FEATURE

Gypsum soil amendment as a management practice in conservation tillage to improve water quality

L. Darrell Norton

Above: No-tillage corn on an eroded landscape in Whitley County, Indiana, June 2007, showing the lingering effects of past erosion on plant productivity.

No-till agriculture is the most common method used to control soil erosion on highly erodible lands in agricultural production in the United States. The interrill, rill, and gulley erosion that are common in conventional tillage on slope lands are reduced with no-tillage. No-till has been shown by many studies to significantly reduce the amount of soil erosion, but results for reduction of runoff quantity and water quality vary depending on soils and conditions. In no-till, chemicals are not incorporated and are applied at or near the soil surface in soluble forms that are subject to movement when runoff does occur. The purpose of this article is to introduce gypsum as a viable soil amendment in no-till agriculture to reduce runoff volume and improve the quality of runoff waters, particularly where manure has been surface applied.

Conservation tillage and in particular no-till or closely related variants have generally increased in popularity with farmers for soil and water conservation benefits since the 1970s. With the increased cost of energy for tillage, the acreage of conservation tillage is expected to increase from the present 38% (4.4×10^7 ha [1.09×10^8 ac]) of cropland and in particular with no-till soybeans (Conservation Tillage Information Center 2007). Also, due to higher energy costs and the resultant large price increases for fertilizers, farmers are turning more and more to manures as a viable way to supplement nutrient additions. In both conservation tillage and other systems, much of the manure is surface applied and not incorporated.

Even though there has been considerable adoption of conservation tillage, which has reduced sediment production, adverse water quality issues have increased and the lingering effects of past erosion on productivity still exist. The hypoxia zone in the Gulf of Mexico and other coastal areas have continued to increase in size, and water quality issues related to nutrients in water bodies in many parts of the United States are major concerns. These problems are predicted to increase with the recent increases in commodity prices and increased acreages of cropland, particularly with lands that were in the Conservation Reserve Program and are now returning to production.

Air quality concerns have resulted in federal legislation requiring coal-fired power plants to reduce emissions of SO_2, NO_x, and more recently mercury. The result has been production of high-quality gypsum ($CaSO_4 \times 2H_2O$). Flue gas desulfurization gypsum is typically +95% pure gypsum. The production of flue gas desulfurization gypsum is expected to double or triple from the present production of over 1.1×10^7 t y^{-1} (1.2×10^7 tn yr^{-1}) (American Coal Ash Association 2007) in the near future due to the new US Environmental Protection Agency Clean Air Interstate Rule of 2004 regarding mercury (Thorneloe 2006). Much of this material is presently being used in wallboard production, but there is a finite amount needed for the wallboard industry and excess production must be

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land-filled or producers must find other uses. Gypsum has been proven to be of value as an amendment for a wide range of applications in soils (Wallace 1994).

RESULTS AND DISCUSSION

We conducted a number of studies to evaluate the effect of using natural or recycled wallboard gypsum to reduce the amount of runoff, soil loss, and soluble phosphorous from lands. Figure 1 shows the results of the average of four years of rainfall simulator experiments where we applied a 5 cm h^{-1} (2 in hr^{-1}) rainfall for 1 h and measured the resultant effect of 2.25 t ha^{-1} (1 tn ac^{-1}) of surface-applied natural gypsum, where secondary poultry lagoon effluent had been surface applied and the soil had a very high level of available phosphorous. Runoff, soil loss, and especially the amount of soluble reactive phosphorous were all reduced significantly with a surface application of gypsum (figure 1).

In a more detailed experiment, we co-applied gypsum and dry poultry litter together at the soil surface or each independently on no-till corn–soybean rotation fields and measured runoff, erosion, and water quality differences with rainfall simulation. We found that an application of 2.25 t ha^{-1} (1 tn ac^{-1}) of surface-applied recycled wallboard gypsum could reduce the concentration of soluble reactive phosphorus, total phosphorous, and total nitrogen when applied to normally fertilized fields (figure 2) in addition to reducing the amount of runoff from no-till fields. When poultry litter was surface applied, the concentrations of soluble reactive phosphorus, total phosphorus, and total nitrogen were significantly increased. When gypsum was co-applied, the concentrations were reduced for all three parameters by approximately one-half, but all were still greater than conventional fertilizer applications. In all treatments, the amount of soluble nitrate lost was not significantly different, meaning the gypsum treatment had no effect on soluble nitrate.

Figure 1

The effect of a surface application of gypsum on runoff amount, soil loss, and soluble reactive phosphorous (SRP) for a four-year rainfall simulation study under both tilled and no-tilled conditions for a Zulch soil near Kurten, Texas (Norton and Mamedov 2006). Gypsum treatment was significantly lower at the $p = 0.05$ level with the t-test.

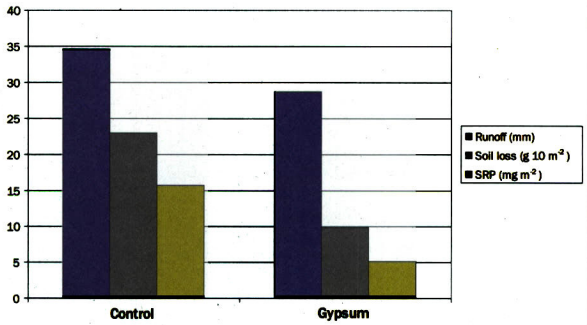
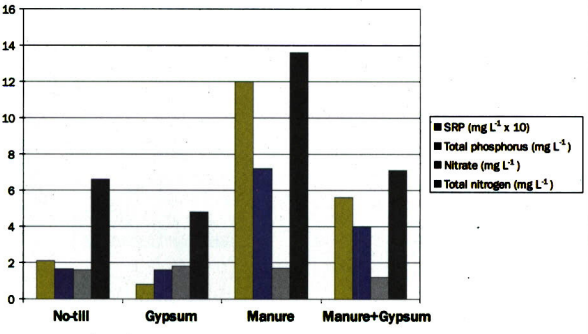


Figure 2

Comparison of gypsum and manure application to no-till agriculture for a rainfall simulator study on a Blount loam soil near Waterloo, Indiana, for amounts of soluble reactive phosphorus (SRP), total phosphorus, nitrate, and total nitrogen in runoff. All are significantly different and the $p = 0.05$ level with Tukey's standardized range test, except nitrate, which was not significantly different in any of the treatments.



SUMMARY AND CONCLUSIONS

No-till agriculture has been proven to reduce soil erosion. However, its effects on runoff quantity and quality vary depending on soil type and conditions. Given the fact that chemicals are applied at or near the soil surface, a potential exists for adverse water quality impacts. We found that using surface-applied gypsum soil amendment to no-tilled soil could reduce runoff, erosion, and improve water quality related to nutrient runoff. Surface application of manure in a no-till system greatly increased the amount of nutrients in runoff water, but

Above: Conventional tillage between terracing showing a combination of degradation of the soil from interrill, rill, and gulley erosion and the failures of structural means of erosion control in Londrina, Parana, Brazil, December 2007.

a co-application of gypsum amendment significantly reduced all major nutrients lost except nitrates.

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