Nitrogen (N) Fertilizer Measuring Instrument On Maize-Based Plant Microcontroller

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Abstract—One of the growth factors of corn plant is fertilizer according to nitrogen fertilizer requirement. The identification of nitrogen fertilizer requirement in corn plant can be done by measuring the green leaf level using Color Leaf Manual, using TCS3200 color sensor combined with Arduino Uno Board microcontroller, and information. In this study a tool was created that could automatically measure the amount of fertilizer needed for corn per hectare. The results of the measurements displayed on the LCD 2x16 bits Micro made a measurement of fertilizer based on leaf color for corn plants. By taking the RGB value from the leaf that comes through the color sensor and then compared with the RGB value in the leaf color chart that has been saved in microcontroller will get the information of the fertilizer dosage needed. The level of truth of the measuring instrument of fertilizer can be categorized good enough with the level of accuracy reached 82%.

Keywords— Arduino Uno, Leaf Color Chart, Corn Leaf, RGB, TCS3200 Sensor

I. INTRODUCTION

Maize (Zea mays L) is an annual crop is one of the main sources of food in Indonesia [1]. Provision of fertilizers or nutrients is one of the factors that affect the growth of corn crops, as done before on rice crops [2]. One of the standard of fertilization in corn crop is to see & measure leaf color. But there are still many corn farmers who provide fertilizer without considering the leaf color conditions so as to provide fertilizer without standard dosage. Whereas the level of fertilizer should also be measured based on the characteristics of the plant. To achieve hybrid corn yield ≥ 8000 kg/ha and suppress result of relative maximum loss 20% n in hybrid corn hence minimum value limit of BWD (Bagan Warna Daun) scale at flowering phase (VT) is 4,2 - 4,5 [3].

Gunarno and Wahyu used the color of rice leaves by utilizing cameras to calculate Nitrigen needs in rice plants [4]. Leaf color in corn plants can also be used to determine whether corn plants have nutrient deficiencies or deficiencies, such as corn plants lacking nutrients N (nitrogen) shows the color of yellowish green leaves. Nitrogenous compounds are the most important items for the growing crops [5].

Measurement of color level with fertilizer requirement is still done by manual that is using leaf color chart which shaped table of color from fiber material consist of 6 colors that is from light green color to dark green. In this study a tool was created that could automatically measure the amount of fertilizer needed for corn per hectare.

Using TCS 3200 sensor that can detect and measure the color value of RGB (Red Green Blue) and controlled using microcontroller like Arduino Uno based on ATmega 328 microcontroller, while [6] using Microcontroller (MSP 430G2553). TCS 3200 sensor will detect RGB value from corn leaves which will be compared with RGB value in color table in the leaf color chart that has been stored on the microcontroller so that it can be determined the dose of fertilizer that must be given to corn crops.

II. RESEARCH METHOD

Corn crops (Zea mays) are one of the grain food crops of the grass family [7]. Maize can be grouped according to age and seed, which according to age can be divided into 3 groups namely: Short-lived (matured): 75-90 days, Medium (mid): 90-120 days, Long lived: more than 120 days.

While according to the seeds, divided into 7 groups: Dent Corn (Corn Dental Corn), Flint Corn (Corn Pearl), Sweet Corn (Sweet Corn), Pop Corn (Corn Picked), Flour Corn (Corn Flour), Pod Corn (Corn Pod), Waxy Corn (Corn Glutinous).

The dose of maize fertilization is Urea 350 kg / ha, SP36 100-150 kg / ha and KCI 100 kg / ha. Fertilizer is given by ditugal as deep as 5 cm with a distance of 10 cm from the stem of the plant and covered with soil. Fertilization can be done with NPK compound fertilizer as in Table 1 and Table 2.

Table 1. The dosage of fertilizer and the time of administration to the plant, when using a single fertilizer urea, SP36 and KCL

Waktu Pemberian	Urea (kg/ha)	SP36 (kg/ha)	KCL (kg/ha)
0 – 7 HST	100	150	150
30 – 35 HST	150	-	-
40 – 45 HST (BWD)	100-150	-	-

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Source: Balai Pengkajian Teknologi Pertanian Kepulauan Bangka Belitung [7]

Table 2. Dosage of fertilizer and time of administration to corn plants when using fertilizer NPK15: 15: 16 (Phonska)

Waktu Pemberian	Urea (kg/ha)	Phonska (kg/ha)
7 HST	-	350
28 – 30 HST	150	-
40 – 45 HST (BWD)	100-150	-

Source: Balai Pengkajian Teknologi Pertanian Kepulauan Bangka Belitung [7]

Abbreviation: HST = Hari Setelah Tanam
BWD = Bagan Warna Daun

The color sensor used is TCS3200 sensor where there is a major component in it is photodiode and current to frequency converter. Photodiode on IC TC3200 is arranged in 8x8 array which later can be arranged in through the sectors of S2 and S3 selectors [8]. Photodiode will emit a current of magnitude proportional to the color level of the base of light that beats it. This current is then converted into a square signal with a frequency proportional to the magnitude of the current. Output frequency is biased by adjusting the feet of the S0 and S1 selectors. Description of the sensor section can be seen in Figure 1 and detail of sensor section as shown in table 3.

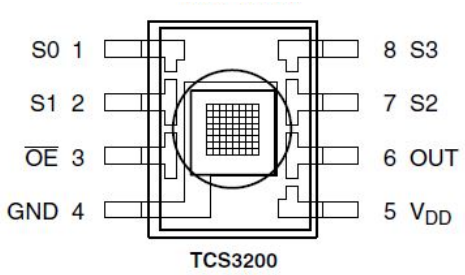

Figure 1. Description of the TCS3200 Sensors section

Table 3. Sensor Section TCS3200

Nama Terminal	I/O	Deskripsi
GND		Power supply ground
OE	I	Active low
OUT	O	Output frekuensi
S0,S1	I	Scala output frekuensi
S2,S3	I	Scala input photodioda
VDD		Supply voltage

The Leaf Color Chart (BWD) as shown in FIG. 2 is a tool consisting of four shades of green, of yellowish green (No. 2 on the card) to dark green (No. 5 on the card) [9]. In Maize Leaf Color Chart (BWD) is only used in the third fertilizer application that is 40-45 (HST) Day after Planting. The BWD readings are done by attaching the top-grade corn that has been perfectly established. The leaf number 3-5 from the most end leaves, the measured leaf is 1/3 of the tip of the leaf. The reading time should be late afternoon so as not to be affected by the sunlight [10]. From the reading result using BWD it can be determined the dose of fertilizer that must be given as shown in table 4

Table 4. Method of determining the dose of urea by using BWD

Skala BWD	Dosis Urea (Kg/Ha)
< 4	150
4 – 5	125
>5	100

Source : Balai Pengkajian Teknologi Pertanian Kepulauan Bangka Belitung [4]

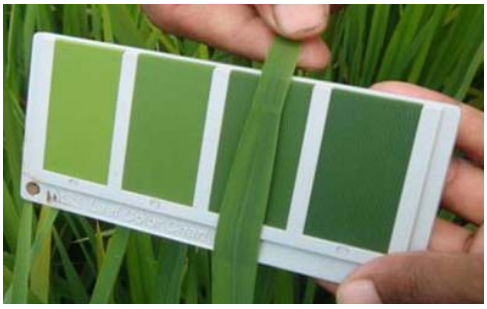

Figure 2. Leaf Color Chart

The color data collection is based on the color of the Leaf Color Chart with 4 levels of green color starting from the number 2 to 5 as shown in Figure 3. It will be stored as retrieval results in the RGB color range that will be process on the microcontroller. In addition, the dose of fertilization on the BWD scale as in Table 5 will also be stored on the microcontroller memory.

Tabel 5. Dose Fertilization On BWD Scale

Scale BWD	Dose Urea (Kg/Ha)	Dose UH Nitrogen (Kg/Ha)
< 4	150	69
4 – 5	125	57.5
>5	100	46

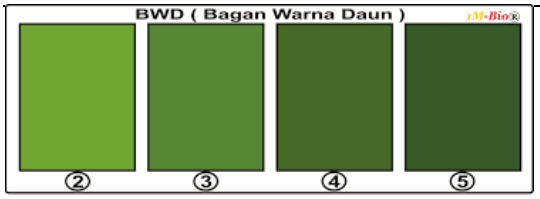

Figure 3. Level Color Leaf Color Chart (LLC)

In addition, data collection as a comparison for the way of fertilization is also done by questionnaire interviews [11] to farmers in Gumuk Hamlet Hamlet Village Nogosari Village Rambipuji and Sumberjo Village Glundengan Village Wuluhan District. In addition, data collection as a comparison for the way of fertilization is also done by interview questionnaire to farmers in Dusun Gumuk Gebang Nogosari Village District Rambipuji and Dusun Sumberjo Village Glundengan District Wuluhan. The result from the questionnaire as shown in table 6.

Table 6. Interview Result of Hybrid Corn Fertilizer Interviewing

Nama	Komoditi	Luas Lahan (Ha)	Teknik Pemupukan	Dose Pupuk (Kg/Ha)	Total Dose Pupuk (Kg/ Ha)
P. Riyadi	Jagung Hibrida	1/4	2 kali	125, 125	1000
Gatot Tajuwit	Jagung Hibrida	1/4	2 kali	100, 100	800
P. Martono	Jagung Hibrida	1/4	3 kali	20, 75, 75	680
P. Aziz	Jagung Hibrida	1/2	2 kali	200, 200	800
P. Miskun	Jagung Hibrida	1/4	2 kali	100, 100	800
P. Soleh	Jagung Hibrida	1/8	2 kali	50, 50	800

note: Total Dose Fertilizer = Area of Land (Hectares) x Number of Dosage Fertilizer

Design tools that have been designed as in Figure 4. The design of the hardware here uses some basic components such as arduino uno Microcontroller, TCS3200 color sensor, 2x16 bit micro LCD, Battery, Module LM2596, and Casing from acrilic. The function of each tool is TCS3200 Sensor to detect corn color level, Arduino as input device output control, micro LCD to display the result of measurement in the form of nutrient value of nitrogen nutrient in the form of urea fertilizer needed (kg / hectare), Batery as Suply voltage or voltage source for the tool and LM2596 as voltage drop for voltage on TCS3200 sensor.

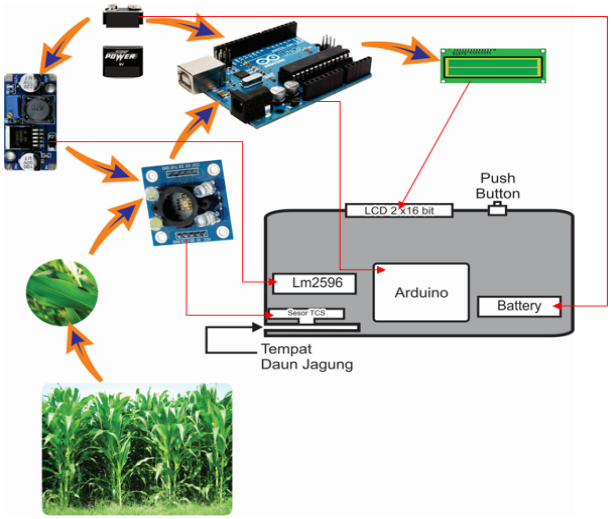

Figure 4. Device Design

While the program flowchart to calculate the urea and nitrogen doze per ha, shown on the flowchart as in figure 5.

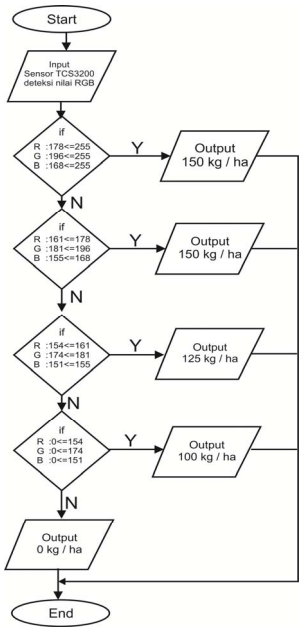

Figure 5. Flowchart Program

To generate a RGB value between 0-255 fixed. The tool needs to be calibrated by determining a fixed value when it is dark (black) and light (white) using the formula:

$$x = 255 * \frac{fo - fd}{fw - fd}$$

Where :
X: RGB value
255: RGB value range
Fo: the frequency value of the detected object
Fd: the frequency value in the dark (black)
Fw: frequensi value in bright state (white color)

After the calibration prose will get the RGB value range, and then searched the leaf color range based on the Leaf Color Chart. This range search aims to obtain the RGB value of the color level on the leaf color chart as a comparison for the nitrogen nutrient (n) nutrient cultivation in corn plants as shown in Table 7.

Table 7. RGB Color Range Search Results

	Tingkatan Bagan Warna			
	2	3	4	5
R	178 – 255	161 – 178	154 – 161	0 – 154
G	199 – 255	181 – 199	174 – 181	0 – 174
B	168 – 255	155 – 168	151 – 155	0 – 151

III. RESULTS AND ANALYSIS

Testing tool is done in accordance with the stages of the process of color detection of leaves are:

a. Color of maize leaf detected TCS3200 sensor
b. Calculate RGB value

c. Compare the proximity of RGB values to the color range of the Leaf Color Chart (BWD) that has detected previous values as reference data.
d. Showing results Fertilization rate is needed in the form of Urea kg / ha.

Testing is done by searching 10 Leaves of maize compared to the manual leaf color chart first and then detected with the sensor as much as 20 times, where the test results as shown in table 8.

Table 8. Test Results

POKOK TANAMAN	DAUN																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	√	√	√	√	√	√	√	√	√	√	√	√	√	√	x	√	√	√	√	√
2	√	√	√	√	√	√	x	√	x	√	√	√	x	√	√	√	√	√	√	√
3	√	√	√	√	√	x	√	√	√	x	√	√	√	√	x	√	√	√	√	√
4	√	√	√	x	x	x	√	√	√	√	√	√	x	√	√	x	√	x	√	√
5	√	√	√	√	√	√	√	√	√	√	√	√	√	x	√	x	√	√	√	√
6	√	√	√	x	√	x	x	√	x	√	x	√	x	√	√	√	√	√	√	√
7	√	√	x	√	√	√	x	√	√	√	√	x	√	√	√	√	√	√	√	x
8	√	√	√	√	√	√	√	√	√	√	√	x	√	√	x	√	√	√	√	√
9	√	√	√	√	√	√	√	√	√	√	x	√	√	x	x	√	√	x	√	√
10	√	√	√	√	√	√	x	√	x	√	√	√	x	√	√	√	√	√	x	x

√ : Fit = 164
X : Error = 36
Percentage : 164 x 100 / 200 = 82%

From the test results, found the shortcomings / weaknesses in the tool, within 40 minutes the tool is turned on voltage on the battery decreased 0.5 V from 9 V to 8.5 V. This affects the color reading on the sensor unstable so the RGB range will changed. Because the range of RGB changes will affect the reading of the color scale on the tool.

IV. CONCLUSION

From the test results of the tool in a sunny or dark weather conditions, with a tool accuracy rate of about 82% can be said that the tool works pretty well. The stability of the tool for the process of reading the color with the supporting battery power source for 40 minutes in a state of life continues to be stable. But after 40 minutes the voltage on the battery decreases around 0.5 V, so it can disturb the stability of color reading on the sensor.

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