Article Id
AL04169

COVER CROPS FOR SOIL FERTILITY AND EROSION CONTROL: A REVIEW

Hehlangki Tyngkan

Email

hehtyngkan@gmail.com

School of Social Science, Department of Agricultural Economics, CPGSAS, CAU (I), Umiam-793103, Meghalaya, India

Soil erosion and degradation is a serious problem globally, especially in the less developed tropical and sub-tropical countries (Lal, 2001). For instance, it has been calculated that between 1980 and 1990, 494, 748, and 243 Mha, respectively, of land in Africa, Asia, and South America were damaged by human-induced soil erosion (Oldeman *et al.*, 1991). As a result, the production and quality of the soil diminish.

Cover crops (CCs) can be added to crop rotation cycles as a strategy to boost production while reducing soil erosion and managing soil and its nutrients sustainably (Dabney, Delgado and Reeves, 2001). Cover crops (CCs) can offer a variety of benefits for the soil, agricultural production, and the environment (Blanco-Canqui *et al.*, 2015).

Cover crops are defined as the crops which are used to cover the ground surface. These crops are cultivated to prevent from soil erosion and limit the loss of nutrients from deep layers due to leaching and surface runoff (Kaye and Quemada, 2017). In order to increase agricultural production and productivity, cover crops are sown in between the main crops.

According to the Soil Science Society of America Glossary of Terms, CCs are defined as a "close-growing crop that provides soil protection, seeding protection, and soil improvement between periods of normal crop production, or between trees in orchards and vines in vineyards. When ploughed under and incorporated into the soil, CCs may be referred to as green manure crops" (SSSA, 2008).

Cover crops are grown due to the numerous benefits they provide, including protecting the soil from wind and water erosion (Dabney *et al.*, 2001). Both living CCs and their leftover deposit on the soil can prevent soil moisture from evaporating by covering it. Cover crops can also improve soil porosity through bio-pores created by roots and increased

earthworm activity, which enhances water infiltration into the soil and decreases runoff (Ruan *et al.*, 2001; Lal *et al.*, 1991). In comparison to no cover crops (NCCs), cover crops have been shown to improve soil physical properties by decreasing soil bulk density (Blanco-Canqui *et al.*, 2011; Haruna *et al.*, 2018), enhancing soil organic carbon (SOC) and aggregation (Steenwerth and Belina, 2008), increasing the proportion of macro pores, increasing water retention saturated hydraulic conductivity and water infiltration, and decreasing soil loss (Cercioglu *et al.*, 2018). This review places special attention on the role of cover crops in retaining soil moisture, reducing soil erosion, enhancing soil and water quality, and bringing about economic benefits.

Soil Erosion Control

In essence, cover crops are planted to prevent soil erosion. These are the best erosion control technologies and environmental preservation techniques. The pioneering work done in Belgium with various cover crops, such as white mustard (*Sinapis alba*), phacelia (*Phacelia tanacetifolia*), oats (*Avena sativa*), ryegrass (*Lolium perenne*), and fodder radish, illustrates the significance of cover crops for limiting soil erosion (*Raphanus sativus sub sp. oleiferus*). The findings showed that the root densities of cover crops ranged from 1.02 kg m3 for phacelia to 2.95 kg m3 for ryegrass. Crop species with fibrous root system (e.g. ryegrass, rye and oats) show high potential to control soil erosion while cover crops with thick roots (e.g. white mustard and fodder radish) are less effective in preventing soil erosion (De Baets *et al.*, 2011).

Soil Moisture Content

In the maize-soybean cropping system, it was found that using cereal rye (*Secale cereale L.*) as cover crop improved soil water (Qi and Helmers, 2010). Similar results were obtained in a 7-year research that used repeated winter rye as a cover crop in the maize-soybean cropping system, which was proven to be successful in preserving soil moisture and raising the soil water table. Reduced evaporation from the soil surface, moisture conservation from irrigation and rainfall, and improved soil moisture availability for succeeding crops are all benefits of using cover crops. Cover crops increased water retention in soil at water potentials related to field capacity and plant available water by 10– 11 per cent and 21 – 22 per cent, respectively (Basche *et al.*, 2016).

Winter annual rye cover crop helps to increase water at field capacity and hence winter annual rye and hairy vetch increase available plant water content (Villamil et al., 2006). Cover crops act as a hindrance between the soil surface and precipitation especially rainfall, it enables to reduce the rainfall intensity that falls on the ground. Through soil pores, which are created by soil macrofauna and reinforced by cover crop root growth, water drips slowly into the ground. Soil water storage is recharged as water infiltration rises rather than draining off (Sharma *et al.,* 2011; Sammis *et al.,* 2012). Another study from the University of California found that cover crops such brome grass, native plants, and strawberry clover can reduce the strength of the soil's surface by 38 per cent to 41per cent, as well as improve soil infiltration rate by 37 per cent to 41per cent and total water uptake by 20 per cent to 101per cent (Folorunso*et al.*, 1992).

Soil and Water Quality

A 25-year study on conventional tillage demonstrates that cover crops can improve soil permeability, soil organic matter, macroporosity, and cotton production. Oats and rye, which are winter cover crops, can increase soil organic carbon in a corn-soybean farming system (Kaspar *et al.,* 2006). Cover crops increase soil water content with the crop biomass and infiltration. However, it also involves decreasing water content through transpiration. Additionally, cover crops assist in preserving soil quality and reducing surface runoff (Qi and Helmers, 2010). Another study that used cover crops under no-tillage (NT), mould board plough (MP), and chisel plough (CP) treatments in annual corn and soybean cropping systems was carried out in Southern Illinois for 12 years. The yield of both treatments with and without cover crops is the same, but the soil organic carbon content of the cover cropped plots was higher (Olson *et al.*, 2014).

Economic Consideration

Winter rye was used as a cover crop for cotton in an experiment that gave yields ranging from $26 to 355 with an average of $81/ha (Schomberg *et al.*, 2014). It was found that cover crops in a no-tillage system and minimum tillage would be $25.60/acre and $15.10/acre, respectively. It is suggested that cover crops may be beneficial in future as continuous use of cover crops improves soil organic carbon, physical properties and level of organic matter (Schnitkey*et al.*, 2016). Economics of cover crops depend on the soil type, weather conditions, region and also the management practices. The economics of cover crops are influenced by the soil type, climate, geographic location, and management techniques.

Utilizing hairy vetch as a cover crop in the cotton production in Northwest Louisiana, the economic effects of short-term and long-term adoption of cover crops were evaluated. Benefits for nutrient credits include decreasing the need for fertilizer (N, P, and K), reducing erosion, spending less on herbicides, and increasing the yield of cash crops after cover crops. The long-term use of cover crops has been demonstrated to improve soil water retention and fertility. An additional benefit for using long-term cover crops resulted by an increase of $13/acre/year as compared to short-term analysis. Overall, total net benefits found to be $1354/acre/year for adoption of long-term cover crops (Adusumilli *et al.*, 1016).

Conclusion

Review suggests that cover crops have excessive ability to contribute to sustainable agriculture production. By minimizing soil erosion (both water and wind erosion), which in turn increased soil hydraulic characteristics (water infiltration), and by boosting the soil organic carbon, cover crops improve the general health of the soil. However, varied advantages of utilizing cover crops depend on the species chosen (legumes, non-legumes, grasses, and brassicas), when the crop is planted and harvested, and how it is harvested (mechanical or chemical). For example, it has been discovered that cover crop species with fibrous root systems are more successful at controlling soil erosion than those with tap roots. After extensive use, cover crops are typically advantageous since research shows that their extensive use has led to cost-effective utilization. Numerous aspects need to be researched, such as the allelopathy effect of employing cover crops, the usage of various cover crop combinations, and their management techniques for enhancing soil health and quality.

Reference

Adusumilli, N., Davis, S.,& Fromme, D. (2016) Economic evaluation of using surge valves in furrow irrigation of row crops in Louisiana: A net present value approach. *Agricultural Water Management,* 174, 61-65. https://doi.org/10.1016/j.agwat.2016.04.024.

Basche, A.D., Kaspar, T.C., Archontoulis, S.V., Jaynes, D.B., Sauer, T.J., Parkin, T.B.,& Miguez, F.E. (2016). Soil Water Improvements with the Long-Term Use of a Winter Rye Cover Crop. *Agricultural Water Management,* 172, 40-50. https://doi.org/10.1016/j.agwat.2016.04.006.

Blanco-Canqui, H., Mikha, M. M., Presley, D. R.,& Claassen, M. M. (2011). Addition of cover crops enhances no-till potential for improving soil physical properties. *Soil Science Society of America Journal*, 75(4), 1471–1478. https://doi.org/10.2136/sssaj2010.0430.

Blanco-Canqui, H., Shaver, T.M., Lindquist, J.L., Shapiro, C.A., Elmore, R.W., Francis, C.A.,& Hergert, G.W. (2015). Cover crops and ecosystem services: Insights from Studies in Temperate Soils.*Agronomy journal*, 107(6), 2449-2474.

Cercioglu, M., Anderson, S. H., Udawatta, R. P.,& Haruna, S. I. (2018). Effects of cover crop and biofuel management on computed tomography-measured pore parameters. *Geoderma*, 319, 80– 88. https://doi.org/10.1016/j.geoderma.2018.01.005.

Dabney, S. M., Delgado, J. A. ,& Reeves, D. W. (2001). Using winter cover crops to improve soil and water quality. *Communications in Soil Science and Plant Analysis*, 32(7–8), 1221–1250. https://doi.org/ 10.1081/CSS-100104110.

De Baets, S., Poesen, J., Meersmans, J.,& Serlet, L. (2011) Cover crops and their erosion-reducing effects during concentrated flow erosion. *Catena*, 85, 237-244.

Folorunso, O., Rolston, D., Prichard, T.,& Loui, D. (1992). Soil surface strength and infiltration rate as affected by winter cover crops. *Soil Technology*, 5, 189-197. https://doi.org/10.1016/0933-3630(92)90021-R.

Haruna, S. I., Anderson, S. H., Nkongolo, N. V., Reinbott, T.,& Zaibon, S. (2017). Soil thermal properties influenced by perennial biofuel and cover crop management. *Soil Science Society of America Journal*, 81, 1147–1156. https://doi.org/10.2136/sssaj2016.10.0345.

Kaspar, T., Parkin, T., Jaynes, D., Cambardella, C., Meek, D., &Jung, Y. (2006). Examining Changes in Soil Organic Carbon with Oat and Rye Cover Crops Using Terrain Covariates. *Soil Science Society of America Journal*, 70, 1168-1177. https://doi.org/10.2136/sssaj2005.0095.

Kaye, J.P.,& Quemada, M. (2017) Using Cover Crops to Mitigate and Adapt to Climate Change. Review. *Agronomy for Sustainable Development*, 37, 4. https://doi.org/10.1007/s13593-016-0410-x.

Lal, R. (1997). Degradation and resilience of soils. Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 100, 997–1010. https://doi.org/10.1098/rstb.1997.0078.

Lal, R. (2001). Soil degradation by erosion. *Land Degradation & Development*, 12, 519–539. https://doi.org/10.1002/ldr.472.

Lal, R., Regnier, E., Eckert, D. J., Edwards, W. M.,& Hammond, R. (1991). Expectations of cover crops for sustainable agriculture. In W. L., Hargrove (Ed.), Cover crops for clean water (pp. 1–11). Ankeny, IA: Soil and Water Conservation Society of America.

Oldeman, L. R., Hakkeling, R. T. A., & Sombroek, W. G. (1991). World map of the status of human-induced soil degradation: An explana tory note. Wageningen: International Soil Reference and Information Center.

Olson, K.R., Al-Kaisi, M., Lal, R.,& Lowery, B. (2014). Examining the paired comparison method approach for determining soil organic carbon sequestration rates. *Journal of Soil and Water Conservation*, 69, 193A-197A.

Qi, Z., & Helmers, M.J. (2010) Soil Water Dynamics under Winter Rye Cover Crop in Central Iowa. Vadose Zone Journal , 9, 53-60. https://doi.org/10.2136/vzj2008.0163.

Ruan, H., Ahuja, L. R., Green, T. R.,& Benjamin, J. G. (2001). Residue cover and surface-sealing effects on infiltration. *Soil Science Society of America Journal*, 65, 853–861.https://doi.org/10. 2136/sssaj2001.653853x .

Sammis, T., Sharma, P., Shukla, M., Wang, J.,& Miller, D. (2012). A water-balance drip-irrigation scheduling model. *Agricultural Water Management*, 113, 30-37. https://doi.org/10.1016/j.agwat.2012.06.012.

Schnitkey, G., Coppess, J.,&Paulson, N. (2016) Costs and Benefits of Cover Crops: An Example with Cereal Rye. *Farmdoc Daily*, 6, 126.

Schomberg, H., Fisher, D., Reeves, D., Endale, D., Raper, R., Jayaratne, K., Gamble, G.,& Jenkins, M. (2014). Grazing winter rye cover crop in a cotton no-till system: Yield and economics. *Agronomy Journal*, 106, 1041-1050. https://doi.org/10.2134/agronj13.0434.

Sharma, P., Shukla, M.K.,& Mexal, J.G. (2011). Spatial variability of soil properties in agricultural fields of southern new mexico. *Soil Science,* 176, 288-302. https://doi.org/10.1097/SS.0b013e31821c0dab.

SSSA. 2008. Glossary of soil science terms. SSSA, Madison, WI. doi:10.2136/2008.

Steenwerth, K.,& Belina, K. M. (2008). Cover crops enhance soil organic matter, carbon dynamics and microbiological function in a vineyard agroecosystem. *Applied Soil Ecology*, 40, 359–369. https: //doi.org/10.1016/j.apsoil.2008.06.006.

Villamil, M., Bollero, G., Darmody, R., Simmons, F.,& Bullock, D. (2006) No-till corn/soybean systems including winter cover crops. *Soil Science Society of America Journal*, 70, 936-1944. https://doi.org/10.2136/sssaj2005.0350.