WESTERN CANADA

Conservation Tillage Effects on Soil Phosphorus Distribution

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Conservation tillage seeding systems are the most rapidly adopted tillage practice in western Canada. Because conservation tillage seeding encompasses a broad range of seeding and fertilization methods, there are questions regarding the long-term impact of reduced tillage on soil fertility.

> While soil phosphorus (P) was found to accumulate near the surface in no-till fields, no negative impact on crop production was recorded due to this nutrient distribution. In-soil band placement of fertilizer P is an effective means of increasing soil P content in the absence of tillage for incorporation.

The role of tillage on soil nutrient levels is largely determined by the nature of each specific nutrient, and the impact that the changes in the soil environment have on its transformations. Thus, immobile nutrients in the soil such as P and potassium (K) tend to be affected substantially by the adoption of reduced tillage management. Most notable is their tendency to become concentrated near the surface of the soil in response to the reduced soil disturbance and elimination of soil inversion characteristic of conventional tillage systems.

One of the main benefits achieved with the adoption of conservation tillage is the maintenance of soil moisture for crop production. By increasing the amount of plant-available water in the soil, both the cropping intensity, and diversity of crops grown can be increased. Previous research in the U.S. Corn Belt has found that while soil P and K were considerably higher in the surface 3 in. depth of no-till treatments, the plowed treatments had uniform nutrient levels down to 9 in. depth. Given the density of corn roots in this soil layer, the stratification of P and K were not considered to be as big a problem as first thought. In fact, by concentrating roots in a zone of higher fertility, nutrient availability may be increased. A similar scenario exists for the root development of crops on the Canadian Prairies, and the maintenance of surface residues helps to maintain plant-available water for crop uptake near the soil surface.

Soil P in long-term tillage studies has been evaluated at the Swift Current Research Centre on a silt loam soil and the Brandon Research Centre on fine sandy loam and silty clay soils. Both of these facilities are part of the Agriculture and Agri-Food Canada Research Centre network on the Canadian Prairies. Swift Current is located in a semiarid region (13 in. annual precipitation, 29 in. potential evapo-transpiration), while Brandon (19 in. annual precipitation, 25 in. potential evapo-transpiration) is in the sub-humid region. Spring wheat was grown at each location, with the fertilizer P applied in the seed row at Swift Current and pre-plant banded at Brandon.

Conventional tillage at both locations involved use of a cultivator with sweeps that mixes but does not invert the soil above the depth of tillage. Soil samples were collected from the experimental plots to include both the crop row and inter-row area, and segmented into varying depths for further analysis. At Swift Current, soil P fractions were determined using the Hedley fractionation procedure. It partitions P into inorganic and organic P fractions of varying availability. Labile P is that soil P that is available or becomes available to plants and microorganisms in a time span of days to a few weeks. Moderately labile P, while not immediately available to plants, has the potential to become available over a period of months to a few years. At Brandon, soil P was determined using the 0.5 M sodium bicarbonate extraction procedure.

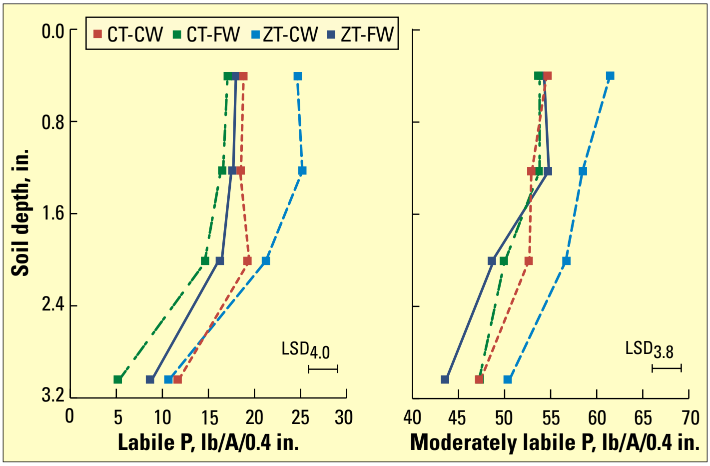

Figure 1. Distribution of labile and moderately labile P in the surface 4 in. of soil (May 1990 sampling).

At Swift Current, results showed that 12 years after converting from conventional till wheat-fallow (CT-FW) to no-till continuous wheat (ZT-CW), forms of P easily available to the crop accumulated in the surface 2.5 in. layer (**Figure 1**).

This was not the case for the no-till fallow-wheat (ZT-FW), or the conventional till continuous wheat (CT-CW), where the concentration of labile P was uniform in the top 4 in. of the soil. The labile P fraction (inorganic P extracted by an anion resin plus organic and inorganic P extracted by 0.5 M sodium bicarbonate) is the soil P that is immediately available, or becomes available to plants within days to a few weeks. This specific treatment difference was attributed to the accumulation of organic materials (crop residues and soil organic matter) at the surface of zero-tilled soils, resulting from the reduction of soil disturbance and mixing of the soil. However, it is important to note that in this study, where 15 lb P_2O_5/A were seed-placed each year, the increased soil P in the surface of no-till continuous wheat fields did not result in increased plant uptake of P. This was attributed to the proven yield increase shown by crops that receive starter P at seeding in soils that remain cool in early spring.

An enhanced P supply, arising from an increased accumulation of available forms of P, would benefit mid-season uptake of P by a high yielding crop. This is illustrated by the increase in moderately labile soil P (sodium hydroxide extractable P). Adoption of no-till seeding with continuous wheat cropping resulted in a substantial increase in plant-available P in the surface 2.5 in. of soil. In soils under zero-tillage management for some time, soil sampling procedures for P determination and P fertilizer recommendations may have to be modified to account for the accumulation of labile forms of P near the soil surface. Furthermore, the accumulation of bioavailable forms of P near the soil surface may have a substantial impact on surface water quality, if soil materials are transported from the field to surface water bodies, despite the reduced erosion risk characteristic of zero-tillage management systems.

At Brandon, soil P distribution was evaluated after completion of a four-year study comparing no-till and conventional tillage. In this study, P accumulation was recorded at the depth of banding under both conventional and no-till, and on both the sandy loam and silty clay soil types (**Figure 2**). In this trial, soils were sampled down to a depth of 6 in., in 1 in. increments. The P accumulated at the 4 in. depth, and was attributed to the repeated application of the nitrogen (N)+P bands throughout the duration of the study. The soil P concentration at the banding depth was higher under no-till than tilled management, presumably due to the lack of soil disturbance and soil mixing with tillage. This increase in P concentration likely reflects accumulation of the nutrient from the previous year's application.

One additional project evaluated the impact of tillage on the distribution of soil P at Indian Head, Saskatchewan, also in the sub-humid (16 in. annual precipitation, 24 in. potential evapotranspiration) region in a heavy clay soil. After four years, no difference was recorded in soil P at 0 to 2 in., 2 to 4 in., or 4 to 6 in. soil depths between conventional and no-till seeding systems. This study involved a series of cereal, oilseed, and grain/legume rotations. Rotation also did not have any impact on soil P distribution.

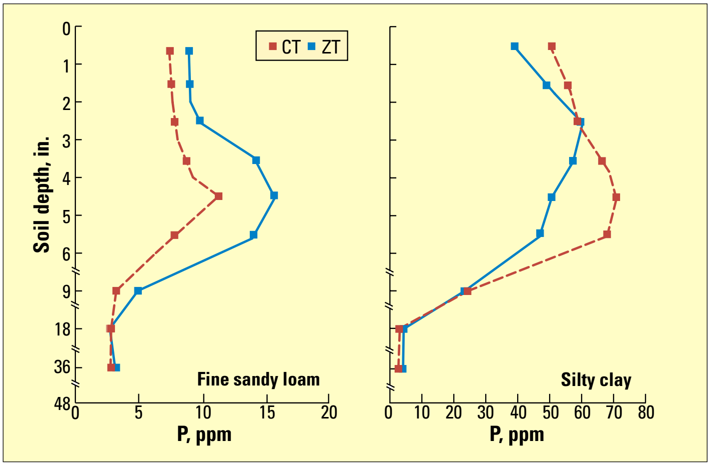

Figure 2. Effect of conventional tillage (CT) and zero tillage (ZT) on P distribution [parts per million (ppm)] through fine sandy loam and silty clay loam soil profiles.

It would appear that soil P can accumulate near the soil surface of no-till treatments, relative to conventional tillage. No negative impact was recorded in these studies due to this nutrient distribution, and is not expected to pose a problem to future production. The accumulation of surface crop residues does an excellent job of maintaining increased plant-available water in no-till fields. This will keep roots active and in a position to access accumulated nutrients. However, under drying conditions, a deficiency of P may mean that plants cannot access these surface nutrients and place an increased importance on in-soil band placement of P.

Fertilizer management with reduced and no-till seeding requires careful attention to placement in order to optimize efficiency of fertilizer-use by the crop. There is little doubt that broadcast application of P onto the residue-covered soil surface is not a realistic management option in most instances. Application of P in bands either with or close to the seed minimizes tie-up by the soil and fosters early season uptake by the crop, increasing the chances for higher crop yields.

One of the challenges facing no-till farmers is fertilizer placement. When side banding is not a choice because of the seeding opener used, the placement of starter P, K, and sulfur (S) fertilizer with the seed can often be limited by the width (spread) in which the selected opener scatters the seeds and fertilizer material. Limiting the amount of these nutrients can often reduce the response to applied N, as a result of imbalance between nutrients.

In the absence of building soil P levels prior to adopting a no-till program, deficiencies in these nutrients should be addressed with low disturbance banding operations carried out independently of seeding. Implementing the best conservation tillage practices will not make up for deficiencies, or imbalances, in soil nutrients required for optimization of crop yield and quality. BC

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