

Nutrient Stratification in No-till Soils

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SCIENCE

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*Editors' Note: Leading Edge is privileged to publish this article by three of North America's most respected soil scientists. John Grove, Ph.D., has focused his applied field research program on chemical and physical management of no-till soils for the past quarter-century. Ray Ward, Ph.D., has developed several agricultural testing laboratories from South Dakota to Oklahoma, and has endeavored tirelessly to improve farmer and agronomist understanding of soils and crop nutrition. Ray Weil, Ph.D., is a professor at University of Maryland and has researched soil fertility for over 25 years in a state where no-till has become the convention. Weil is also the author of the textbook *The Nature and Properties of Soils, 14th Edition*, Prentice Hall, 2008.*

Nutrient 'stratification' commonly refers to a distribution of nutrients that is non-uniform with soil depth, and especially to situations with higher concentrations of nutrients (such as phosphorus or potassium) near the soil surface. Nutrient stratification certainly does occur in agricultural soils, but is generally not a problem for plant nutrition, and is at times beneficial. Nutrient stratification has existed since soils began weathering and coming under the influence of terrestrial

plants with roots. Nutrient stratification apparently was not an issue for the functioning or robustness of prairie or forest ecosystems, which endured and frequently prospered

for thousands or even millions of years without any mechanism for redistributing nutrients other than biological processes and water percolation. However, in the minds of many agriculturalists the common assumption or implication is that soil nutrient stratification is inherently a negative attribute for crop production, and one which must be alleviated by deep fertilizer placement and/or tillage. This article will explore the evidence for

Surface application of lime in no-till can raise soil pH at depths of 12 inches or more over periods of several years.



Photo by Ray Weil.

No-till is becoming the standard practice in place like Pennsylvania. The heavy mulch improves the crop and the soil. But could the situation be improved further by deep placement of fertilizers?

or against this proposition, as well as reviewing the plant and soil processes involved in both the creation and mitigation of nutrient stratification.

Stratification Concerns: Historical Context

When mechanized no-till cropping first got started in Virginia, Kentucky, and nearby regions in the 1960s and early '70s, we heard concerns about stratification of both nutrients and soil acidity (lower pH near the soil surface). Many agronomists worried that farmers would have to deep plow to periodically incorporate lime and fertilizer. Generally, these concerns never became reality.

For ameliorating soil acidity, many studies in no-till systems have demonstrated that surface application of lime (without mechanical incorporation) is highly effective. This is perhaps not so surprising because it is near the surface that soil is acidified by the actions of precipitation (which is typically acidic even when not influenced by human activities), ammonium oxidation, and decay of organic materials. Surface application of lime in no-till can also be effective in raising soil pH at depths up to 30 cm (12 inches) or more over periods of several years.¹ Percolating water and bioturbation move

¹ E.F. Caires, G. Barth & F.J. Garbuio, 2006, Lime application in the establishment of a no-till system for grain crop production in southern Brazil, *Soil & Tillage Res.* 89: 3-12. See also R.L. Blevins, L.W. Murdock & G.W. Thomas, 1978, Effect of lime application on no-tillage and conventionally tilled corn, *Agron. J.* 70: 322-326. W.W. Moschler, D.C. Martens, C.I. Rich & G.M. Shear, 1973, Comparative lime effects on continuous no-tillage and conventional tilled corn, *Agron. J.* 65: 781-783.