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Interpreting Within-Field Spatial Variability of Rice Yield Using Soil Chemical Properties

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Objectives

To obtain the basic information for site-specific soil management to improve nutrient use efficiency of rice plant in Korea, the spatial variability of grain yield in relation to soil properties should be evaluated. This research therefore was carried out to quantify thecausal factors of yield spatial variability within-field level under a direct-seeded and transplanted rice culture in Korea.

Materials and Methods

The two paddy fields (designated as field A and field B) were used for this research. These fields are located in experimental farm of National Institute of Crop Science, RDA (37016'N). Each field was almost flat (0.07%) and field size was 60m110m and divided into 66 plots with 10m 10m for each plot. The experiment was carried out in the year of 2002 and 2003 under different cultivation methods and fertilizer application. Soil samples in each plot from the surface soil (0 to 15 cm) were collected for the analysis of soil chemical properties. Grain yield for each plot was also measured near by the soil sampling point of each plot. Several statistic procedures were used to relate the relationship between soil factors and rice yield using two years experiment data. Application of Boundary line and the Liebig' Law were applied to interpret within-field spatial variability of grain yield during the experiment implementation.

Result and Discussion

1. Descriptive statistics analysis: The coefficient of variation (CV) for rice yields and soilvariables was shown in Table 1. CV for rice yield was 12.8%. CV for soil variables varied from 2.1% for pH to 19.6% for EC.

Table 1. Descriptive statistics for soil chemical properties and grain yield (n=197).

Variable	Mean	Std Dev	Minimum	Maximum	C.V (%)
Yield (kg/ha-1)	5680	73.0	3300	7580	12.8
CEC (cmol+/kg)	9.44	1.02	7.65	10.4	12.8
Clay (%)	27.9	2.14	22.0	32.2	7.6
Total N (%)	0.120	0.010	0.097	0.148	8.3
Organic matter (%)	21.2	1.603	16.2	25.1	8.56
Available P (mg/kg)	84.6	9.92	66.4	108.4	11.7
Available Si (mg/kg)	103	17.9	72.6	165.4	17.3
EC (dS/cm)	0.326	0.064	0.200	0.590	19.6
PH	5.72	0.123	5.39	6.120	2.1
Mg (cmol+/kg)	0.807	0.079	0.605	0.997	9.7
Ca (cmol+/kg)	3.681	0.380	2.792	4.471	10.3
Na (cmol+/kg)	0.731	0.088	0.579	1.070	12.0

2. Correlation analysis and stepwise regression procedure: Correlation analysis showed several soil variables that have significant correlations with grain yield. However, the largest correlation was obtained for CEC

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(r=0.61). Stepwise regression procedure with forward selection was carried out to identify the soil variables with the most significant influences on grain yield. Selected soil variables: Yield=-357+56CEC+ 4.08Clay+13.5OM+0.84SiO2-120.2Mg *r2adj*= 0.55 (1), this could explain about 55% of spatial variation of grain yield.

*3. **Application of Boundary line analysis and the Law of the Minimum:*** Boundary line analysis was carried out for grain yields response to soil variables. This bounrary line was fomulated from equation: Y= .{1-.exp(.X) (2). Where Y is yield, X indicated a parameter such as: soil variable, , and are constant. If we exclude from the equation (2), Y value ranges from 0 to 1 and can be used as indices expressing the degree of influences on grain yield. Finally, the index formula obtained from equation (2) that describe the grain yield response to the variation in the test parameter, where the other factors are close to non-limiting level in terms of grain yield (Table 2).

Table 2. Boundary line formulas for the grain yield response to soil variables.

Parameter	Boundary line formula	Index formula	R2
CEC (cmol+/kg)	*f*(CEC)=893*[(1-32.9*EXP(-0.5326*CEC)]	ICEC=1-32.9*EXP(-0.5326*CEC)	0.997
Clay (%)	*f*(Sand)=893*[1-15.4*EXP(-0.162*Clay)]	IClay=1-15.4*EXP(-0.162*Clay)	0.981
Total N (%)	*f*(TN)=893*[1-11.2*EXP(-33.7*TN)]	ITN=1-11.2*EXP(-33.7*TN)	0.949
Organic matter (g/kg)	*f*(OM)=893*[1-3.31*EXP(-0.129*OM)]	IOM=1-3.31*EXP(-0.129*OM)	0.995
Available Si (mg/kg)	*f*(Si)=893*[1-2.65*EXP(-0.025*Si)]	ISi=1-2.65*EXP(-0.025*Si)	0.978
Mg (cmol+/kg)	*f*(Mg)=893*[1-1.89*EXP(-2.75*Mg)]	IMg=1-1.89*EXP(-2.75*Mg)	0.978
Ca (cmol+/kg)	*f*(Ca)=893*[1-2.52*EXP(-0.699*Ca)]	ICa=1-2.52*EXP(-0.699*Ca)	0.986
Available P (mg/kg)	*f*(P)=893*[1-4.52*EXP(-0.038*P)]	IP=1-4.52*EXP(-0.038*P)	0.995

The limitting factor that has the lowest index value was selected for each plot (Fig. 1), and regressed to the respective grain yield. That is Y= *a* min[*IOM*, *I*A.P, *I*TN,*I*CEC].

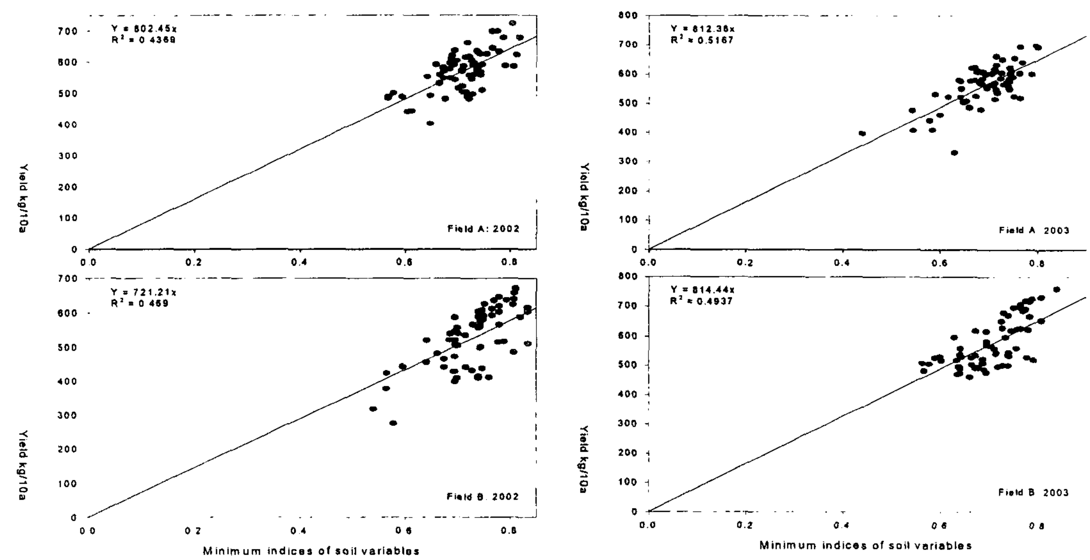

Fig. 1. Relationships between grain yield and minimum indices of soil variables at field A and field B

Conclusion

The results of this research indicated that CEC, clay, organic matter and available Si are considered as the most important soil variables, which have significantly influenced spatial variability ofrice yield. Stepwise regression analysis showed that the selected soil variables caused about 55% of spatial variability of rice yield. Application of boundary line and the Law of Minimum of the limiting factors could interpret average of about 48% of within-field spatial yield variability caused by soil factors.