FIELD MAPPING FOR PADDY RICE

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ABSTRACT

Soil chemical properties, relief of field surface, SPAD values and grain yield were investigated in a 0.5ha paddy field in 1999 to obtain basic field information for precision agriculture. Descriptive statistics of field information showed that the coefficient of variation ranged from 1.63% to 38.7%. Field information showed a high spatial dependence for within paddy field. The ranges of spatial dependence were from 15m to 60m, respectively. Kriged maps enable the visualization and comparison the spatial variability of field information. The causes of spatial variability of the field information could be explained rationally by a field management map. Grain yield was negatively correlated with pH, relief values, whereas, was positively correlated with total C, total N, C/N ratio, mineralizable N, available P and exchangeable K, Ca at the significant level of 1%.

Keywords : soil map, relief map, SPAD map, yield map, field management map, field information map, precision agriculture

INTRODUCTION

Precision agriculture for paddy field is expected to increase the yield/quality of crop, reduce the environmental impacts and increase the financial profit through site-specific-soil/fertilizer management within field. Against this background, Lee C-K. et al. (1999, 2000) and Yanai et al. (2000) reported the spatial dependence of a paddy field information, i. e. grain yield, straw yield and soil chemical properties using geostatistical method. Lee M-Z et al. (1999) also reported the spatial dependence of a small size paddy field and upland selected soil properties, i. e. pH, EC and NO_3-N^- using geostatistical method. But these papers were not sufficient for the comprehensive comparison of field information. The objectives of this study were ; 1) To evaluate variation of field information, such as soil chemical properties, relief values, SPAD values and grain yield using a descriptive

statistics. 2) To estimate their spatial dependence using geostatistics and map their information by kriging method. 3) To map field management information in order to interpret causes of spatial variability of them. 4) To estimate a mutual relationship among them.

MATERIALS AND METHODS

Experimental field

The experiment was carried out in an experimental farm of Kyoto University located in Takatsuki, Osaka prefecture. In this research, test plant was *Oryza sativa* L., cv. MINAMI-HIKARI, a high-yield variety. The experimental field was divided into 100 plots as 10m× 5m.

Sampling and analyses of soil

Soil sampling was carried out on May 10, 1999, before transplanting of seedlings, for the investigation of the spatial variability of soil chemical properties. Chemical properties of the soil samples (100) were analyzed 12 items, such as pH, electrical conductivity (EC), total C, total N, C/N ratio, mineralizable N, inorganic N, available P, exchangeable Ca, Mg, K, Na.

Measurement of relief value

Relief value of field surface was investigated on November 4, 1999, after harvest using a measuring tape and an optical type surveying instrument (Sokkia Co. SET4100s). Relief value was collected 1 point as a representative value of one plot and measured total 100 points in the field.

Measurement of SPAD value

SPAD value was taken 5 times by SPAD meter (MINOLTA SPAD-502) during the growing period of paddy rice, i. e. between July 12 and October 21. It was used as the growth index for paddy rice. SPAD value was measured total 15 points at each plot. The average value was considered as a representative value of one plot.

Investigation of grain yield

Grain yield was investigated between October 29 and November 3 in 1999. The grain yield was collected by a 4-row head-feeding combine harvester (YAMMAR Co. Ee-8) for each plot. The grain mass was measured by a load cell (KYOWA Co. LT-50KF) and also moisture content was measured by a single kernel moisture tester (SHIZUOKASEIKI Co. CTR-800E).

RESULTS AND DISCUSSION

Spatial dependence and kriged maps of soil chemical properties

Table 1 indicates the results of the descriptive statistics, i. e. the minimum, maximum, average and coefficient of variation(CV) of the 100 data for each of the 12 chemical properties. The CVs for EC, total C, total N, mineralizable N, inorganic N, available P, exchangeable Mg, K and Na exceeded 10%, indicating considerable within field variability even in the paddy field. Figure 1(left) shows the semivariograms for soil chemical properties.

Table 1 Descriptive statistics of soil chemical properties and relief value

Properties	Minimum	Maximum	Average	CV(%)
pH	6.14	6.66	6.40	1.63
EC (10^{-4}S/m)	82.7	175	108	14.7
Total C (10^{-2}kg/kg)	2.15	4.56	3.17	16.0
Total N (10^{-2}kg/kg)	0.23	0.39	0.29	12.7
C/N ratio	9.09	13.2	11.0	8.2
Mineralizable N (mg/kg)	59.3	148	88.9	18.6
Inorganic N (mg/kg)	7.74	34.5	13.6	34.7
Available P(g/kg)	1.70	3.02	2.33	13.6
Exchangeable Ca (cmol(+)/kg)	10.1	15.4	12.5	9.34
Exchangeable Mg (cmol(+)/kg)	0.88	1.92	1.40	13.2
Exchangeable Na (cmol(+)/kg)	0.12	0.25	0.17	14.9
Exchangeable K (cmol(+)/kg)	0.43	0.85	0.64	12.0
Relief (cm)	0.00	7.20	3.65	38.7

The Q values ranged from 0.50 to 1.00 for pH, EC, total C, total N, C/N ratio, mineralizable N, available P, exchangeable Ca, Mg, K and Na, suggesting highly developed spatial structure. The Q value of inorganic N was 0.78, however it was considered to show a low spatial dependence based on the visual judgement rather than using the fitting model with low R^2. For the properties except inorganic N, therefore, the ranges can be considered as the distance of spatial dependence. The ranges were about 15m for inorganic N, respectively. The ranges of pH, total C, total N, mineralizable N, available P and exchangeable Ca, Mg, Na, K were about 20m to 58m, respectively, indicating much longer spatial dependence for these properties. Figure 1(right) shows the kriged maps of the properties, which were drawn by block kriging based on the data within the ranges. Considerable spatial variability was clearly observed for all the properties except inorganic N in accordance with the results of the semivariograms.

Spatial dependence and kriged map of relief value

Table 1 indicates the minimum, maximum, average and CV of the 100 samples for relief value. The CV was 38.7%, indicating the spatial variability even in the paddy field. Figure 2(left) indicates the semivariograms. The Q value shows 0.70 and 59m for ranges in figure 2(a)(left). The semivariogram, however showed the spatial dependence around 20m. With this reason, relief value has a long and short trend within field, simultaneously. To analyze the each property, the measured data was transformed to plane data by plane equation and least squares method. The semivariogram of plane data shows in figure 2 (b)(left), and figure 2 (c)(left) shows the semivariogram to subtract the plane data from measured data. The Q value was 0.56, and the range was 20m. Therefore, rational sampling interval of relief value considered about 20m. Figure 2(right) shows the kriged maps of the each property. Considerable spatial variability

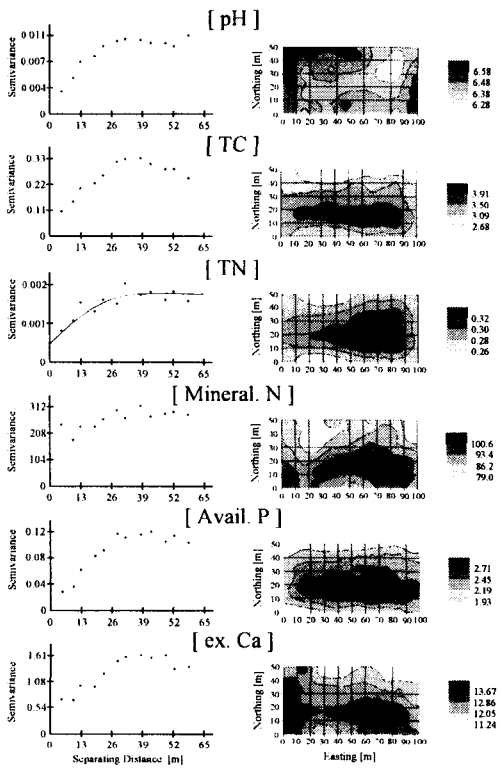

Fig. 1 Semivariogram and kriged maps of soil chemical properties.

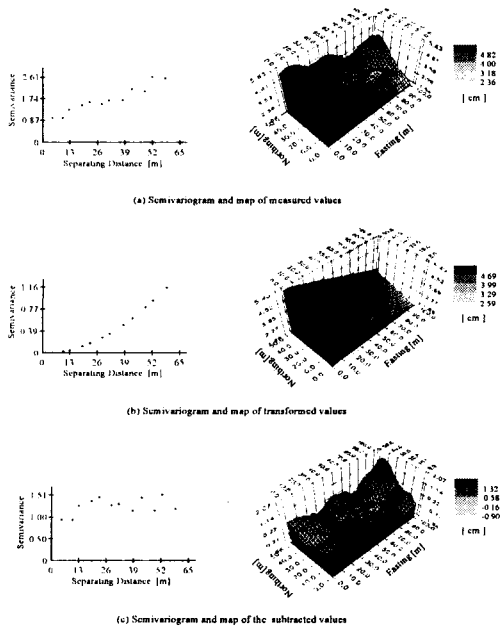

Fig. 2 Semivariogram and kriged maps of relief value.

was clearly observed for the relief value. As these results, relief value was thought to consist of a long trend of a flow direction of irrigation water and many short trends.

Spatial dependence and kriged map of SPAD values

Table 2 indicates the minimum, maximum, average and CV of the SPAD values. The CVs of every growing stage of SPAD values differed from 3.2% to 7.7%. The CVs of the SPAD 1,3 were lower than the SPAD 2. It was thought that the spatial variability decrease due to the uniform basal dressing and topdressing. If basal dressing was absorbed, the spatial variability gradually occurred owing to the variability of the soil fertility like SPAD 2. As the paddy rice under severe nitrogen stress took up nitrogen after topdressing, then the spatial variability rapidly decreased like SPAD 3. Figure 3(left) shows the semivariograms. The semivariograms of SPAD 3, 4 and 5 shows a different pattern with the others. The Q value of SPAD 2 was 0.86, the range was about 17m, suggesting a high spatial dependence. The Q values of SPAD 3 and 4, however, were 0.31, 0.56, the ranges were about 59m, suggesting a low spatial dependence. These results suggest that the spatial variability of SPAD values change during the growing period, rational sampling interval for SPAD values also change according to it. The rational sampling interval of SPAD values considered about 17m because topdressing has been done based on the growing investigation of paddy rice at panicle formation stage (SPAD 2). Figure 3(right) shows the kriged maps. The maps clearly showed that the spatial variability of the growth of paddy rice decreased by topdressing.

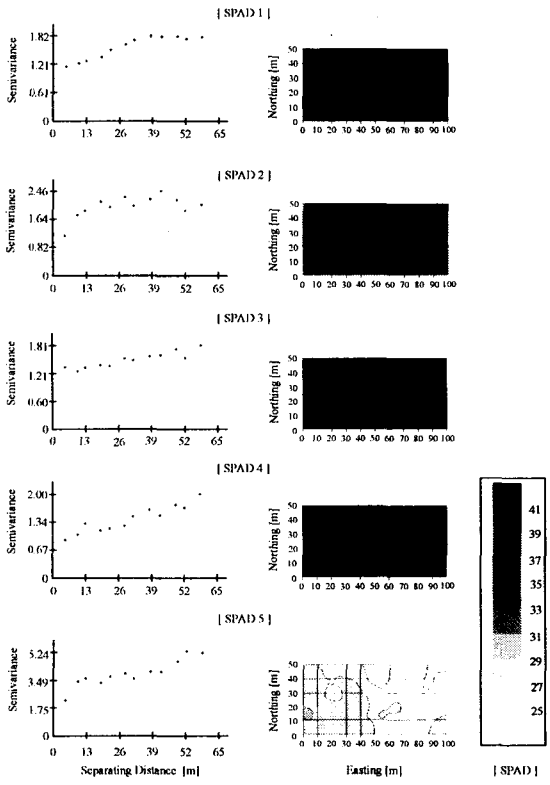

Fig. 3 Semivariogram and kriged maps of SPAD value.

Table 2 Descriptive statistics of SPAD values and grain yield

Properties	Minimum	Maximum	Average	CV (%)
SPAD 1	36.6	42.8	39.9	3.20
SPAD 2	32.4	40.2	35.6	4.10
SPAD 3	32.6	39.3	36.3	3.35
SPAD 4	35.0	41.8	37.9	3.31
SPAD 5	22.9	31.5	26.7	7.66
Yield (t/ha)	6.01	8.02	7.33	5.89

Spatial dependence and kriged map of yield

Table 2 indicates the minimum, maximum, average and CV of the yield. The CV for yield was 5.9%, indicating the spatial variability even in the paddy field. Figure 4 (left) indicates the semivariogram. The Q value indicates 0.66 and 53m for range, suggesting highly developed spatial dependence. This range was longer than 13 m, which was estimated based on the investigation in 1997. This would be due to the difference in field size, sampling number and field management. Figure 4 (right) shows the kriged map based on the result of the semivariogram. Considerable spatial variability was clearly observed for the yield. The spatial variability pattern of yield showed the similarity with soil chemical properties for total C, total N, C/N ratio, mineralizable N, available P and exchangeable Ca. It also showed the opposite similarity with relief value. Unfortunately, it didn't show the similarity with SPAD values.

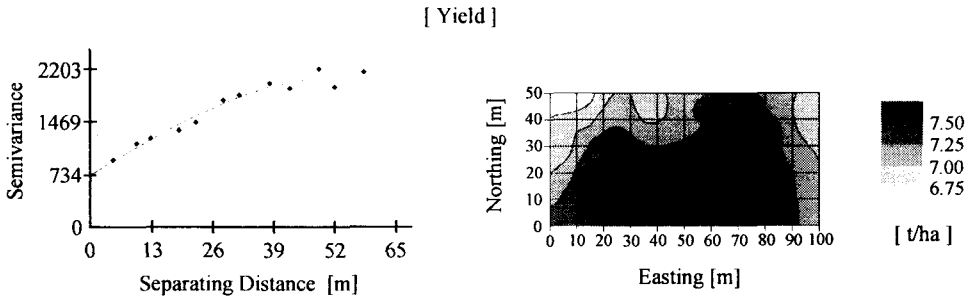

Fig. 4 Semivariogram and kriged maps of grain yield.

Field management map

Spatial variability for total C, total N, mineralizable N and available P reflected the irrigation water flow from northwest to southeast and the working direction within field.

Further, the field was divided into five fields in the past. Thereby, relief value reflected the undulation at 20m interval within field. Field management map showed useful to interpret the cause of spatial variability for field information.

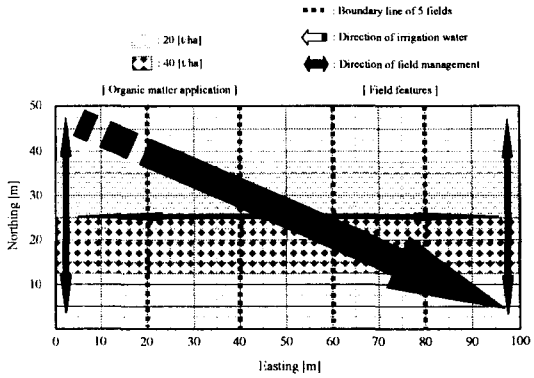

Fig. 5 Field management map.

Relationship between grain yield and another

The relationships between grain yield and soil chemical properties, relief, SPAD are indicated in table 3. It can be seen that grain yield positively or negatively correlated with measured field information. Grain yield was negatively correlated with pH, relief value, whereas, was positively correlated with total C, total N, C/N ratio, mineralizable N, available P and exchangeable K, Ca at the significant level of 1%. It is consider that grain yield was affected by these soil factors and relief value. However it didn't correlated with SPAD values.

Table 3 Correlation coefficient between the soil chemical properties, relief value, SPAD values and grain yield. (** : Significant level 1%, number of samples : 100)

Parameters	Yield	Parameters	Yield	Parameters	Yield
pH	- 0.332**	Inorganic N	- 0.155	Relief	- 0.297**
EC	0.052	Available P	0.545**	SPAD 1	0.082
Total C	0.467**	Exchangeable Ca	0.315**	SPAD 2	0.116
Total N	0.404**	Exchangeable Mg	0.090	SPAD 3	0.066
C/N ratio	0.285**	Exchangeable Na	- 0.186	SPAD 4	- 0.141
Mineralizable N	0.359**	Exchangeable K	0.378**	SPAD 5	- 0.042

CONCLUSIONS

Field information showed a spatial variability in the paddy field. Descriptive statistics of field information showed that the coefficient of variation ranged from 1.63% to 38.7%. Field information also showed a high spatial dependence for within paddy field. The ranges of spatial dependence were from 15m to 60m, respectively. Kriged maps enable the

visualization and comparison the spatial variability of field information. The causes of spatial variability of the field information could be explained rationally by a field management map. Grain yield was negatively correlated with pH, relief values, whereas, was positively correlated with total C, total N, C/N ratio, mineralizable N, available P and exchangeable K, Ca at the significant level of 1%.

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