Spatial yield variation of oil palm in a fertilizer response trial in Malaysia

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Introduction

The inherent palm to palm variability of fresh fruit bunch (ffb) yield of oil palm has been recognized since its commercial plantings in the 1920s. Uniformity trials with oil palm have generally shown that ffb yields of individual palms are highly variable and their coefficient variation (CV) could exceed 30% (Webster, 1938, Chapas, 1961, Goh and Alwi, 1988). The high variability in fresh fruit bunch yields of oil palm has prompted planters to demarcate their land into smaller unit, more uniform fields for ease of implementing the correct practices for maximum yield and profitability. Currently, the areas of these management units in large plantation groups are usually in a range of 40 to 60 hectares. With the advent of new technology, knowledge and tools, it should be possible to manage even smaller fields and capitalize n the advantages of precision agriculture such as lower losses of inputs. However, proper site-specific management requires an understanding of the source of the variability in the field. The prime purpose is to allow the demarcation of the field into clusters of palms where within each cluster, the palms are spatially related but between the clusters, they are independent. Thus, each cluster of oil palms is unique and can be managed separately for optimum returns to investment. Therefore, the main objectives of this paper are to quantify the range of spatial variation of ffb yield, and to assess the spatial pattern of fbb yields in an oil palm fertilizer response trial.

Materials and Methods

Fresh fruit bunch yields of oil palms were obtained from a fertilizer response trial conducted in Tawau, Sabah. The major soil types within the trial were identified as Batang family (Typic Hapludults) and Kumansi family (Typic Paleudults). The Experiment was a 3 x 3 x 2 factorial combinations of N, P and K arranged in a randomized complete block design (RCBD) with 3 replicates. The plot size was 30 palms and measurements such as ffb yields were recorded from the 12 central palms. Thus, each experimental plot had a guard row consisting of 18 palms. Fertilizer treatments were first imposed in 1992. FFB yields were recorded a 10 day intervals and the results were summarized on an annual basis in this study. Point map of the individual palms in the trial site showing their relative positions in the field were made and geocoded using MapInfo Professional Version 4.0. Geostatistical analysis software was used to define semivariograms and interpolate ffb yields at unsampled areas using kriging. Fresh fruit yields were adjusted using the difference method (Makridakis et al., 1998) in order to remove the N and K effects. There is no significant effect to P treatments and thus, no adjustment was made for it. Spherical model was fitted to the semivariogram. Interpolation of ffb yields was carried out by the point kriging method, followed by the procedures described by Burgess and Webster (1980 a and b). Yield maps were constructed by first using the point kringing method to estimate ffb yields at unsampled locations and then clustering them into similar ffb yield classes.

Results and Discussion

(a) FFB Yields of Oil Palm

The annual mean ffb yields obtained in the past 8 years ranged from 146 to 244 kg palm^{-1} yr^{-1}. Withdrawal of N and K fertilizers significantly reduced the overall ffb yields about two years later staring from 1993. The annual palm to palm yield variations were very high as indicated by the coefficient of variations (CV) of 32 to 52%.

(b) Semivariogram analysis

Semivariance analysis was conducted to understand the sources of high variations in annual ffb yields. Results showed that spatial variation accounted for most of the variation and could explain 72% to 78% of the total variation in ffb yield. The balance of the 22 to 28% was due to random variation, suggesting that measurement error and genetic variability had only a small influence on the ffb yield variation in oil palm. The average range of spatial correlation of ffb yield was 16 m, indicating that the maximum spatial variation of ffb yield was reached within 2 to 3 palms. This might be due to the canopy structure of oil palm, which extends to the immediate neighboring palms only while its roots have been shown to exploit soil resources at least 2 palms away. Therefore, any strong environmental influence on the oil palm would probably affect the nearest 3 palms most similarly.

(c) FFB Yield of Oil Palm

Anisotropic examination of the semivariograms showed that spatial variability of ffb yields was not influenced by the directions of the samples (palms), that is, the range and nugget remained similar regardless of whether the measured palms were aligned in a North-South or East-West direction. The maps showed distinct spatial patterns in ffb yields within the field. The presence of a thin layer of laterite in the middle portion of the field tended to lower the ffb yields.

(d) Biennial Yield Fluctuation

The annual ffb yields trend was investigated by categorizing the changes in yield between two years into 3 classes, namely, a) no change in yield, b) yield decline and c) yield increase. Results appeared to suggest a biennial yield fluctuation particularly in the eastern and western portions of the field. Thus, an area with high ffb yield will have a tendency to produce lower yield the following year. This implies that it may not be possible to just use the external factors which affect the yield map in a year as a prognostic tool to predict the yield pattern in the following year as commonly done in annual crops. The implications of the interaction between spatial and temporal yield patterns should be investigated in relation to their potential impact on site specific crop management.

Conclusions

The high variation of ffb yields of oil palm could be separated into random and spatial components. The spatial variation accounted for 72 to 78% of the total variation in ffb yields. The mean spatial range of ffb yields was reached within 2 to 3 palms distance. The kriged ffb yield maps showed that the presence of a layer of laterite in the soil was probably a major factor affecting the spatial variability of ffb yields. The yield maps also showed distinct patches of high and low ffb yields indicating that site specific management should be implemented in the field. However, there was also an indication of biennial ffb yield fluctuation in oil palm that can be complicate the implementation of site specific crop management.

Benefits from the study

Development of site specific management in oil palm based on spatial and temporal variations. This will lead to the reduction in agronomic inputs, soil deterioration, environmental pollution and cost of agricultural inputs.

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