Tillage as a Stormwater Tool

Joshua L. Heitman and Richard A. McLaughlin, Department of Crop and Soil Sciences, North Carolina State University

Road construction and maintenance activities can severely impact soil physical conditions and limit their capacity to infiltrate stormwater. Prior research has demonstrated short-term benefits of tillage to reduce soil bulk density and increase surface infiltration rates on compacted soils. We conducted a study of the effects of tillage and amendments on soil properties, particularly infiltration rates, over several years at multiple locations.

Based on our study, including five trials where infiltration rate and bulk density were measured for a minimum of 24 months, benefits of tillage appear to be maintained for at least two years. Compared to compacted controls, bulk density following tillage was an average of 11% lower than that of control after 24 months or more. This translates into an average increase in soil porosity of 15%. Some small changes were sometimes observed within in the first few months after tillage, but there was generally little change (i.e., increase in bulk density) beyond the first 6 months post-tillage.

Surface infiltration rates with tillage averaged more than three times larger than compacted controls. At a minimum, infiltration rates were just less than double those observed for compacted control fill material. There was not a consistent trend upward or downward in infiltration rates from the first to the last set of observations following tillage. Compacted controls did, however, sometimes show subtle increases in infiltration rate with time.

Tillage depth was evaluated in three trials with shallow tillage targeted at 15-cm depth and deep tillage targeted at 30-cm depth. No differences were observed in surface bulk density or infiltration rate based on depth of tillage. There was an effect in terms of penetration resistance, with deeper tillage resulting in reduced penetration resistance at deeper depths within the soil profile. This may provide some long-term benefit for plant growth, but this was not evident in our observations.

Compost amendment along with tillage was tested in four of five trials. There was no effect associated with compost addition in two of the trials, which had the coarsest textured soils. In the other two trials, compost further reduced bulk density (and increased porosity) compared to tillage alone. In these two trials, only one showed increased surface infiltration with compost compared to tillage alone. Other amendments applied with tillage in one trial (cross-linked polyacrylamide and gypsum) were generally no different than tillage alone.

Traffic from routine mowing was evaluated in three trials. There was no significant effect of traffic on bulk density in any of these trials. There was an effect of traffic on infiltration rate in one trial. In that trial, traffic following tillage decreased infiltration rate compared to tillage with

no traffic. When compost was added, there was no effect of traffic compared to tillage with or without compost addition.

Overall, results from the field trials suggest that applying tillage to compacted soils post construction can have a substantial short-term benefit for reduced bulk density, increased porosity, and increased infiltration rate. These benefits appear to be maintained over periods of two years or more. Traffic may reduce benefits under some circumstances, but the addition of compost can potentially mitigate this effect.

Tillage with and without compost amendment was also evaluated in two demonstration sites along active roadways. A major difference in these evaluations was that the control comparison was an existing stand of grass rather an intentionally compacted control in the field trials. As such, these demonstration sites represent a retrofit of tillage practices to existing grass as opposed to a new construction or problem soil, which is more consistent with the control in the five field trials. For natural rainfall events at the two demonstration sites, tillage reduced runoff compared to the existing grass stand by 8 and 12% over 26 and 18 events, respectively. For the same natural rainfall events, tillage plus compost reduced runoff compared to existing grass by 38 and 48%, respectively. At one of these sites, runoff reduction compared to the control grass stand appeared to diminish within a year of tillage treatment (with or without compost). At the other site, reductions in runoff were mostly maintained throughout monitoring, although reduction was more modest with tillage alone. At the end of monitoring for each of these demonstration sites, bulk density and infiltration rate were no different between control and tillage, but bulk density was lower and infiltration rate was higher (by a factor of 2-3) for tillage with compost addition compared to control. These results suggest that there may be limited benefits of tillage in healthy grass stands unless compost is incorporated into the soil with the tillage.

Recommendations

- Tillage can provide an effective best management strategy to reduce bulk density, increase porosity, and enhance infiltration for disturbed, new construction soils. It may also be beneficial for soils in locations which are known to have problems with infiltration and grass establishment. After tillage, establishment of a vigorous grass stand is important to maintain benefits.

- Benefits of tillage for existing grass stands where there are no observed/known problems are likely to be short-term or minimal. Under these circumstances, compost addition may help to increase infiltration compared to existing grass stands.

- Depth of tillage should be targeted to loosen soil to 6-8 inches in order to lower surface density and increase surface infiltration. Tillage to greater depth did not provide an obvious benefit for stormwater management when tested in our field trials.

- Routine mowing traffic (under favorable soil moisture conditions) does not substantially reduce infiltration benefits from tillage, once grass is established. Mowing under non-ideal (wet) conditions when soil strength is reduced may have a detrimental effect on infiltration rates, and this effect will likely persist unless the soil is re-tilled. Addition of compost may help to maintain the benefit of tillage practices when more traffic is expected or necessary.

- Compost does not provide a consistent benefit under all circumstances. A single rate of compost addition was evaluated in the present studies. Additional work is needed to assess the conditions under which compost addition is necessary and the rates at which it should be applied.

- Benefits of tillage for enhanced soil porosity and increased stormwater infiltration was found to persist for two or more years, suggesting it will likely be a permanent condition unless trafficked under wet conditions.