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SPATIAL AND TEMPORAL VARIABILITY OF SURFACE SOIL MOISTURE CONTENT OF AN ALFISOL AS INFLUENCED BY TILLAGE OPERATIONS IN OYO STATE, SOUTHWESTERN NIGERIA

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ABSTRACT

This study was carried out to evaluate the spatial variation of surface soil moisture content as influenced by tillage practices. A total of 500 samples were collected at every 3 m along the x-axis and 10 m apart along the y-axis and water content of the samples was determined gravimetrically. The data were subjected to different regression analysis to determine the best-fit model. The spatial variability of soil moisture content was extrapolated using a semi-variogram. Out of all the models tested. The 4th degree polynomial model estimated the variogram better at R^2= 0.7465 compared to the 3rd degree polynomial of R^2= 0.4679. Surface mapping was constructed using the coefficient of the best-fit model. The Contour maps so developed revealed rather uniform surface moisture content for plots with minimum tillage than the zero tilled plots.

KEY WORDS: Soil moisture content, semi variogram, best fit model, Tillage

Soil is a dynamic natural resource that has both static and dynamic properties; it contains vast numbers of organisms and serves as a recycle room for nutrients and toxic substances, usually to plants (Elliot and Walker, 1982). Since the soil is dynamic and responsive to humans and environmental influences, for example, tillage and cultivation practices; the various characteristics of soil vary in space and time. Hence, evaluating agricultural land management practices requires knowledge of soil spatial variability and understanding of the relationships.

Soil moisture is the key defining variable that integrates all components of the surface energy balance and as such is of major importance to climate models and their surface schemes. An understanding of the soil moisture balance and its variability (spatial and temporal) is instrumental in quantifying the linkage between a region's hydrology, ecology and physiography (geology) (Jayeoba et al., 2007).

Tillage involves the mechanical manipulation of the soil. The primary objectives of tillage are (1) to control weeds, (2) to present a suitable seedbed for crop plants, and (3) to incorporate organic residues into the soil. It is one of the most commonly used management practice and also considered essential in the management of soils (Young and Wakentins, 1971).

Geostatistics, based on the theory of regionalized variables, is the primary tool of spatial variability analysis. The results obtained from a geostatistical analysis are dependent on a number of variables, such as sampling frequency and number, sampling spacing and accuracy, and analysis parameter selection (Burgess and Webster, 1980a). Proper interpretation of the semi-variogram and selection of appropriate models are very important to the analysis process (Vieira et al., 1981)This study sought to evaluate the spatial variability of surface soil moisture content under the influence of tillage practices on an Alfisol.

MATERIALS AND METHODS

The sample field with sandy loam (Alfisol) was located in the College Farm of the Federal College of Forestry, Ibadan, Oyo state. The sample site was divided into minimum tillage and no-till land cropped to maize. Five hundred core soil samples were collected on the two experimental sites using a grid method at a distance of 3m apart along the X axis and 10m along the Y axis. The sampling was done forty-eight (48) hours after a heavy rain, when the soil is assumed to have attained field capacity. Samples were collected at varying depths of 0-10cm, 10-20cm and 20-30cm. The samples were weighed before and after drying. Drying was carried out at 105°C for 72 hours. Moisture content was determined gravimetrically. The data were entered in x, y, z order where x is the distance along the x-axis and y is the distance along the y axis while z is the variable value. Considering a transect with equally spaced

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samples and measurements of soil moisture (z), FVARIOGRAM directive was use to forms an experimental variogram from a set of values $Z(x_1)$, $Z(x_2)$….$Z(x_n)$ at location $x_1, x_2…x_n$. The semi variance γ(h) is estimated as:

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} \{z(X_i) - z(X_i + h)\}^2 \quad \ldots(1)$$

where: h is lag distance,

γ (h) is semi-variance for interval distance class h,

zi is measured sample value at point i,

zi+h is measured sample value at point i+h, and

N(h) is total number of pairs for the lag interval h.

Geostatistical analysis and semivariogram model selection were done with GENSTAT WINDOWS version, Geo-statistical procedure (Mvariogram) (Gamma Design Software, Plainwell, Michigan). Mapping of kriged data was done with Surfer version 7 (Golden Software Inc., Golden, Colorado).

RESULTS AND DISCUSSION

Computation of semi-variogram from equation 1 given in the methodology above produced a set of lags and variogram, which were further plotted to estimate the best fitted model, that best extrapolated the spatial variability.

Fig. 1 represents a linear estimate of lag in meters against the variogram, with R^2 (Co-efficient of determination) of 0.1914. This estimate was rather too low to be accepted, hence more graph were also plotted with R^2 of 0.116, 0.1731 and 0.0956 for logarithm, Power and Exponential models respectively. These models failed to produce satisfactory results.

Third degree Polynomial model produced a R^2 of 0.4679 while the 4^{th} degree Polynomial estimated the variogram at R^2 =0.7456(Fig. 3 & 4) which was much better than all the models used.

The 4^{th} degree Polynomial model provided the

Fig. 1: Linear relationship between lag and semi variogram

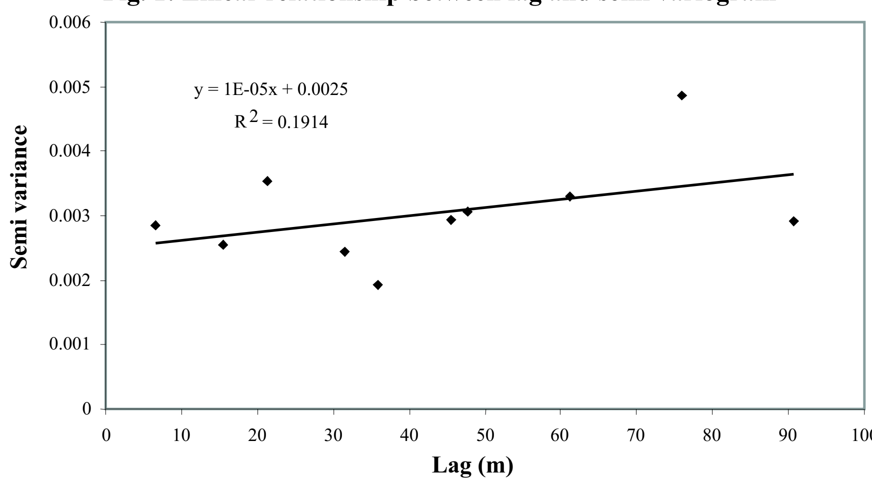


Fig. 2: 3^{rd} degree Polynomial relationship between lag and semi variogram

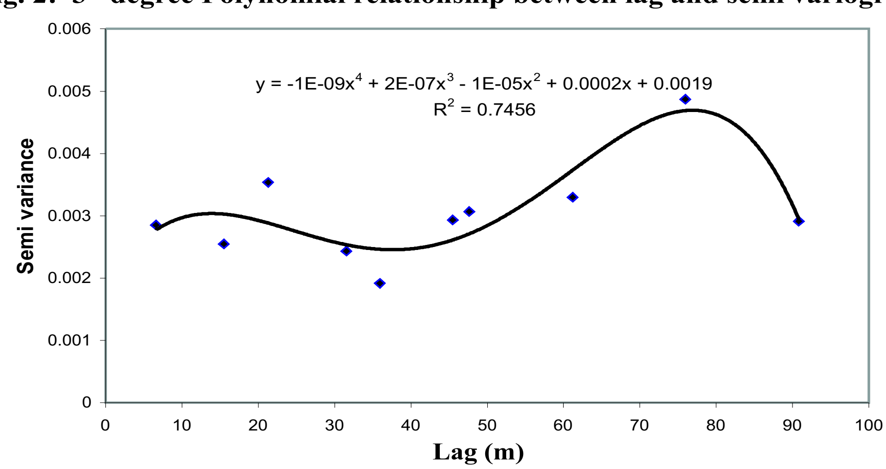
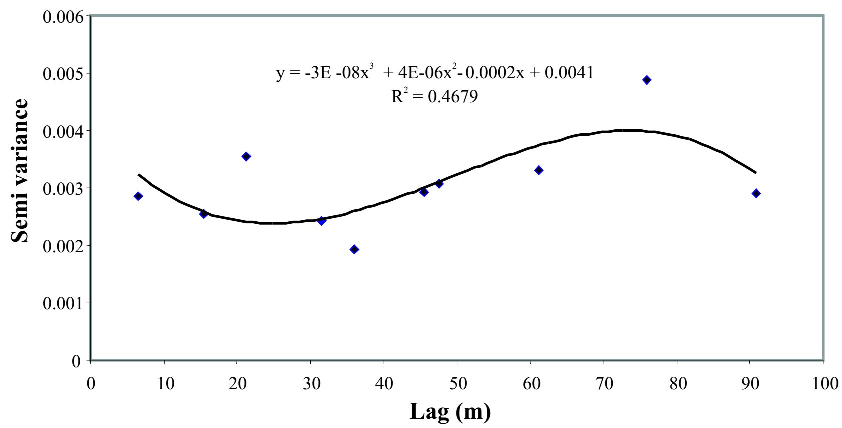


Fig .3: 4th degree Polynomial relationship between lag and semi variogram



required parameters that were used for the surface mapping of soil moisture isolines as indicated in Fig4.

The relationship indicates that surface moisture content of the field varied in space, with the zero tillage plots having higher but highly varied surface soil moisture than the tilled plots, probably due to mulching effect provided by the residue of the previous season crops. The low surface moisture of the tilled plots might be due to improved porosity and the uniformity of the moisture content might be due to the mixing effect of the tillage operation. Janowicz et al. (2003) wrote that there was a correlation between vegetation cover and soil moisture variability. The trend of their results showed that vegetation cover has the ability to reduce variability in soil, which is also the case in the present study where the samples from the zero tillage showed a strong regularity in the moisture content compared to the minimum tillage (Fig. 4). Various other studies have also shown that patterns of soil moisture are directly related to topographic and vegetative indices. High soil moisture levels have been found to be associated with zones of topographic convergence, while low soil moisture is associated with topographic divergence (Beven and Kirkby,1979; Barling et al., 1994)

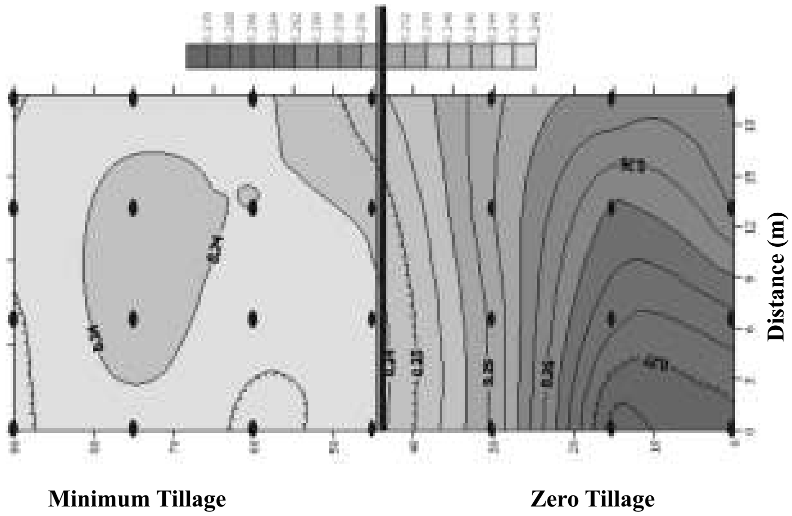
Many researchers have studied the frequency distributions of soil moisture parameters. Francis et al. (1986) assessed the relationship between plant cover, incorporated organic matter and soil moisture in a stressed semi-arid Mediterranean environment. They found surface moisture to be normally distributed, stating that transforming (no indication of the nature of transformation was provided) the data did not produce significant improvements in the correlation between observed and theoretical values. Weekly soil moisture samples of the 0-60 cm horizon, taken from the Barapani region of northern India by Sharma and Singh (1987), were found to follow a truncated normal probability distribution. Vachaud et al. (1985) found as a by-product of the study of soil retention curves and the relationship between soil texture and moisture, that the frequency distribution of soil moisture across a cultivated field in Tunisia was approximately lognormal.

CONCLUSION

Geostatistics is a useful tool for determining the sampling intensity required to characterize the spatial variability of soil properties with a specified level of precision. Once the average semi-variogram is determined widely spaced measurement can be used to krige value of surface soil moisture contents.

4th degree polynomial model provided the required parameters that were used for the surface mapping of soil moisture isolines.

Fig. 4: Contour plot of the effect of tillage on surface moisture content at field capacity



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