EROSION PREVENTION AND SOIL COVER

There is no environment on Earth where the rate of soil formation exceeds the rate of soil erosion in poorly managed exposed soil. It is therefore imperative that soil erosion be minimized as much as possible. Erosion is effectively managed by maintaining a living cover of vegetation at all times. There are three types of erosion: tillage, wind and water. Tillage erosion is essentially eliminated by switching to no-till agricultural practices. Not only is the practice of tillage eliminated but soil aggregation can recover over time and the binding of soil aggregates by roots, living and dead, reduces other forms of erosion as well.

Wind erosion is exponentially related to amount of soil cover. This is a physical process and does not require that the soil cover is living. Maintaining stubble and residue covers are effective as is using living cover crops. Dry and/or cold conditions will necessitate non-living soil cover. Water use is increased when plants are present through transpiration. Therefore, living cover crops in arid regions will deplete soil moisture such that the cash crop productivity may be hindered. The biomass returned to the soil by these crops is also reduced. Wind erosion is also affected by soil texture and landform. Coarse textured soils tend to dry out quicker and are less cohesive making them susceptible to wind erosion. Sand sized particles do not tend to travel far and wind erosion of sands tends to be limited to within a field. Silts and clays are harder to detach but once suspended are easily transported long distances. Exposed hilltops are much more susceptible to wind erosion but long stretches of flat land can lead to even greater wind erosion as windspeeds increase along the uninterrupted terrain.

Water erosion has some similarities to wind erosion in that well aggregated clays are difficult to detach but can travel greater distances once they are detached. However, water erosion tends to be concentrated in different areas of a field, particularly within water flow paths. The longer and steeper the flow path, as well as the larger the catchment area, the greater the potential for water erosion. The erosivity of water is related to the velocity at which the water is flowing. Steep slopes contribute to increased velocity but so do long slopes where water can gain momentum and depth. Any interruption to the flow of water reduces the erosive power. Residue cover plays an important role in interrupting the flow of water and is sufficient for limiting water erosion throughout much of a field. Areas where water collects and flows may need more aggressive erosion prevention. Permanent vegetation is the most effective mechanism for preventing water erosion. Silt traps can be used if necessary to trap sediment to prevent downstream impacts.

In highly productive areas, there may be excessive crop residues such that seeding operations and crop emergence are hindered (see Figure 1). In these situations, a reduction in the amount of crop residues retained may be necessary for farm operations, yet, some residues do still need to be retained for nutrient cycling, carbon sequestration, and preventing erosion. Because SWAT MAPS integrate topographic and soil texture information, they can be used effectively to identify erosion risks and develop an erosion prevention plan. Additionally, in-season imagery (such as with SWAT CAM) can be used to assess soil cover to ensure that management practices are retaining adequate soil cover, living or non-living.

Figure 1*. Examples of the impact of crop residues in different zones. Top image shows light residue in a Zone 1 with excellent early growth. Bottom image shows thick residue in a Zone 10 with excess moisture and cold soil slowing emergence.*

Phosphorus (P) runoff into surface waters is a major issue worldwide, particularly in areas of intensive agriculture. In high enough concentrations, phosphorus causes eutrophication of water bodies, leading to algae blooms, death of fish and other aquatic wildlife, and in some cases toxins in the water rendering it unusable for livestock (Government of Canada, 2020; Alexander et al. 2008). Studies have shown that the amount of P measured in runoff from fields is highly correlated to soil test P in the soil surface (Duncan, et al., 2017; Little et al. 2006; Cornell University Cooperative Extension, 2021). Agriculture must strive to achieve a level of soil P that doesn't result in loss of productivity, balanced against any risk to the environment. Fortunately, advanced 4R Nutrient Stewardship guidelines for phosphorus—that help guide the right source, rate, time and place of phosphate fertilizers and manures—help reduce the potential of high soil P loading that leads to increased runoff. While 4R practices cannot directly quantify reductions in P loss, the guidelines may currently be the most practical tool available to farms to mitigate environmental loss of P without compromising soil productivity (Bruulsema, 2017). SWAT MAPS allow a farm to identify areas with high soil P levels, allowing reduced P applications in these areas to draw down excess soil P levels. *Phosphorus typically has low mobility in soils and much of the contamination of surface water bodies is through soil erosion, where soil particles containing excess P are eroded from fields and deposited in surface water.* As such, mitigating soil erosion along with appropriate 4R phosphorus management prevents most phosphorus contamination from fertilizers.

Metrics

Stubble height is an important contributor to the efficacy of stubble to mitigate wind driven erosion. However, the achievable stubble height is highly dependent on the crop type and how tall the crop grew in that particular field, zone, and year. As such, actual field measurements of stubble height should be limited to checks as to whether the farmer is following this general principle rather than measuring actual stubble heights. Soil cover by trash and living plants can be estimated from manually analyzing quadrats within a field for percent coverage or by automated imagery instruments and analyses such as SWAT CAM (example image shown in Figure 2). The duration that bare soil persists is more important than the percent coverage averaged over the course of the year provided that there is at least a modest amount of soil cover.

Recommended Metric: Soil cover presence measured by automated imagery (such as SWAT CAM).

Figure 2. *A SWAT CAM picture showing two years of crop residue and stubble from durum (2022) and canola (2023). Picture was taken after snow melt on April 22, 2024, prior to sowing lentil with a low disturbance drill.*

References

Alexander, R. B., Smith, R. A., Schwarz, G. E., Boyer, E. W., Nolan, J. V., & Brakebill, J. W. (2008). Differences in phosphorus and nitrogen delivery to the Gulf of Mexico from the Mississippi River Basin. *Environmental Science & Technology*, *42*(3), 822-830.

Bruulsema, T. (2017). 4R Phosphorus management practices for major commodity crops of North America. *International Plant Nutrition Institute, Norcross, GA*, 12.

Cornell University Cooperative Extension. (2021, May). *How to Calculate the NY Phosphorus Index*. Retrieved from Agronomy Fact Sheet Series- Fact Sheet 10: http://cceonondaga.org/resources/how-to-calculate-the-ny-phosphorus-index

Cornell University Cooperative Extension. (2021, May). *Managing P Runoff with the P Index*. Retrieved from Agronomy Fact Sheet Series - Fact Sheet 13: http://nmsp.cals.cornell.edu/publications/factsheets/factsheet13.pdf

Duncan, E. W., King, K. W., Williams, M. R., LaBarge, G., Pease, L. A., Smith, D. R., & Fausey, N. R. (2017). Linking soil phosphorus to dissolved phosphorus losses in the Midwest. *Agricultural & Environmental Letters*, *2*(1), 170004.

Government of Canada. (2020, January 24). Agriculture and Water Quality. Retrieved from Agriculture and Water Quality: https://www.agr.gc.ca/eng/agriculture-and-the-environment/agriculture-and-water/watershed-protection/agriculture-and-water-quality/?id=1371491033072

Little, J. L., Nolan, S. C., & Casson, J. P. (2006). Relationships between soil-test phosphorus and runoff phosphorus in small Alberta watersheds. 150 pp. Alberta soil phosphorus limits project, 2.

Acronym & Abbreviation Guide

4R — Right Source, Right Rate, Right Time, Right Place
Nutrient stewardship framework to optimize nutrient use efficiency and reduce losses.

SWAT CAM
High-resolution imaging tool used to measure bare soil, residue, crop canopy, and weed distribution.

SWAT MAPS
High-resolution soil, water, and topography maps forming the foundation of precision agronomy within the SWAT ECOSYSTEM.