Crop residues and their impact on crop production: a review

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Abstract

Water conservation and storage, nutrient availability, and crop yields can improve by returning crop residue. Efficient utilization of crop residue may have beneficial impact on soil and crop production. We theorized that residual influences of crop residues vary with the amount of residues used. Crop residue amounts depend on crop growth and selected soil properties. From 1978 through 1985, crop residues were reverted at 0,50, 100, and 150% of the quantity produced by the previous crop (averaging 0 to =6 Mg ha-' yr-I). Residual effects of the 150% residue amount increased grain production 16% compared with the 0% amount (4900 vs. 4250 kg ha-', respectively), and were not affected by time or other management practices. Increasing previous residue amount did enhance soil N availability (from 73.0 to 82.3 kg autoclavemineralizable N ha-') and Bray soil P (16.7 to 20.3 kg ka-'). Residual effects of crop residue are prolonged (half-life of = 10 yr) and probably result from changes in soil properties that boost soil nutrient availability. Previous crop residues provide a valuable source of organic matter that can be used for soil fertility restoration or external use. In order to manage agricultural land sustainably, a better understanding of the effect of crop residue management on the soil-water-plant system is needed.

Keywords: Crop production, Growth, residue, soil

Introduction

Returning increased amounts of crop residues to the soil increased soil organic matter content, microbial activity, nutrient availability, water infiltration and storage, and crop yields (Unger and McCalla, 1980; Fribourg and Bartholomew, 1956; Prasad and Power, 1991). By using management practices such as type of tillage, fertilization, and use of cover crops can modify the crop residue amonut (Maskina et al., 1993). Understanding the effects of crop residues on soil properties and crop yields may be of greater standing in the future because of interest in using crop residues for production of paper products and ethanol. This is in addition to the conventional use of crop residues for fodder and bedding. Unfortunately, we presently have little information to evaluate the long-term impact of returning crop residues on soil productivity. Currently, we do not know the magnitude or duration of the effects of crop residue management practices on soil properties and crop production after we terminate to use these practices. Crop yields after we ceased returning crop residues in various amounts. It is believable that the management practices used for crop production could modify the type of response we obtained to the residual effects of using various crop residue amounts. Generally as quantity of crop residue increased, soil temperature decreased, soil water storage increased, and crop yields (both grain and stover) increased (Power et al 1998). The 16% greater grain yields of the 150% crop residue amounts over the 0% amount relates favorably with the 17% response documented by Maskina et al. (1993). Part of the crop residues derived from annual cropland are commonly exported for external use, such as fodder or bioenergy production in temperate regions with silty loamy soils. Since cropland is fertilized with manure from cattle fed with crop residues in mixed farming, residues are not completely exported in the case of fodder. It's also necessary to consider the size of the residues. The mineralization rate is influenced by the region of soil-residue interaction. The broader the area of interaction with soil and microorganisms have limiting the residues. Cereal straw should be chopped and spread uniformly on the ground in a no-tillage method (reviewed in Soane et al., 2012). A major factor is the height at which the plant is cut at harvest. It is important to note that crop residues are not only the above-ground part not harvested for crop production, but also the below-ground parts. Root systems are crop residues consistently incorporated into the soil (Soane et al., 2012). The roots correspond to a certain quantity of organic matter and are also affected by type of tillage. Different crop types produce different quantities and sizes of residues at different depths.

Crop residue

The above-ground portions of the plant that are not harvested for food production are known as crop residues. And when residues are exported, the stubble (of cereals) is still left on the ground. Crop yield and crop type are the two main factors that influence the amount of crop residue produced. Where crop yields are lower, such as in south-eastern Europe, the amount of residue produced is higher. Lignin, cellulose, hemicellulose, as well as micro and macronutrients, make up crop residues. These residues degrade differently depending on their lignin and cellulose content, as well as their C/N ratio, which is crop dependent, as well as the climate and soil conditions. High-C/N residues (e.g., wheat straw) decompose slowly, resulting in the immobilisation of soil nitrogen. It's important to remember that crop residues include both the above-ground and below-ground sections of the plant that haven't been harvested for crop production.

Crop residues that are continuously immersed into the soil are known as root systems (Soane et al., 2012). The roots are influenced by the form of tillage and correspond to a certain amount of organic matter. Crop varieties contain a range of quantities and sizes.

Impact of crop residue

It is important to define soil structure in order to understand the impact of any form of land management on soil hydraulic properties. The arrangement of soil particles (sand, silt, and clay) into aggregates or peds is referred to as soil structure. Water storage and movement, air exchange between soil and atmosphere, and heat transfer are all influenced by soil structural patterns.

1. Organic matter in the soil and aggregate constancy: The content of soil organic carbon (SOC), especially the fraction of labile SOC (also known as "particulate organic matter" because it cycles relatively quickly in the soil) has a significant impact on the quality of soil structure (Tisdall et al., 1982). Labile organic matter is also important for preserving soil structure and providing nutrients. Soils with a high organic matter content have larger, deeper, and more durable aggregates that resist compaction, while soils with a low organic matter content have the opposite. A soil with less than 3.4 percent organic matter (i.e., 2 percent SOC) is commonly known to have unstable aggregates and is thus vulnerable to soil degradation in temperate European regions. Exposure to rainfall has the greatest impact on aggregate stability at the soil surface. A bare soil (one in which crop residues have been exported or ploughed into the soil) is in direct contact with raindrops, facilitating the breakdown of soil aggregates and thereby increasing soil erodibility. Under conservation tillage, macro-aggregates, on the other hand, play an important role in preserving organic matter by slowing its decomposition (Beare et al., 1994). De Gryze et al. (2005) found that macro-aggregate formation had a linear relationship with wheat straw incorporation, but no relationship with soil temperature, in a laboratory experiment focusing on the short-term dynamics of macro-aggregates.

2. Soil compaction: Complete porosity, pore size distribution, bulk density, and penetration resistance are the four metrics used to measure soil compaction. Since soil compaction inhibits root development, these measures are likely to be negatively associated with root growth and rooting depth. Whether or not residues are present, tillage has a significant impact on soil compaction. Tebrügge et al. (1999) observed lower bulk density at the surface layer in no-tilled treatments due to the accumulation of crop residues on the surface in a long-term analysis in Germany. They found that a no-tilled treatment had higher bulk density (at 0-30 cm) than reduced and traditional tillage treatments.

3. Water retention: Tillage practises combined with crop residue application affect not only the cover rate at the soil surface, but also the total soil porosity and organic matter content. Mulumba et al. (2008) used wheat straw as mulch at various rates on tilled and uncropped soils to assess water retention and usable water capacity at a depth of 0-10 cm.

4. Role of crop residue in crop production: Residue management has a dynamic and variable impact on crop production, resulting from both direct and indirect effects and interactions. One direct impact is the presence of residues on the soil surface, which creates a direct barrier to crop emergence. Indirect effects include residue mineralization, which increases the amount of nutrients available to plants, or the presence of pesticides. Climate and weather factors must be taken into account when researching the effect of crop residue management on crop production, as previously mentioned. Years that are hot and dry would not have the same impact as years that are colder and wetter. Despite the fact that research on the effects of crop residue management has been carried out in various parts of Europe and around the world, there is still a need to obtain results for particular contexts.

5. Growth and development: It matters not only whether or not residues are added, but also where they are located in the soil profile, for crop emergence. Gallardo-Carrera et al. (2007) found that soil crusting in the absence of residues at the soil surface, combined with high air humidity and regular rainfall, decreases germination quality. Crusting is more likely when the soil contains moisture, in addition to the effect of raindrop effects. The presence of crop residues above the seeds can slow or obstruct crop emergence, forcing seedlings to work around the physical barrier (Arvidsson et al., 2014). Wuest et al. (2000) demonstrated in a glasshouse experiment in Oregon that residues above winter wheat seeds (as in no-tillage) or mixed around the seeds (as in reduced tillage) block the cole and delay crop emergence.

6. Nutrient uptake: In this part, we'll look at two of the most important nutrients for plant growth: nitrogen and phosphorus (P). As far as we know, no research has been done on the relationship between residue management and plant potassium (K) uptake. In the first section of this study, the effect of crop residue management on soil chemical properties (specifically N and P in soils) was addressed (Lemtiri et al., 2016).

7. Crop yield: Pittelkow et al. (2015) found that zero-tillage reduces yield in humid climates (aridity index greater than 0.65) regardless of residue retention, while in dry climates (aridity index less than 0.65) zero-tillage in combination with residue retention and crop rotations increases rainfed crop productivity. They also mentioned that retaining residue is critical. A combination of unfavourable weather conditions (wet years) and residue retention will result in yield reduction (Riley, 2014). In drier years, however, crop residue retention will improve water conservation in soils, resulting in higher yields (Linden et al., 2000; Riley, 2014).

Conclusion

The variety and contrasting effects of crop residue management on soil physical properties, soil functions, and crop production have been illustrated in this study. We spoke about how important the environment (soil and climate) is, as well as the complicated relationships between the different compartments of the soil-water-plant system. Crop residue preservation has a number of environmental and ecological benefits. In terms of soil hydraulic properties, crop residues on the soil surface increase hydraulic conductivity at the surface, while tillage affects soil hydraulic properties both above and below the surface. However, the impact of crop residue management on soil hydraulic properties is unknown. One of the key reasons for this is that there aren't enough research on the topic. It is undeniable that residue preservation improves long-term soil quality, but it is also undeniable that it is not sufficient for all agro ecosystems in terms of crop output. The impact of crop residue management on crop production is heavily influenced by soil type, crop rotation, and, in particular, weather conditions. It has been shown, for example, that combining wet and dry. According to the literature review, research on soil physical properties seldom consider crop production, and vice versa. In order to disentangle the network of interactions and discern direct from indirect effects, studies of the entire soil-water-plant system should be performed rather than independent studies on separate soil functions. Given the significance and variability of the experimental background, as well as the lack of cross-disciplinary approaches in most studies, crop residue management studies should take a holistic approach. Despite the fact that several studies have been conducted around the world on the effect of crop residue management on various aspects of the soil-water plant system, more are required that conform to high exclusion criteria.

References

Arvidsson J., Etana A. & Rydberg T., 2014. Crop yield in Swedish experiments with shallow tillage and no-tillage 1983-2012. Eur. J. Agron., 52, 307-315.

Austin A.T. & Ballaré C.L., 2010. Dual role of lignin in plant litter decomposition in terrestrial ecosystems. Proc. Natl. Acad. Sci., 107(10), 4618-4622.

Bassem Dimassi J.-P.C., 2013. Changes in soil carbon and nitrogen following tillage conversion in a long-term experiment in Northern France. Agric. Ecosyst. Environ., 169, 12-20.

Beare M.H. et al., 1994. Aggregate-protected and unprotected organic matter pools in conventional- and no-tillage soils. Soil Sci. Soc. Am. J., 58(3), 787

Brennan J. et al., 2014. The effect of tillage system and residue management on grain yield and nitrogen use efficiency in winter wheat in a cool Atlantic climate. Eur. J. Agron., 54, 61-69.

Bronick C.J. & Lal R., 2005. Soil structure and management. Geoderma, 124(1-2), 3-22. Buysse P. et al., 2013. Fifty years of crop residue management have a limited impact on soil heterotrophic respiration. Agric. For. Meteorol., 180, 102-111.

Chenu C. et al., 2014. Stocker du carbone dans les sols agricoles : évaluation de leviers d'action pour la France. Innov. Agron., 37, 23-37.

Christian D.G. & Miller D.P., 1986. Straw incorporation by different tillage systems and the effect on growth and yield of winter oats. Soil Tillage Res., 8, 239-252.

Silva A.P., Nadler A. & Kay B.D., 2001. Factors contributing to temporal stability in spatial patterns of water content in the tillage zone. Soil Tillage Res., 58(3-4), 207-218.

Dam R.F. et al., 2005. Soil bulk density and crop yield under eleven consecutive years of corn with different tillage and residue practices in a sandy loam soil in central Canada. Soil Tillage Res., 84(1), 41-53.

De Gryze S. et al., 2005. A quantification of short-term macroaggregate dynamics. Soil Biol. Biochem., 37(1), 55-66.

Franzluebbers A.J., 2002. Water infiltration and soil structure related to organic matter and its stratification with depth. Soil Tillage Res., 66(2), 197-205.

Gallardo-Carrera A. et al., 2007. Effects of seedbed structure and water content at sowing on the development of soil surface crusting under rainfall. Soil Tillage Res., 95(1-2), 207-217.

Green T.R., Ahuja L.R. & Benjamin J.G., 2003. Advances and challenges in predicting agricultural management effects on soil hydraulic properties. Geoderma, 116(1-2), 3-27.

Holland J.M., 2004. The environmental consequences of adopting conservation tillage in Europe. Agric. Ecosyst. Environ., 103(1), 1-25. Karlen D.L. et al., 1994. Crop residue effects on soil quality following 10-years of no-till corn. Soil Tillage Res., 31, 149-167.

Kladivko E.J., 1994. Residue effect on soil physical properties. In: Unger P.W. Managing agricultural residues. Boca Raton, FL, USA: Lewis Publishers, 448.

Lahmar R., 2010. Adoption of conservation agriculture in Europe. Land Use Policy, 27(1), 4-10.

Lemtiri et al., 2016. Crop residue management in arable cropping systems under temperate climate. Part 1: Soil biological and chemical (phosphorus and nitrogen) properties. A review. Biotechnol. Agron. Soc. Environ., 20(S1)

Lewis D.B. et al., 2011. Labile carbon and other soil quality indicators in two tillage systems during transition to organic agriculture. Renewable Agric. Food Syst., 26(4), 342-353.

Linden D.R., Clapp C.E. & Dowdy R.H., 2000. Long-term corn grain and stover yields as a function of tillage and residue removal in east central Minnesota. Soil Tillage Res., 56(3-4), 167-174.

MacLeod C.A. & Schoenau J., 1997. The influence of crop residues on plant phosphorus uptake, http://www.usask.ca/soilsncrops/conferenceproceedings/previous_years/Files/97/1997docs/564.PDF, (04.10.2015).

Malhi S.S. et al., 2011. Influence of long-term tillage, straw, and N fertilizer management on crop yield, N uptake, and N balance sheet in two contrasting soil types. Commun. Soil Sci. Plant Anal., 42(20), 2548-2560.

Messing I. & Jarvis N.J., 1993. Temporal variation in the hydraulic conductivity of a tilled clay soil as measured by tension infiltrometers. J. Soil Sci., 44(1), 11-24.

Morris N.L. et al., 2010. The adoption of non-inversion tillage systems in the United Kingdom and the agronomic impact on soil, crops and the environment – A review. Soil Tillage Res., 108(1-2), 1-15.

Müller M., Kurz G. & Yaramanci U., 2009. Influence of tillage methods on soil water content and geophysical properties. Near Surf. Geophys., 7(1), 27-36.

Mulumba L.N. & Lal R., 2008. Mulching effects on selected soil physical properties. Soil Tillage Res., 98(1), 106-111.

Noack S.R. et al., 2014. Management of crop residues affects the transfer of phosphorus to plant and soil pools. Soil Biol. Biochem., 71, 31-39.

Pagliai M., Vignozzi N. & Pellegrini S., 2004. Soil structure and the effect of management practices. Soil Tillage Res., 79(2), 131-143.

Peel M.C., Finlayson B.L. & McMahon T.A., 2007. Updated world map of the Köppen-Geiger climate classification. Hydrol. Earth Syst. Sci., 11(5), 1633-1644.

Pittelkow C.M. et al., 2015. Productivity limits and potentials of the principles of conservation agriculture. Nature, 517(7534), 365-368.

Ramos M.C., Nacci S. & Pla I., 2003. Effect of raindrop impact and its relationship with aggregate stability to different disaggregation forces. CATENA, 53(4), 365-376.

Rasmussen K.J., 1999. Impact of ploughless soil tillage on yield and soil quality. Soil Tillage Res., 53(1), 3-14.

Riley H., 2014. Grain yields and soil properties on loam soil after three decades with conservation tillage in southeast Norway. Acta Agric. Scand. Sect. B, 64(3), 185-202.

Singh B. et al., 1994. Residue and tillage management effects of soil properties of a typic cryoboroll under continuous barley. Soil Tillage Res., 32(2- 3), 117-133.

Six J. et al., 1998. Aggregation and soil organic matter accumulation in cultivated and native grassland soils. Soil Sci. Soc. Am. J., 62(5), 1367.

Soane B.D. et al., 2012. No-till in northern, western and south-western Europe. Soil Tillage Res., 118, 66-87. Soil Classification Working Group, 1998. The Canadian system of soil classification. Ottawa, ON, Canada: National Research Council of Canada.

Soon Y.K. & Lupwayi N.Z., 2012. Straw management in a cold semi-arid region. Field Crops Res., 139, 39-46.

Starr J.L. & Timlin D.J., 2004. Using high-resolution soil moisture data to assess soil water dynamics in the Vadose zone. Vadose Zone J., 3(3), 926.

Swan J.B. et al., 1994. Surface residue and in-row treatment effects on long-term no-tillage continuous corn. Agron. J., 86(4), 711.

Tebrügge F. & Düring R.-A., 1999. Reducing tillage intensity – a review of results from a long-term study in Germany. Soil Tillage Res., 53(1), 15-28.

Tisdall J.M. & Oades J.M., 1982. Organic matter and water-stable aggregates in soils. J. Soil Sci., 33(2), 141-163.

Turmel M.-S. et al., 2015. Crop residue management and soil health. Agric. Syst., 134, 6-16. USDA, 1999. Soil taxonomy A basic system of soil classification for making and interpreting soil surveys. Washington: USDA.

Van-Camp L. et al., 2004. Reports of the technical working groups established under the thematic strategy for soil protection. EUR 21319 EN/6. Luxembourg: Office for Official Publications of the European Communities.

Van den Putte A. et al., 2010. Assessing the effect of soil tillage on crop growth. Eur. J. Agron., 33(3), 231-241.

van Es H.M. et al., 1999. Integrated assessment of space, time, and management-related variability of soil hydraulic properties. Soil Sci. Soc. Am. J., 63(6), 1599.

Vogeler I. et al., 2009. Effect of tillage systems and P-fertilization on soil physical and chemical properties, crop yield and nutrient uptake. Soil Tillage Res., 103(1), 137-143.

Wahl N.A. et al., 2004. Effects of conventional and conservation tillage on soil hydraulic properties of a silty-loamy soil. Phys. Chem. Earth Parts ABC, 29(11-12), 821-829.

Wuest S.B., Albrecht S.L. & Skirvin K.W., 2000. Crop residue position and interference with wheat seedling development. Soil Tillage Res., 55(3), 175-182.