Development of a decision support system for mapping variable rate fertilizing application on Soybean (*Glycine max*) cultivation

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Abstract. Precision Farming (PF) has been developed in many countries. It is need an appropriate and integrated technology to achieve the goals, such as global positioning system (GPS) to mark the geographical coordinate, ArcGIS to map the spatial data, Variable-rate Application (VRA) to show the variability of soil properties on the field and Decision Support System (DSS) to establish the best management practices for the field operation. The objective of this research was to develop a decision support system for mapping VRA of precision fertilizing on soybean cultivation. The system generates a VRA map and shows the amount of required fertilizer for soybean according to the field and soil properties data. The DSS was developed using web application to facilitate the flexibility, and scalable access via internet. To execute the application, user requires to select the coordinates of the field and soil sample points and fertilizer dose data. The friendly user of DSS program was successfully produced with the VRA map showed the data of recommendation fertilizer as the decision support system. The outcome from this study was the application mapping VRA. Further steps are needed in order to apply this application to the farmers.

1. Introduction

Precision farming (PF) is an innovation in agricultural practices and management and it has been developed in many countries. In agricultural management system, information and technology are combine by PF to identify, analyze and manage the information of spatial variability on the field to reach the optimum use of agricultural input, sustainable agricultural and conserve the natural environment. The main goal of PF is to matches between agricultural inputs (fertilize, irrigate, etc.) and soil condition. Crops need is based on the specific location characteristic on the field so that during farming the input application will not overdoses or less doses [1].

Applying PF can increases the productivities up to 57 % as well as decreases the cost during farming [2]. It is the time for PF to be applied in Indonesia in agricultural inputs arrangement according to the specific needs of a particular place in each location in one land area, thus that each land area gets input according to its needs.
In its application, PF requires appropriate and mutually integrated technology. Technology used in PF are global positioning system (GPS) to mark geographical coordinates and ArcGIS to map the spatial data which is one of the application in geographic information systems (GIS). The mapped information is the soil properties from laboratory tests and using paddy soil test kit, called perangkat uji tanah sawah (PUTS), so that the actual distribution can be seen on the farming field. The map results are used as a reference in making a Variable-rate Application (VRA) map which then becomes the reference in determining the fertilization recommendations. VRA is a technology to show the variability of soil nutrient in the field. The determination of fertilization recommendations is carried out by a decision support system (DSS), where the results of the soil laboratory tests are classified according to the existing class and then the recommendations are decided according to the existing class. DSS is a management system that provides the facilities to analyze data for decision making. This practice is more efficient and effective, so there is no over-application or over-treatment and or any lack of farming Planning, processing, technological problems and its parameters can be optimize using DSS to increase productivity, efficiency and effectiveness of farming [3].

Applying PF in Indonesia was not easy due to Indonesian farmer lack of knowledge about the tools. Laboratory test to check the soil properties was taking time, thus the results were no longer up to date. Besides that reason, the application of PF was also expensive. Faster soil test is needed to shorten the time between the test and planting [4]. In this study, the soil test used was PUTS with the qualitative results (high, medium and low) [5]. The VRA map needs simple, fast and easy program in order to make it as a friendly user for farmers. In this study, DSS program to determine the recommendation for precision soybean fertilization was made to be easier in the making of VRA recommendation map. As motivated by related works of [6, 7, 8, 9], the program/ application was designed as a decision support toolbox, where farmers can upload their own data and retrieve their outputs. The program produced from this study may improve the business value by avoiding the risks of over or less-doses of fertilizer thus can enhance the profit in the using of natural resources.

2. Methodology
Program/ application that is made based on web-GIS was a combination of mapping graphic design, digital maps with geographical analysis, computer programing and database that are interconnected into one part web design and web mapping [10]. Web-GIS uses mapping graphic design sourced from Google Maps Application Programming Interface (API) that can be freely accessed by developers. Google Maps API is a library in the form of javascript that allows other developers to use this application in their applications [11]. The coordinate data of soil sample, soil nutrient data and fertilizer dosage data were collected by observation in the field and from literature review from previous study (data not shown).

3. Result and Discussion
Based on the observation result about soil nutrient (N, P, and K) in the field, there was a different soil nutrient in 1000 m. sq. Figure 1. shows the highest value of soil nutrient N (red color) in the center of the field. According to the classification of soil nutrient [12], the value of N in this study were classified as low (<0,1 %).

Figure 1. Value of soil nutrient N.
Figure 2 shows the lowest value of soil nutrient P (violet color) in the center of the field. According to the classification of soil nutrient [12], the value of P in this study were classified as low (< 20 ppm) and medium (> 41 ppm).

![Figure 2. Value of soil nutrient P.](image1)

Figure 3 shows the highest value of soil nutrient K (dark green color) in the lower right corner in the field. According to the classification of soil nutrient [12], the value of K in this study were classified as low (< 20 ppm) and medium (21 – 40 ppm).

![Figure 3. Value of soil nutrient K.](image2)

To meet the requirements of technology based PF, the application to make fertilizer recommendations for plants is necessary. This application was built to make ease for users to create fertilization recommendation maps. DSS is a webserver-based application and uses the database as the data storage. The main page or log in page of the web is a page that appears when the URL or web address is typed. This page is used by the user to access the next page according to the access authorization owned by that user. The appearance of the main page is shown in Figure 4.

![Figure 4. First page view of the application.](image3)

After the login page, there is a fertilizer dosage data page (Figure 5). On this page, fertilizer dosage data is entered at the number of 10 day after the plant (DAP) and 30 DAP for each nutrient class according to the classification from Karsidi and Haryati [13].
After the fertilizer dosage data page, there is a page for inputting the coordinate data. On this page, input the coordinate data of the mapped land (Figure 6) to display the position of the land on the map. Besides coordinate data, nutrient classes and sample location codes were also included.

The last is the page of mapping result of fertilization recommendations (Figure 7). This page is for displaying the map results from previously inputted data. The map displayed is in the form of a fertilizer recommendation map that is featured with a description of the color and the dosage that will be applied to the planting land. The data of recommendation fertilizer for 10 DAP and 30 DAP will be shown when the grid in VRA map clicked.

4. Conclusion
The friendly user of DSS program was successfully produced with the VRA map showed the data of recommendation fertilizer as the decision support system. The outcome from this study was the application mapping VRA. Further steps are needed in order to apply this application to the farmers.
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