IMPLEMENTATION OF FERTILIZER VARIABLE RATE TECHNOLOGY (VRT) OF RICE PRECISION FARMING IN FELCRA SEBERANG PERAK

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ABSTRACT

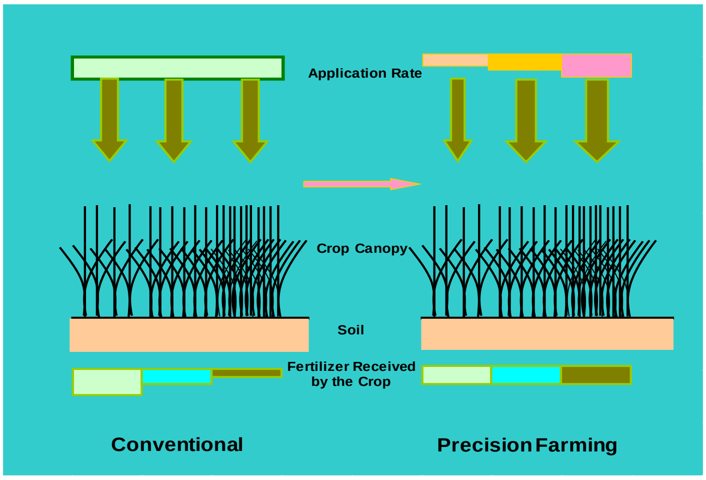
The management of variability is a very important aspect of precision farming in order to achieve optimum production costs and yields in rice production. It starts from the land preparation, seeding, crops care and maintenance until harvested by farmers. Each process has a unique requirement for managing existing field variability. The use of chemical inputs for the crop care process, such as fertilizer application in rice production, has become crucial activities that need more attention. At present, the conventional application of fertiliser is applied at a blanked rate without taking into account crop parameters that have spoiled the nutrient uptake of the crop. The right amount of fertilizer at the right time and at specific location will help farmers to save production costs and more environmentally friendly by reducing the use of fertilizer inputs. For this reason, MARDI has developed variable rate technology (VRT) for the use of fertilizer application as a solution for farmers. The technology is being implemented for three (3) seasons in FELCRA seberang perak. The study showed that the amount of input was reduced by 11.9 percent compared to the conventional fertilizer application by the adoption of VRT fertilizer. It also reduced the number of workers involved in the application of fertilizer by 50 percent, which was reflected in the reduction of the cost of production. It is also expected that this study will make a contribution to rice players and industry as a new agricultural technology to Industrial revolution (IR 4.0) that is currently being researched in Malaysia.

Key words: variable rate technology, fertilizer application, green area index, location specific

INTRODUCTION

The average national yield of rice in Malaysia is around 4.5 ton per hectare and the national level of self-sufficiency (SSL) is less than 75 percent. Efficient management of fertilizers is one of the key factors contributing to the high productivity of submerged rice growing systems. The awareness and interest in improving the efficiency of the use of nutrients has increased among the players in the agricultural sector and rice industry specifically. Driven by the environmental belief that crop nutrients are excessive in the environment and that farmers are concerned about rising fertilizer prices and stagnant crop prices, there is a new wave of pressure to improve the efficiency of nutrient use and technologies related for inputs applications. Precision farming has therefore come across as saviours in this situation by manipulating temporal and spatial variabilities. Variable rate fertilizers in precision farming is a nutrient management approach that considers the amount of fertilizer to be used on the basis of soil fertility, soil type, field level, puddling, water management, pests and diseases (Abu Hassan, 2004; Chan, 2013).

Figure 1. Different between variable rate fertilizer application and conventional fertlizer application



Variable rate fertilizers are applied to the right amount of fertilizer at the right time in the right place. A better synchronisation between crop demand and nutrient supply must be put in place at the right time. It is necessary to improve the efficiency of the use of nutrients, especially for N. Split applications of N during the growing season, rather than a single, large application prior to planting, are known to be effective in increasing the efficiency of N use. Crop growth stages information must be inplaced in order to understand crop growth variability.

Variable-rate fertilizer management practises through fertilizer manipulation by providing the correct amount of fertilizer sufficient to set the existing level of variability towards the recommended target rate. Most crops are location-specific and season-specific. It depends on a number of factors, such as cultivar, management practises and climate. It is critical that realistic yield targets are set and that nutrients are used to meet the target yield (Abu Hassan, 2001). Over or under application will result in reduced efficiency of use of nutrients or losses in yield and crop quality. Green Area Index (GAI) reference model has been developed by MARDI for these purposes. The implementation of this approach will reduce the amount of fertiliser used, improve crop quality, ensure environmental quality without compromising yield.

MATERIAL AND METHODS

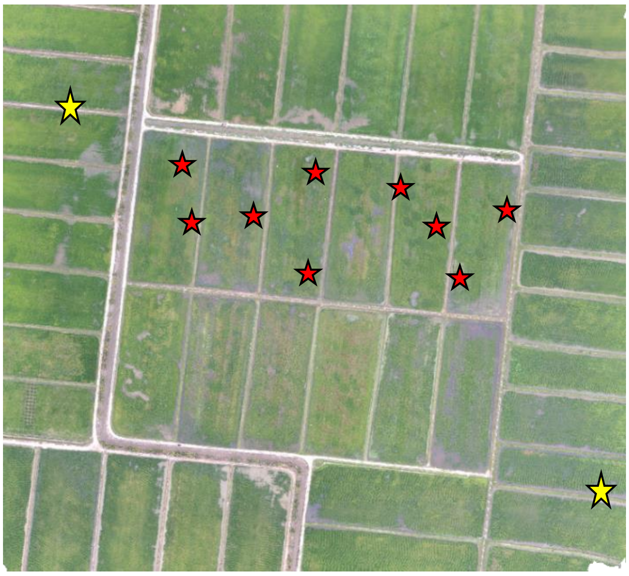
The variable rate fertilizer applicator and the global navigation satellite system (GNSS) have been used to adjust the fertilizer application rate using the treatment map generated. The field position determined by the GPS receiver and the treatment map content of the desired rate, the input concentration is changed as the applicator operates in the field. Treatment map generated on the basis of the green area index (GAI) reference model, ground through data sampling and the unmanned aerial vehicle (UAV) normalised vegetation difference index (NDVI) image sampling. All field data are required to determine the crop population, the size of the crop and the chlorophyll content to generate the SPAD map and the GAI map. Ground through data gathered in 9 sampling plots.

Figure 2. Data sampling (a) field data gathering (b) shoot size measuring (c) SPAD meter reading

(a) (b) (c)

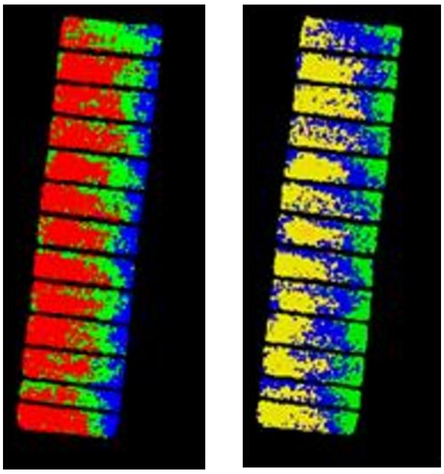
UAV with DJI Phantom 3 Professional Multirotor type is used to capture NDVI images. The Pix4D Capture apps is used for automatic UAV flight programming. The NDVI camera used is a UAV-mounted MAPIR Survey3 . Agisoft Photoscan is used for image mosaics while PCI Geomatica is used for image processing and analysis to established GAI maps and SPAD maps.

Figure 3. location reference for UAV image sampling



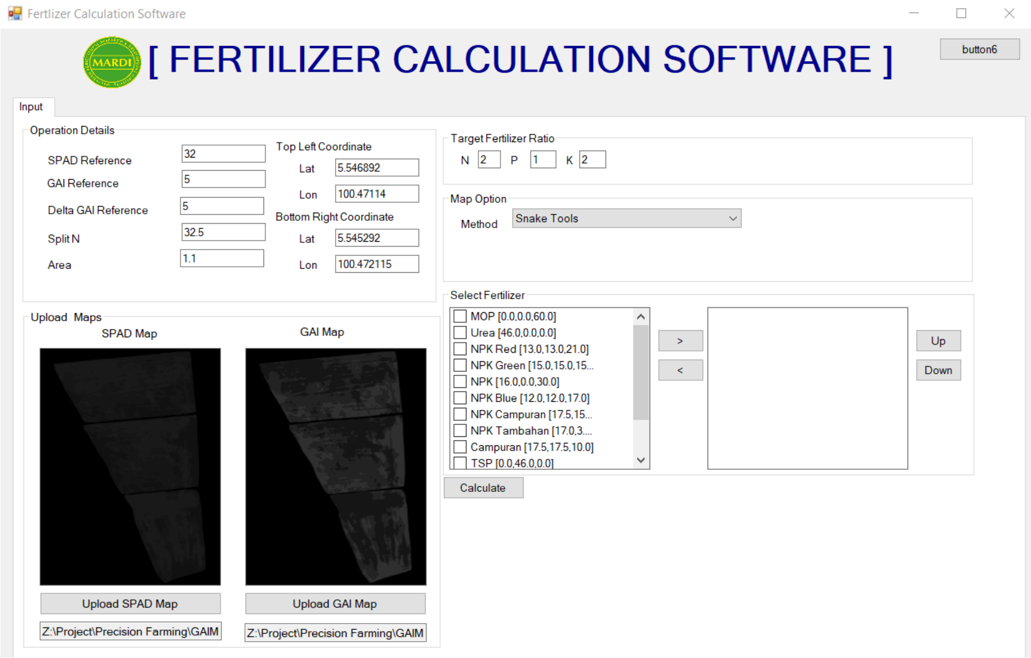
SPAD maps and GAI maps that have been generated are used in the fertilizer calculation software that has been developed to produce fertilization treatment maps that contain fertilization rate information according to specific locations. The type of fertilizer to be used is also set in the software to be selected when producing a fertilizer treatment map. The NPK ratio target should be set for the season.

Figure 4. Maps generated from data collected (a) SPAD map (b) GAI map



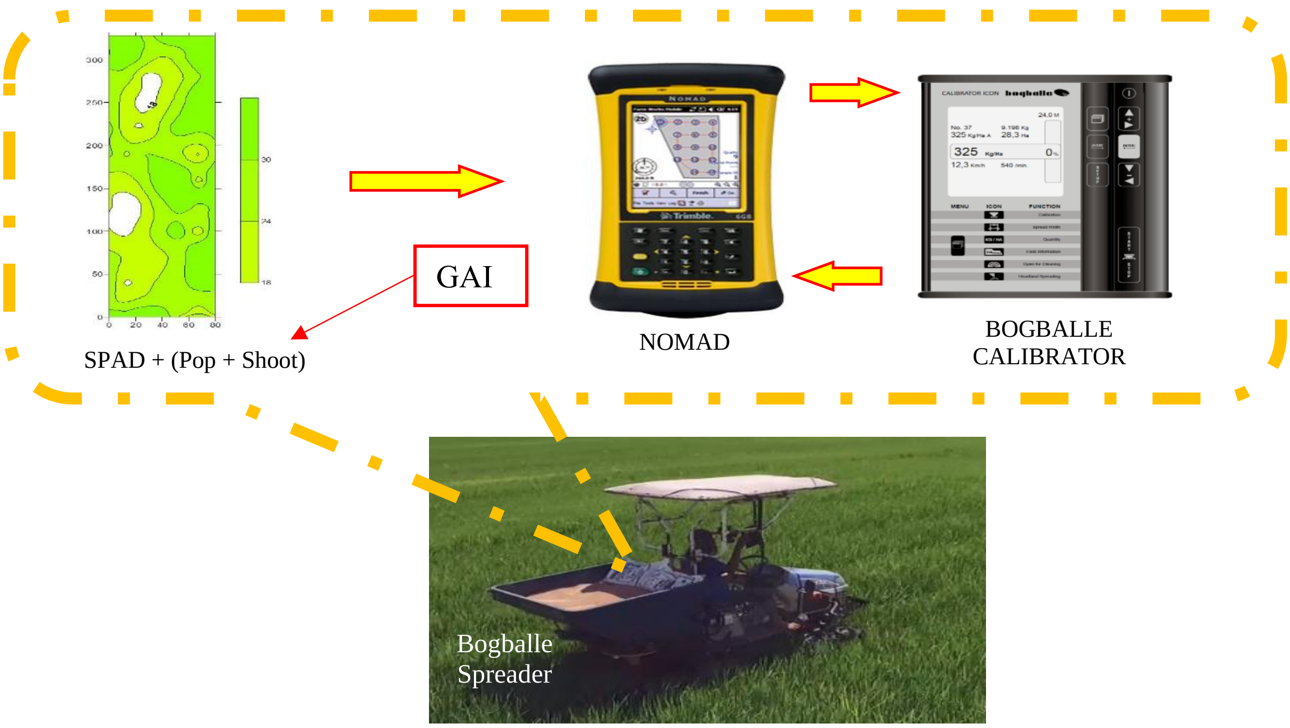
(a) (b)

Figure 5. fertilizer calculation software



The generated variable rate fertilizer treatment map will be uploaded to NOMAD which will communicate with fertilizer spreader system used (bogballe M3 spreader with calibrator) with light weight prime mover (ISEKI high clearance) to applied the fertilizer.

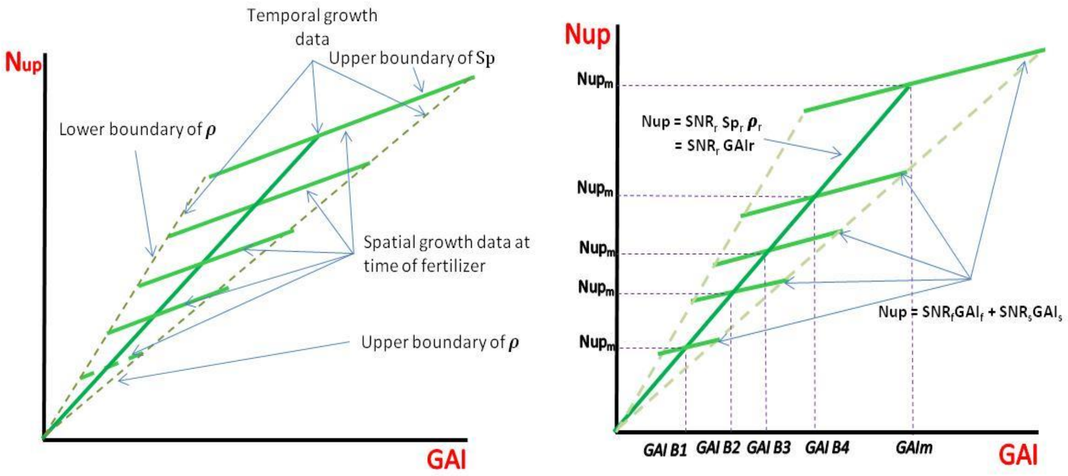
Figure 6. fertilizer applicator system with prime mover



RESULT AND DISCUSSION

The GAI reference model consists of two generic temporal (1) and spatial equations (2) that show a relationship between Nitrogen (Nup) fertilizer intake and green area index. The GAI model is formed by combining these two generic equations and is found to be suitable for use in fertilizer calculations for N fertilizer variables.

Figure 7. GAI model for reference crop



A simple approach to estimating the variable N is to normalise planted crop data with reference crop data. This normalization technique leads to the production of decision coefficients. By incorporating the coefficient of results into the temporal equation and subsequently simplified, the general formula for estimating N is formulated using a formula;

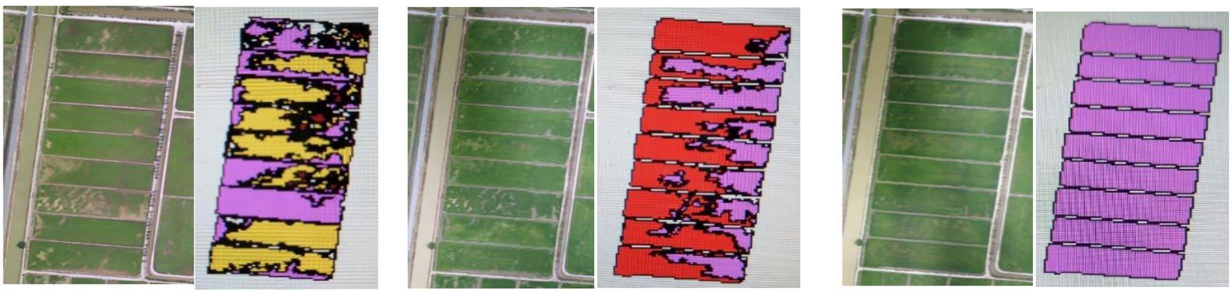
$$\Delta Nup_{fn-n+1} = (2 - \frac{\%N_{gn}}{\%N_{rn}})(\frac{GAI_{gn}}{GAI_{rn}})SNR_r(GAI_{rn+1} - GAI_{rn}) \qquad (1)$$

or

$$\Delta Nup_{fn-n+1} = \left(2 - \frac{\%N_{gn}}{\%N_{rn}}\right)\left(2 - \frac{Sp_{gn}}{Sp_{rn}}\right)\left(\frac{\rho_{gn}}{\rho_{rn}}\right)SNR_r(Sp_{rn+1} - Sp_{rn})(\rho_{rn+1} - \rho_{rn}) \qquad (2)$$

The SPAD meter was found to be accurate in estimating the N percentage in the canopy (Teoh, 2010; Teoh, 2012). This tool can be used to measure N percent and is used as an indicator for image processing and analysis of plant indices. GAI values were obtained manually from population and leaf size data. These parameters will be correlated with NDVI images. These images will be converted to SPAD maps and GAI maps. These maps were processed using fertilizer calculation software to calculate the amount of fertilizer, the rate of fertilizer use and to produce a treatment map

Figure 8. Variable rate fertilizer treatment map generated based on crop stages (a) 30 DAS (b) 45 DAS (c) 60 DAS



(a) (b) (c)

The treatment map generated shows that the crop conditions are more homogeneous towards 60 days after sowing (DAS) as the variability is manageable from 30 DAS and 45 DAS. The knapsack motor blower could be used as a low-cost variable rate fertilizer applicator based on the development of the treatment map. It also needs proper boundary marking when applying fertilizer with the help of a GPS backpack. However, the availability of a variable rate applicator mounted on a light weight high clearance prime mover has made the work much easier, as shown in Figure 9.

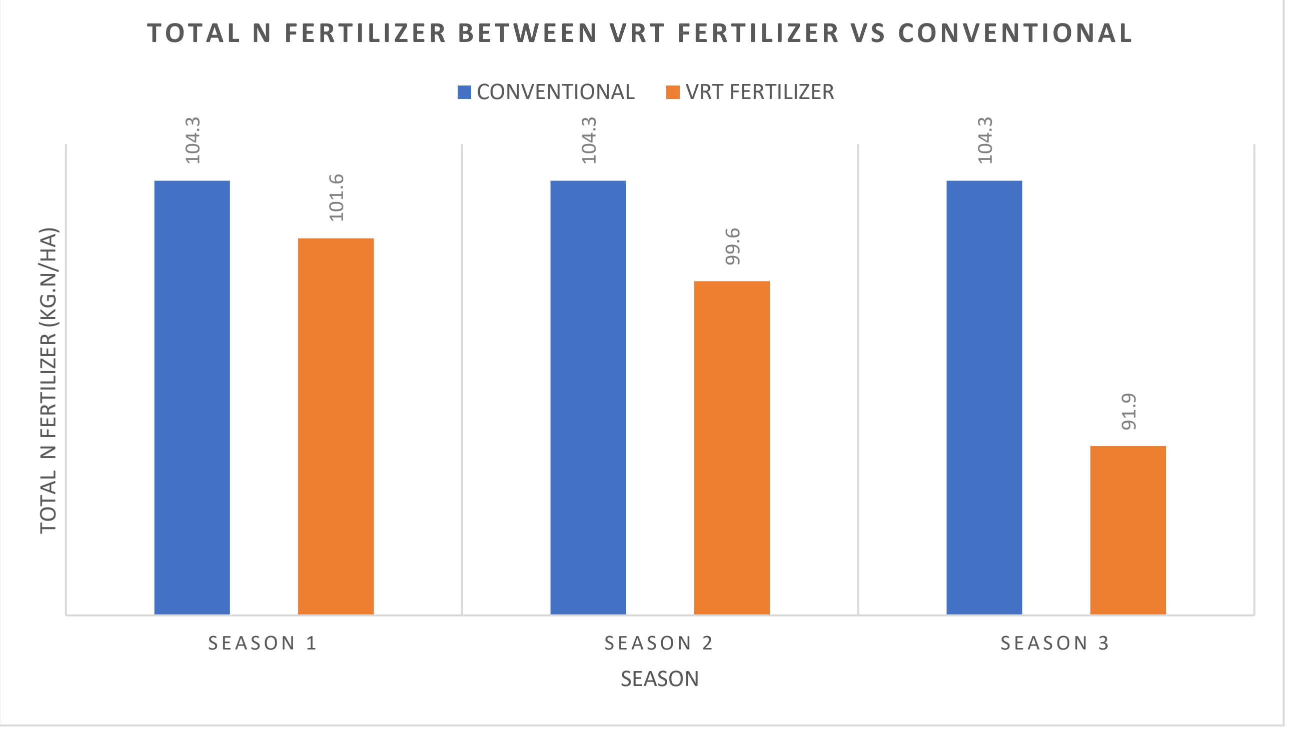
Figure 9: VRT application for fertilizer

Table 1. Comparison between variable rate vs conventional

Fertilizer Application	Variable rate	Conventional
Operation (ha/hr)	**2.73**	**1.5**
Field Variation (%)	**5 -10**	**22 - 30**
Capacity (kg)	**300 - 400**	**25**
Spreading distance (m)	**14 - 16**	**8 - 10**

The operation time for variable rate fertilizer application using bogballe spreader required about 20 to 30 minutes per hectare compared to knapsack motor blower due to big capacity of input tank and wide spreading distance. It also has less field variation due to operator fatigue. It achieved about 50 percent greater than conventional method.

Figure 10: Total N fertilizer between VRT fertilizer vs conventional



The total kg N of fertilizer has been reduced about 2.60 percent in season 1 compare to the conventional fertilizer rate application. The reduction continued almost double from season 1 in the next season at 4.50 percent. The total kg.N/ha has been cut to 11.90 percent in season 3.

Water quality index in paddy plot with variable rate imposed have a slightly higher compared with normal blanket rate plot due to lower amount of fertilizer used in variable rate plot. (Norlida et. al, 2019).

CONCLUSION

The results indicate that by using VRT fertilizer, the amount of fertilizer input in total kg. N per hectare was reduced by 11.9 percent compared to conventional fertilizer usage. Variability in the application of fertilizers can be managed as a result of a homogeneous rate on the 60DAS treatment map. It also reduced the number of workers involved in the fertilizer application activities by 50 percent compared to conventional method. This study is also expected that this study will continue in the near future with more exciting revolutionary technologies for different inputs and applicators that are more cost-effective for rice players and industry especially small farmers.

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