Paper No :

MSAE2018-AI005

Effect of Variable Rate Application Using Inorganic Liquid Fertilizer on Paddy Leaves Chlorosis

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ABSTRACT

Paddy plant shows numerous symptoms due to nutrients deficiency. Chlorosis and leaf burn on paddy plant tend to happen whenever spraying liquid fertilizer is not in the right measurement where chlorosis happened due to application of low fertilizer concentration rate while leaf burn was caused by over spraying of high fertilizer concentration rate. This study used variable rate application (VRA) with solely liquid fertilizer as only source of fertilizer to fertilized the paddy plant and used SPAD chlorophyll meter to measured nitrogen content for fertilizer calculation. The experiment performed in greenhouse and had four treatment rates (50% fixed rate, 100% fixed rate, 150% fixed rate and VRA) that arranged in RCBD design with four replications for each treatment rates. The results showed there was no any sign of leaf burn on the leaves however chlorotic condition was observed on the paddy leaves for all the treatment rates where VRA had the lowest chlorosis. Variable rate application of liquid fertilizer capable to diagnose nitrogen content of paddy leaves accurately and manage to reduce chlorosis symptoms on the leaves compared to uniform application.

KEYWORDS

Nutrients deficiency, Leaf burn, Paddy plant, Nitrogen content, SPAD chlorophyll meter.

Paper presented at the 2018 MSAE Conference, Serdang, Selangor D. E., Malaysia.
7 & 8 February 2018

INTRODUCTION

Chlorotic sign on the leaves plant could indicate the nutrient deficiency disorder due to low concentration rates of fertilizer used during fertilizer application. Meanwhile, leaf burn on the leaves observed after applying the liquid fertilizer as foliar application which could indicates the high dosage of concentration rates used and show inefficient liquid fertilizer application. Usually, numerous symptom was shown by the paddy plant whenever having nitrogen deficiency (Dobermann and Fairhust, 2000). One of the symptoms was chlorotic condition where the leaves become yellow-pale and yellow white. Chlorosis can be defining as a condition where the paddy leaves produces insufficient chlorophyll content since chlorophyll was responsible for the green colour of leaves therefore related to the leaf nitrogen content in the plant (Armstrong, 2002). If paddy plant has nitrogen deficiency, leaves will become light green and chlorotic at the tip especially for old leaves. While for young leaves, the leaves will become narrow, short, erect and yellowish. Paddy shows obvious symptoms when suffering from nitrogen and these symptoms are usually diagnosed by using visual morphological diagnoses in the field

However, visual morphological diagnoses require vast amounts of experience and most of the time practitioner use this method in the field that sometimes cause less accurate result (Lee and Lee, 2013). Fortunately, hand-held tool such as SPAD chlorophyll meter was created and has advantage to diagnose agricultural crop nutritional status especially chlorophyll content in the leaf which have close relationship with nitrogen content level in the plant ((Balasubramanian et al., 2000). Currently, SPAD chlorophyll meter widely used to detect nitrogen deficiency in paddy cultivation to improve nutrient-nitrogen based application by monitoring nitrogen content in the leaves and enhanced efficient of fertilizer management to more precise **(**Ghosh et al., 2013).

Therefore, SPAD chlorophyll meter can become a viable tool in this experiment to diagnose the nitrogen content in the leaf and later apply accurately the liquid fertilizer to the rice plant based on variable rate application (VRA) technique to fix the problem of leaf-chlorosis and leaf burn in the rice cultivation

MATERIAL AND METHOD

Site and soil

The experiment was conducted at Ladang 2, Universiti Putra Malaysia in greenhouse with coordinates 3.0087° N, 101.7037° E. MR219 paddy cultivar was planted in the pot for the experiment. Pots of 40 cm height and 34 cm diameter size filled with 10 kg of uniformly mixed soil were used. The experimental soil used was sandy loamy clay with pH 5.5, CEC 17 cmol kg^{-1} soil, 17.3 g organic C kg^{-1}, 1.60 g total N kg^{-1}, 6.3 mg available P kg^{-1}, and 85.6 mg K kg^{-1}.

Treatment and cultural operations

The experiment was laid out in a randomized complete block design (RCBD) with four treatment rates and four replications for each treatment rate. The treatment rates were uniform rate (50% fixed rate, 100% fixed rate, and 150% fixed rate) and variable rate application (VRA) by using SPAD chlorophyll meter to measure chlorophyll content of the leaf to calculate fertilizer amount. The experiment used an inorganic liquid fertilizer as solely fertilizer application without granular fertilizer application and were given according to; NPK liquid fertilizer (21:21:21) was used during early crop establishment (15 DAT) and mid-tillering (35 DAT), while NPK liquid fertilizer (15:15:15) was used during panicle initiation (55 DAT) & flowering (65 DAT). This experiment only took account of N content in the leaves to determine the liquid fertilizer concentration rate while other mineral elements were followed according to supplier recommendation. Single seedling sown per pot were performed for paddy seeds in the experiment after pre-germinated in nursery tray for 15 days. Water regime in the pot was setup according to conventional method with 3 cm maintaining water from the soil. Other control measures such as pest and disease control were performed accordingly to prevent experimental variability.

SPAD measurement

Chlorophyll meter (SPAD-502, Minolta Camera Co., Japan) was used in the experiment for taking the SPAD reading before and after liquid fertilizer application; at the early crop establishment (15 & 18 DAT), mid-tillering (35 & 38 DAT), panicle initiation (55 & 58 DAT) & flowering (65 & 68 DAT). Outermost and

ISBN 978-967-16145

fully expanded leaves of paddy plant were taken at the tip, midway and base of the leaf and then were averaged (Yuan et al., 2016)

N application formula

The N application formula was modified after Gholizadeh et al., 2011 to determine the amount of N liquid fertilizer for VRA treatment in the experiment. At early crop establishment (15 DAT) until mid-tillering (35 DAT), this formula was used to determine nitrogen content; (mg/L) = 0.80 + 0.93*SPAD. Then, at panicle initiation (55 DAT) and flowering (65) stages, this formula was used to determine nitrogen content; (mg/L) = -2.61 + 0.98 *SPAD. Overall formula to determine amount of liquid fertilizer (mL) needed for spraying was; (mL) = [A - (1 or 2 / 1000)] / C where: A is the threshold level of N in the paddy leaves in mg/mL while C is the N amount in percentage of the liquid fertilizer used.

Plant sampling

Sampling to measure the number of chlorosis and leaf burn on paddy leaves was conducted from 15 DAT until 95 DAT for all treatment rates. All the sampling was collected and recorded as parameter data to determine the effect of chlorosis and leaf burn on paddy leaves between VRA fertilizer application and uniform fertilizer application.

Statistical analysis

Data were subjected to analysis of variances by using Statistical Analysis System Software (SAS 9.1, SAS, USA) and differences between treatments means were compared by using Tukey's honest significant difference (HSD) test and Least Significance Difference (LSD) test at 0.05 probability level.

RESULTS AND DISCUSSION

SPAD reading pattern

Pattern of SPAD reading was varies with different treatment rates applied to the paddy plant as shown in Figure 1. The change of SPAD reading according to different DAT of liquid fertilizer application was as follows; the highest SPAD reading was observed during 68 DAT for treatment rates (100%, 150% and VRA) and VRA was the highest in SPAD reading compared to other treatment rate's SPAD reading. While low SPAD reading was observed during early stage of paddy planting where 150% was the lowest compared to other treatment rates. From the SPAD reading pattern of the entire treatment rates, VRA in Figure 1 shows steady increment from 15 DAT until 68 DAT without shows any decrease in SPAD reading and present sigmoid curve according to lifespan of paddy (Hu et al., 2014).

However, treatment rates of 50%, 100% and 150% show decrease in SPAD reading at 65 DAT before liquid fertilizer application was performed. The decrease in SPAD reading during between 58 DAT and 65 DAT indicate insufficient nitrogen content even though the reading was not below than 35 of SPAD reading. These was similar as reported by Islam et al., (2009) where the reduction in SPAD readings was observed below SPAD threshold level of 35 during period of 55 DAT until 68 DAT for different paddy cultivars with different nitrogen fertilizer application. While SPAD reading pattern for 50% treatment rate shows only increment in SPAD reading from 15 DAT until 55 DAT, however keep decrease in SPAD reading after spraying liquid fertilizer at 58 DAT until 68 DAT and this clearly indicates that treatment rate of 50% was unable to supply sufficient nutrients source especially nitrogen to develop sufficient chlorophyll content in plant which was important for efficient photosynthesis process in green leaves to produce better growth and yield (Amane Makino, 2011).

ISBN 978-967-16145

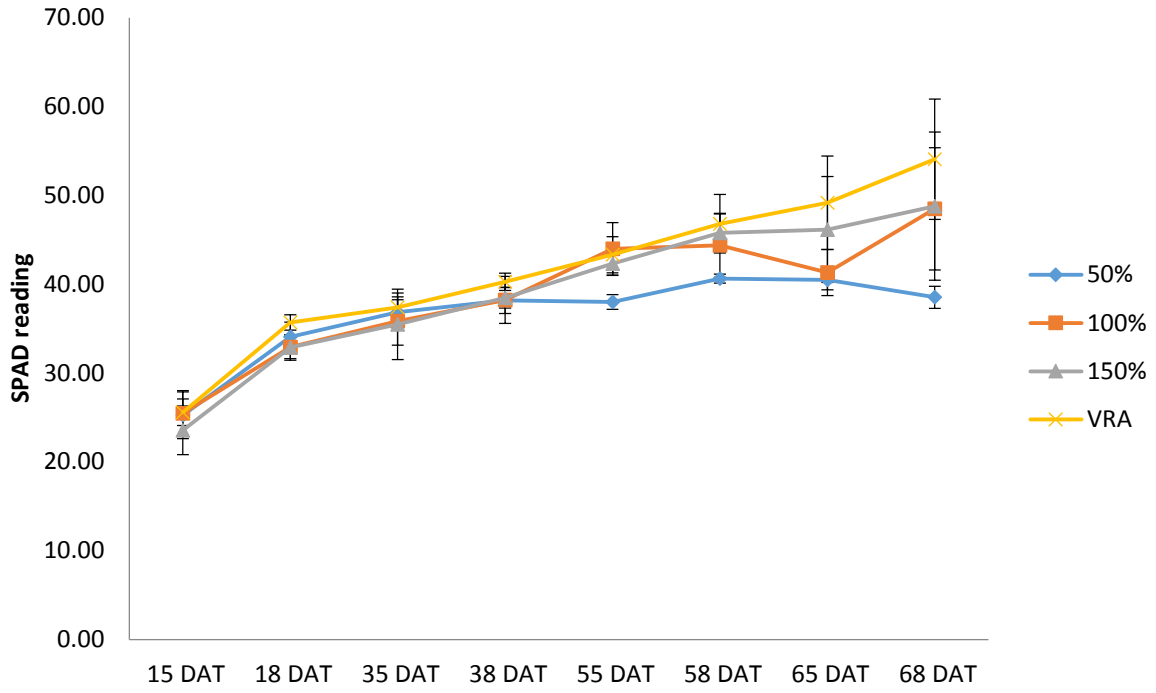

Figure 1: SPAD reading of paddy leaf received different fertilizer treatment rates during four split time of liquid fertilizer application.

Chlorosis effect on paddy leaves

In the experiment, chlorosis which was the discoloration on the leaves was determined based on changing colour from green to yellowing whether on certain leaf regions or complete region of leaf which usually exhibit earlier at older leaves compared to new leaves since nitrogen was a mobile type of nutrient deficiency (Fageria et al., 2009). Leaf chlorosis was the sign of reduction in photosynthesis process in the plant due less function of chlorophyll to reflect green light to produce green colouration thus direct reflect to less nitrogen content in leaf (Mona et al., 2012). The number of chlorosis was count on every 4 stages after liquid fertilizer application from early stage (15 DAT) until flowering stage (65 DAT). All the treatment rates and type of fertilizer application show chlorosis symptom on paddy leaves in the experiment.In the early stages (15 DAT) and during mid-tillering (35 DAT,) visible leaf chlorosis was begun to exhibit by all the treatment rates and was early sign of the nitrogen deficiency symptom in the plant. During 35 DAT until 95 DAT, VRA has the lowest chlorosis count compared to other treatment rates.

The increment in chlorosis count on the paddy leaves from 35 DAT until 75 DAT was usually happened because nitrogen demand during period of tillering and panicle initiation was critical and need in large amount for plant growth development and production of flower (Fageria and Santos, 2015). The highest amount of chlorosis count during 65 DAT was observed at paddy plant that received fertilizer through uniform application; 50% and 100% treatments rate while the lowest amount of chlorosis count during 65 DAT was observed at paddy plant that received fertilizer by using VRA application. The reason why high chlorosis count was observed for both 50% and 100% treatment rates during 65 DAT because there was reduction in SPAD readings for both treatment rates as shown in Figure 1. This can be speculated there was reduction in plant leaves chlorophyll contents and reduction of chloroplast number in leaf which responsible for leaf greenness due to nitrogen deficiency during 65 DAT (Huang et al., 2004). As shown in the Table 1 and Figure 1, it was clearly stated that uniform application of liquid fertilizer in the experiment unable to provide enough nutrients for the plant growth during active growth (35 DAT), panicle initiation (55 DAT) and flowering stages (65 DAT) until at the end of harvesting stages (95 DAT) due high accumulation of chlorosis count. Meanwhile, paddy plant that received liquid fertilizer by using VRA method show less chlorosis count from 35 DAT until 95 DAT because paddy plant received sufficient nutrients sources from fertilizer rate that went through adjustment based on actual needed by the plant from leaves measurement of SPAD chlorophyll meter. This shows that VRA liquid fertilizer application by

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using SPAD chlorophyll meter capable to predict accurate nitrogen needed by paddy plant for stable development of plant growth with less deficiency symptoms to the paddy plant 's health.

Table 1: Comparison of chlorosis on plant leaves between treatment rates and different types of fertilizer application on various DAT

Treatments	15 DAT	35 DAT	55 DAT	65 DAT	75 DAT	85 DAT	95 DAT
50%	1.00a	2.00a	3.75a	5.00a	5.75a	6.25a	6.75a
100%	1.00a	1.50ab	3.50ab	4.75a	5.25a	6.00a	6.50a
150%	1.00a	1.25ab	3.50ab	4.50a	5.00a	5.25a	5.75ab
VRA	0.00b	0.25b	1.25b	2.75b	3.00b	4.00b	4.50b
Type of fertilizer Application							
Uniform	1.00a	1.58a	3.58a	4.75a	5.33a	5.83a	6.33a
VRA	0.00b	0.25a	1.25b	2.75b	3.00a	4.00b	4.50b

* means separation in each column followed by the same letter are not significantly different at p = 0.05.

CONCLUSION

The experiment shows application of variable rate - liquid fertilizer by using SPAD chlorophyll meter capable to diagnose nitrogen content in the leaf and provided accurate nitrogen needed by paddy plant for liquid fertilizer application. Liquid fertilizer application show no any burn on the leaves for every treatment rates however required more frequent of liquid fertilizer spraying to reduce leaves chlorosis and nutrient deficiency symptoms to improve paddy plant 's health for better growth and yield production.

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ISBN 978-967-16145