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Mapping the Variable-Rate Application (VRA) of Precision Fertilizing for Soybean

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ABSTRACT

Information on the spatial and temporal diversity of soil properties is very important for farmers in making decisions for farming, namely applying agricultural inputs (in this case is about fertilizer) with appropriate treatment, in the right place, at the right time and the right amount to achieve precision farming. The application of Geographical Information Systems (GIS) in providing visual information and spatial analysis can be used to support the process of decision making in site-specific agricultural management. The research aims to produce a map of recommended variability rates for Urea, SP-36 and KCl fertilization applications for soybean based on N, P and K soil status. The determination of fertilizer dosage for soybean in each N, P and K soil level uses existing recommendations, in this case referring to the research done by Permadi and Haryati (2015). They used high, medium and low values for each N, P and K soil status, and suggested to apply the fertilizers when soybean at the age of 10 DAP and 30 DAP. The mapping was done at two fields of 1000 m.sq with 9 grids of 10m x 10m for each field. The results of the recommendation of urea fertilizer at field D were uniform at the amount of 0,1218 kg/ 100m.sq at 10 DAP and 0,0522 kg/ 100m.sq at 30 DAP. For the recommendation of SP-36 fertilizer were varied in two groups, 4 (four) grids with low P content, should be applied with 0,104 kg/ 100m.sq of SP-36 at 10 DAP and none at 30 DAP and for other 5 (five) grids with medium P content, should be applied with 0,080 kg/ 100m.sq SP-36 at 10 DAP and none at 30 DAP. Then, the recommendation for KCl fertilizer on all grids was uniform at the amount of 0,147 kg/ 100m.sq at 10 DAP and 0,063 kg/ 100m.sq at 30 DAP. At field B, the recommendation for urea fertilizer in all grid was uniform at the amount of 0,1218 kg/ 100m.sq at 10 DAP and 0,0522 kg/ 100m.sq at 30 DAP. For SP-36 fertilizer in 4 (four) grids with medium P content, should be applied with 0,080 kg/ 100m.sq SP-36 at 10 DAP and none at 30 DAP, and for other 5 (five) grids with medium P content, should be applied with 0,040 kg/ 100m.sq SP-36 at 10 DAP and none at 30 DAP. Finally, the recommendation for KCl fertilizer on all grids was uniform at 0,147 kg/ 100m.sq at 10 DAP and 0,063 kg/ 100m.sq at 30 DAP.

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1. Introduction

Soybean is a crop which has protein contents that are needed by humans. Soybean is one of the main food crops after rice and corn, therefore the productivity of soybean needs to be improved. To increase soybean productivity, it depends on precision farm preparation and fertilization. Nitrogen (N), Phosphorus (P), and Potassium (K) soil status are very important for plant growth including soybean. They are important components for crop growth which have active parts in the metabolic process that cannot be replaced by other nutrients. Plant growth and productivity are often hampered because the availability of nutrients in the soil is not sufficient for crops. Availability of N, P and K in soil have an important part of soil productivity. The availability of these soil nutrients is determined by two factors, namely congenital factors and dynamic factors. The congenital factor is soil main materials, which affect the soil orders. Dynamic factor is an unstable factor, specifically the soil management, irrigation, fertilization, and the return of compost [4].

In soybean cultivation, the application of fertilizer is still based on general recommendations, specifically 25-75 Urea kg/ ha + 50-100 SP-36 kg/ ha + 50-100 KCl kg/ ha (Musaddad, 2008 in Manshuri, 2010). Even though the conditions of N, P and K soil status and balance in each location are very diverse. Therefore, fertilizing of N, P and K in general soybeans cultivation is inefficient and can accelerate the soil degradation, because the fertilizer is not given in accordance with the crops need as well as the carrying capacity of the land. This situation will lead to a hidden hunger indication because there is no suggestion for soybean fertilization on the land [2].

In conventional agriculture, all parts of the land get uniform treatment. The constant application rate is often based on measuring the composite soil samples to represent the average characteristics of the entire land. With such treatment, the possibility that can occur is the over-application or vice versa under-applications of fertilizers. With the precision application, the agricultural input can be managed according to the need of the crop growth at each location in the land [6].

It is the time to replace the conventional agriculture method to precision agriculture system, which in its application is expected to increase food crop production as well as to save the expenses and energy in farming. Therefore, to implement precision agriculture, the information of soil status is important. This research is aimed to specifically mapping the N, P and K soil status before planting to create a variable rate application of recommended fertilizer for soybeans.

2. Methodology

The research was conducted at the Agro-technology Innovation Centre of Gadjah Mada University (PIAT-UGM) located in Berbah District, Sleman Regency, Yogyakarta. Two fields with different utilization in the past (named it B and D) were chosen for planting the soybean with each area of 1000 sq.m. Each field was set for 10m x10m grid, so there were 9 grid in one field. The object for mapping was the N, P and K soil status of two soybean farms using ArcGIS software. Tools for collecting primary data were the Global Positioning System (GPS) to record the area and sample points coordinates, a trowel for collecting soil sample, a bucket and plastic ziplock and Soil Test Kit for Wet Land (PUTS) for measuring the N, P and K soil status (Fig. 1).

A soil sample was collected from 5 random subpoints in each grid, and each sample was measured 3 times for its N, P and K. The results were classified in the qualitative range: Low, Medium, and High [1]. The N, P and K soil for each grid were also measured quantitatively in soil Laboratory for calibration and classified using criteria from Soepraptohardjo (1983) in Yamani [7] (See Table 1).

A B C

Fig. 1. Soil Test Kit for Wet Land (PUTS) color indicator : (A) N indicator, (B) P indicator and (C) K indicator

Tabel 1
Classification Criteria of N, P and K soil status

Soil Properties	Unit	Classification				
		Very Low	Low	Medium	High	Very High
N	%	< 0.1	0.1-0.2	0.21-0.5	0.51-0.75	> 0.75
P_2O_5 HCl	mg/100 g	< 10	Oct-20	21-40	41-60	> 60
K_2O HCl	mg/100 g	< 10	Oct-20	21-40	41-60	> 60

(Source: Soil Capability Survey LPPT-Bogor, 1983 [7])

The results were the soil status maps with a scale of 1:350 for field D and 1: 400 for field B. They showed the distribution of N, P and K soil status and this information were used to create the variable rate application map of urea, SP-36 and KCl fertilizer for soybean in each plot according to the recommendations.

In this study, fertilization recommendations used the results by Permadi and Haryati [5] research (Table 2). With the matching method, the map of distribution N, P and K soil status were converted into a recommendation map of the variable rates of Urea, SP-36 and KCl fertilization applications.

Table 2
N, P and K recommendation fertilizing for soybeans in each soil status class

Soil Nutrient	Class Category	Fertilizer Dose (kg/ha)	Application schedule	
			10 DAP	30 DAP
N	LOW	174 UREA	70%	30%
	MEDIUM	152 UREA	70%	30%
	HIGH	117 UREA	70%	10%
P	LOW	104 SP-36	100%	-
	MEDIUM	80 SP-36	100%	-
	HIGH	40 SP-36	100%	-
K	LOW	210 KCl	70%	30%
	MEDIUM	190 KCl	70%	30%
	HIGH	150 KCl	70%	30%

Source: Permadi and Haryati [5]

3. Result and Discussion

3.1 Map of N Soil Status Distribution

The results of mapping N soil status measured by field test (PUTS) and laboratory test on field D and field B are presented in Figures 2 to 5. Based on the maps of N soil status, both field D and field B showed no variability, but the N value using PUTS field test was *high*, while the N value using lab test was *low*. There were many factors might influence these results, including the individual interpretation in observing the PUTS field test when the result fell into between two colors of classification. The sample treatment for laboratory test also affected of losing N content due to the mobility character of N soil. For PUTS field test, the soil sample directly observed without any treatment such as air-dried.

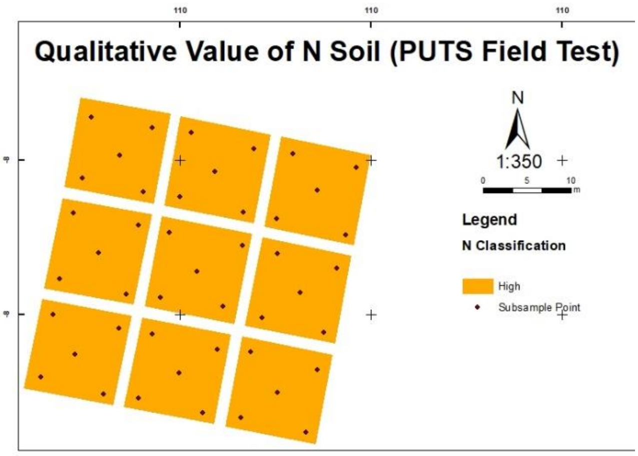

Fig. 2. Map of N Soil status Distribution by Field Test on Field D

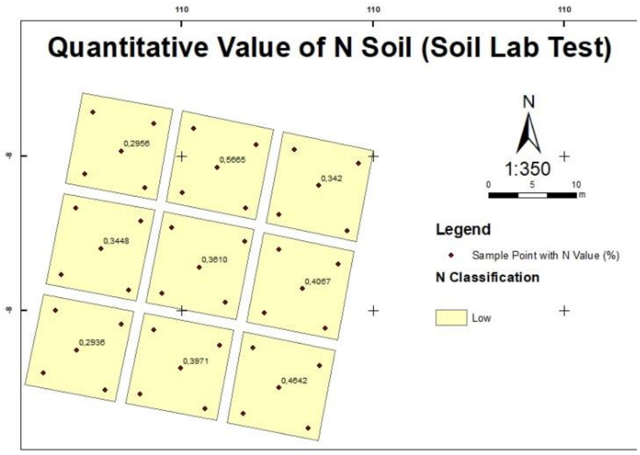

Fig. 3. Map of N Soil status Distribution by Laboratory Tests on Field D

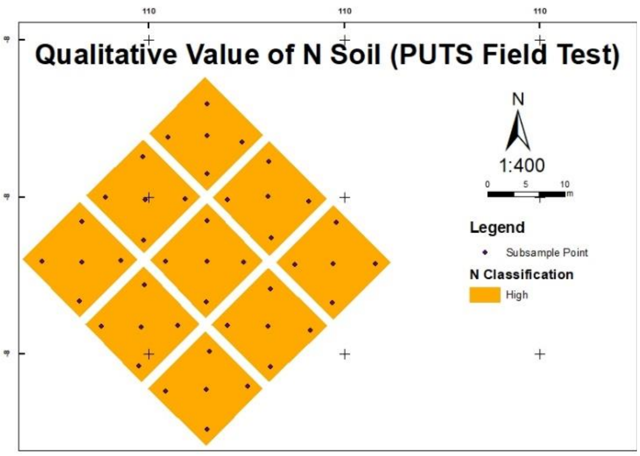

Fig. 4. Map of N Soil status Distribution by Field Test on Field B

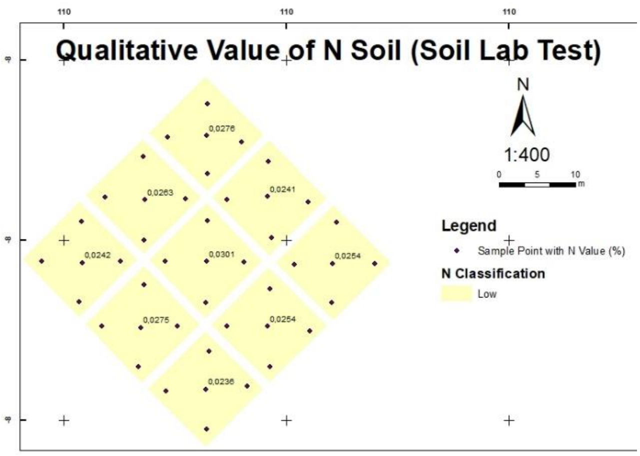

Fig. 5. Map of N Soil status Distribution by Laboratory Tests on Field B

3.2 Map of P Soil Status Distribution

The results of mapping P soil status measured by field test (PUTS) and laboratory test on field D and field B are presented in Figures 6 to 9. Based on the maps of P soil status, there were variability in field D and field B. On field D (Fig. 6) the PUTS field test results 1 (one) grid with *medium* P soil status and 8 (eight) grids with *high* P soil status, while the result of the laboratory test (Fig. 7) showed 4 (four) grids with *low* P soil status and 5 (five) grids with *medium* P soil status.

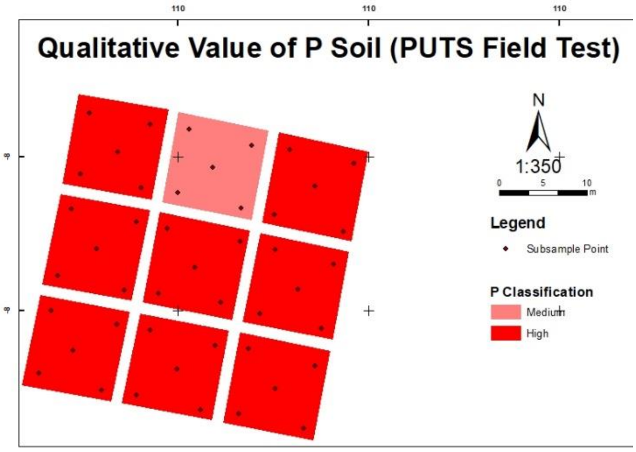

Fig. 6. Map of P Soil Status Distribution by Field Test on Field D

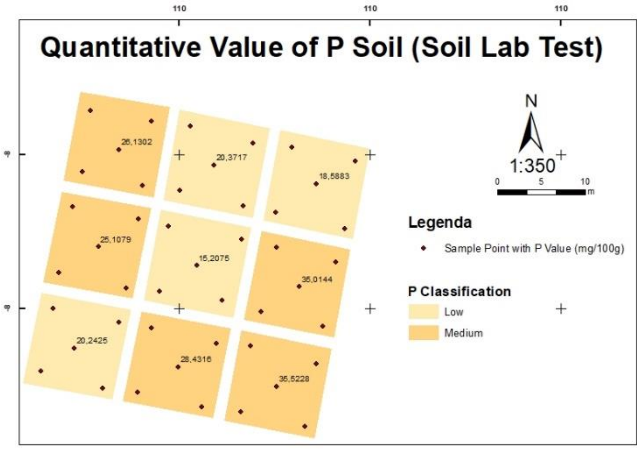

Fig. 7. Map of P Soil Status Distribution by Laboratory Tests on Field D

In field B (Fig. 8) the P soil status were all *high* using the PUTS field test, while the results using laboratory test (Fig. 9) showed 4 (four) grids with *medium* P soil status and 5 (five) grids with *high* P soil status. Laboratory soil test gave the exact value of the nutrient content which can be easily interpreted when classifying into the qualitative range, while field soil test using colorimetric method gave a wider range that sometimes was not easy to decide the status.

3.3 Map of K Soil Status Distribution

The results of mapping K soil status by field test (PUTS) and laboratory test on field D and field B are presented in Figures 10 to 13. Based on the maps of K soil status, both field D and field B did not show any variability, but the results using PUTS field test were different compared to the results using the laboratory test. The K soil status tested using PUTS was *medium* and K soil status with laboratory test was *low*. The color indicator for K value in the PUTS test had a slight difference between *low* and *medium* range which sometimes gave a wrong interpretation for the beginners.

3.4 Map Recommendation for Fertilizer Application

Due to the accuracy, the data of N, P and K soil status from the laboratory test were used as the input data. They were combined using matching methods with the fertilizer recommendations from Permadi and Haryati research [5], as shown in Table 2, to build the map of variable rate application for fertilizing the soybean. The results of the dosage recommendation applied to the field D and B were listed in Table 3 and the maps of variable rate application were shown in Figures 14 to 16 for field D and 17 to 19 for field B.

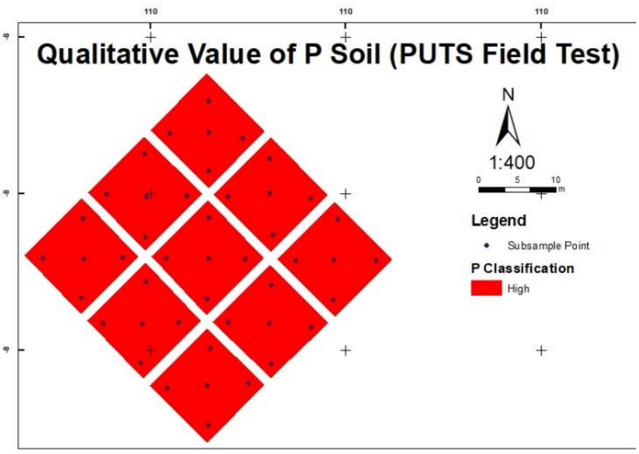

Fig. 8. Map of P Soil status Distribution by Field Test on Field B

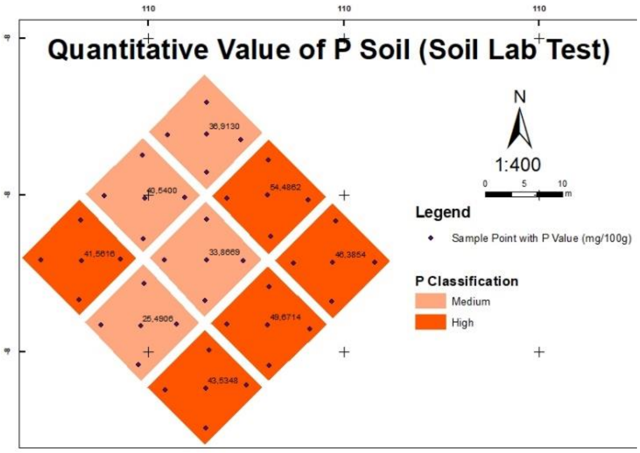

Fig. 9. Map of P Soil status Distribution by Laboratory Tests on Field B

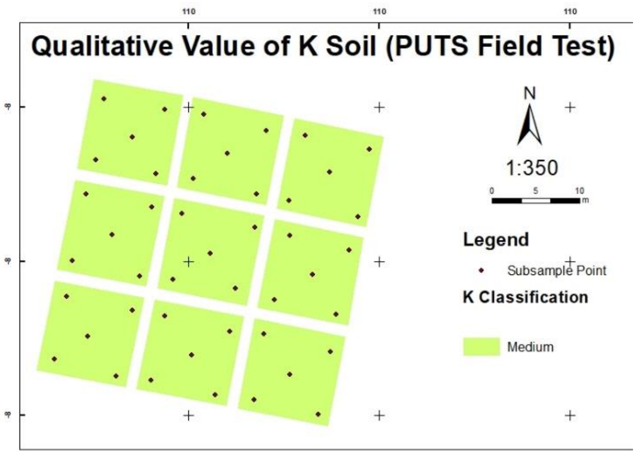

Fig. 10. Map of K Soil status Distribution by Field Test on Field D

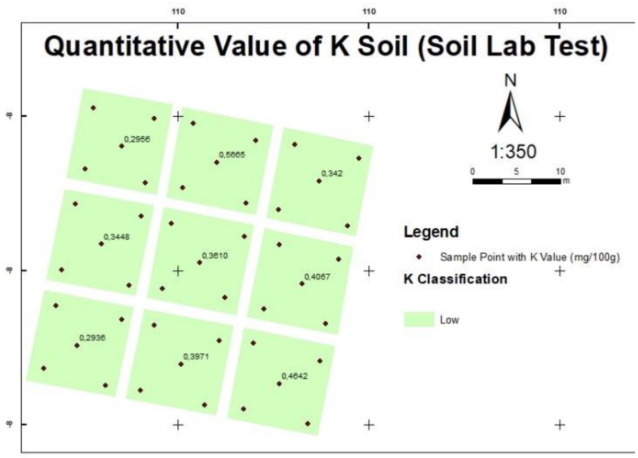

Fig. 11. Map of K Soil status Distribution by Laboratory Tests on Field D

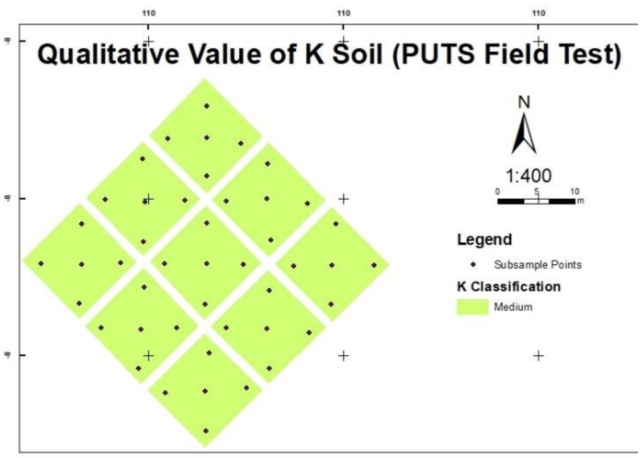

Fig. 12. Map of K Soil status Distribution by Field Test on Field B

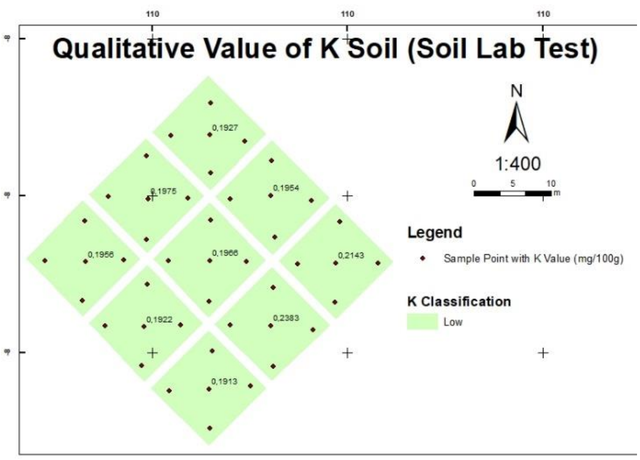

Fig. 13. Map of K Soil status Distribution by Laboratory Tests on Field B

Table 3
The Dosage Recommendation Fertilizer for Field B and D

Soil Nutrient	Class Category	Fertilizer Dose (Kg/100m.sq)	
		10 DAP	30 DAP
	LOW	0,1218	0,0522
N	MEDIUM	0,1064	0,0456
	HIGH	0,0819	0,0351
	LOW	0,104	0
P	MEDIUM	0,08	0
	HIGH	0,04	0
	LOW	0,147	0,063
K	MEDIUM	0,133	0,057
	HIGH	0,105	0,045

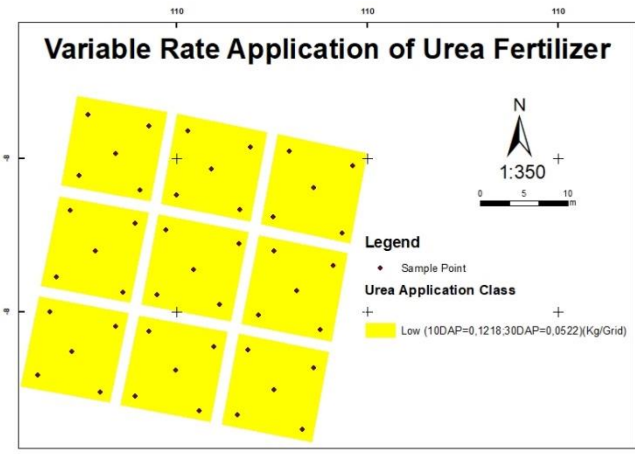

Fig. 14. Map Recommendation for Application Urea Fertilizer on Field D

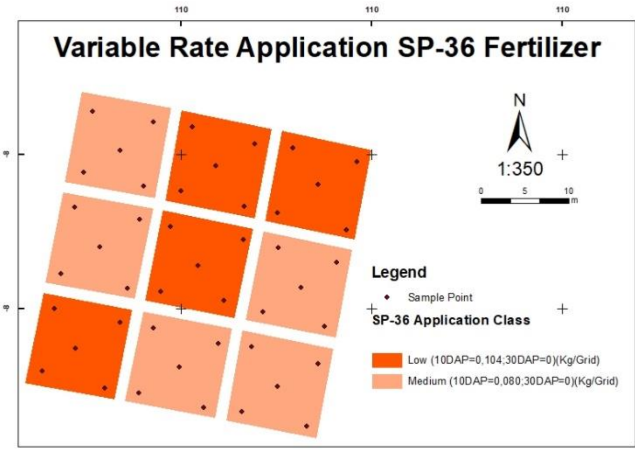

Fig. 15. Map Recommendation for Application SP-36 Fertilizer on Field D

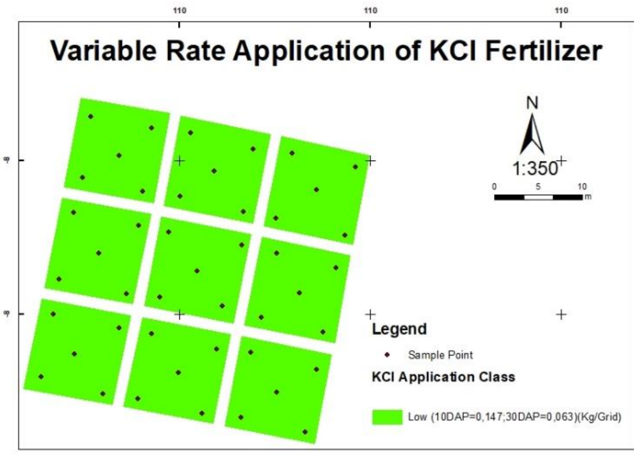

Fig. 16. Map Recommendation for Application KCl Fertilizer on Field D

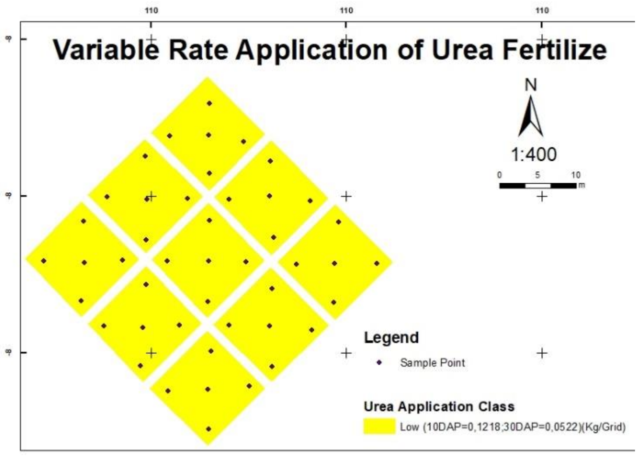

Fig. 17. Map Recommendation for Application Urea Fertilizer on Field B

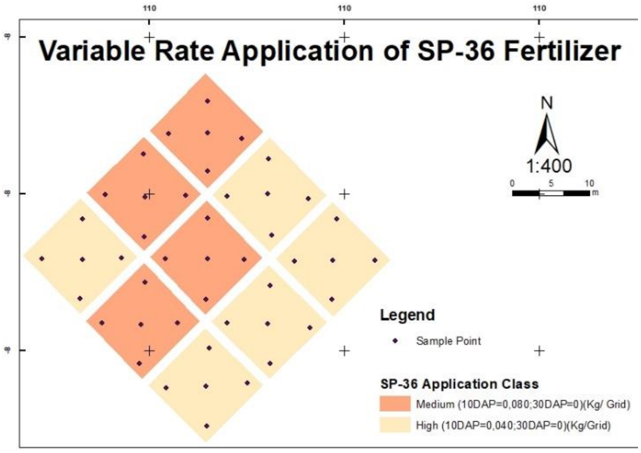

Fig. 18. Map Recommendation for Application SP-36 Fertilizer on Field B

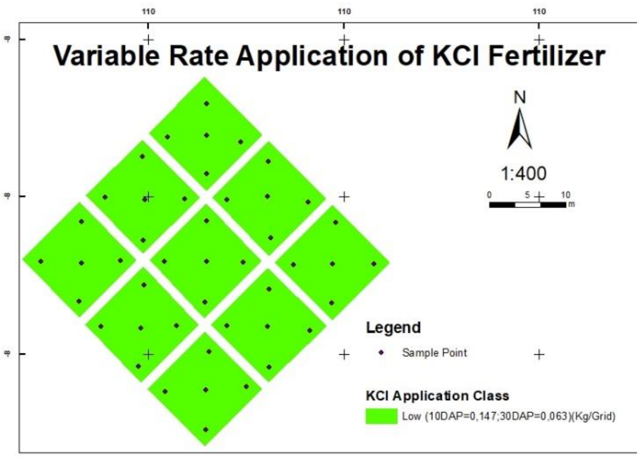

Fig. 19. Map Recommendation for Application KCl Fertilizer on Field B

4. Conclusion

The results of the recommendation application of urea fertilizer at field D were uniform at the amount of 0,1218 kg/ 100m.sq at 10 DAP and 0,0522 kg/ 100m.sq at 30 DAP. For the recommendation application of SP-36 fertilizer were varied in two groups, 4 (four) grids with low P content, should be applied with 0,104 kg/ 100m.sq at 10 DAP and none at 30 DAP and for other 5 (five) grids with medium P content, should be applied with 0,080 kg/ 100m.sq at 10 DAP and none at 30 DAP. Then, the recommendation application of KCl fertilizer on all grids was uniform at the amount of 0,147 kg/ 100m.sq at 10 DAP and 0,063 kg/ 100m.sq at 30 DAP.

At field B, the recommendation application of urea fertilizer in all grid was uniform at the amount of 0,1218 kg/ 100m.sq at 10 DAP and 0,0522 kg/ 100m.sq at 30 DAP. For SP-36 fertilizer in 4 (four) grids with medium P content, should be applied with 0,080 kg/ 100m.sq at 10 DAP and none at 30 DAP, and for other 5 (five) grids with medium P content, should be applied with 0,040 kg/ 100m.sq at 10 DAP and none at 30 DAP. Finally, the recommendation for KCl fertilizer on all grids was uniform at 0,147 kg/ 100m.sq at 10 DAP and 0,063 kg/ 100m.sq at 30 DAP.

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