PROBABILITY DISTRIBUTIONS AND ALTERNATIVE TRANSFORMATIONS OF SOIL TEST NO_3-N AND PO_4-P, IMPLICATIONS FOR PRECISION AGRICULTURE

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ABSTRACT

Several alternative distribution functions and transformations of soil test N and P to normality are discussed.

INTRODUCTION

Recommendations for fertilizer N in crop production and precision agriculture depend on statistical analyses of data which represent soil NO_3-N and PO_4-P fertility typical of management zones and fields. Non-normal distributions of soil test N and P are commonly log transformed prior to statistical analysis for interpolation with methods such as kriging, regression, or multivariate methods such as principle component analysis. These data are transformed to ensure that analysis meet the assumptions of normality for the distribution of data and equality of variances.

METHODS

Soil samples (0-5 and 5-15 cm) were collected at 50 to 100 sample sites for 7 agricultural fields from 10 to 100 acres in size in July and August 2012. Landform attributes (surface curvature, slope, aspect) and elements (upper, middle, lower slope positions and depressions) were calculated from digital elevation data (LIDAR) with LandMapR software (Macmillan 2003). Grids of 50 or 100 points at a 20 m interval were located in selected fields, to include the upper, middle and lower landform elements.

Soil test NO_3-N (2 M KCl) and PO4-P (0.5 M $NaHCO_3$) were determined with a colorimetric method (Total nitrate was determined by cadmium reduction and analysis by flow injection analyzer (AOAC 1990, Method 968.07) for the 0-5 and 5-15 cm increments. At each site, a weighted average of soil test N or P was calculated for 0-15 cm. Statistical distributions of soil test N and P were determined in JMP 11.0 (SAS Institute Inc. 2014) for a range of functions including normal 2 and 3 mixture (mixture of normal distributions for multi-modal data), gamma, lognormal, Weibull, Johnson Sl (leading to the lognormal family of distributions), Su (unbounded for Y) and Sb (bounded on both tails). The lowest value of the corrected Akaike Information Criterion was used to identify the distribution which best fit the data.

RESULTS

Statistical distributions of soil test NO_3-N and PO_4-P, calculated by landform element for each field, varied from lognormal, exponential, Gamma, Weibull, Johnson Sl and Su, to normal 2 mixture. No single distribution accounted for the majority of data sets.

Table 1. Frequency of probability distributions for NO3-N and PO4-P

		NO_3-N			**PO_4-P**		
Distribution	N	Lower	Middle	Upper	Lower	Middle	Upper
Exponential	4	1	0	1	1	0	1
Gamma	7	2	3	0	1	1	0
Johnson Sl	6	0	0	0	1	4	1
Johnson Su	1	1	0	0	0	0	0
LogNormal	11	1	1	3	3	2	1
Weibull	3	1	1	0	0	0	1
Normal 2 Mixture	2	0	2	0	0	0	0

DISCUSSION

Statistical analysis of soil test N and P for zones based on landform elements should be based on the appropriate distribution function. Transformations based on the lognormal, exponential, gamma, Weibull and Johnson family of distributions or normal quantile should be considered where appropriate.

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