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Correlation and Spatial Variability of Soil Properties Affecting to Sugarcane Yield in Kamphaeng-Saen Soil

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ABSTRACT

The effects of some soil properties on yield, yield components and qualities of millable cane were analyzed using classical stepwise regression methodologies. The aim of the study was to determine the soil variability, which was effected yields and qualities of the millable cane. By this, 140 grid sample units of 20 ¥ 20 square meters were allocated in the sugarcane field on Kamphaeng-Sean soil series. In each grid unit, there was 15 rows of 1.33 meters apart. Duck manure and 16-20-0 chemical fertilizer were used as a basal fertilizer. Soil chemical analysis was determined by standard analytical methods. Yield and sugarcane quality such as CCS and fiber percentage was collected in each individual grid. Stepwise regression analysis show significant affects from total soil nitrogen and exchangeable potassium to sugarcane yield and CCS respectively. Semivariogram of yield (millable cane), number of cane and cane weight give a guideline for precision agriculture or site-specific nutrient management approach.

Key words: sugarcane, kamphaeng-saen soil, correlation, spatial variability, yield, quality

INTRODUCTION

Natural soil properties are varying and complex particularly from a fertility standpoint. To understand the heterogeneity of soil and to be able to use the understanding to predict the outcomes of soil management practices, we need to understand the spatial variability and correlation of factor related to plant growth.

Precision agriculture addresses spatial variability across a field in order to optimize application of fertilizer and other inputs on a site-specific basis (Beverly, 1996). Precision farming is sometimes called “prescription farming”, “site specific farming” or “variable rate technology.” (Johannsen, 1995). Kamphaeng-saen soil series is located in Western region of Thailand. The main upland crop in this area is sugarcane. Most of sugarcane production area in Nakhon pathom was grown on Kamphaeng-saen soil series. The area of study was located around a reservoir in experimental field of Soil Science Department, Kasetsart University at Kamphaeng-saen campus. The objective of this study was aim to determined soil variability, which affect to sugarcane yield and quality. In order to applied this understanding to the management zone concept in precision agriculture.

MATERIAL AND METHOD

Land preparation and field layout

The sugarcane experiment was started October 1997, on a Kamphaeng-sean soil series. A

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research field was divided into 135 individual 20 ¥ 20 m^2 grids. Furrow is the irrigation system in this field. The field was leveled to escape from flooding and drainage. Each unit received standard cultural practices. Grid location was tracked by using GPS (Trimble" ProXR). Topographic map of research field was collected by classical survey method and then GIS implemented altitude data with grid location (figure 1).

In each grid, composite soil samples were taken at 2 levels, i.e., 0-30 and 30-60 cm to represent topsoil and subsoil characteristics. Their main chemical properties, namely pH, conductivity, organic matter content, available phosphate and exchangeable cations (K, Ca, Mg and Na) were analyzed. Co-ordinate of sampling point was recorded by GPS in latitude/longitude format. Field data were entered to spreadsheet and GIS software. Sugarcane variety K84-200 has been transplanted during March 30, 2001 to April 7, 2001 in 20 ¥ 20 m^2 plot, in 15 rows per plot, 1.33 m apart. In the first year, planted cane received basal application with duck manure at 200 kg/rai and 16-20-0 at 50 kg/rai. Top dressing with ammonium sulfate (21-0-0) was applied in 2 and 4 month after transplanting.

Data collection and plant analysis

Sugarcane height was recorded at 8 months old by sampling 5 canes from each plot. Red tag was marked on sampling stalk for monitoring the growth. Sugarcane was harvested at 9 months. Yield and yield components were recorded. Yield components, which comprise of fresh weight, leaf sample at top visible dew -lap and dry matter were recorded. Manual harvesting was used in yield monitoring in each plot by 5 out of 15 rows (1/3 of the grid).

Sugarcane was harvested at nine months old from 5 rows out of 15 rows in each grid unit (1/3 of the grid area). Millable cane yield and its yield components, i.e. stalk number and cane weight per stalk were recorded after hand cutting. Moreover the representative cane stalks sample of each grid unit was determined for (%) Brix, Pol, and Fiber. The CCS was then calculated by using the equation as follow (Meade and Chen, 1977)

$$CCS = \frac{3/2\ P\ [1 - F + 5]}{100} - \frac{\frac{1}{2}\ B\ [1 - F + 3]}{100}$$

Correlation and spatial analysis

Correlation between sugarcane yield, quality and soil properties were analyzed by

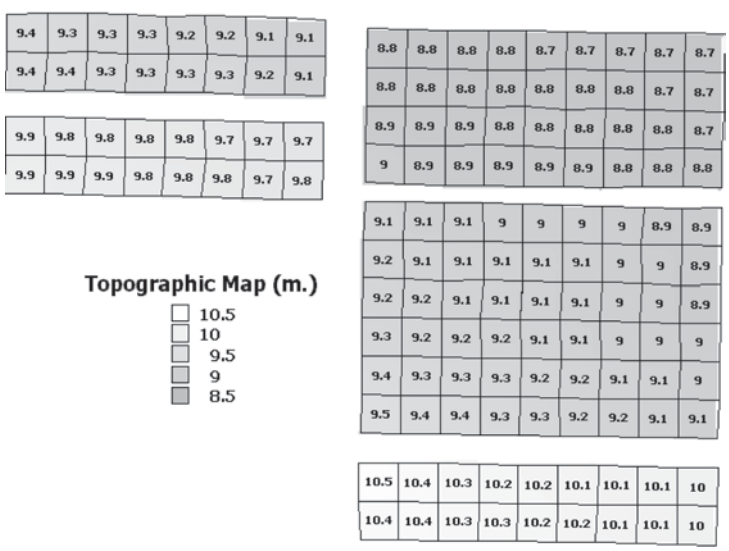

Figure 1 Topographic map and grid layout of study area.

stepwise multiple regression. Spatial analysis was performed by Surfer" version 7.0. The modification of spatial parameter was done by visual approach.

RESULTS AND DISCUSSION

Statistical correlations between yield, yield components and yield qualities of planted care vs soil properties were show in Table 1. Total soil nitrogen both top and sub soil effect to sugarcane yield in term of millable cane and cane number. The relation ship between nitrogen availability on sugarcane has been reported in many publications. Parashar *et al*. (1978) reported that high cane yields were obtained where the crop received the highest N application rate and the most frequent irrigations. The low land area in the northeastern of study area has poor drainage causing by the clayey soil texture. Reddy *et al*. (1978) also mentioned on significant interactions between nitrogen and moisture with positive effects on cane yield but negative effects on sugar yields at high rate of both N and soil moisture. Size of sugarcane which demonstrated by cane weight (kg/cane) increase significantly when extractable potassium in tap soil increase. Potassium availabilities in sub soil have positive effect sugarcane qualities in case of CCS but give negative correlation on fiber percentages. Classical statistic analysis could reflect only some significant factor. Geostatistic analysis could facilitate in identifies the variability of area and generate some idea about management zone.

The variogram can capture the characteristics of sugarcane field as functions of spatial soil variability. Semi-variogram of millable cane yield, number of cane and cane weight (Figure 3) shown the same value of tolerance (Lag distance or range = 90 meters). From the range it can be interpreted that the variance of the yield is more than 90 meters which larger than grid size of this study. So, in the next research, we can enlarge the grid size and increase a sampling unit from this result.

CONCLUSION

The spatial analysis of soil properties was revealed the pattern of variability of studying area which will be a trend for management zone for the variable rate fertilizer application. Main soil factor affected to sugarcane yield can use to generate the management zone option for variable rate fertilizer application supplemented by economic analysis

Table 1 Correlation coefficient between yield, yield components and yield qualities of sugarcane to some soil chemical properties. (Only highly significant Coefficient Correlations ($p \leq 0.01$) are shown in the table.)

	Total Soil nitrogen		Organic matter		Available P		Exchangeable K		pH (1:1)		Electrical conductivity	
Depth 1/	A	B	A	B	A	B	A	B	A	B	A	B
Millable cane	0.406	-0.206										-0.177
Cane member	-0.198	0.417					-0.255					-0.179
Cane weight							0.386					
C.C.S.				-0.170				0.377				
Fiber (%)			0.336					-0.302				0.169

Notes : 1/ A = top soil (0 – 30 cm.)
B = sub soil (30 – 60 cm.)

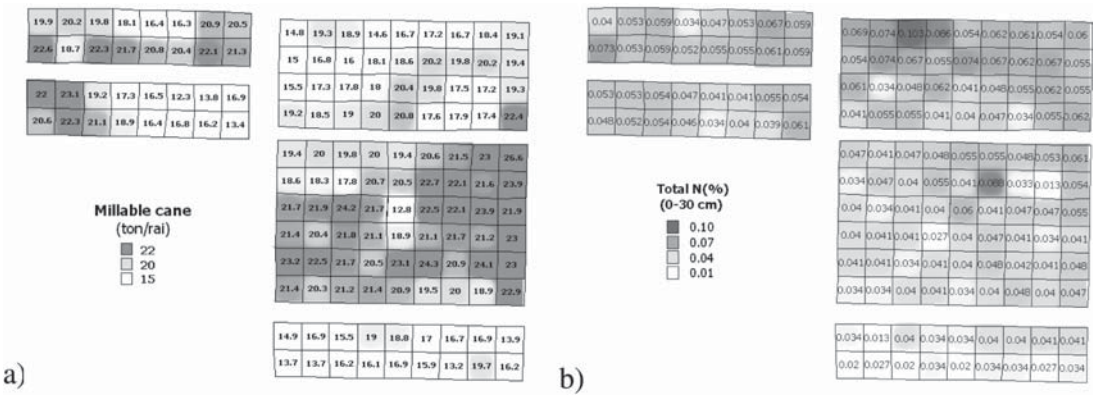

Figure 2 Thematic maps of (a) sugarcane yield (ton/rai) and (b) total nitrogen in topsoil (0-30 cm.)

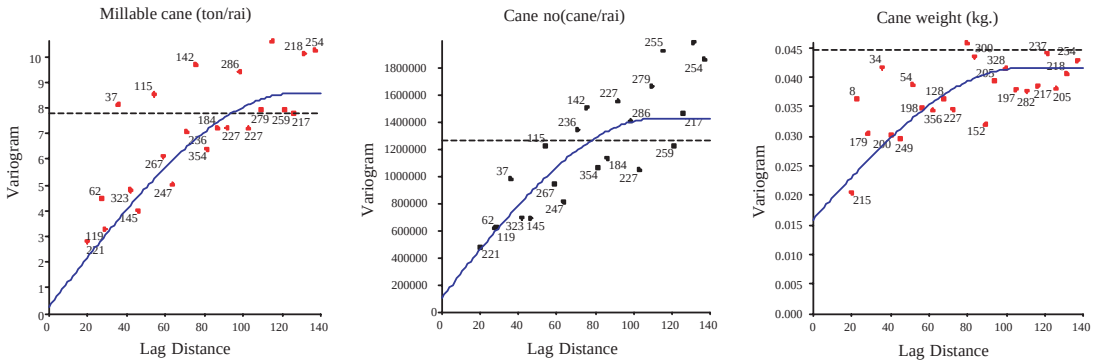

Figure 3 Variogram of millable cane yield (a) , number of cane (b) and cane weight (c).

and spatial analysis (cut and fill technique).

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