Reducing Fertilizer Application and Rice Growth and Yield Mapping by Variable Rate Treatment in Paddy Fields

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Abstract

Precision agriculture is a developing technique that can modify the current agricultural production system dramatically. Variable rate fertilization by applying the optimum amount of fertilizer can reduce fertilizer use and environmental pollution. The rice cultivar for this experiment was *Oryza sativa* L. cv. Haepyeongbyeo. Three paddy fields were divided into control and variable rate treatment (VRT) plots and grid sampling was conducted with each of thirty 10m?10m cells. The amount of basal fertilizer, and topdressing at tillering stage, in each cell was based on soil chemical analysis, and the amount of topdressing at panicle initiation stage in each cell based on plant leaf area index and chlorophyll meter value. There was no yield decrease by reduced fertilizer, and variation of yield was decreased by the effect of variable rate fertilization. According to experimental results, variable rate fertilization of paddy rice was effective at reducing fertilizer without yield decrease. It also decreased variations in growth and yield.

Media summary

Reducing nitrogen fertilizer by variable rate treatment and confirming effect to rice growth and yield in Korean rice paddy fields.

Key Words

Rice, precision agriculture, variable rate fertilization, N fertilizer,?yield mapping

Introduction

Precision agriculture is a developing and contemporary technique of the world. The variable rate fertilization technique is a part of precision agriculture and can reduce amount of fertilizer use and environmental pollution and improve rice grain quality. Fertilizer recommendations are decided by soil chemical properties and plant growth, and optimum amount of fertilizer is spread into each field. This study was conducted to investigate the effect of reduced fertilizer through variable rate application on growth and yield of paddy rice.

Methods

The plant variety was Oryza sativa L. cv. Haepyeongbyeo. We used three fields, and divided each field into control and variable rate treatment (VRT) plots. In each plot, grid sampling was conducted with each of thirty 10m?10m cells. Control plots were managed by farmer's traditional practice. For the Variable Rate Treatment the amount of basal fertilizer, and topdressing at tillering stage, in each cell was based on "Recommendations of fertilizers for crops based on soil testing (Lee, 1998)".

$N(kg/10a) = 12.74 - (1.52 ? OM(\%)) + (0.028 ? SiO_2(mg\ kg^{-1}))$
$P_2O_5(kg/10a) = (100 - P_2O_5(mg\ kg^{-1})) ? 0.1$
$K_2O(kg/10a) = (0.03 ? 10 - K_2O(cmol\ kg^{-1})) ? 47.1$

The amount of topdressing at panicle initiation stage in each cell based on plant leaf area index (LAI) and chlorophyll meter value. We collected soil infiltration water for environmental analysis and sampled rice grain for grain quality analysis.

Results

Field 1

We could reduce fertilizer N-P-K=7.1-100-64.8% at VRT plot than control, and growth characteristics of control and VRT plot were similar. Yield was 4.3% higher than control in VRT plot, and variations of growth and yield were similar in each plot. There was no yield decrease by reduced fertilizer, but there was experimental error by lodging, and variation of yield didn't decrease.

Field 2

We could reduce fertilizer N-P-K=23.6-100-47.5% at VRT plot than control, and growth characteristics of control were better than VRT plot. Yield of VRT plot was 2% lower than control, but was not significant difference. Variations of plant height and chlorophyll meter value of VRT plot were lower than control, and variations of other growth characteristics and yield were similar. There was a little yield decrease by reduced fertilizer, and variation of chlorophyll meter value was decreased by the effect of variable rate fertilization.

Field 3

We could reduce fertilizer N-P-K=32.2-100-53.6% at VRT plot than control, and the most of growth characteristics of control were higher than VRT plot, but chlorophyll meter value was lower. Yield was 0.5% higher than control in VRT plot than was no significant difference. Variations of growth characteristics and yield of control and VRT plot were similar, and variation of yield in VRT plot was very low. There was no yield decrease by reduced fertilizer, and variation of yield was decreased by the effect of variable rate fertilization.

Nitrate contents of soil water and rice quality

There was not much difference in nitrate contents of soil infiltrated water between control and VRT plot. Quality of rice grain was measured by protein, fatty acid and amylose contents of brown rice grain. And quality of rice grain in VRT plot was improved as compared to control by low amount of nitrogen fertilizer application.

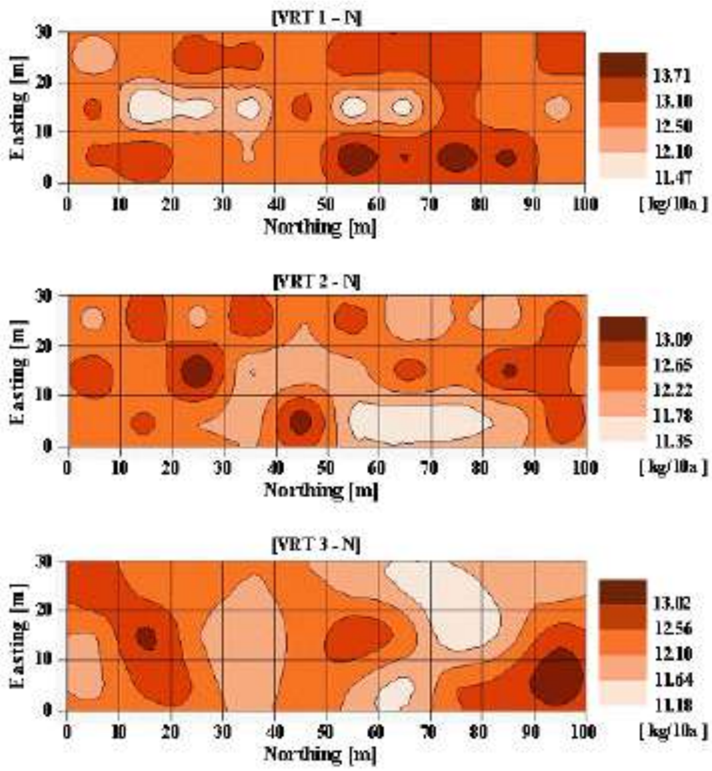

Figure 1. Maps of nitrogen fertilizer recommendation based on soil chemical analysis.

Table 1. Statistical parameters of growth characteristics and yield in field 3

?	Plant Height		Tiller No.		Dry Weight		CM*		LAI*		YIELD	
	Control	VRT	Control	VRT	Control	VRT	Control	VRT	Control	VRT	Control	VRT
Min.	86.33	77.33	18.67	15.33	30.50	29.30	120.3	188.6	3.81	2.75	651.8	657.2
Max.	104.7	90.00	26.33	24.00	42.35	46.22	237.6	293.1	6.30	5.40	789.6	766.9
Avg.	90.88	85.00	22.17	20.46	36.90	34.79	198.8	238.1	5.30	4.54	708.1	711.5
SD*	3.64	3.10	2.01	2.03	3.24	3.45	25.90	25.89	0.61	0.59	27.82	29.40
CV*	4.01	3.65	9.06	9.92	8.79	9.93	13.03	10.87	11.50	13.11	3.93	4.13

* CM: Chlorophyll meter value?? LAI: Leaf area index
? SD: Standard deviation?? CV: Coefficient of variation

Table 2. Correlation coefficients between growth characteristics in VRT 3

?	PH	Tiller No.	DW	CM	LAI	Fertilizer	LAI?CM	Yield
PH	1.000?	?	?	?	?	?	?	?
Tiller No.	0.473**	1.000?	?	?	?	?	?	?
DW	0.467**	0.679**	1.000?	?	?	?	?	?
CM	-0.018?	-0.188?	-0.143?	1.000?	?	?	?	?
LAI	0.572**	0.589**	0.508**?	-0.070?	1.000?	?	?	?
Fertilizer	-0.316?	-0.176?	-0.125?	-0.016?	-0.357?	1.000?	?	?
LAI?CM	0.445*	0.345	0.305?	0.597**?	0.754**?	-0.305?	1.000?	?
Yield	0.625**	0.576**?	0.491**	0.151?	0.508**	-0.067?	0.488**?	1.000?

* PH : Plant height?? DW : Dry weight?? CM : Chlorophyll meter value

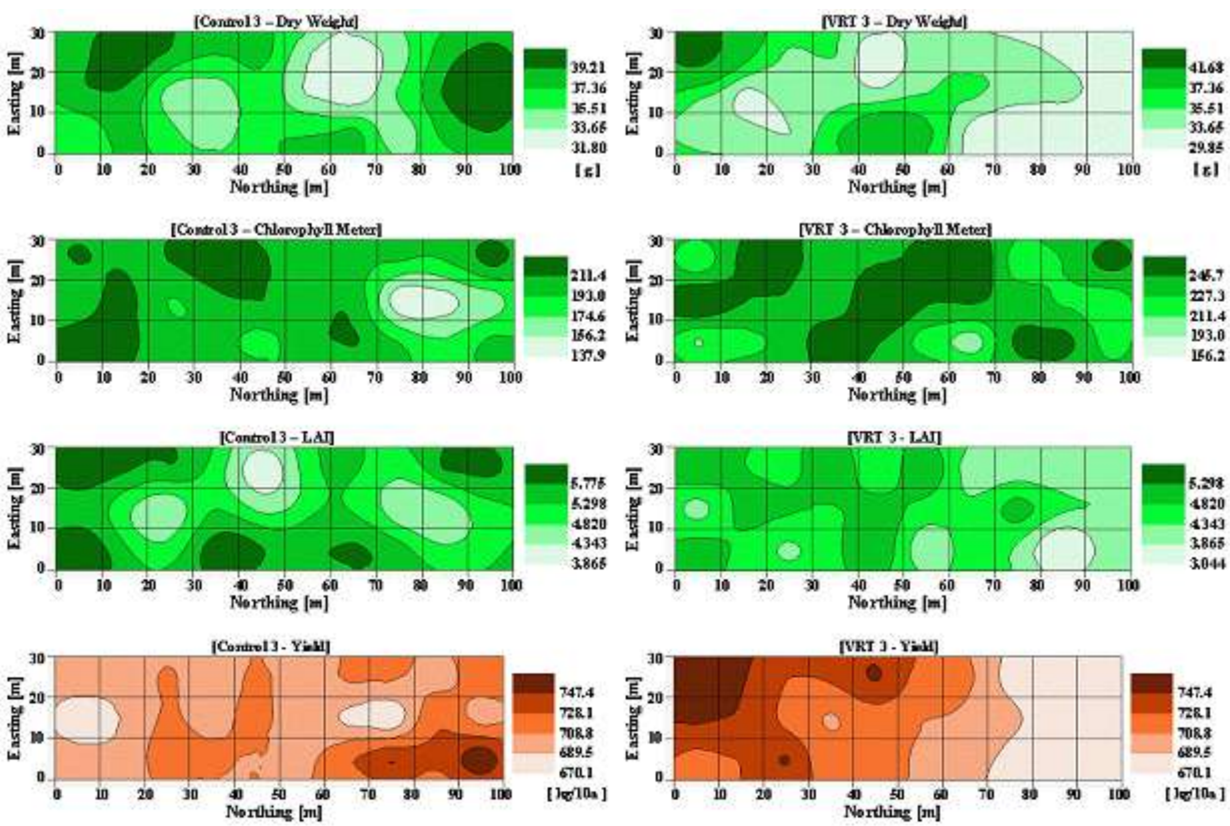

Figure 2. Maps of growth characteristics and yield of control and VRT plot in field 3.

Table 3. Protein, amylose and fatty acid contents of rice grain

Component	Contents (%)					
	Field 1		Field 2		Field 3	
	Control	VRT	Control	VRT	Control	VRT
Protein	8.95* 8.6-9.3**	8.392 8.6-9.2	8.45 8.4-8.6	8.71 8.6-8.8	6.87 5.65-8.7	6.47 5.6-6.8
Amylose	20.07 20.0-20.1	19.77 19.7-19.8	19.51 19.4-19.6	19.26 19.2-19.3	20.79 19.7-22.3	20.30 20.0-20.9
Fatty acid	20.3 20.1-20.5	19.62 19.1-20.0	18.55 18.0-18.9	17.71 17.3-18.1	22.29 19.9-27.6	20.87 19.9-23.1

* : mean??? ** : range

Conclusion

According to result, variable rate fertilization of paddy rice was effective on reducing fertilizer without yield decrease and decreasing variations of growth and yield. And quality of rice grain in VRT plot was improved as compared to control by low amount of nitrogen fertilizer application.

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