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Biodiversity - 2015: Manure usage in restoration of degraded crop land

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Abstract

In the Great Plains of North America, soil degradation particularly by wind erosion became a problem in the late 18th and early 19th century soon after agriculture expanded to the semi-arid region and the land was broken from sod. Soil degradation is a consequence of anthropogenic activity and environmental disturbances that cause alteration in many aspects of soil properties and infl uence crop productivity. Zika and Erb (2009) estimated that annual dryland degradation could reduce global terrestrial net primary productivity by approximately 2%. Th e 2012 United Nation Convention to Combat Desertifi cation stated that the high susceptibility of dryland soils to degradation as a consequence of water defi ciency and drought conditions could infl uence global sustainability and food security (UNCCD, 2012). Furthermore, by 2030 as the world demand for food, energy, and water is anticipated to increase by 50, 45, and 30%, respectively; this requires more land and likely resulting in more land deforestation and ecological degradation (UNCCD, 2012). In the Great Plains of North America, soil degradation, particularly by wind erosion, became a problem in the late 18th and early 19th century soon aft er agriculture expanded to the semiarid region and the land was broken from sod (Stewart, 2004). Th e risk of soil degradation by erosion remained through most of the 20th century. Following World War I, large expanses of the Great Plains suff ered from wind erosion due to the expansion of cultivated land, moldboard plowing, and disking operations (Li et al., 2007) and wheat–fallow cropping systems (Janzen, 2001; Stewart, 2004). Consequently, some farmlands in the Great Plains Region lost their economical activity as a result of losing topsoil, rich with organic materials, to erosion induced by tillage and over-cultivation (Tanaka and Aase, 1989; Stewart, 2004). Topsoil thickness is one of the essential factors in evaluating soil quality and plant productivity (Izaurralde et al., 2006). Th e unique characteristics of topsoil positively influenced nutrient storage and cycling, water and energy transfer, and crop yield. Losing topsoil through erosion decreases the soil organic matter (SOM) pool and negatively infl uences soil properties, which reduce crop productivity (Tanaka and Aase, 1989; Stewart, 2004; Larney and Angers, 2012). The addition of organic amendment was found to not only increase SOM but also may decrease soil bulk density, increase soil hydraulic properties, and improve soil aggregation (Arriaga and Lowery, 2003; Mikha and Rice 2004). Furthermore, many years of organic amendment additions may infl uence soil Agronomy chemical properties and nutrient dynamics. Diacono and Montemurro (2010) reported that long-lasting applications of organic amendments can enhance soil organic carbon (SOC), available K, and extractable P. Annual solid feedlot manure applications over an 11-yr period in Alberta, Canada, increased soil chemical parameters, such as SOM, available P and N, electrical conductivity (EC), and sodium absorption ratio and decreased surface soil pH as the manure application rates increased (Chang et al., 1991). Soil pH decreased 0.3 to 0.7 units more in the surface 0- to 15-cm depth compared with deeper depths. On the other hand, manure

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additions increased soil pH in the surface 15cm compared with ammonium nitrate (NH4NO3) additions, which was attributed to the basic cations added by the manure (Eghball, 2002).Therefore, some farmlands lost top soil rich with organic materials and plant nutrients and consequently decrease their economic value. This study evaluates land productivity and changes in soil properties of eroded land influenced by (1) nitrogen types (manure vs. commercial fertilizer); (2) nitrogen rates (high vs. low) and (3) tillage practices (no-tillage vs. conventional tillage). Two eroded sites were chosen in central Great Plain Region, one site in Akron, CO with topsoil loss of approximately 17 to 20 cm and the second site located in Hays, KS with topsoil loss of approximately 25 cm. The Akron site was established in 2007 and the Hays site was established in 2006. The annual manure application range between 11 to 15 Mg manure per ha for the low N rate and approximately 22 to 30 Mg manure per ha for the high N rate. Throughout the first 5 years of the study period, weather patron specifically the precipitations affected the yield. The amount of rain and its distribution throughout the growing seasons and during the crop critical period in addition to the ambient temperature explained some yield response to the treatments. The least limiting Water Range (LLWR) was influenced by manure addition. The relationship between the LLWR and crop yields was stronger in Hays site than in Akron site. In Hays site, annual manure addition significantly altered soil chemical properties compared with commercial fertilizer especially at the top 15 cm. Soil organic C and changes in soil organic C were greatly influenced by manure addition. Soil inorganic N leaching was also detected during the winter months. Overall, the addition of organic amendments restored the productivity of eroded soil and improved some aspects of soil quality compared with commercial fertilizer. Apparently, more than 5 years are required to assess the treatment benefits on soil quality and productivity in such eroded land.

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