a cell as one seed per cell. Water was supplied at necessary periods during the first two weeks after planting. After the second week of planting 1g/l of Albert solution was applied daily. The nursery period was four weeks.

➢ *Media Fumigation*

Media fumigation was practiced by using “Nemasol” (Metham Sodium). Fumigation period was 21 days and watering and mixing was practiced three times on that period. After 21 days of fumigation period poly bags were filled with media and kept two days before transplanting.

➢ *Preparation Of Grow Bags And Media*

Black color 300-gauge poly bags (35*40cm 2) were filled with disinfected coir dust. Several punctures will be made at the lower one-third of the bag to facilitate drainage.

➢ *Crop Establishment*

Healthy and vigorous seedlings (3 to 4 weeks old) was transplanted in poly bags. Plants was arranged in single rows in a greenhouse. The space between rows were 120cm and between two plants were 90cm intra-row space).

➢ *Fertilizer Application*

The water used to prepare the nutrient solution was with the following characteristics: pH:7.90; and EC: 0.30 dS/m. In order to achieve complete, the nutrient solution the following substances were used: Potassium Sulfate (K_2SO_4), Di phosphorus Pentoxide(P_2O_5), Magnesium Sulfate ($MgSO_4$), Boric acid (H_3BO_3), Iron Chloride ($FeCl_3$), Manganese Sulphate ($MnSO_4$), Zinc Oxide (ZnO)

and Copper Sulphate (CuSO4), Ammonium Mole date (NH4) 6Mo7O24). EC was maintained at standard level. According to growth stage of the plant, fertilizer requirement was calculated.

- *Other than that, all the Management Practices were done According to the Recommendation for the Tomato.*

- *Leaf Color Comparison*

✓ *By using Leaf Color Chart*

Leaf color was measured and compared among five treatments. Using the RHS color chart gives the standard references for recording plant colors which are developed by 'Royal Horticultural Society'.

✓ *By using Image J Software*

All leaves from each plant were laid on a white background to ensure that the photograph would have only two colors with the highest contrast. It is also mandatory that no other object appear in the photograph because they may be mistakenly included as part of leaves. For this study, all leaves were placed with the upper side facing upward while capturing no flash was used. All the photographs were taken inside a dark room and so a white light was used. In that case a fluorescent lamp of 100 watts bulb was used. All this, in order to get the same light conditions to all the photographs. Then photographs were captured and fed to the software to measure color intensity.

III. STATISTICAL ANALYSIS

The experiment was a completely randomized design with five Nitrogen treatments. the five treatments were, T1-complete nutrient solution with excess Nitrogen, T2-complete nutrient solution with optimum Nitrogen level. and T3 (critical), T4, and T5 treatments were the complete nutrient solutions with dearth Nitrogen levels. Ten plants were allocated for each treatment. Data entering and analysis was done using Microsoft Excel. Data was analyzed using SAS software. All the parametric data was analyzed by using ANOVA (Analysis of Variance). Mean separation by Duncan's multiple tests.

IV. DISCUSSION

Table 1 Table of Leaf Color Chart Results

	Week 02	**Week 03**	**Week 04**	**Week 05**	**Week 06**	**Week 07**
T1	Strong yellow green color	Strong yellow green color	Strong yellow green color	Moderate olive green	Moderate olive green	Moderate olive green
T2	Strong yellow green color	Strong yellow green color	Strong yellow green color	Moderate olive green	Moderate olive green	Moderate olive green
T3	Strong yellow green color	Strong yellow green color	Strong yellow green color	Moderate olive green	Strong yellow green A	Brilliant yellow Green Yellow green group
T4	Strong yellow green color	Strong yellow green color	Strong yellow green color	Moderate yellow green Yellow green group	Strong yellow green B Yellow green group	Strong greenish yellow b Yellow green group
T5	Strong yellow green color	Strong yellow green color	Strong yellow green color	Moderate yellow green Yellow green group	Strong yellow green B Yellow green group	Strong greenish yellow Yellow green group

Considering leaf color chart results, in 5th, 6th and 7th weeks, colors of the T4 and T5 were belongs to yellow green group and other colors were belongs to green group. However, use of visible green color-based detection of the least deficient (12.5%, lesser than optimum) N in T3 could be done only at the 7th week. (Table 1). Week 1,2 and 3 were showed green group colors and it was difficult to identified.

➢ *Assessment based on Image J software*

- *Green Color*

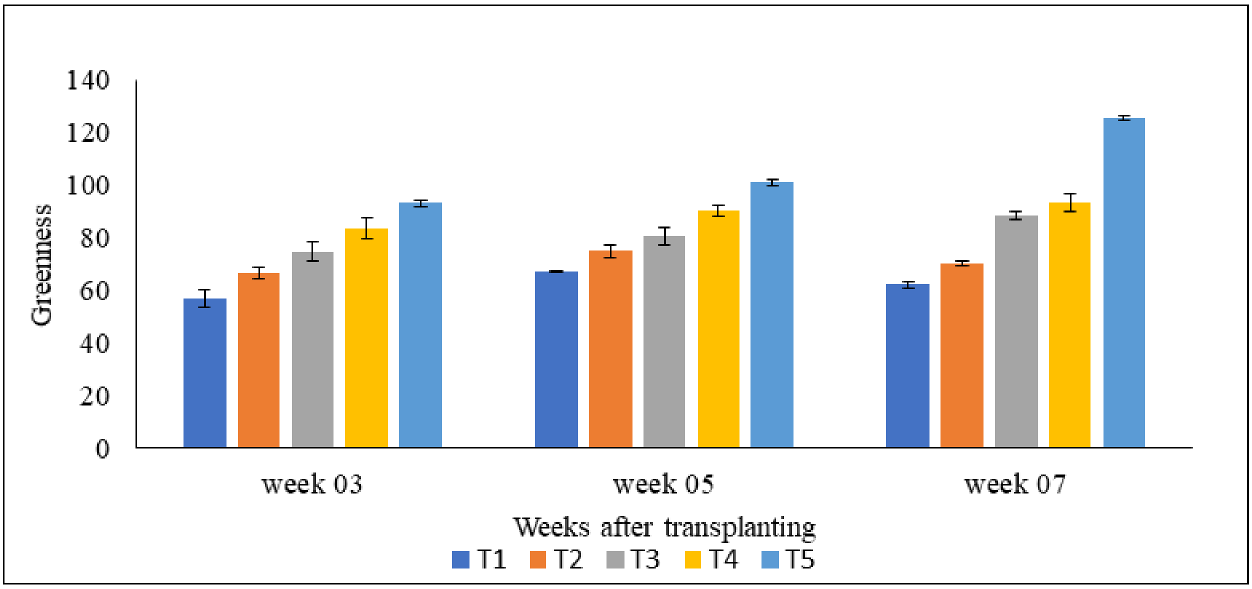

Figure 1: Green color variation of tomato plants grown in different N treatments with time
Note: with decreasing of green color of the leaves, color values getting increased

Table 2 Variation of Leaf Green Color Among Treatments of Tomatoes with Weeks after Transplanting

Treatments	**week 03**	**week 05**	**week 07**
T1	56.71443^{d}	67.23^{b}	62.06^{c}
T2	66.56933^{c}	74.89^{b}	70.43^{c}
T3	74.589^{bc}	80.55^{a}	88.54^{b}
T4	83.6965^{b}	90.14^{a}	93.4^{b}
T5	93.02933^{a}	100.96^{a}	125.67^{a}

Considering green color intensity has been significantly affected by nitrogen treatments starting in 3rd week. The lowest green color intensity was showed in T5, and the highest green color intensity value showed in T1 in 3rd week. Within T3 and T4 there was not significantly difference among green color intensities. (Fig.01; Table 02). (Here in the graph, with the increasing of the value, green color intensity reduced.)

- *Red Color and Blue Color*

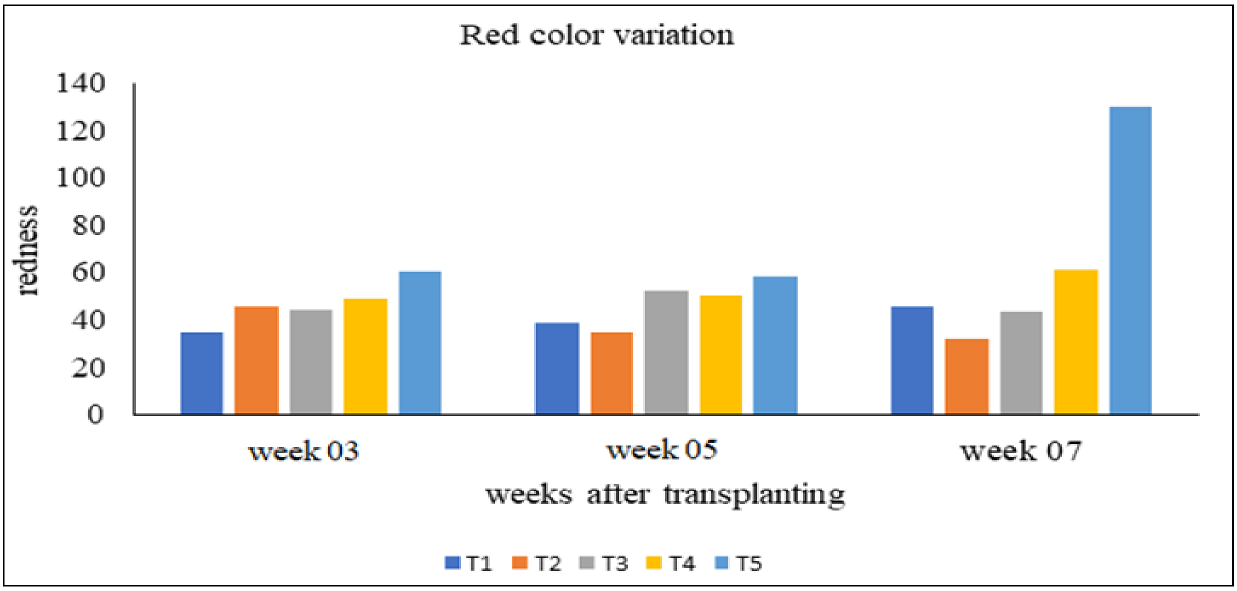

Fig 2 Red Color Variation of Tomato Plants Grown in Different N Treatments with WAP

Table 3 Variation of Leaf Red Color Among Treatments of Tomatoes with Weeks after Transplanting

Treatment	week 03	week 05	week 07
T1	34.71267[d]	38.6 [b]	45.2 [c]
T2	45.51567[c]	35 [b]	31.71[c]
T3	43.83367[bc]	51.98 [a]	43.37 [b]
T4	48.958[b]	50.48 [a]	61.31[b]
T5	60.36467[a]	58.53 [a]	130.21[a]

Considering red color variation, red color also significantly different among treatments. But there is not significant relationship with treatments.

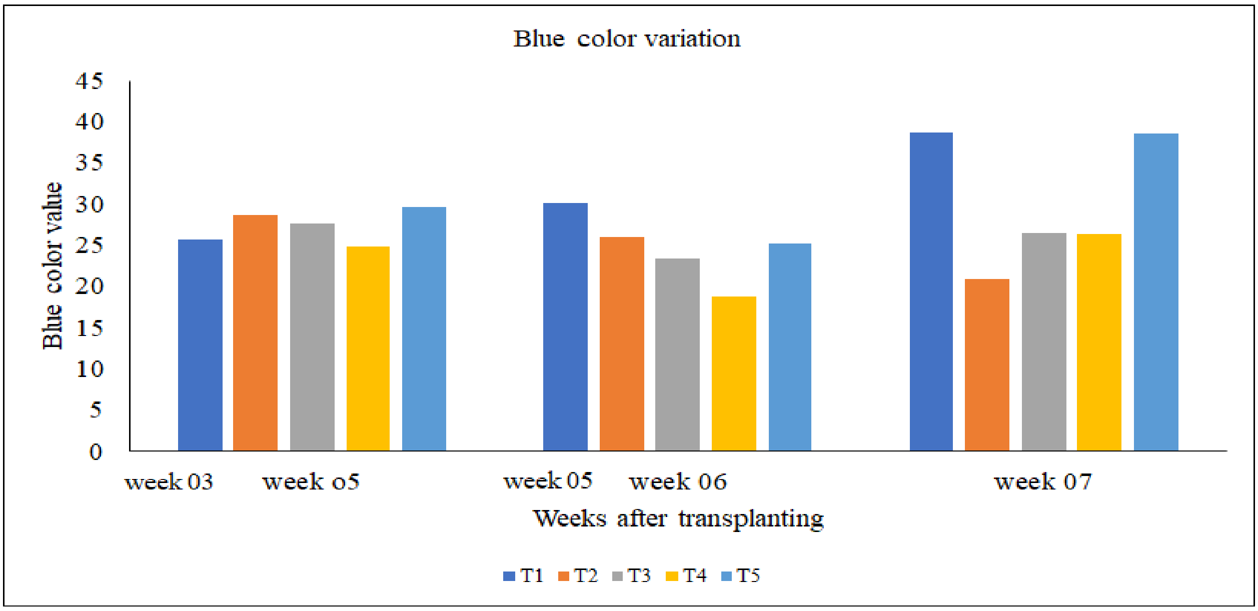

Fig 3 Blue Color Variation of Tomato Plants Grown in Different N Treatments With Time

Table 4 Variation of Leaf Blue Color Among Treatments of Tomatoes with Weeks after Transplanting

Treatment	week 03	week 05	week 07
T1	25.69633 [d]	30.13 [a]	38.75[a]
T2	28.68868 [c]	25.98 [b]	20.82[c]
T3	27.63767 [bc]	23.44 [c]	26.48[b]
T4	24.889[b]	18.76 [c]	26.31[b]
T5	29.592 [a]	25.2 [b]	38.57[a]

Blue color was also significantly different among treatments. But there was no relationship between treatments and the color variation.

V. CONCLUSION

Diagnosis of N deficiency of tomato leaves, even at the 50% below optimum level could be effectively done by digital detection of green color of the leaves with the use of Image sensing much earlier (at 3rd WAP) without waiting for visible color changes according to the leaf color chart results. (In 5th WAP). The option of "use of Leaf color chart" for this purpose was found to be less effective and time-consuming. Other than that could occur human errors as well. Therefore, the positive results found with the use of the image sensing method for detection of N deficiency of tomatoes would be used to develop an effective and efficient method for leaf color-based diagnosis of nutrient deficiencies in large-scale crop cultivations, particularly in protected culture in Sri Lanka.

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