ISBN : 978-623-96220-1-5

Development of Leaf Color Level Sensors for Measuring the Nutritional Need of Chrysanthemum based on Raspberry pi

S. Arifin[1], Christa[2], R. Firgiyanto[2], D.E. Putra,[3]

[1]Department of Information Technology, Politeknik Negeri Jember, Indonesia
[2]Department of Agriculture Production, Politeknik Negeri Jember, Indonesia
[3]Department of Agribusiness, Politeknik Negeri Jember, Indonesia

*christa@polije.ac.id

Abstract. Chrysanthemum (Chrysantium Morifolium) is one of the most popular ornamental flower plants in Indonesia. The advantages of chrysanthemum include adjustable flowering properties so that they can be produced all year round with varied flowers and easier handling. Apart from being used as cut flowers, chrysanthemum plants can be used as traditional medicine and also as insect poison medicine. The quality of chrysanthemums is largely determined by external appearances such as stalks, leaves, and flower crowns. So that it takes an intensive maintenance effort from seeding to harvesting in order to obtain good flower quality. One of the factors that greatly influence the maintenance of chrysanthemum is the provision of nutrients or nutrients. Lack of nutrients in the chrysanthemum will inhibit growth so that it can reduce the quality of the flowers produced. In this paper, a camera-based sensor is developed to measure the color level of chrysanthemum leaves. Leaf color levels were measured through histogram processing on the raspberry pi device. Image processing results are compared with the standard Leaf Color Chart (LCC) to obtain accurate readings.

1. Introduction

Chrysanthemum (*Chrysantium morifolium*) is one of the most popular ornamental flower plants in worldwide and Indonesia [1] [2] [3] [4]. The advantages of chrysanthemum compared to other ornamental plants include adjustable flowering properties so that it can be produced all year round with varied flowers and easier handling [5]. Chrysanthemum flowers are considered important economically because of its various uses for example for landscaping and cut flowers for vases decoration, making wreaths and hair ornaments [6]. Apart from being an attractive potted plant and as a cut flower, chrysanthemum can be used as a traditional medicine and also as an insect poison medicine [7]. Research conducted by [8] on Chrysanthemum morifolium, showed that this type of chrysanthemum extract has a fairly high antioxidant content. This is also supported by research [9], showing that the essential oil contained in Chrysanthemum indicum flowers has the ability to inhibit the growth of 15 kinds of microorganisms and [10] the chrysanthemum plant is often used as a tea and anti-inflammatory in traditional Chinese medicine. The most popular type of chrysanthemum is the standard type of chrysanthemum [11]. Based on data [12], the harvested area for chrysanthemum is the largest compared to other ornamental plants in 2018, which is 1,110.52 ha followed by roses with a harvest area of 411.10 ha and the third place is tuberose plants with a harvest area of 309, 67 ha. This harvest area has decreased slightly compared to 2017 with a decrease of 4.56 percent, namely from 1,163.55 ha in 2017 to 1,110.52 ha in 2018. The total amount of cut chrysanthemum production in 2018 reached 488.18 million stalks, followed by roses with a production of 202.06 million stalks, and tuberose with a production of 116.91 million stalks. This production is expected to continue to increase in line with the increasing demand for chrysanthemum, thus requiring sustainable abundant and high quality crop production [13]. Increasing urbanization and human populations put continuous pressure on the industry as space in cities shrinks so people are forced to satisfy their gardening desires by planting crops in pots or on terraced buildings [14]. Chrysanthemum has wide adaptability for varying climatic and soil conditions [15]. The quality of chrysanthemum cut flowers is very much determined by the external appearance starting from the stalks, leaves and crown of the flower so that intensive maintenance efforts are needed from seedling to harvesting in order to obtain a good quality outer appearance. For maximization of yield and quality of flower crop, various management practices like proper dose of manures and fertilizers [16].

Lack of nutrients in chrysanthemum will cause obstacles in plant growth and development accompanied by other symptoms that can reduce the amount of production, appearance and quality of the flowers produced. On the other hand, excessive nutrient application will adversely affect plant growth [17]. Therefore, in this study, a portable sensor device was developed that can measure leaf color levels to determine the nutritional needs of chrysanthemum plants. The Raspberry Pi microcomputer based sensor device integrated with an RGB camera [18]. The output is based on the standard Leaf Color Chart (BWD). This research is expected to be able to determine the need for plant fertilizers in accordance with the conditions of plant needs which can eventually be converted into the fertilizer dose given to the chrysanthemum plant so that the fertilizer application is balanced.

One of the efforts to increase chrysanthemum production is by increasing the number of plant populations planted and increasing the number of flowers and the number of stalks planted. This increase can be obtained optimally if it is supported by the provision of balanced fertilizers because the need for nutrients for plants also increases along with the addition of the number of flowers so that plant quality is maintained in the hope that it will increase income for farmers because the selling price of chrysanthemum cut flowers is influenced by flower quality. produced [19]. The most widely felt benefits of fertilizers are providing the necessary nutrients for plants and helping to prevent the loss of fast-losing nutrients such as N, P, and K which are easily lost by evaporation or by percolation water. Several studies regarding fertilization applications have been carried out, including by [20], [21]; [22]. One of the possible applications of Precision farming technology, among others, is the management of leaf color images based on leaf color charts as an alternative in determining the dose and concentration of fertilization because the level of leaf color is strongly influenced by the amount of chlorophyll in the leaves, while the amount of chlorophyll is influenced by the availability of nutrients absorbed. by planting mainly nitrogen. Leaf color chart (BWD) was first developed in Japan, and later researchers from China's Zhejiang Agricultural University developed a better and calibrated BWD with indica, japonica and hybrid rice. This BWD is a suitable tool for optimizing the use of N, with various sources of N fertilizers, organic fertilizers, bio fertilizers, or chemical fertilizers. In the past, there has been a simple tool to determine the amount of chlorophyll in plant leaves called SPAD-52 (KONICA MINOLTA 1989), but this tool is still quite expensive. This tool digitally records the relative number of chlorophyll molecules, so it is very sensitive and accurate. The recording is called the SPAD value, calculated based on the amount of light transmitted by the leaf in two wavelength beams where the absorbance of chlorophyll differs. Research on the use of image processing in the analysis of fertilizer requirements using BWD on chrysanthemum has never been done before, but general image processing research [23] has been carried out, among others [24] who conducted research on automatic spray applications based on image processing of land images, [25] conducted research on the use of cell phone cameras to estimate the color of rice leaves such as when using a leaf color chart (BWD), [26] developed a leaf color level sensor device to determine fertilizer requirements for soybean crops and [27] through fertilization recommendations using BWD.

2. Material and Sensing Process

2.1 Hardware Design

The prototype case is made using 3D printer technology. The prototype is designed with a size of 4x4x20cm. The device consists of a camera sensor box frame and a raspberry pi controller. The controller uses a 5 inch Raspberry HDMI LCD as a display. The system uses a power supply from a 5 volt power bank 2.1 A. The box design is designed using CAD which is then converted to * stl format. Figure 1 is a case design used as a measuring device for the intensity of leaf color. The tool uses a Pi Camera with a 5MP resolution as a leaf color intensity sensor. The next stage is carried out by making electronic circuits according to system requirements. Figure 2 is a system block diagram of the device created.

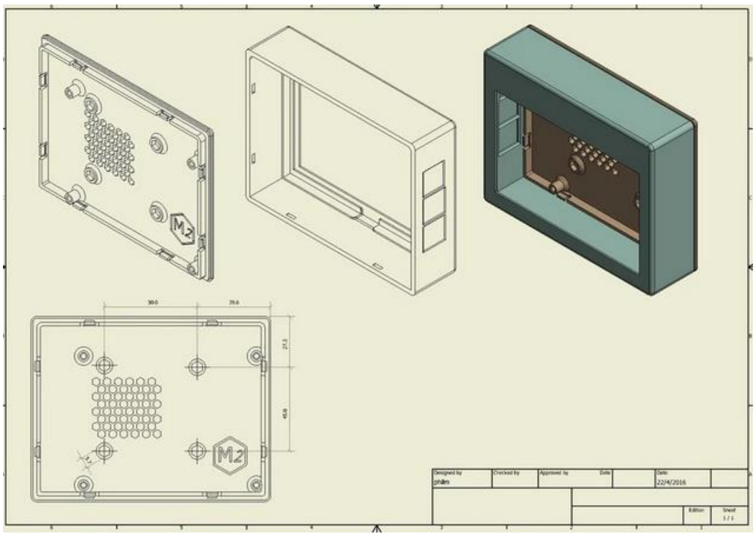


Figure 1. The case design used as a measuring device for the intensity of leaf color

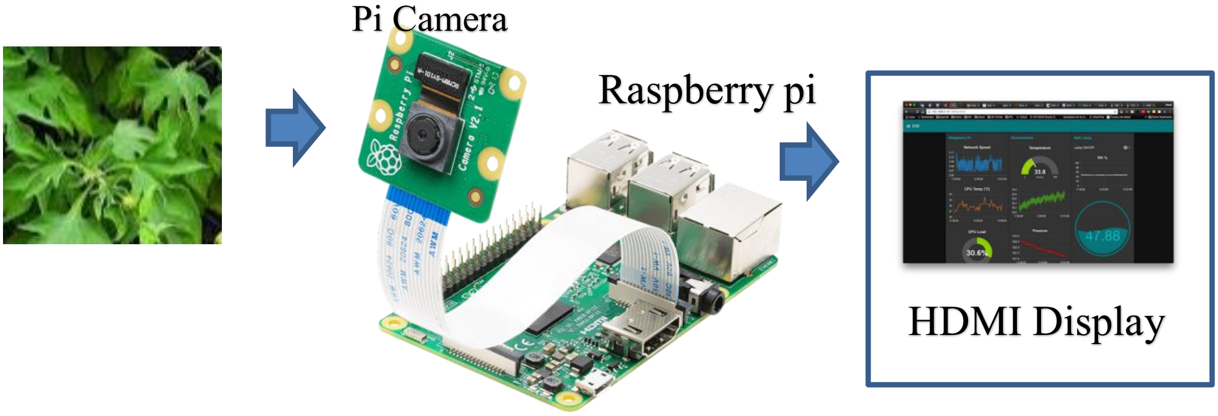


Figure 2. The system block diagram of the device created.

2.2 Software Design

The website was built using python software on a raspberry pi device. The device uses image data from the Pi Camera for processing leaf color intensity. After capturing the chrysanthemum leaves, then the RGB image is converted to HSV format to reduce noise in the image. Convert RGB to HSV using equation 1). Furthermore, to obtain the intensity level of the leaf color, the HSV image was processed using the histogram feature. The histogram will provide a data set of R, G and B values in a certain pixel area. The histogram equation is a method for processing images to adjust the contrast of an image by modifying the histogram intensity distribution. The objective of this technique is to assign a linear trend to the cumulative probability function associated with the image. Histogram processing using equation2. Figure 3 is a programming flowchart on Rasberry Pi using the Python language.

$$V = \max(R, G, B)$$

$$S = \begin{cases} \frac{V - \min(R,G,B)}{V}, jika\ V \neq 0 \\ 0 \end{cases} \quad \text{...1)}$$

$$s - RGB(x,y) = I_R(x,y) + I_G(x,y) + I_B(x,y)$$

$$\text{mod}_{s-RGB} = \arg\max(histogram\_s - RGB) \quad \text{...2}$$

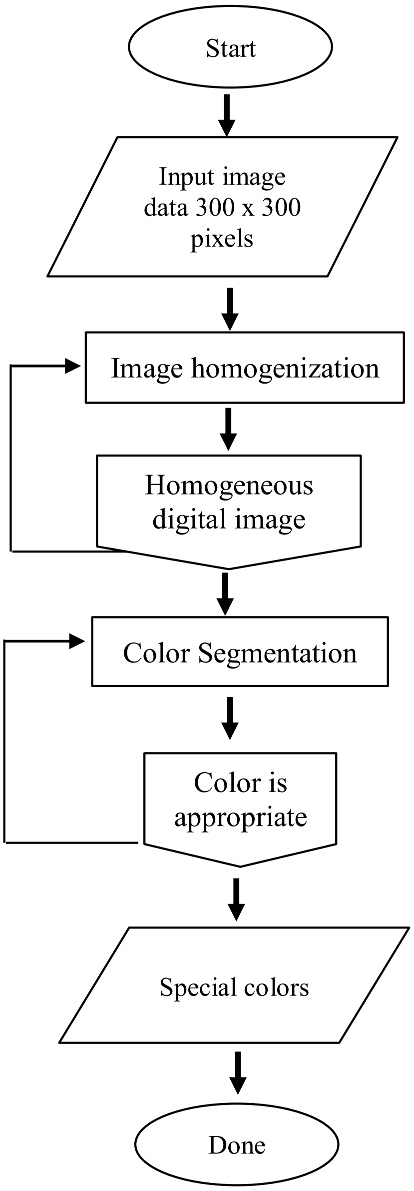


Figure 3. The programming flowchart on Rasberry Pi using the Python language

3. Result and Discussion

3.1. System Realization

Power for the system using 2 batteries 85760 arranged in parallel. By using the balancer module, the battery can be recharged using a 5v usb charger. In addition to the electronic box which consists of several circuits, there are other parts that are related to and are still part of the electronic circuit, namely the sensor circuit. A sensor circuit like this consists of two slots as a place to place the sensor. This sensor circuit is connected directly with a cable to the i2c pin (SDA / SCL) of the microcontroller. The battery box and electronic circuit are designed separately to make recharging the device easier. The sensor box is equipped with an indicator LED as a sign that the sensor is working or dead. Figure 4 is the result of the form of the device used for the monitoring system.

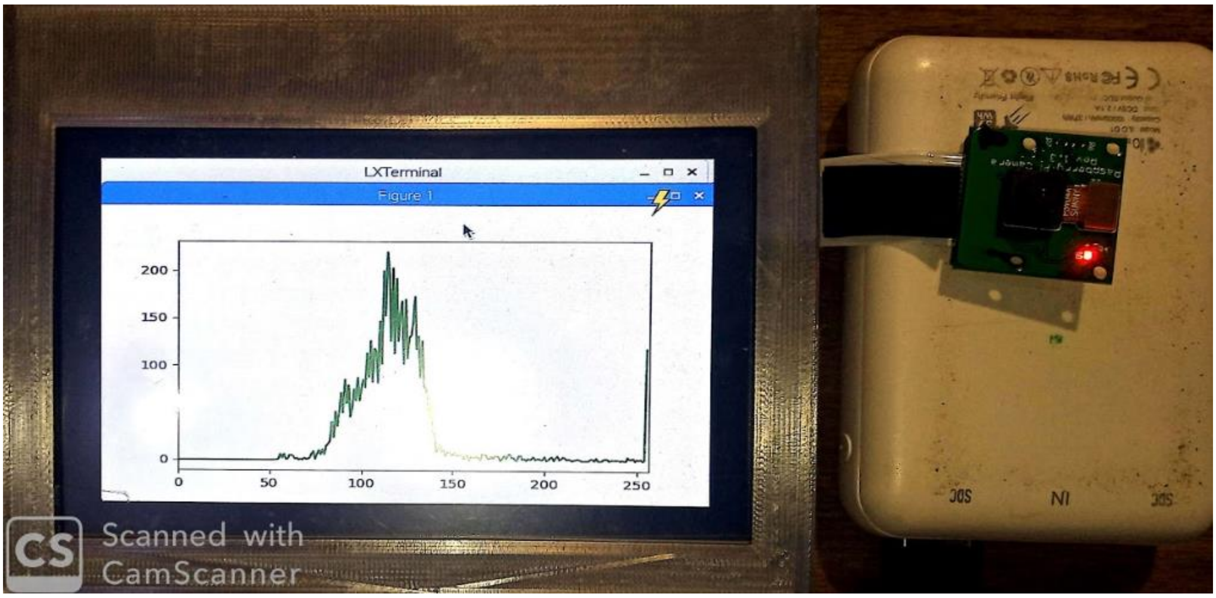


Figure 4. The form of the device used for the monitoring system

In the analysis of leaf image RGB data, the cumulative frequency distribution of the RMean, GMean and BMean components is generally assumed to follow the normal distribution. However, a recent study reported that the cumulative frequency distribution of leaf color followed an oblique distribution. For example, Wu et al. found that the cumulative frequency of tea leaf color had an oblique distribution, and the deviation with new and old leaves had a clear difference [27]. In addition, the humidity conditions on corn leaves were associated with deviation in the grayscale values in the RGB blade model [28]. The asymmetry of the skewed distribution can be explained by the partial frequency distribution of the slanted distribution curve. Several parameters that can be derived from the skewed distribution include mean, median, mode, skewness, kurtosis, and others.

The SPAD leaf chlorophyll meter is one of the most widely used handheld meter for rapid assessment and does not destroy chlorophyll content in many plants [29]. In this paper, the frequency distributions of the green, and gray scale channels in the RGB leaf image are analyzed. By extracting the relevant distribution parameters, a model was created for the correlation of the color characteristic parameters and the SPAD chlorophyll concentration values. When the inclination parameters were exploited, we found that the degree of installation and the prediction accuracy improved considerably. The proposed spatial model can more accurately predict SPAD values, and explain the physiological significance of leaf color change.

The main process carried out is calibration with the BWD table. In this case, the maximum pixel value on the histogram is adjusted to the color classification in the BWD. Nutrient table values are also entered into the python program. This will provide direct recommendations to the user when the tool hits the leaves. The processing features are illustrated in Figure 5.While the BWD table used in this study is shown in Figure 6.

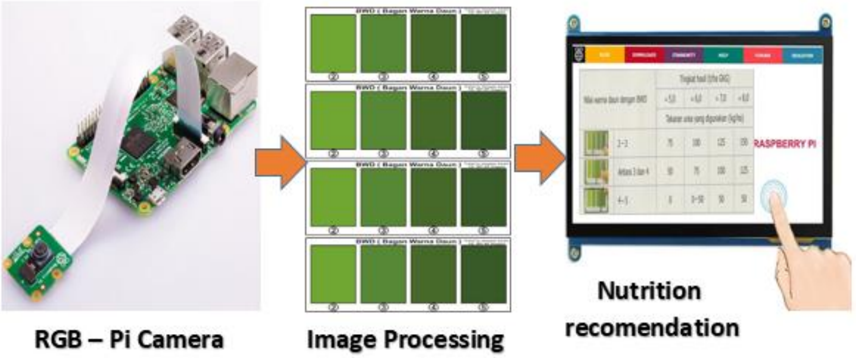


Figure 5. The processing features are illustrated

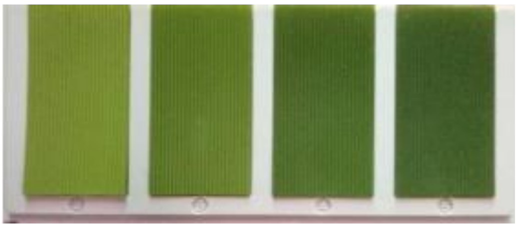
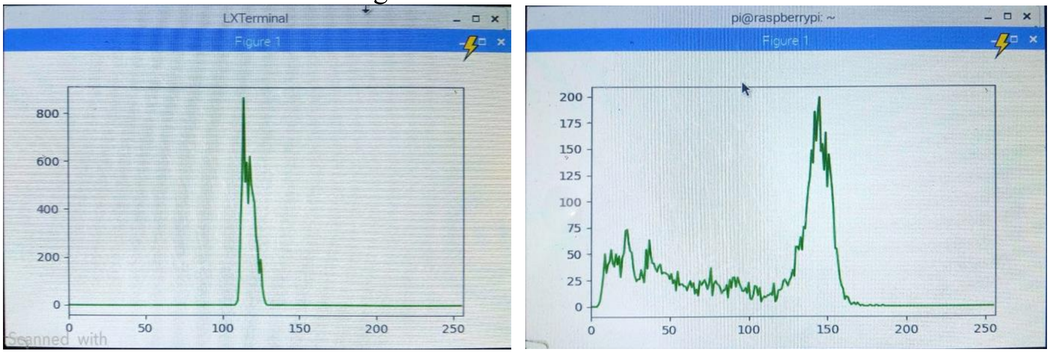


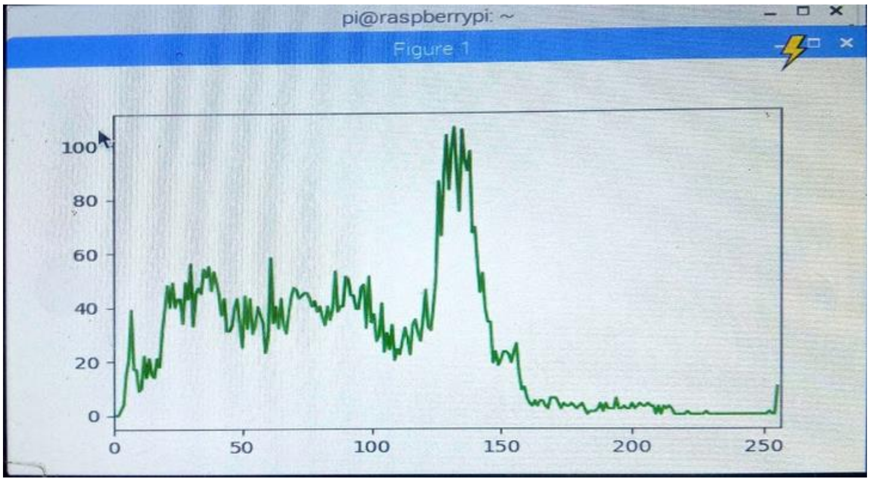
Figure 6. BWD table used

3.2. Testing result

Before conducting field testing, the histogram values on the R, G, B and Gray channels are displayed in graphic form. This is used to test the best channel for use as a parameter in leaf color classification. In this case, the green channel provides a responsive difference to the color of the leaves. This is because the color of the chrysanthemum leaves is predominantly green. The results of reading the Histrogram value for each channel are shown in Figure 7.



(a) (b)



(c)

Figure 7. The results of reading the Histrogram value of a) scale 2-3, b) scale 3-4, c) scale 4-5

Furthermore, the data reading test was carried out on the leaf color directly. In this process, the readings are compared directly with manual measurements using the BWD table. Through a series of tests, the value is obtained according to figure 8.The level of readability is influenced by the light intensity in the environment. The brighter the light intensity in the surrounding environment, the lower the accuracy of reading the data. In normal light intensity, the color reading device has an accuracy of about 92%. In bright light intensity, the color reading device has a high accuracy of about 80%. The image resolution used in image processing is 320x240.

```
123
123
125
125
118
113
120
123
126
125
120
[illegible]
[illegible]
121
120
120
120
123
125
121
121
```

skala2-3

5t/ha: 75kg/ha
6t/ha: 100kg/ha
7t/ha: 125kg/ha
8t/ha: 150kg/ha

```
129
132
129
134
131
129
129
127
132
129
132
134
127
129
127
129
129
134
134
129
132
129
```

skala3-4

5t/ha: 50kg/ha
6t/ha: 75kg/ha
7t/ha: 100kg/ha
8t/ha: 125kg/ha

```
147
149
147
145
142
147
147
143
147
147
145
145
147
147
[illegible]
[illegible]
[illegible]
145
145
147
147
149
```

skala4-5

5t/ha: 0kg/ha
6t/ha: 0kg/ha
7t/ha: 50kg/ha
8t/ha: 50kg/ha

```
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
140
0
```

out of range

Figure 8. Testing result

4. Conclusion

Based on the test results, it was concluded that the system could determine the intensity of leaf color well (92% accuracy) in normal light conditions. If the sensor detects a leaf color value on a scale of 2-3, it will give a recommendation of 75kg / ha (yield rate: 5t / ha). If the sensor detects a leaf color value on a scale of 3-4, it will give a recommendation of 50kg / ha (yield rate: 5t / ha). If the sensor detects a leaf color value on a scale of 4-5, it will give a recommendation of 0kg / ha (yield rate: 5t / ha). Meanwhile, if the light intensity of the environment is too bright, the accuracy will decrease. This is because the brightness level of the image can affect the maximum pixel value in the histogram processing. In future research, an LED light device will be added that can reduce the error of reading images caused by light interference from the environment.

Acknowledgment

The authors would like to acknowledge the financial support of this work by grants from PNBP 2020, State Polytechnic of Jember. The author also thanked the P3M and Information Technology Department, State Polytechnic of Jember, which has provided support and assistance in completing this research.

References

[1] Firgiyanto R, Kasutjiningati, Pertami R R D and Sukri M Z. 2019. *Budidaya tanaman hias: Konsep Dasar Bertanam Tanaman Hias. Politeknik Negeri Jember* (Jember Indonesia: Polije Press)
[2] Wediyanto A, Marwoto B, Rochalia R G , Syai M, Nuraini F, Gandasari D, Lesmana K and Ernawati S. 2008. *Standart Operasional Prosedur Budidaya Krisan Potong. Departemen Pertanian* (Jakarta Indonesia: Departemen Pertanian)
[3] Rosyidah H A, Kristanto B A and Slamet W 2019 *J. Agromedia* **37** 25-31
[4] Vanlalruati, Sindhu S S, Anand P and Kumar G 2019 *Indian J. of Agricultural Sciences* **89** 1282-1286
[5] Indah T, Dewanti P and Wijaya K A 2015. *J. Berkala Ilmiah Pertanian Universitas Jember* **9** 1-4
[6] Chandel A, Gupya Y C and Bhatia S 2020 *Int. J. Curr. Microbiol. App. Sci* **9** 577-583
[7] Febrianto R A and Islami T 2019 *J. Produksi Tanaman* **7** 1427–1434
[8] Pin D D, Yang Y T and Gow C Y 1999 *LWT-Food Science and Technology* **32** 269-277
[9] Zhu S, Yang Y, Yu H, Ying Y and Zou G 2005 *J. of Ethnopharmacology* **96** 151-158
[10] Yang L, Aobulikasimu N, Ping C, Jin H W and Hong L 2017 *Molecules Article* 22
[11] Ni'mah S 2018 *J. Produksi Tanaman* **6** 1671-1676
[12] Badan Pusat Statistika [BPS]. 2018. *Statistik Tanaman Hias Indonesia. Badan Pusat Statistika* (Jakarta Indonesia: Badan Pusat Statistika)
[13] Budiarto K, Nugroho E D S, Sulyo Y and Soedarjo M 2012 *J. Hort. Ed. Khusus* **2** 148-153
[14] Abrol A, Dhiman S R, Puja S, and Sharma M 2018 *J. of Hill Agriculture* **9** 165-170
[15] Thumar B V, Chovatiya N V, Butani A M, Bhalu V B and Jindal M 2020 *J. of Pharmacognosy and Phytochemistry* **9** 411-413
[16] Rajan K, Bhatt D S, Chawla S L, Bhatt S T and Priya S 2019 *Curr Agri Res* 7337-342 doi : http://dx.doi.org/10.12944/CARJ.7.3.09
[17] Hayati N Q, Nurmalinda and Marwoto B 2018 *J. Hort.* **28** 147-162
[18] Widiawan B, Kautsar S, Purnomo F and Etikasari B 2017 *J. Ilmiah Pendidikan Teknik Elektro* **2** 143-148. Doi http://dx.doi.org/10.30870/volt.v2i2.2047
[19] Wuryaningsih S 1992 *J. Hort.* **2** 26-34
[20] Riskiawan H Y, Rizaldi T, Setyohadi D P S, and Leksono T 2017 *Nitrogen (N) fertilizer measuring instrument on maize-based plant microcontroller. 4th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI).* doi:10.1109/eecsi.2017.8239080
[21] Warsito and Nuryani N 2005 *J. Hort.* **15** 97-101

[22] Rahmawati I and Winarto B 2016 *J. Agron. Indonesia* **44** 76 – 82
[23] Winarno W, Riskiawan H Y, Rizaldi T and Setyohadi D P S 2018 *Proceeding of the International Conference on Food and Agriculture* p 394-400
[24] Tangwongkit R, Salokhe V M and Jayasurya H P W 2006 *Agricultural Engineering International: CIGR E-journal* **8**
[25] Astika I W 2010 *International conference, The Quality Information for Competitive Agricultural Based Production System and Commerce, Procceding AFITA* (Bogor: AFITA)
[26] Winandar 2011 *Pengembangan perangkat sensor tingkat warna daun untuk menentukan kebutuhan pupuk tanaman kedelai [Skripsi].* Departemen Teknik Mesin dan Biosistem Fakultas Teknologi Pertanian (Bogor Indonesia: Institut Pertanian Bogor)
[27] Leghari S J, Leghari U A, Buriro M, Laghari G M, Soomro F A and Khaskheli M A 2016 *European Academic Research* **4** 900-916
[28] Widiastuti L 2016 *Agronomika* **11** 30-42
[29] Dewanti P C, Guritno B and Herlina N 2017 *J. Produksi Tanaman* **5** 77 – 83
[30] Bres W and Jerzy M. 2008. *Agronomy Research* **6** 435-444