2019 International Conference on Advancements in Computing (ICAC)
December 5-6, 2019. Malabe, Sri Lanka

Smart Crop and Fertilizer Prediction System

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***Abstract*—Agricultural industry plays a major role in the process of economic development as well as the Gross Domestic Product of Sri Lanka. One of the significant issues in the industry is lacking an accurate way to identify the best crop that can be grown with the available soil fertility in a particular land. Since most of the farmers have a lack of knowledge about soil nutrients, they start cultivations by believing myths in society and few of them use scientific approaches. This research mainly focuses on suggesting the best crop according to soil fertility of land and also it recommends a fertilizer plan to optimize the amount of fertilizers applied for suggested crops. The paper presents a tool with embedded sensors that measure soil fertility and developed a cross- platform mobile application to suggest the best crops according to available soil fertility. Further, a fertilizer plan will be suggested to optimize fertilizer usage in order to increase profitability and avoid soil degradation. To evaluate the final product, the same soil sample was tested in the lab and using sensors embedded tool. Results obtained by those tests proven that both generate approximately equal Nitrogen (N), Phosphorus (P) and Potassium (K) values.**

***Keywords*—Crop, Fertilizer, Soil nutrients, Soil degradation, Harvest**

I. INTRODUCTION

People increasingly used to depend on machinery, rather than doing their daily basic needs manually in order to save their time and effort. Even though farmers had to use so much of man- hours to fulfil their needs in cultivation in good old days, now they can gain the same amount of work with lesser time and lesser manpower by using a single machine operated by only one person [1].

Knowing the ground conditions which are required to grow the particular crop which farmers desired to grow is the key point of successful cultivation [2]. Hence, they require to know the conditions of soil as well as environmental. Even though environmental conditions are not easy to predict and when farmers start an outdoor plantation, they can apply different nutrient types as they wish to grow the plants. To identify the soil condition in specific area, farmers can perform a soil test, which is a series of tests that helps to identify the nutrient level of the soil.

According to the information authors have gathered from the Research Centre, Gannoruwa, Sri Lanka, the most trusted and popular soil testing mechanism is testing the soil with the help of professionals in a laboratory. The majority of the farmers don't have enough time to visit the laboratories and who have a lack of knowledge about cultivation, will tend to believe myths about the best crop for a specific area, and continue the cultivation without thinking much.

Starting a plantation with the belief of myths will not be a success in all the times and there will be no guarantee that it is the best option that the farmer can rely on. Soil conditions of a particular ground will vary with the time, so it will be helpful if the farmer notifies time to time with a nutrient plan which helps to maintain the soil to gain more results from the cultivation.

If there is a way for people to identify the best crop according to the environmental conditions in the area and the soil type of their ground on their own, it will be a very helpful solution for better results and to save time.

The paper presents a solution based on IoT (Internet Of Things) and so that it leads to the use of technology on fulfilling cultivation purposes effectively and efficiently by getting correct information about nutrition conditions for asuccessful cultivation.

II. LITERATURE REVIEW

Several techniques were proposed previously by authors for N, P, K prediction from humidity, Electric Conductivity (EC), pH and temperature. The common way is doing lab testing rather using relevant sensors. The chief goal of the research is to reduce time by using relevant sensors to get readings. Crop suggestion modules have deployed previously using Support Vector Machine Algorithm and normal lab testing.

In July 2017 group of researchers Sabina Rahaman, Harshitha M, Anusha R, Bhargavi Y. R, and Chandana M from Department of Electronics and Communication Engineering BMS Institute of Technology, Bangalore 560064 have invented a research which detects NPK Ratio Level Using SVM Algorithm and Smart Agro Sensor System They have integrated a sensing module with an Image processing setup to monitor the essential details needed for plant growth from the soil. As inputs, they have got Temperature/Humidity, Soil Moisture, and pH level. Which means those things directly affect to the fertilizer level of the soil. Furthermore, Image Acquisition, enhancing the image using Grey scale analysis, Adaptive Histogram analysis, and feature extraction Methods have used by the research team for better results [3].

The authors have analyzed Image Acquisition, enhancing the image using Grey scale analysis, Adaptive Histogram analysis and feature values in comparisons with database feature extraction and Mutism which is used to classify into ratio level of NPK indicating which Nutrient is low. Further they have successfully given moisture level (dry/wet) of soil, humidity reading, and pH scale [3].

Researchers Khakal V.S., Deshpande. N. M, and VarpeP. B. Department of E &TC, PDVVP COE

Ahmednagar have research Measurement of NPK from pH value and they have used NPK Micro sensors other than pH and temperature sensor and mainly they have prepared a desktop application for view the results so in our system it will be more user- friendly to using a smart application [4].

A group of researchers Komal Abhang, Surabhi Chaughule, Pranali Chavan and Shraddha Ganjave have done a research on soil analysis and crop fertility prediction after referring results gathered by testing the particular ground soil using normal lab tests done by the Agricultural Department. The main aim of their system was to atomize the current manual soil testing procedure. In their system, they have built hand held devices using pH meter which gives pH value of soil. pH is negative log of hydronium ion mole per litre pH = - log [H3O+]. With help of this pH value they estimate NPK of that soil, which are necessary Macronutrients of soil [5].

They have trained crop databases for their software model and they have classified that particular soil sample into a particular class using a classification algorithm. Depending on class determined by their system they give a list of crops suitable for that particular soil sample. Also, it provides the suggestion of fertilizer for a particular crop [5].

Researchers N. Sivakumar, T. Amudha, and N. Thilagavathi in Bharathiar University, Tamilnadu, India has done a research on the Development of a Novel Bio-Inspired Framework for Fertilizer Optimization to optimize the number quantity of fertilizers applied to crops by using Fruit Fly Optimization (FFO) algorithm. FFO algorithm is a popular bio-inspired optimization algorithm, aimed to resolve complex optimization problems and is inspired by the foraging behaviour of fruit flies. Initially the individual fruit fly has its own random position value. Each fruit fly refers to a different quantity of fertilizer and best food position refers to the optimal quantity of fertilizers with minimum cost. To find the optimal values, the algorithm starts with randomly initializing the three- dimensional position (x, y, and z- axis), referred to as three primary nutrients of fertilizers N, P and K respectively [6].

The random location in search space can be changed by generating the random value and by adding with the initial location value, by using a random position. The new position value of each individual fruit fly is evaluated to check whether the destination quantity of fertilizer is reached or not. If not, the distance to the origin is identified first and then, the value of smell concentration(s) and the smell concentration function, also known as fitness function are estimated. The fitness function is used as the objective function for calculating the quantity of fertilizer and the cost of fertilizer [6].

The researchers Joon-Goo Lee and Haedong Lee, Aekyung Moon in Electronics and Telecommunications Research Institute, Daegu, Korea have done a research on monitoring and the prediction of crop growth by using image processing technique [7].

They have gathered the required information such as location, size, leafp area index, the canopy of the crop and suggested the effective segmentation method of Crop of Interest (COI) at horticulture greenhouse. They have proposed to do their research in two ways. Such as, A color image of the crop is segmented in the green and non-green region.A depth image of the crop is removed near crops as rear crops and both sided crops.They have tried to overcome the problems in the existing methods which use the threshold of each colour channel. So to overcome those errors they have suggested to use a ratio of each colour channel that is strong on changeable illuminance [7].

Researchers, B. MiloviC and V. RadojeviC have done research on the importance of data mining in Agriculture. In order to maintain the growth of the selected crop and generate a fertilizer plan d to handle widely distributed data set with the nutrient levels the plant need in different time periods. They have used data mining techniques to organize the data set and gather the required data by using patterns and algorithms [8].

There are many types of data mining techniques that can be used for agriculture according to their research. As an example, they have used K-nearest neighbor for simulating daily precipitations and other weather variables and estimating soil water parameters and Climate forecasting. And Neural Networks for the forecasting of water resources variables in agriculture [8].

III. METHODOLOGY

A. Overall System Description

Figure 1 shows the high-level view of the proposed methodology that is designed to get expected output results. This methodology consists of four main components as input subsystem, mobile application subsystem, processing subsystem and display subsystems. The input sub system is able to read inputs, such as pH, Electrical Conductivity EC), Humidity and temperature readings in the ground soil.

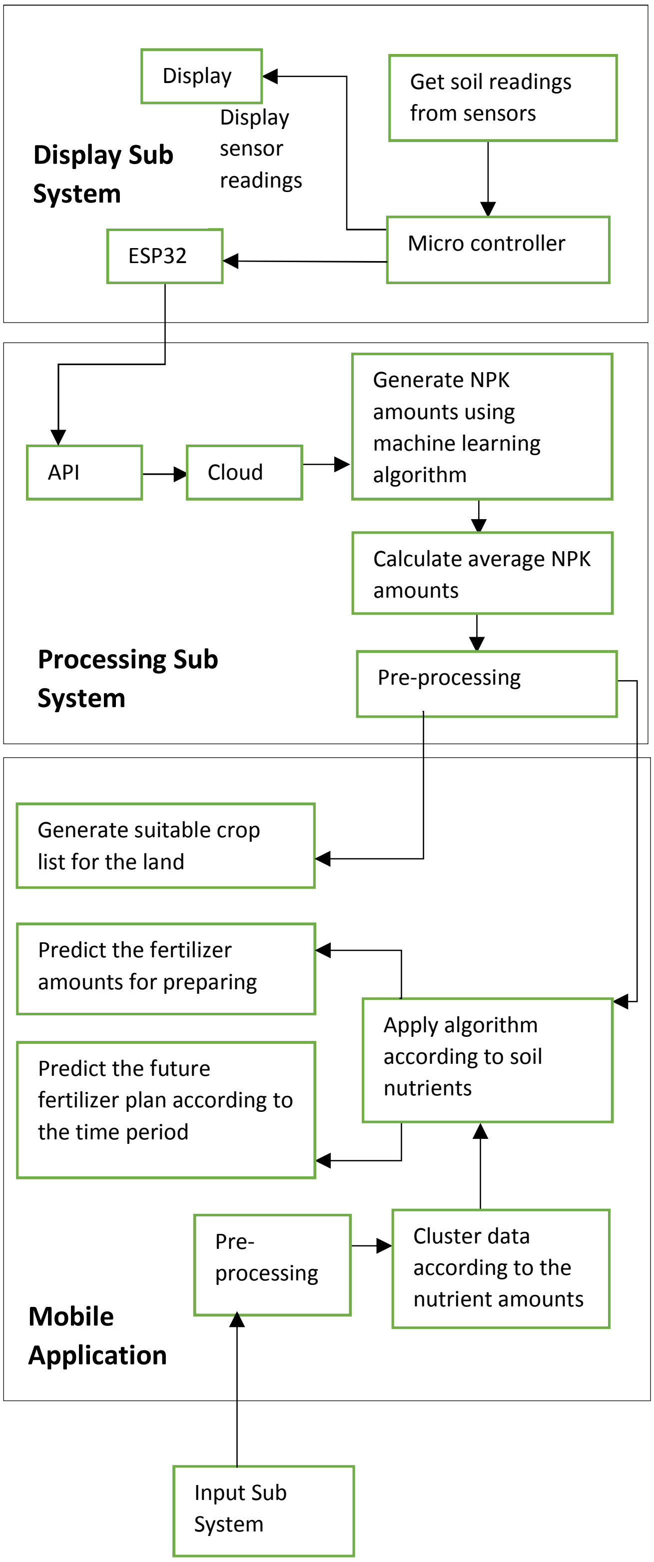

Fig. 1 - High-level view of predicting the expected results

Processing subsystem redirecting gathered data to the cloud using the API gateway. The main function of this subsystem is to predict the average NPK amounts in the soil using a derived machine- learning algorithm to predict the results.

The mobile application subsystem designed with a cross- platform mobile application and it facilitate farmers to select best crop for the land and maintain the growth of the cultivation with a better fertilizer plan. This application design with a user-friendly interface to enter the required parameters easily, so the App automatically suggests the minimum reading count needed to take from the land.

Input subsystem equipped with sensors to read farming land soil parameters, so mobile application retrieves sensor reading from the cloud server, calculates the average of sensor readings and displays existing N, P, K percentages in soil. Then the application analyzes existing nutrient levels in soil with in-built data set and suggest list of most suitable crops that can be grown in that land.

The derived machine learning algorithm has an ability to provide an optimized fertilizer plan and it has the facility to recommend as well as suggested crop which will be suitable for farming. Further, the algorithm enables farmers to arrange the land according to the selected crop in order to increase profitability and reduce soil degradation.

Whenever the farmer selects a crop from the suggested crop list, the application retrieves the fertilizer amount required to use in to the land for that selected crop using in-built fertilizer dataset in the database. Using the data retrieved, it generates average N, P, K percentages that should exist in that particular land respectively.

$$R = p \times \left(\frac{x}{a} \times m\right) \qquad (1)$$

Where,
R - Average nutrient percentages that should exist in the land
p - Amount of a particular nutrient included in 1 Kg of fertilizer
x - Amount of fertilizer that should use for the selected crop
a - Area retrieved from the database in m^2
m - Area of land in m^2

By comparing those generated nutrient percentages with soil existing nutrient percentages, nutrient deficiency of that particular land for the selected crop can be obtained. To overcome that deficiency, the required amount of fertilizers that should use into that land is recommended.

$$F = f \times (R - e) \qquad (2)$$

Where,
F – Recommended fertilizer amount
f– Fertilizer amount that contains 1 Kg of a particular nutrient
R - Average nutrient percentages that should exist in the land

e – Land existing nutrient percentages

If by any chance farmer wanted to grow different crops other than crops included in the suggested list, he can search for that crop details. If the requested crop can be grown in the land only by adjusting the existing nutrient levels in soil, App suggests the amount of fertilizer that should be used in order to plant that crop. So the farmer can make the land suitable for that crop to have a better harvest. This also helps to avoid soil degradation since there is no chance to use excess fertilizers.

According to the selected crop, the App will generate a fertilizer plan, which will vary with the soil nutrient levels of the relevant ground at the current time. The matching fertilizers that can be used for the growth of a single crop have so many varieties and each and every crop requires different kinds of fertilizers in different time periods.

The specific crop has a specific amount of time that should apply the nutrients to the soil for a better growth. According to that time period, the soil nutrients will be changed due to climate changes. So for the better accuracy the application will be using the soil nutrients that were generated by the sensor sub system in each time duration.

The input data set has the specific fertilizers that should apply according to the time period, with respect to the nutrient percentages included in the fertilizer. The collected data will then be pre-processed and divided into different clusters according to the specific NPK amounts of each fertilizer, in order to have a better idea about the total NPK amounts in all the fertilizers.

The processing of predicting the fertilizer plan will be done by a machine learning algorithm. As the inputs, it provides the data set and the fertilizer amounts in soil according to the specific time period to the input layer. The hidden layers will maintain the calculations for predicting the specific amounts that should apply from each fertilizer. The output layer will maintain to show the predicted results to the user. It will denote the total fertilizer amount (FA) that should apply by the following algorithm.

$$FA = \mathrm{h}\left[\mathrm{x}_1 * \left(\frac{\mathrm{a}_1}{100}\right) + \mathrm{x}_2 * \left(\frac{\mathrm{a}_2}{100}\right) +..+ \mathrm{x}_\mathrm{n} * \left(\frac{\mathrm{a}_\mathrm{n}}{100}\right)\right] \quad (3)$$

Where,
FA – The total fertilizer amount
h - Hectares in the ground
x – The specific fertilizer
a – The amount that should apply from each fertilizer

The mobile application will output the generated fertilizer results for the crop according to the time period that the user has to apply the fertilizers, and notify by sending a push notification to the user's mobile.

B. Algorithmic Implementation

The proposed system predicts the expected results by extracting the selected data set that shown in the Table 1 from the data that the authors gathered from the Agriculture Department, Gannoruwa, Sri Lanka.

Table I - Crop Dataset

Crop	Area(Acre)	Urea (N)	T.S.P (P)	M.O.K (K)
Corn	2.5	75	100	50
Peanut	1	14	40	30
Mung bean	2.5	30	100	75
Soy Beans	1	50	100	75
Thala	1	20	48	24
Gram	1	14	40	30
Kaupi	1	14	40	30

The overall derived hybrid algorithm is shown as the Figure 2 below.

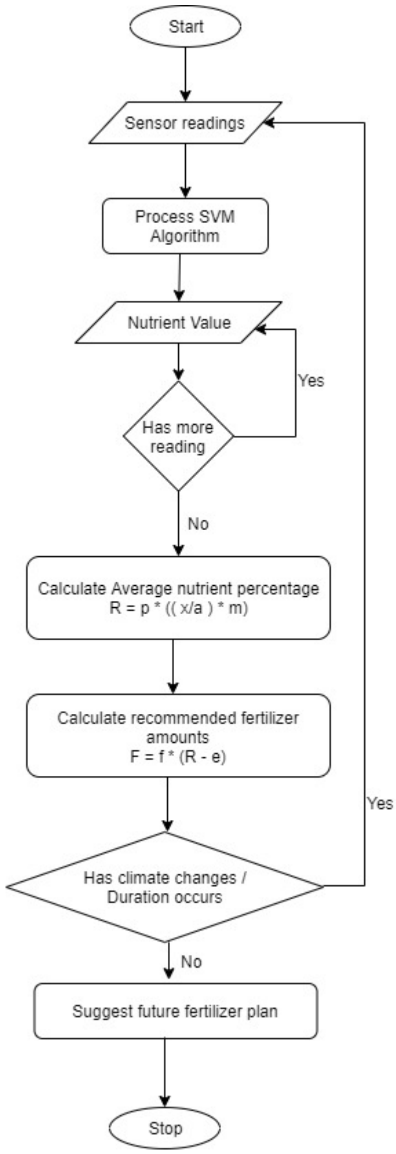

Fig. 2 – Derived Hybrid Algorithm

IV. RESULTS

Multi Class SVM algorithm is used to optimize the quantity Nitrogen, Phosphorus, Potassium application to various crops by analyzing the different types of common fertilizers used in dry & wet zones, nutrient availability in soil and the nutrient requirement of crops. SVM vectors are data points that are closer to the hyper plane and influence the position and orientation of the hyper plane. Using these support vectors helps to maximize the margin of the classifier.

So, in this module, the authors use temperature, EC, Humidity, pH which gathers from sensors as vectors. And as classes authors define various crop fertilizer levels as an example the best Nitrogen percentage of banana is around 90 (Kg/Ha) according to regular lab nutrient tests. Using 50 data of data set and train the model for individual crops. The reason for the minor variation is mainly sensor reading which gathers from sensors cannot grant 100% accuracy. Using Multi- Class SVM is much accurate because this research only has 50 sets of limited data sets.

Fertilizer cost is also aimed to be minimized with the optimization of fertilizers. Table II presents the optimal solution obtained by FFO (Fruit Fly Optimization) algorithm to satisfy the NPK requirement of crops. The optimal values are arrived without considering the available NPK in the soil. The deviation between the actual (lab tested) NPK requirement and the system suggested value is very minimal and ranges between 0.5% and 2 %.

The below Table II shows regular lab tasting values with SVM developed model output results. SVM model capture the main vectors as pH, Humidity, EC, Temperature and classifying three main individual models such as N, P, K per fertilizer. According to the deviation and 20% minor false accuracy can be given as the main reason for the minor difference between the SVM model and the lab testing results.

TABLE II - Comparison of the NPK values

Sample No.	**Crops**	**Regular lab test Nutrient (Kg/Ha)**			**SVM Optimal Solution (Kg/Ha)**		
		N	***P***	***K***	***N***	***P***	***K***
1	Banana	90	45	45	89.40	44.40	44.40
2	*Brinjal*	300	100	200	299.83	99.83	199.83
3	Beans	210	35	450	209.86	34.86	449.86
4	Cucumber	30	60	30	29.07	58.07	29.07
5	Tomato	80	40	40	78.87	39.87	39.87
6	Sugarcane	70	35	35	68.89	34.89	34.89
7	Black gram	25	50	75	24.79	74.79	74.79
8	Chili	135	62	50	134.47	49.47	49.47

After building the model, the application will train the data set to get a better accuracy. To gain more accuracy, it is necessary to train at least 100 data sets with variant pH, temperature, EC and humidity level of the soil. It achieves over 80% accuracy after building the model using the trained data set. In order to get predicted crops, system use output of SVM algorithm. In order to get predicted crops, system use output of SVM algorithm. System compare with the crop dataset and then output crop list through mobile application.

Mobile application will suggest the most suitable crop list according to the soil conditions and the user has the ability to search for a crop and see whether if the searched crop is suitable for the soil or not. Also the user has the ability to see the future fertilizer plan for the selected crop.

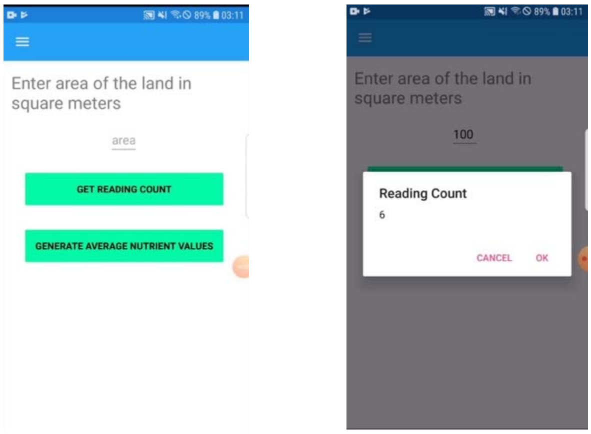

Fig. 5 – Generate the reading count

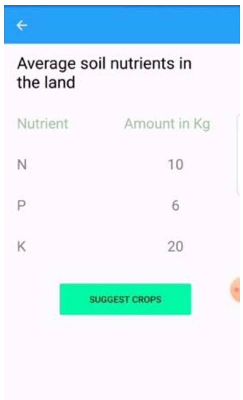

Fig. 3 - Generate average NPK values according to the readings

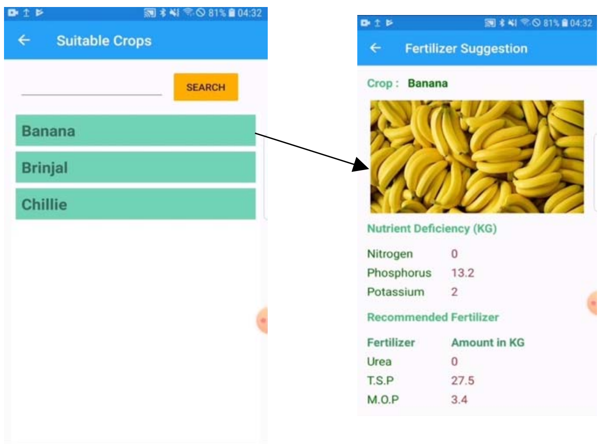

Fig. 4 – Suitable crop list for the ground and the NPK amounts that should apply for the soil

Fig. 6 -Shows the availability of the searched crop

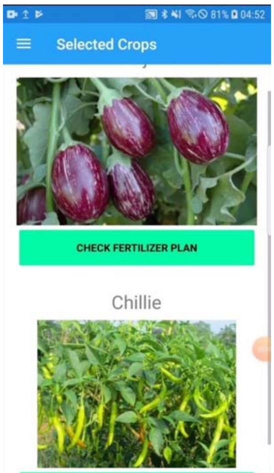

Fig. 7 - Future fertilizer plan for the suitable crops

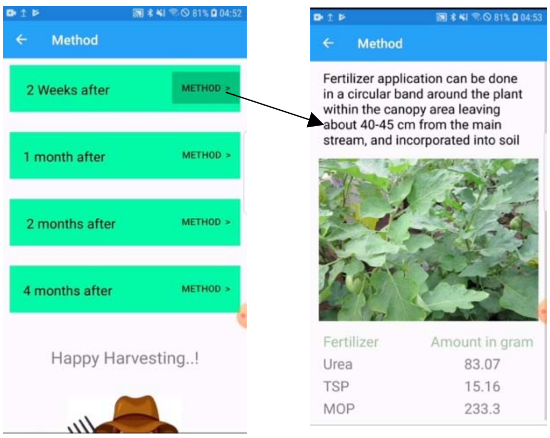

Fig. 8 – Timeline and the description of the fertilizer plan

V. CONCLUSION

Since the early days of the agricultural era Sri Lankan Agriculture has played a strategic role in the process of economic development. Through this project, authors have analyzed that can make the agricultural industries more efficient and profitable with the aid of technology. This project puts forward a solution based on IOT. Through its methodology, the effectiveness of such procedures is explained. Hence prototype uses the aid of pH sensors and moistens sensors. The project points out a procedure in which can extract data from a specific agricultural land without assuming the status of the soil through plain insight also educates an individual about such procedures.

ACKNOWLEDGMENT

This work has been supported by Sri Lanka Institute of Information Technology, Malabe, Sri Lanka. Futher authors would especially like to thank Director, Dr. W.L.G. Samarasinghe, and Ms. K.H.A.D.U.K. Hapuarachchi in Horticultural Department in Gannoruwa for providing the facilities for conducting lab tests and help to collect test data.

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